

BRC CLOSURE PLAN

BMI COMMON AREAS CLARK COUNTY, NEVADA

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May 2007

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and to the best of my knowledge comply with all applicable federal, state and local statutes, regulations and ordinances. I hereby certify that all laboratory analytical data was generated by a laboratory certified by the NDEP for each constituent and media presented herein.

Dr. Ranajit Sahu, C.E.M. (No. EM-1699, Exp. 10/07/2007) May 10, 2007
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I hereby certify that I have subjected the attached document to quality control review by external reviewer and have also reviewed the document myself.

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ACRONYMS AND ABBREVIATIONS

Aa	alluvial aquifer
ADD	average daily dose
AMPAC	American Pacific Corporation
Anaconda	Anaconda Copper Mining Company
AOC3	Settlement Agreement and Administrative Order on Consent: BMI Common Areas, Phase 3
ARARs	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BAT	best available techniques
BEC	Basic Environmental Company
BEP	best environmental practices
bgs	below ground surface
BII	Basic Investment Inc.
BMI	Basic Management Inc.
BPC	British Petroleum Company
BRC	Basic Remediation Company
BRI	Basic Refractories, Inc.
C&C	Coverdale & Colpitts
CAMU	Corrective Action Management Unit
CAP	Corrective Action Plan
CEC	cation exchange capacity
COPCs	chemicals of potential concern
CRC	Colorado River Commission
CSF	cancer slope factor
CSM	Conceptual Site Model
DAF	dilution attenuation factor
DBS&A	Daniel B. Stephens & Associates, Inc.
DPC	Defense Plant Corporation
DQA	data quality assessment
DQIs	data quality indicators

ACRONYMS AND ABBREVIATIONS

DQOs	Data Quality Objectives
DTA	O,O-diethylphosphorodithoioic acid
ECA	Environmental Conditions Assessment
ECAO	Environmental Criteria and Assessment Office
ECI	Environmental Conditions Investigation
ERA	ecological risk assessment
FOD	frequency of detection
FSSOP	Field Sampling and Standard Operating Procedures
ft/ft	foot per foot
GIS	geographic information system
GISdT [®]	Guided Interactive Statistical Decision Tools
gpm	gallons per minute
GWTS	Groundwater Treatment System
H ₂ SO ₄	sulfuric acid
HCl	hydrochloric acid
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HISSC	Henderson Industrial Site Steering Committee
IEUBK	Integrated Exposure Uptake Biokinetic Model
IPS	Industrial Planning Section
IRIS	Integrated Risk Information System
IRMs	interim remedial measures
Kerr-McGee	Kerr-McGee Chemical Corporation
LADD	lifetime average daily dose
LOQ	limit of quantitation
LOU	Letter of Understanding
MCLs	maximum contaminant limits
MDL	method detection limit
MEL	Magnesium Electron, Ltd.
mg/kg	milligrams per kilogram
mg/L	milligrams per liter

ACRONYMS AND ABBREVIATIONS

MgO	magnesium oxide
Montrose	Montrose Chemical Corporation
NCEA	National Center for Environmental Assessment
NDEP	Nevada Division of Environmental Protection
NFA	No Further Action
NFAD	No Further Action Determination
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OPM	Office of Production Management
PAHs	polycyclic aromatic hydrocarbons
PARCC	precision, accuracy, representativeness, comparability, and completeness
PCBs	polychlorinated biphenyls
pCi/L	picocuries per liter
PEF	Particulate Emission Factor
Pioneer	Pioneer Chlor-Alkali Company
POPs	Persistent Organic Pollutants
PPRTVs	Provisional Peer Reviewed Toxicity Values
ppt	parts per trillion
PRGs	preliminary remediation goals
psi	pounds per square inch
PSQs	Principal Study Questions
Qal	Quaternary alluvium
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RAS	remedial alternatives study
RFC	Reconstruction Finance Corporation
RfD	reference dose
RIBs	Rapid Infiltration Basins
ROD	Record of Decision
SAR	structure-activity relationship

ACRONYMS AND ABBREVIATIONS

SDG	Sample Delivery Group
SOPs	Standard Operating Procedures
SQL	sample quantitation limits
SRC	Site Related Chemicals
SSLs	soil screening levels
Stauffer	Stauffer Chemical Company
SVOCs	semi-volatile organic compounds
TCE	trichloroethylene
TDS	total dissolved solids
TEFs	toxicity equivalency factors
TEQ	toxic equivalency
TIMET	Titanium Metals Corporation
TOC	total organic carbon
TMCf	Tertiary Muddy Creek formation
TSS	total suspended solids
UCL	upper confidence limit of the mean
USDOE	U.S. Department of Energy
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
VOCs	volatile organic compounds
WAA	War Assets Administration
WECCO	Western Electro Chemical Company
WPB	War Production Board
WRF	Water Reclamation Facility

SECTION 1

1 INTRODUCTION

In February 2006, Basic Remediation Company (BRC) and others executed the *Settlement Agreement and Administrative Order on Consent: BMI Common Areas, Phase 3 (AOC3)*¹ with the Nevada Division of Environmental Protection (“NDEP” or “Division”) for certain property located in Clark County, Nevada. This property (the “Site”) covers approximately 2,690 acres: 2,287 acres east of Boulder Highway, 34 acres west of Boulder Highway (“Parcel 9”); and 369 acres contiguous to Parcel 9 (“Parcel 5/6”). Together, these three parcels compose the “Basic Management, Inc. (BMI) Common Areas”, and they lie within the southeastern quadrant of the Las Vegas Valley (Figure 1-1). Figure 1-2 depicts the 2,287 acre tract east of Boulder Highway, and Figure 1-3 depicts the two tracts to the west of Boulder Highway. The Site is shown in context with nearby features such as the BMI industrial complex, neighboring land uses, historic conveyance ditches and the like on Figure 1-1.

The AOC3 defines the overall framework within which the Site is to be characterized and chemical pollutants remediated, as necessary. Among other matters, the AOC3 specifically “governs the performance and/or completion of Environmental Contaminant characterization, the screening and selection of Remedial Actions, and the implementation and long-term Operation and Maintenance of Division-approved Remedial Actions, each and all as necessary to implement the existing Record of Decision (ROD) and future ROD(s) concerning Soil Pollution Conditions and Water Pollution Conditions at the Site.”² The steps and sequence by which these characterization and remedial actions are to be performed are stated in the *Scope of Work*, which is a part of the AOC3. This Closure Plan has been prepared pursuant to the AOC3, and particularly in furtherance of the Scope of Work. This Closure Plan is also responsive to the existing ROD referenced in the AOC3 text quoted above, which is NDEP’s *Record of Decision, Remediation of Soils and Sediments in the Upper and Lower Ponds at the BMI Complex* (November, 2001). BRC has endeavored to limit the extent of technical detail in this Closure Plan – in an effort to improve its readability, accessibility, and to keep the document to a

¹ Periodically, this document will reference other project documents that have been or are being prepared to achieve the goals of this closure effort. While some of these documents have been approved and are, thus, final, others are in development. These latter documents will always be referred to as “Draft” in this Plan. The inclusion of such Draft documents in this Plan does not in any way imply NDEP concurrence or approval of such documents – rather, these references are simply in order to create a manageable narrative.

² AOC3, §1.9

manageable length. Technical details are to be found in the various documents referenced in this Plan.

This revision of the Closure Plan (Revision 1) incorporates NDEP comments dated January 18, 2007 on the August 2006 *BRC Closure Plan*, as well as a completely re-written Section 4, based on a meeting between BRC and NDEP to review these comments. All NDEP comments and BRC's response-to-comments on the August 2006 version of the Closure Plan are provided in Appendix A. As discussed with and requested by the NDEP, detailed responses to each of the Section 4 comments are not provided at this time. However, included in Appendix A is a redline/strikeout version of the text showing the revisions from the August 2006 version of the Closure Plan. Because of the substantial revisions to Section 4, redline/strikeout for this section is based on the revised draft version commented on by NDEP on March 21, 2007.

The Closure Plan contains the history of the Site, its future uses, BRC's characterization and remediation plans with respect to soils and to waters, the objectives and methods of such remediation plans, and various maps, tables, figures and other references as might be useful to the regulator and other stakeholders. This Closure Plan conceptually describes the steps that BRC will undertake to assess risks at the Site and, hence, to make risk-based decisions (including decisions to seek no further action determinations ("NFADs") for discrete parcels within the Site). The term NFAD is defined in the AOC3 in Section XVII. These steps include dividing the Site into discrete exposure areas ("sub-areas"), the identification of possible receptors and pathways, the identification of actual and potentially contaminated media, the definition of risk assessment source terms (such as data collection, and fate and transport modeling), and how risk-based decisions will be made (including the consideration of background data) for the purposes of prompting remediation, determining appropriate uses, seeking NFADs for sub-areas, and Site Closure. In brief, the Closure Plan states why BRC is choosing to progress down certain paths and how BRC is going to proceed through characterization, remediation, and assessment activities to effect Site Closure—the ultimate aim of the AOC3.

The Site is near the BMI Industrial Complex, in Clark County, Nevada, approximately 13 miles southeast of Las Vegas and two miles northeast of the City of Henderson's downtown. The property represents what is known as the BMI Common Areas; as noted above, the total extent of the Site is approximately 2,690 acres and is composed of the properties east of Boulder Highway (2,287 acres), the Parcel 9 area west of Boulder Highway (34 acres), and the Parcel 5/6 and CAMU Area west of Boulder Highway (369 acres). For ease of use, the term "Eastside" area

will be used to denote the areas east of Boulder Highway as well as the Parcel 9 area, which is located immediately adjacent to and west of Boulder Highway. The proposed Corrective Action Management Unit (CAMU)³ area of approximately 114 acres lies within the 369 acre portion west of Boulder Highway.

The Site consists of:

- land on which unlined wastewater effluent ponds (and associated conveyance ditches) were built and into which various industrial plant wastewaters were discharged from 1942 through 1976 (see Figure 1-2);
- land on which lined wastewater effluent ponds were constructed and into which effluent from the Titanium Metals Corporation (TIMET) plant was discharged from 1976 to 2005 (see Figure 1-2);
- land on which the City of Henderson constructed municipal wastewater rapid infiltration basins (“RIBs”— see Figure 1-2);
- land which BMI conveyed to the City of Henderson and upon which the City of Henderson is presently building a wastewater treatment plant (the Water Reclamation Facility [WRF]— see Figure 1-2);
- land on which unlined wastewater effluent ponds were constructed but which were either never used or rarely used (see Figure 1-2);
- land which appears never to have had historical use (see Figure 1-2); and
- land which was used for private, industrial landfills (see Figure 1-3).

The Eastside Area of the Site is shown in Figure 1-2 and the CAMU Area of the Site is shown in Figure 1-3. Figure 1-2 shows the various sub-areas into which the Eastside Area has been subdivided for purposes of focusing the processes of exposure identification, remediation, and, later, development. The rationale for this subdivision is discussed in Section 4. Note that two sub-areas in the Eastside Area are not subject to soils remediation under the AOC3: these are the WRF sub-area, which is owned by the City of Henderson, and the “No Further Action (NFA) Areas”

³ The proposed CAMU is a lined and capped landfill into which the contaminated soils and sediments, from the Eastside Area will be placed and interred.

sub-area, which is owned by the Landwell Company. As noted above, Figures 1-1 and 1-2 also depict the geographic relationship of the Site to the cities of Henderson and Las Vegas. Figure 1-1 shows both the Eastside and CAMU areas as well as other significant features such as the BMI industrial plants, neighboring land uses, historic conveyance ditches, and the like. The Eastside Area is within the City of Henderson's boundary; the CAMU Area is within Clark County. Further detail and maps of the Site are found in Section 4 of this Closure Plan and in the NDEP-approved *Corrective Action Plan* (BRC 2006a).

The CAMU Area has also been sub-divided for ease of discussion into various sub-areas more fully described in the *Draft CAMU Area Conceptual Site Model* (Daniel B. Stephens & Associates, Inc. [DBS&A] and BRC 2007) and in the *Remedial Action Plan* (BRC 2006b), under review by the NDEP. The CAMU sub-area will not be developed (except to contain the CAMU); however, adjoining parts (known as Parcel 5/6) may be redeveloped.

All media—soils, air, and groundwater—are covered by the AOC3. Groundwater and vadose zone contamination, as might exist under the two sub-areas that have been granted NFAs with respect to soils are still subject to the AOC3 and will be remediated, as and if necessary by BRC, to achieve the purpose of the AOC3, which is overall Site Closure.

Over the past 15 years, a multi-phased investigation has been conducted by BRC and others under the oversight of the NDEP to identify the hydrogeology of the Site and the nature and extent of chemical occurrences⁴ in the Site soils and groundwater. This investigation is continuing. Results of the studies conducted to date have been used to construct two Conceptual Site Models (CSM) - one for the Eastside Area and one for the CAMU Area. Section 4 of this Plan contains a summary of both CSMs. After completion of several investigations in the planning stages or underway, BRC will also prepare a more detailed *Draft Eastside Conceptual Site Model* which will contain additional technical detail beyond what has been presented in summary fashion in Section 4 of this Plan for the Eastside Area. BRC has prepared a separate *Draft CAMU-Area Conceptual Site Model*, which has been provided to NDEP for review. NDEP has provided comments, and this document will be revised as needed in the future.

⁴ The term chemical (as in chemical occurrence and chemical concentrations), as used in this sentence and throughout the remainder of this Closure Plan, refers to various organic and inorganic compounds. A complete list of all Site Related Chemicals (SRC) is provided in Section 3 of this Closure Plan.

1.1 CLOSURE PLAN GOAL

The goal of the Closure Plan is to execute the provisions of the AOC3 such that remediation of the Site results in chemical concentrations in Site media which:

1. Do not pose an unacceptable risk to human health and the environment under anticipated future uses, including residential use in the Eastside Area; or
2. Are representative of background conditions at the Site.

Because the owner of the Site plans to redevelop the Eastside Area according to a master-plan which includes residential, commercial, and civic uses, BRC has chosen to use the U.S. Environmental Protection Agency (USEPA) residential standard as the human health risk standard for the Eastside Area, recognizing however that there may be portions of the Eastside Area in which this standard cannot be achieved. Should this occur, BRC will discuss alternative USEPA risk standards with the NDEP for those portions of the Eastside Area so affected.

The CAMU sub-area will be the permanent location for the remediation wastes from the Upper and Lower Ponds and associated conveyance ditches. These wastes will be interred in the proposed CAMU. After construction of the CAMU, this sub-area will essentially include the CAMU and the older Slit Trenches and the closed BMI Landfill. Appropriate long term monitoring will be conducted in this area as required by the NDEP. Details concerning the CAMU are found in the *Remedial Action Plan* (BRC 2006b).

1.1.1 Human Health Protection

For human health protection, BRC's goal is to remediate the Eastside Area sub-areas such that they are suitable for residential uses, assuring health protective conditions at unit 1/8th-acre exposure areas. The 1/8th-acre area corresponds to the size of a typical residential lot size, as presented in USEPA's 1989 *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part A)* (RAGS). There are only two exceptions to this general goal of residential end use in the Eastside Area, specifically, the "Trails & Recreation" sub-area (see Figure 1-2), and the WRF sub-area.

Risk level and cleanup goals consistent with USEPA precedents and guidelines for residential uses have been established and are discussed in Section 9 of this Plan.

1.1.2 Protection of Groundwater Quality

Characterization and, if necessary, subsequent remediation of groundwater is specified by the AOC3 for the entire Site. Certain groundwater characterization work has been completed by BRC in 2004 (Eastside Area) and 2005 (CAMU Area)⁵; certain work is on-going (*e.g.*, quarterly groundwater monitoring in the Eastside Area; analyses and the construction of a Eastside Area-wide hydrological model); and certain work is planned in the near-term (*e.g.*, determination of upgradient groundwater conditions; aquifer testing, etc.). While the 2004 and 2005 investigations (along with investigations of groundwater conditions by other neighboring property owners) have provided a foundational understanding of groundwater under the Site, data gaps remain. Major data gaps are discussed in Section 4. As further data are collected to close these data gaps, these data will be added to the characterization of groundwater in the respective CSMs, which are intended, like all CSMs, to be “living” documents. Once the groundwater is characterized sufficiently under the Eastside Area and under the CAMU Area, in accordance with the AOC3 BRC will prepare appropriate Remedial Alternatives Study (RAS) documents and submit these to the NDEP for its review. If remediation is necessary of the groundwater(s), such will be performed by BRC, all in accordance with the provisions of the AOC3.

1.1.3 Ecological Receptors

BRC has assessed ecological resources for the Site as a whole and arrived at the conclusion that there are no significant ecological resources present that will be adversely affected by the proposed development. In particular, BRC has evaluated such resources for the sub-area known as the Trails & Recreation sub-area whose development plans have evolved over time. BRC provided the NDEP with substantial documentation during a January 3, 2007 meeting to explain the development plans for this sub-area. These plans indicate that the Trails & Recreation sub-area will receive a substantial amount of fill material and development after remediation is complete. The NDEP believes that these developments do not constitute suitable habitat and hence an ecological risk assessment is not necessary. As noted in Section 10 of this Plan, an ecological risk assessment work plan will be developed if and when impacts and receptors are identified. For example, if it is discovered that off-Site impacts are adversely affecting ecological receptors it may be necessary to develop an ecological risk assessment work plan.

⁵ The details of these investigations will be contained in the respective Draft CSMs being prepared for the Eastside and CAMU areas.

1.2 DOCUMENT ORGANIZATION

Based on suggestions provided by the NDEP to BRC,⁶ this Closure Plan contains the following sections:

1. Introduction
2. Site History
3. Site Related Chemicals List
4. Eastside Area CSM: Overview
5. Data Verification and Validation Reports
6. Data Usability Evaluations
7. Data Quality Objectives, including Principal Study Questions
8. Remedial Alternative Studies
9. Risk Assessment Methods – Human Health
10. Risk Assessment Methods – Ecological

As noted earlier, per the Scope of Work in the AOC3, there are a number of other, free-standing plans pertinent to the characterization and remediation of the Site. A list of these documents and their current status is provided in Table 1-1.

1.3 ITERATIVE APPROACH TOWARD CLOSURE

The characterization, remediation, and assessment processes stipulated in the AOC3 are designed to lead to determinations, by sub-area in the Eastside Area, of no-further action with respect to Eastside Area soils, determinations(s) of no-further action with respect to Site groundwater(s), and ultimately to Site Closure. These determinations will be risk-based. In other words, the decision endpoint in each case is a risk assessment. The processes are specified and depicted in the Scope of Work of the AOC3 and are purposefully iterative in order to achieve a robust and defensible risk assessment result. For example, it can be stated here that the processes leading to

⁶ See Part I Comments from the NDEP to BRC (NDEP, July 11, 2005).

determinations of no-further action in the Eastside Area soils contain an iterative loop (Figure 1-4). In the loop, at a given stage of remediation, risk assessment will not be initiated unless proper data sufficiency, representativeness, and adequacy analysis is first achieved. If necessary, additional data will be gathered or analyzed to meet the goals of data quality required for risk assessment. The risk assessment will, in turn, help to assure that these data characteristics are properly evaluated. Once risk assessment is completed, the assessment will be made as to whether the remediation conducted meets cleanup goals. If cleanup goals are not achieved, additional remediation, associated confirmation sampling, and assessment cycles will be conducted until a decision end point is reached – namely that the cleanup goals are either met (and the NFAD is issued or Site Closure is achieved, as the case may be) or proven infeasible because it is technically impractical or too costly, in which case changes in land use or institutional controls may be considered.

Thus, Figure 1-4 shows the overall sequence of steps that will be taken in order to effect Site closure. This sequence will generally be followed by BRC, and any changes to this sequence that may become necessary will only be made with NDEP concurrence.

1.4 PROJECT ROLES AND RESPONSIBILITIES

Specific roles and responsibilities have been defined for key project personnel to ensure that project goals are achieved. Each defined role will be performed by a responsible, qualified individual. These roles include the Project Program Manager, the Risk Assessment Task Manager, the Hydrogeology Characterization Task Manager, the Project Statistician, and the Construction Manager. The Project Program Manager is Dr. Ranajit (Ron) Sahu, C.E.M., who is responsible for the successful and timely completion of the specified activities. The Program Manager is responsible for assuring that all policies and procedures set forth in the project plans are followed by the project team. Details of team functions and curricula vitae are found in BRC's most current *Soil and Groundwater Clean-Up Team Professional Profiles*, which is submitted to the NDEP on a periodic basis.

SECTION 1 REFERENCES

Basic Remediation Company (BRC). 2006a. Corrective Action Plan (CAP) for the Basic Remediation Company (BRC) Common Areas Remediation Project.

BRC. 2006b. Remedial Action Plan (RAP).

Daniel B. Stephens & Associates, Inc. (DBS&A) and BRC. 2007. Draft CAMU Area Conceptual Site Model.

Nevada Division of Environmental Protection (NDEP). 2001. Record of Decision, Remediation of Soils and Sediments in the Upper and Lower Ponds at the BMI Complex. Henderson, Nevada. November 2.

U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part A). Interim Final. Office of Emergency and Remedial Response, Washington, D.C. USEPA/540/1-89/002. December.

SECTION 2

2 SITE HISTORY

In 1941, approximately 5,000 acres of empty desert in the southeastern quadrant of the Las Vegas Valley was deeded by the United States for use as the site of what was to become the world's largest magnesium plant, a plant that would play a critical role in World War II. Since that time, parts of the original site have remained industrialized, parts of the site have been used for the disposal of a variety of industrial wastes, parts of the site have been abandoned, parts of the site have been converted to other uses, and some parts have remained virgin desert. Over the past 63 years, more than 80 private and public entities have owned or leased or operated facilities on the original site, engaging in a wide range of commercial enterprises from heavy manufacturing of chemicals and metals to warehousing and distribution. The land's uses and ownership are, in a word, complex. But they are, in large part, known.

The land encompassed by the Closure Plan is owned by only one of the many entities that have been involved at the site since 1941, and although the present owner has never been engaged in manufacturing at the site, it is important to establish the historical context for the site as a whole since this context is crucial to understanding the smaller site that is the subject of the Closure Plan. Accordingly, this section provides an overview of the ownership, manufacturing, disposal, and regulatory histories of the original site.

2.1 SITE OWNERSHIP

2.1.1 United States Government – 1941 to 1949

The United States military, in response to the outbreak of war in Europe in 1939, established a substantial aircraft-purchasing program. Magnesium was a crucial component in aircraft production and, by 1940, the demand for magnesium exceeded the supply.¹ The government took action to make certain that the available magnesium was being used appropriately. On February 12, 1941, the Priorities Division of the Office of Production Management (OPM) requested magnesium producers to allocate stocks to defense industries. The next day, the OPM gave complete preferential status to defense needs for magnesium over non-defense orders. In May, the OPM added magnesium to the list of critical materials and placed the material under

¹ Report on Magnesium, p. 8, July 24, 1943. NARA I, RG 46, Box 469, Folder: (General) Magnesium Correspondence. [BR030913-925]

industry-wide control. The OPM issued an “M Order,” making mandatory the curtailment of magnesium for all non-defense uses.²

When in late 1940 President Franklin Roosevelt called for the development of a vast “arsenal of democracy,”³ Howard Eells, President of Basic Refractories, Inc. (BRI), was one of many industrialists that responded. Mr. Eells formed an alliance with a British company, Magnesium Electron, Ltd. (MEL), which operated a magnesium plant in England and was willing to provide technical support for the construction and operation of similar facilities in the United States.⁴

On April 23, 1941, accompanied by Lt. Colonel P. Scheeburger, the Air Corps Chief of the Industrial Planning Section (IPS), Mr. Eells and others affiliated with BRI met with Air Corps personnel and Edgar Lewis, the Special Assistant to the Assistant Secretary of War, and proposed that the company operate a magnesium project.⁵ BRI personnel prepared a compelling proposal, pointing out that there were three necessary requirements to produce magnesium: (1) magnesium oxide (MgO), (2) chlorine (as a gas), and (3) electric power. Mr. Eells felt that the company’s 30 million tons of magnesite deposits in Nye County and hydroelectric power obtained from Boulder Dam could readily fill the need.⁶ He indicated that one of the major problems that existed was a lack of capital.⁷ He proposed construction of a 60,000-ton capacity plant at BRI’s magnesite property in Gabbs as well as a 20,000-ton magnesium plant and a chlorine production facility at a location to be determined. He reiterated that while government funding would be required and assurances regarding patent issues were needed, BRI’s relationship and agreement with MEL eliminated the need for experimentation to develop plant design and production methods.⁸ The Air Corps’ Colonel Hopkins and Mr. Lewis referred Mr. Eells to the Reconstruction Finance Corporation (RFC) for funding to be obtained through its

² Chronological List of OPM Press Releases on Magnesium. NARA I, RG 46, Box 474, Folder: WPB Magnesium. [BR032030-031]

³ FDR Speech, December 29, 1940.

⁴ “Magnesium,” circa 1943. NARA I, RG 46, Box 478, Folder: Las Vegas Basic Magnesium. [BR032509-561, @BR032536]

⁵ War Department Memo # 231, April 23, 1941. UNLV Special Collections, T-6. [BR000607]

⁶ Magnesium Project, BRI, April 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009407-430]

⁷ Magnesium Project, BRI, April 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009420]

⁸ Magnesium Project, BRI, April 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009421-422]

subsidiary, the Defense Plant Corporation (DPC), and told him what needed to be done before approaching the Air Corps engineers.⁹

BRI was invited to meet with additional Air Corps and War Department personnel on May 21, 1941, at which time the government requested that BRI study the costs associated with its plan and prepare three proposals—one for a 5,600-ton unit, another for two 5,600-ton units, and a third proposal for three 5,600-ton units. The decision as to whether to proceed on a one-, two-, or three-unit facility was to be referred to the Secretary of War with a recommendation by the Air Corps after consideration of capital and production costs, housing, labor, and power. Other action items were identified and the IPS recommended that the plant location should be referred to Washington for approval by a higher authority.¹⁰

BRI submitted a formal request to the Army Air Service to authorize the project the next day.¹¹ The Air Corps forwarded the request to the Patent Liaison Branch asking for direction as to making the patents available to BRI. The Air Corps pointed out that “the Under Secretary of War has directed that the setting up of all magnesium production projects be given the highest priority.”¹²

Negotiations continued and technicians from England came to the United States to assist.¹³ In the meantime, William Knudsen, Director General of the OPM, wrote to the Under Secretary of War advising that annual magnesium metal capacity required for national defense needed to be increased from 30 million to 400 million pounds. Knudsen stated that companies building facilities “will be requested to immediately change their plans to provide the capacities indicated.”¹⁴

By June 12, BRI submitted a detailed plan for three proposals in which BRI also recommended construction of a magnesium refining plant. At the meeting, the IPS told BRI that it needed to

⁹ War Department Memo # 231, April 23, 1941. UNLV Special Collections, T-6. [BR000607]

¹⁰ War Department Memo # 255, May 17, 1941. UNLV Special Collections, T-6. [BR000945] PS, Notes on Basic Refractories, May 21, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010507-512]

¹¹ Eells to Assistant Chief, Materials Division, May 22, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010497-498]

¹² P. Schneeberger to Chief, Patent Liaison Branch, May 28, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010484-485]

¹³ P. Schneeberger to Basic Refractories, June 9, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010462]

¹⁴ Frederick Hopkins to Chief, Industrial Planning Section, June 10, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010452] See also Chronological List of OPM Press Releases on Magnesium. NARA I, RG 46, Box 474, Folder: WPB Magnesium. [BR032030-031]

apply for priority assistance with the OPM so that the company would be able to obtain steel and machine tools. BRI again reiterated its need for working capital. The government requested that BRI furnish a statement regarding assurance that MEL would provide advice and assistance in the plant construction and operation. BMI told IPS that it would form a subsidiary with ownership shared by BRI and MEL. The subsidiary was to be the lessee for the DPC lease that would be negotiated.¹⁵

That same day, Colonel Schneeberger sent a telegram to the Air Corps Facilities Section that the IPS was “definitely assured” that BMI would receive necessary assistance from the British technicians, as well as all designs, plans, drawings, specifications, and process information needed to construct and operate the facility. The Air Corps Experimental Engineering Section was convinced that the plans were sound and approved the proposed installations. Colonel Schneeberger commented on the swiftness that BRI was able to produce plans to increase the size of the project, which had grown from a maximum capacity of 33.6 million to 112 million pounds.¹⁶

On June 23, 1941, MEL documented its commitment to provide the drawings and information needed to construct the plants, and that it would send trained personnel and staff needed to operate the facility. The only caveats were that BRI had to obtain a “complete indemnity” from the United States government against any patent infringement action and the British Air Ministry had to agree to allow the technical staff to leave England.¹⁷ The proposed Basic Magnesium plant was intended to be a duplicate of the British plant¹⁸ and was subject to patents assigned to Magnesium Development Company.¹⁹

Final negotiations continued with a conference held on July 22 to work out details of agreement and compensation terms,²⁰ a request by the Air Corps for additional information regarding land

¹⁵ PS, Notes of Basic Refractories, June 12, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010315-317]

¹⁶ Telegram, Industrial Planning Section, June 12, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010352-359]

¹⁷ C.J.P. Ball, to H.P. Eells, June 23, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010350]

¹⁸ Metallurgical Operations at Basic Magnesium Inc. April 23, 1942, p. 1. NARA II, RG 234, Entry 1065, Box 102, Metals Reserve Company Contract File 1940-1955. [BR004804]

¹⁹ See for instance, Inter-office Memorandum to Chief Patent Liaison Office, June 16, 1941 and attached list of patents. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010421-424] Basic Magnesium and Magnesium Development entered into a license agreement in or about December 1941. Reuben T. Carlson, DPC to Marvin Braverman, April 24, 1942. NARA II, RG 234, Entry 1065, Box 102, Metals Reserve Company Contract File 1940-1955. [BR004811]

²⁰ Memorandum of conference, July 22, 1941. UNLV Special Collections, T-6. [BR000907]

improvements on July 23,²¹ and a meeting with the RFC regarding mining claims on July 24. RFC wanted assurance that there were at least 12 million tons of ore in the claims to be leased to the government.²²

On August 1, 1941, after nearly five months of talks, negotiations with the DPC culminated. Basic Magnesium Inc., (which was formed by BRI and MEL) and the DPC entered into an agreement for the construction and operation of the magnesium facilities, which were designated Plancor 201.²³

Finally authorized, the project gained momentum. On August 4, the War Department informed the DPC that it would reimburse the DPC for the acquisition and installation of the plant facilities²⁴ and several days later the DPC approved Basic Magnesium's request to purchase \$9.5 million of electrical equipment.²⁵ By August 18, the DPC, Bureau of Reclamation, and Basic Magnesium conferred and agreed that DPC would buy water and power services at Lake Mead and Boulder Dam and would construct water lines, power lines, and transformer stations from Lake Mead and Boulder Dam to the plant site, which was to be located southeast of Las Vegas, then a small railroad watering station. The DPC agreed to negotiate power and water contracts, and that power to Gabbs would be provided by constructing a transmission line some 60 miles to connect the plant site to the California Electric Company power system at Millers, Nevada.²⁶

The DPC assigned an engineer to the project, whose general duties included authorization to approve plans, designs, specifications, and construction schedules for the construction of the plant. The DPC engineer was also responsible for approving vendor bills and to oversee the acquisition and installation of machinery and equipment. He was authorized to approve contractors employed by Basic Magnesium, as well as the contracts entered into in conjunction with the construction program.²⁷

²¹ P. Scheeberger to D.W. Stewart, BRI, July 23, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009274]

²² Memorandum of conference, July 24, 1941. UNLV Special Collections, T-6. [BR000904-906]

²³ Agreement, August 1, 1941. NARA II, RG 72, Entry 147, Box 13, Folder: Basic Magnesium. [BR004860-870]

²⁴ Robert Patterson to DPC, August 4, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010246-248]

²⁵ P. Schneeberger to Chief, Facilities Section, Materiel Division, August 13, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009938-939]

²⁶ D.W. Stewart to Assistant to Chief, Materiel Division, August 18, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009933-935]

²⁷ W.L. Drager to Basic Magnesium, October 31, 1941. UNLV Special Collections, T-6. [BR001027] Lewis E. Ashbaugh was appointed on September 4, 1941 and was replaced by Ralph Adams on October 31, 1941. By October 12, 1942, there were twenty-two DPC employees working at the Basic Magnesium plants. In addition, ten Basic

By September 11, the Reclamation Service of Department of Interior made arrangements to buy the power needed for the magnesium plant from the Metropolitan Water Company. After survey and consultation by the engineers of the Reclamation Service, a preliminary “Appendix A” for the magnesium plant was drafted, indicating that a new site had been selected for the magnesium plant.²⁸

Mr. Ells stated that Basic Magnesium was short of technical personnel and preparation of a complete Appendix A “would necessitate a long delay in beginning the project.” Perhaps given the urgency of the wartime situation in Europe and the American military’s pressing need to rearm and modernize, Colonel Schneeberger advised he would authorize the project anyway.²⁹

Colonel Schneeberger followed up with a memo to the Air Corps Facilities Section explaining why the project should not follow usual procedure.³⁰ The Chief of the Facilities Section forwarded the request to the War Department. The War Department concurred that complying with procedure would probably result in a delay, but felt that the decision was up to the Air Corps.³¹ The Facilities Section was willing to grant Colonel Schneeberger and the IPS authority to proceed with the final approval of the project if the DPC concurred.³² The DPC sent IPS a telegram, stating that it would accept the Air Corps’ commitment without preparation of a detailed Appendix A, but that one would be required when the construction was close to completion.³³

The sheer magnitude of the project called for extraordinary planning and organization skills.

- Land acquisition arrangements had to be made.
- The plant site was barren desert.

Magnesium employees were assigned specifically to assist the DPC staff. See: Personnel, Salaried Employees, Defense Plant Corporation, as of October 12, 1942. Anaconda Document Collection, American Heritage Center, University of Wyoming. [BR006429]

²⁸ D.A. Graham, Notes on Basic Magnesium, September 11, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009911-912]

²⁹ D.A. Graham, Notes on Basic Magnesium, September 11, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009911-912]

³⁰ P. Schneeberger to Chief, Facilities Section, Materiel Division, September 13, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009902-903]

³¹ Edgar Lewis to W.F. Volandt, September 20, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009890]

³² Letter to W.L. Drager, DPC, September 23, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009878]

³³ John W. Synder, Executive Vice President, DPC, to Major J.L. Bowling, December 2. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009557]

- There was no water at the site. A large water supply line had to be installed from Lake Mead over mountains and some 20 miles to the plant site.
- There was no power at the site. Dual power lines were required from Boulder Dam to the facility.
- There were no local services. Houses, schools, hospital, stores, markets, post office, fire department, churches, sewage facilities, and the like all had to be built.
- The facilities to extract and process ores so that the magnesium plant would have the raw material needed had to be constructed.
- A means to transport the ores from Gabbs to the magnesium plant had to be decided.
- The magnesium production facilities themselves had to be built. These would encompass a massive complex approximately two miles in length, and which would include a chlorine plant, preparation plant, chlorination plant, metals recovery plant, and an electrolysis plant, as well as the support facilities for each.

As it turned out, Colonel Schneeberger's decision to approve the project without a completed Appendix A had far-reaching implications. The DPC typically used the Appendix A to ascertain the soundness of the project plan, check for items overlooked in the planning phase, see if costs were over- or underestimated, and ultimately as a tool to watch over the government's investment. Under normal circumstances, after the project was authorized, the contractor would provide a fully completed Appendix A with its costs substantiated. The Appendix A would be updated as necessary as expenditures were made, and the DPC could readily track the progress of the project and identify any potential problems. Without an Appendix A and a competent operator, mistakes, such as those which were to occur with the magnesium plant's waste effluent system, occurred.

For example, a summary of anticipated costs provided to the IPS on August 1, 1941, included \$204,000 for a waste or "trade" effluent drainage system.³⁴ However, in March 1942, it was "suddenly" discovered that no design work had been done to provide adequate facilities for trade effluent disposal. Basic Magnesium's engineers decided to ask the MEL consultants to

³⁴ D.W. Stewart to Assistant Chief of Material Division, August 1, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009272]

investigate the problem.³⁵ A neutralization plant was designed that was supposed to provide an adequate area to allow for the evaporation of a volume of 5,000 gallons of effluent per minute. However, an error was made in the calculations and the neutralization plant was only one-tenth of the size actually required. Additional waste disposal ponds had to be constructed. To compound the problem, H.C. Mann, the Project Manager, ordered the immediate construction of the ponds—which ultimately encompassed approximately 1,670 acres—and another miscalculation was made. The person making the calculations made “one very bold assumption...which was decidedly in error as later experience has proved. He assumed that there would be no underground percolation.”³⁶

Acquisitions

The site selected for the magnesium plant was situated in the barren desert approximately 13 miles southeast of Las Vegas, Nevada. (See Figures 2-1 and 2-2). The federal government already owned a substantial amount of land in proximity to the selected site. That federal land was withdrawn from entry and made available for use to the DPC for the plant site and for future use if needed. Basic Magnesium deeded the state and private land that it had previously acquired to the DPC on November 27, 1941.³⁷ The land holdings acquired by the government are depicted in Figure 2-3.

Construction on the project began on September 15, 1941, before all of the land had been officially deeded. Within three weeks, the first cost increase request was submitted to the IPS.³⁸ Further problems developed and by November Colonel Schneeberger was informed of “material differences” developing between the American and British personnel and that these differences were delaying the project. In addition, Col. Schneeberger confirmed concern about the purity of the ore deposits at Gabbs and indicated a further survey might be necessary.³⁹

Basic Magnesium’s Director of Plant Protection and Chief Investigator informed Air Corps District Planning Office of “irregularities” in the management of the facility, including: lack of

³⁵ S.J. Fletcher, Neutralization of Effluent Liquor, March 13, 1942. UNLV Special Collections, T-6. [BR033898]

³⁶ E.H. Clary, “Trade Effluent,” in History of Civil Engineering, October 21, 1944. UNLV Special Collections, T-22. [BR033889-910]

³⁷ Map, Basic Magnesium Site and Vicinity, U-41, Issue No. 6, August 24, 1944. [NARA, San Bruno, RG 121, WAA Property Disposal Records, Box 13] See also F. McComthe to Cliff Young, June 15, 1956. [BR001532-533] Ray Pavey to GSA, August 31, 1954. [BR001516-517]

³⁸ P. Schneeberger to Chief, Facilities Section, October 7, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009838-841]

³⁹ P. Schneeberger, Notes on Basic Magnesium, November 10, 1941. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009775]

organization and responsibility, misuse of company equipment, extravagant use of Government funds, unqualified people hired to fill key positions at high salaries, and abuse of overtime payment.⁴⁰

On the morning of December 7, 1941, Japan attacked the United States naval base at Pearl Harbor, Hawaii. The Congress immediately approved the President's declaration of war against Japan, and before month's end, Germany and Italy had declared war on the United States. The Plancor 201 project—already a matter of great urgency—had become critical to the war effort of the United States itself.

By early 1942, the DPC had become dissatisfied with the project's progress, and an investigation was initiated. One of the individuals who looked into the matter reported back, describing chaos: "The site was cleared before one final drawing had been made. I have seen construction men leaning over [draftsmen's] shoulders to see the last line drawn; then they'd rush out into the field and put up that much more of it...."⁴¹ The DPC Supervising Engineer, Ralph Adams, was reportedly not up to the task either, as the investigator noted: "If I ever saw a stupid old fuddy-duddy, it's Adams. I'd guess that he's an old-school civil engineer bewildered by a million angles of the most complex scientific project in the world."⁴²

The DPC decided to retain an outside consultant, Coverdale & Colpitts (C&C), to direct, supervise, and coordinate the engineering and construction of the Basic Magnesium facility. C&C entered into an agreement with Basic Magnesium on April 9, 1942, and immediately set about trying to get the project back on track.⁴³ By May 23, the DPC engineer and auditor had determined that the project was over-committed⁴⁴ and, on June 30, when C&C completed its cost estimate for Plancor 201, they informed the IPS that the cost overrun was more than \$20 million. Outraged, the IPS ordered that a conference be arranged with people "competent to discuss the situation at the earliest possible moment to enable this office to take necessary action to protect the government's financial interest and at the same time avoid delay in completion of the

⁴⁰ E.K. Merritt to Industrial Planning Officer, February 6, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009623-624]

⁴¹ Paul Harrison to Donn Sutton, February 12, 1942. NARA I, RG 46, Box 477, Folder: Basic Magnesium Notes. [BR032409-417, @ 32411]

⁴² Paul Harrison to Donn Sutton, February 12, 1942. NARA I, RG 46, Box 477, Folder: Basic Magnesium Notes. [BR032409-417, @ 32414]

⁴³ Letter agreement, April 9, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR008928-932]

⁴⁴ Telegraph, Weber to H.P. Eells, May 23, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR008896]

project.”⁴⁵ The conference was held July 3 at which IPS claimed to be shocked to find out that Basic Magnesium appeared “suddenly to be bankrupt.” The company had no funds with which to meet payroll for the week, and it was IPS’ position was that the problem was the DPC’s. IPS personnel, Lt. Colonels Doolan and Shawhan, stated that the “Government might well be forced to install an interim or temporary receiver until the matter was worked out.”⁴⁶

Searching for solutions, the Air Corps explored the possibility of forcing Basic Magnesium to abandon the English technology for the chemical processing. The IPS ascertained that the agreement contained no provision concerning the process to be used and told the Air Corps that refusal to authorize or approve the purchase of certain types of equipment was a method that they could use to exert control over processes used at the site. The IPS referred the Air Corps to the DPC for a more definitive answer.⁴⁷

While the government explored its options on how and where it could find additional funding for the project, relations between C&C and Basic Magnesium deteriorated. In part, Mr. Eells used the imposition of C&C as construction engineers as the catalyst for his position that the “DPC has taken the completion of the construction of this plant out of the hands of Basic Magnesium, Inc., and is proceeding to construct it itself...”⁴⁸ Mr. Eells claimed that C&C’s role was forced on Basic Magnesium.⁴⁹ he stated, “To show you how sweeping [the DPC’s] responsibility was in the mind of those who directed [C&C’s] appointment, it was stated in one of the meetings in Mr. Husband’s office that I might as well take a holiday.”⁵⁰ On August 15, Mr. Eells pointed out to the War Department that Basic Magnesium lacked the authority and responsibility to fulfill its obligation because C&C did not function as a part of Basic Magnesium’s organization.⁵¹

⁴⁵ Teletype Message P. Schneeberger to Col. F.M. Hopkins, July 2, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR008948-949]

⁴⁶ G.D. Carrington, July 3, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010264-265]

⁴⁷ A.E. Jones to Acting Chief, Industrial Planning Section, June 30, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR008972]

⁴⁸ G.D. Carrington, July 6, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR010263]

⁴⁹ S.P. Brown, Notes on Basic Magnesium, July 8, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR008934]

⁵⁰ H.P. Eells to P. Schneeberger, August 1, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR008810-812]

⁵¹ H.P. Eells to P. Schneeberger, August 15, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR008763] See also H.P. Eells to P. Schneeberger, September 3, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR008715]

Allegations of blame for the cost overruns were in no shortage. The Truman Committee⁵² found that there was “entirely too much dependence placed on the overly optimistic estimates of quality and quantity of the magnesite ore deposits....”⁵³ The Committee also commented that BRI’s objective was to commercialize its magnesite deposits and that the company was not acting on patriotic motives to assist in relieving the shortage of magnesium metal.⁵⁴

Apparently it was clear to the government that further intervention was required to keep the magnesium project going. The WPB and the DPC approached the Anaconda Copper Mining Company (Anaconda) on August 5, 1942, and implored Anaconda to take over the operations of Basic Magnesium. At this initial meeting, P.G. Spilsbury represented Anaconda. The WPB briefed him on the “background of the proposition ... that Anaconda consider purchasing the controlling interest ... and take over the operation and management” of Basic Magnesium. The WPB then requested that Mr. Spilsbury talk with Sam Husbands, President of the DPC. Mr. Spilsbury spent an hour with Mr. Husbands who spent the time “reviewing the whole situation and begging [Anaconda] to consider taking over management because of the record which we demonstrated and the faith he had in our ability.”⁵⁵ Mr. Spilsbury related the information regarding the corporate relationship between BRI and MEL, indicating that Basic Magnesium was a “dummy company set up in response to the suggestion of the RFC.”⁵⁶

By mid August 1942, Anaconda had swiftly investigated the development of the Basic Magnesium ore reserves at Gabbs⁵⁷ and had visited the magnesium plant. Clyde E. Weed, Anaconda’s Vice President in Charge of Mining Operations, summarized his observations to J.R. Hobbins, Anaconda’s President, “I do not believe that the organization, as now constituted, can ever operate a plant successfully, and one of the first jobs would be revamping this organization to make it workable.”⁵⁸ He continued, indicating that if Anaconda were to take over the management of the plant, the company would need to obtain several assurances from the DPC. These assurances included that the DPC would have to agree to provide the money to complete

⁵² On March 1, 1941, the U.S. Senate authorized formation of the Committee to Investigate the National Defense Program for the purpose of conducting an inquiry into potential waste and corruption in defense contracts. The committee was commonly known as the Truman Committee.

⁵³ Truman Committee findings. NARA I, RG 46, Box 478, Folder: Las Vegas Basic Magnesium. [BR032557]

⁵⁴ Truman Committee findings. NARA I, RG 46, Box 478, Folder: Las Vegas Basic Magnesium. [BR032559]

⁵⁵ P.G. Spilsbury to J.R. Hobbins, August 5, 1942. [BML008466] Imperial Chemical Industries owned 48 percent of the MEL stock.

⁵⁶ P.G. Spilsbury to J.R. Hobbins, August 5, 1942. [BML008467]

⁵⁷ Reno Sales Memorandum to C.E. Weed, August 17, 1942. Anaconda Document Collection, American Heritage Center, University of Wyoming. [BR005870]

⁵⁸ C.E. Weed to J.R. Hobbins, August 17, 1942. [YBD13486]

the construction and to make any changes the company considered necessary. Likewise, Anaconda wanted to “be given a free hand in making decisions, as far as engineering goes, without consulting Defense Plant engineers.... We should be given a free hand in the management in order to develop a proper organization.”⁵⁹ Mr. Weed reported that he and Frederick Laist, Anaconda’s Vice President in Charge of Metallurgical Operations, agreed:

1. That magnesium has a future as a metal.
2. That the process as developed will be successful in making magnesium.
3. That the process is subject to improvement in both metallurgy and costs.
4. That this will give us the opportunity to study the magnesium business, and that at the end of the emergency, the Anaconda would be in position to decide definitely whether they wish to remain in the magnesium business.⁶⁰

Mr. Laist summarized his conclusions to Mr. Hobbins, “Acquisition of the controlling interest in Basic Magnesium seems to be an excellent way of obtaining a position in the magnesium business and learning all about it with a minimum of risk.”⁶¹

Correspondence suggests that the take-over request was a closely held secret while negotiations were underway. On September 1 and 2, Mr. Weed and R.B. Caples, Anaconda’s Manager of its Great Falls (Montana) Reduction Plant, met with Mr. Eells in Cleveland regarding the organization and development of Basic Magnesium. Mr. Eells told them that after the DPC installed C&C, the British interests insisted that Major C.P. Ball and H.C. Mann be in charge of running the Basic Magnesium plant. Major Ball brought a staff of six British engineers to Nevada, and forty-five engineers from the plant were sent to England for six months to study the MEL plant operations. Mr. Eells informed the two Anaconda representatives that Basic Magnesium contracted with the DPC to supply all requirements of magnesite from the Gabbs properties at a royalty of \$0.0025 per pound of magnesium produced. He indicated that if another entity operated the plant, the royalty doubled.⁶²

⁵⁹ C.E. Weed to J.R. Hobbins, August 17, 1942. [YBD13487]

⁶⁰ C.E. Weed to J.R. Hobbins, August 17, 1942. [YBD13488]

⁶¹ Frederick Laist to J.R. Hobbins, August 16, 1942. [BML10204]

⁶² R.B. Caples, Memorandum of Visit with Mr. Howard P. Eells, Jr. at Cleveland, Ohio, September 1st and 2nd, 1942. Anaconda Document Collection, American Heritage Center, University of Wyoming. [BR006306-310] Regarding royalty, see also “Legal Summary,” in Engineer’s Final Report, n.d. NARA II, RG 234, Entry 146, Box 114, Folder: DPC Engineers Reports and Appendices, Plancor 201. [BR004114-115]

Negotiations between Anaconda and the DPC continued to progress, and Anaconda evaluated various options for taking over the operations of the plant.⁶³ Reno Sales, Anaconda's Chief Geologist, provided Mr. Weed with mining district maps for the Gabbs area. On September 19, Mr. Weed reported back to Mr. Sales that the maps "came in very handy in our discussion of the Basic Magnesium problems with the DPC. When I have finished with the maps I will return them to you at Butte. We are meeting with the Defense Plant officials again on Monday, and I imagine at that time something very definite will be decided."⁶⁴

On September 28, Mr. Weed wrote to Mr. Sales, "You might be interested to know that the Basic Magnesium set-up is about cleaned up and undoubtedly we are elected to operate the property for the balance of the emergency. Also confidentially, as Mr. Hobbins has not as yet announced it, Frank Case will go there as manager, and Mr. Satterthwaite, Superintendent of the zinc plant at Great Falls, will go there as his assistant."⁶⁵

Basic Magnesium, BRI, MEL, and Anaconda came to an agreement on September 30, 1942.⁶⁶ The DPC agreed to purchase the mining claims in Nye County for \$450,000 and Anaconda agreed to pay \$75,000 for 52,500 shares of Basic Magnesium stock.⁶⁷ The take-over was not made public knowledge until the end of October, when the Secretary of Commerce issued a press release.⁶⁸ The next day Cornelius F. Kelly, chairman of Anaconda's board and chief executive officer of the company, issued a statement that Anaconda's participation in the enterprise "has been undertaken at the invitation of the government and of the English and American interests in Basic Magnesium. Our function is that of management...without responsibility [for what] has occurred prior to our taking over and is undertaken for the purpose of doing what we can at the request of all the interested parties to aid in the war effort."⁶⁹ On November 30, 1942, the Air Corps Facilities Section was informed that it was "officially confirmed that Anaconda own[ed]

⁶³ Memorandum Summarizing Various ideas respecting the Basic Magnesium setup, September 1, 1942. [YBD15148-154] Letter to C.F. Kelley, September 5, 1942. [YBD15131-135]

⁶⁴ C.E. Weed to Reno Sales, September 19, 1942. Anaconda Document Collection, American Heritage Center, University of Wyoming. [BR005879]

⁶⁵ C.E. Weed to Reno Sales, September 28, 1942. Anaconda Document Collection, American Heritage Center, University of Wyoming. [BR005878]

⁶⁶ Agreed upon procedures, September 30, 1942. [YBD15102-106]

⁶⁷ Excerpt from Minutes of Meeting of Board of Directors of Basic Refractories, October 20, 1942. [YBD15642-646]

⁶⁸ Press Release, RFC 1679, October 26, 1942. NARA I, RG 46, Box 473, Folder: Basic Magnesium D.P.S. Files Rev. [BR031838] See also W.H. Hoover, General Counsel to Richard Inglis, Hauxhurst, Inglis, Sharp & Cull, October 19, 1942. [YBD15737-044]

⁶⁹ "ACM Acquires Interest in Basic Magnesium Inc." *Great Falls Tribune*, October 27, 1942. [BR006300]

controlling interest in BMI.”⁷⁰ Filings with the Nevada Secretary of State’s office reveal that Anaconda representatives, including J.E. Hobbins, Frederick Laist, C.F. Kelly, C.E. Moran, W.K. Daly, J.H. Quayle, Jr., and F.M Brynes, had become officers and/or directors of Basic Magnesium.⁷¹

The effects of Anaconda’s involvement and expertise were readily apparent. For instance, personnel set about determining changes to the organization and processes used that would save money and/or materials at the magnesium plant in Henderson. One of the first steps taken was to remove the English engineers from supervisory positions and thereafter they functioned solely as consultants.⁷² Major process improvements were made after Anaconda assumed control of Basic Magnesium, including the elimination of peat from the flow sheet,⁷³ reducing the chlorine consumption, and reclaiming some of the by-products—particularly cell melt and chlorinator cleanings.⁷⁴ In testimony presented to Congress, Basic Magnesium personnel claimed that over \$1.1 million had been saved through “improvements that have been made or suggested since Anaconda took over the management....”⁷⁵

Anaconda worked diligently with the Air Corps to eliminate items not essential to the operation of the Basic Magnesium facility and to keep construction costs as low as possible. As a part of its on-going assessment of funds expended and anticipated to be spent, Wilbur Jurden, Anaconda’s Chief Engineer, wrote to Major J.L. Bowling of the Army Air Corps, requesting additional funding for emergency construction items essential to bring the plant to its full capacity and to ensure its continued operation.

Additional waste disposal ponds were among these emergency facilities:

The tailings water from the plant contains considerable impurities and injurious chemicals and we are not allowed to let any of this water drain into the Las Vegas Gulch from whence it would

⁷⁰ Jesse Bowling to G.H. Moriarty, December 3, 1942. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR008663-664]

⁷¹ Officers, Directors, and Designation of Resident Agent, June 14, 1943. Nevada Secretary of State. [BR039135]

⁷² Roy E. Thomas, Chief Engineer, April 30, 1945. UNLV Special Collections, T-6. [BR008015]

⁷³ Satterthwaite to R.B. Caples, Manager, ACMC, Great Falls, MT, April 17, 1943. Anaconda Document Collection, American Heritage Center, University of Wyoming. [BR006273-274]

⁷⁴ Investigation of Industrial Centralization (Basic Magnesium Plant), Hearings before a Special Committee, 78th Congress, Second Session, Part 5, November 27 and 28, 1944, pp. 457-458, containing text of letter from H.G. Satterthwaite to F.O. Case, November 23, 1944. [BR038409-410]

⁷⁵ Investigation of Industrial Centralization (Basic Magnesium Plant), Hearings before a Special Committee, 78th Congress, Second Session, Part 5, November 27 and 28, 1944, pp. 457-458, containing text of letter from H.G. Satterthwaite to F.O. Case, November 23, 1944. [BR038409-410] An extensive list of cost saving efforts and improvements after Anaconda took over are detailed on pages 457-476 of the hearing transcript. [RB038409-422]

go into Lake Mead. Results of operations to date have shown conclusively that the effluent ponds already constructed are inadequate and unless these additional ponds are constructed and quickly, we may find ourselves faced with a curtailment of production due to the inability to dispose of the effluent water and as production of magnesium is rapidly increasing this situation is becoming worse.⁷⁶

Construction of the effluent ponds began between December 7 and 29, 1942. By April 19, 1943, the ponds had been completed and were in use.

The first metallic magnesium production at the Basic Magnesium plant occurred on August 31, 1942. The plant was in full production by July 12, 1943, and by the end of July 1943, the plant was producing at 110 percent of capacity.⁷⁷ On April 8, 1944, the War Production Board (WPB) ordered Basic Magnesium to curtail production. Between April 20 and May 13, 1944, four units were shut down. On July 26, the WPB ordered a further curtailment with two more units to be shut down. Operations ceased at two more units in October, and by November 15, the remainder of the plant shutdown. The magnesium operations at Henderson ceased “after 807 days of continuous operation” and after having produced 166,322,685 pounds of marketable refined or alloyed magnesium ingots, billets, or slabs.⁷⁸ Production of by-products from August 1942 to November 1944 was:⁷⁹

Liquid chlorine	15,843 tons
Caustic soda	45,314 tons
Flux	1,287 tons
Magnesium chloride	735 tons

Basic Magnesium’s efforts under Anaconda’s control were an extraordinary accomplishment. Frank Case, who had been appointed by Anaconda to serve as General Manager for Basic Magnesium, explained that they strove to make it a viable concern: “We [the management staff]

⁷⁶ Wilbur Jurden, Chief Engineer, Anaconda, to Major J.L. Bowling, Production Division, DPC, April 21, 1943. NPRC-MPR, Accession 342-54-4046, Box 15, Folder: Correspondence 88A, 88B. [BR009535-545, see BR009540-541 for evaporation pond line item.] Construction of the ponds was completed prior to the submission of the funding request.

⁷⁷ Final Engineer’s Report, Part “C” – Historical. NARA II, RG 234, Entry 146, Box 114, Folder: DPC Engineers Reports and Appendices. [BR004127]

⁷⁸ A Chronological History of Basic Magnesium, November 16, 1944. Anaconda Document Collection, American Heritage Center, University of Wyoming. [BR033096-098]

⁷⁹ Investigation of Industrial Centralization (Basic Magnesium Plant), Hearings before a Special Committee, 78th Congress, Second Session, Part 5, November 27 and 28, 1944, pp. 518-519. [BR038446] Production was given in terms of sales and shipments.

as a group are very optimistic now about our chances of making [Basic Magnesium] a commercial success; a company that can compete with the Dow Company – we might just as well be outspoken about it....”⁸⁰

However, with the demand for magnesium declining, Anaconda decided that it did not want to acquire the Basic Magnesium site,⁸¹ and the DPC therefore engaged J.M. Montgomery & Co., Inc. to supervise the overall management of the facilities.⁸² The Operating Agreement between DPC and Basic Magnesium was terminated on May 16, 1945, together with all of the company’s purchase rights under the Agreement.⁸³

The world-scale magnesium plant and its associated facilities had been constructed from scratch in a period of less than 20 months under very difficult conditions at a cost of over \$130 million. The plant operated from August 1942 until November 1944, when the government ascertained that it had a sufficient magnesium supply and so shut down the magnesium operations. The government’s agreement with Basic Magnesium for the operation of the plant was terminated and, in May 1945, the United States engaged J.M. Montgomery & Co., Inc. to supervise the overall management of the facilities.⁸⁴ Guy F. Atkinson Company replaced J.M. Montgomery & Co. under a Property Protection and Maintenance contract in November 1946.⁸⁵

Lessees

In an effort to recoup some of its investment for building the facility, as well as to ensure production of things still needed for the war effort, the government proceeded to lease portions of site to various companies. The table below depicts these leases:

⁸⁰ Hearing of the Sub-Committee on Light Metals and Aviation of the Special Committee Investigating the War Program, May 11, 1943. NARA I, RG 46, Box 478. [BR032165-166]

⁸¹ Imperial Chemical Industries to J.R. Hobbins, July 12, 1945. [BML1172-173] The letter refers to Anaconda’s loss of interest in magnesium. Anaconda purchased MEL’s shares in Basic Magnesium and the company continued to exist until Anaconda dissolved it in November 1974. Consent to Dissolution, November 14, 1974. Nevada Secretary of State. [BR039210]

⁸² Agreement, May 14, 1945. NARA II, RG 72, Entry 147, Box 13, Folder: Basic Magnesium Plancor 201. [BR004907-913]

⁸³ L.A. Kelly, Counsel, Office of Defense Plants, Memorandum Accompanying SPB-5. Army Corps of Engineers, Sacramento. [BR001551-553]

⁸⁴ Agreement between DPC and J.M. Montgomery, May 14, 1945. [BR004907-913]

⁸⁵ Cost-Plus-A-Fixed-Fee Property Protection and Maintenance Contract, November 29, 1946. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 12]

Company	Lease Area
Allied Productions	Undefined buildings and space
Amecco Chemicals, Inc.	Electrolysis Building No. 2 and adjacent chlorination building
Basic Boat Builders	Lease 480 square feet in Canteen Building S-12
Bureau of Reclamation	A portion of the site on which transformers were located
Carter Printing & Engraving	Print Shop, rooms 14 and 17 in Building K-33 ⁸⁶
City Mercantile Company	Unknown
Coulter, Harden & Company	Purchase of cell melt, rental of equipment and office space in Central Laboratory Building K-33 ⁸⁷
Desert Furniture & Carpet Company	Warehouse space ⁸⁸
Gelatines, Inc.	Peat Building B-5, Peat Building B-6, Peat Slab B-30, Secondary Peat Building B-8, and Canteen S-14
Hardesty Chemical Company	Electrolysis Building No. 2 and adjacent chlorination building
Hodsdon Brothers, Inc.	North portion of the Magnesite Garage T-30, and some equipment ⁸⁹
Industrial & Metallurgical Engineering Company	Space and equipment in Permanent Laboratory Building K-33
Mineral Materials Company	Manganese Ore Company Spur Track
Myers-Thornton Gas Company	Propane storage area ⁹⁰

⁸⁶ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

⁸⁷ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

⁸⁸ Sales Brochure, Plancor 201. n.d.

⁸⁹ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

⁹⁰ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

Company	Lease Area
Nevada Clay Products Company	Buildings B-12, B-22 and certain portions of B-2
Nevada Wholesale Meat Company	Lease 11,000 square feet in Cafeteria Building S-11 ⁹¹
Nevada, New York & Ohio Chemical Company	East end of Preparation Plant Building ⁹² and the east side of Building B-2 ⁹³
O.J. Scherer Company	First leased south half of Change House S-8 and Building K-5. Transferred work to Building T-3. ⁹⁴
Sears Robuck & Company	Warehouse space ⁹⁵
State of Nevada, Employment Service Department	Office space in McNeil Administration Building K-2 ⁹⁶
Stauffer Chemical Company (Stauffer)	Three parcels, space in the permanent laboratory building, parking area, and tank cars
True Gems	Change House Building S-9 ⁹⁷
Underwriters Salvage Company of New York	Leased 9,960 square feet in Building T-4
United States Vanadium Corporation	Refinery Buildings J-1 and J-5, a portion of Flux Plant and equipment, laboratory space, the west half of Change House S-7, shop and maintenance equipment, and three settling ponds. ⁹⁸

⁹¹ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

⁹² See item 1 in John R. Reilly to Irving Gumbo, December 10, 1947. [BR002336]

⁹³ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

⁹⁴ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

⁹⁵ Sales Brochure, Plancor 201. n.d.

⁹⁶ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

⁹⁷ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

⁹⁸ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

Company	Lease Area
Vadelite Corporation	Portions of Administration Building
Western Electro Chemical Company (WECCO)	Salt Storage Building, Acid Tank Neutralization area, Railroad Unloading Platform, Unit 4, Office building in K-36 area, Change House S-2, and Storage Yard (between Tr. 11 and 12 and 8 th and 9 th streets)
Western Mineral & Development Corporation	Laboratory room in Building K-33 ⁹⁹
Mendelsohn, William	Portion of McNeil Administration Building K-2 ¹⁰⁰

In addition, the government leased machinery and/or equipment to Lithalloys Corporation and Bakelite Corporation. It is unknown if the machinery and/or equipment was used on site or moved to another location.

In November 1946, the RFC, as successor to the DPC, transferred the site to the War Assets Administration (WAA).¹⁰¹ Charged with selling off the government-owned wartime facilities, the WAA arranged for a utilization study and appraisal of the plant.

The Government appraiser believed that the best use for the property was as facilities for a diversified chemical industry.¹⁰² Within 1 week after the report was published, the WAA offered the Colorado River Commission (CRC) the opportunity to purchase, lease, or take over the Basic Magnesium plant.¹⁰³ Negotiations were formally initiated and, in a Letter of Intent dated March 17, 1948, the WAA agreed to transfer all the rights and assets (personal and real property) that were associated with the Basic Magnesium project, Plancor 201, to CRC.¹⁰⁴

⁹⁹ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

¹⁰⁰ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

¹⁰¹ Memorandum of Understanding, November 8, 1946. Army Corps of Engineers, Sacramento. [BR001539-546]

¹⁰² Industrial Utilization Study and Facilities Appraisal Report, Volume 1, October 1, 1947 [BR003398]

¹⁰³ Letter to Colorado River Commission, October 7, 1947. NARA, San Bruno, RG 269, Box 21, Basic Magnesium Case Files, Folder: Board Memoranda Plancor 201, (1 of 3). [BR002334-335]

¹⁰⁴ Letter of Intent, March 17, 1948. BMI [BR001408-413]

Conveyances

Date	From	To	Area
6/3/1949	WAA	CRC	See 2- 4
Unknown	WAA	Department of Interior, Bureau of Reclamation	Six parcel located within Section 13, T 22S, R 62E, with electrical transmission facilities. Parcel sizes were 2.726, 8.035, 3.871, 2.42, 12.186, and 19.119 acres. ¹⁰⁵ See Figure 2-4.

2.1.2 Colorado River Commission – 1949 to 1953

Acquisitions

Negotiations between the CRC and the federal government were concluded and the property was transferred to the CRC in a deed dated June 3, 1949.¹⁰⁶ Figure 2-5 depicts the land transferred to the CRC.

Lessees

The CRC’s goals were to obtain the property in order to prevent its cannibalization and to then sell it in such a way to ensure the continued operation of the facilities and encourage industrial development of the area.¹⁰⁷ In the meantime, while it negotiated sales of the property, the CRC continued leasing portions of the facility, as shown in the table below:

¹⁰⁵ See Quitclaim Deed, June 3, 1949, Item 4, pp. 3-5. [BR001605-607]

¹⁰⁶ Quitclaim Deed, June 3, 1949. Army Corps of Engineers, Sacramento. [BR001603-615]

¹⁰⁷ Assignment of Lease. NARA San Bruno, RG 291, Real Property Files, Box 1, Folder: Nev-5, Inspection of Leases. [BR002880]

Company	Area
Combined Metals Reduction Company	Metal Unit 10, Refinery Building J-2, East half of Change House S-7, ¹⁰⁸ Loading Platform J-12 and approximately 88.09 acres of land. As of May 23, 1952, the company was in the process of amending the lease to include Buildings P-1, T-1, T-11, T-18 and additional land. ¹⁰⁹
Daniel Furse and Dante Bagni	Cafeteria
Henderson Riding Club	Land near sewage plant
J.W. Conroy	Buildings T-38 and T-39
Mainor, William	Land near sewage plant
Miller, Haynes & Smith, Inc.	Building K-38
National Lead Company	Metal Units 7, 8, and 9, Change House S-1, Cafeteria Building S-11, Peat Building B-5, S-14, Refinery J-1, Refinery J-5, and approximately 62.12 acres of land.
National Lead Company	Metal Unit 10, Refinery Building J-2, East half of Change House S-7, Canteen S-12, and Loading Platform J-12. (Assigned from Combined Metals Reduction/ Pioche Manganese)
Paraffine Companies, Inc.	Manganese Ore spur and land
Post Transportation Company	One half of Change House S-3 and Land for garage
Stauffer	Chlorine and Caustic plant and land. ¹¹⁰ Approximately 237.476 acres.

¹⁰⁸ Combined Metals to have the right to occupy the west half of Change House S-y when lease with United States Vanadium Corporation expired or was terminated.

¹⁰⁹ Agreement of Sale, CRC to BMI, May 23, 1952. [See BR001362]

¹¹⁰ Agreement of Sale, CRC to BMI, May 23, 1952. [BR001627-644]

Company	Area
Union Pacific Railroad Company	Office space in laboratory Building K-33
US Lime Products Corporation	Portion of preparation plant building B-1 and Building B-21.
US Treasury Department, Bureau of Federal Supply	Approximately three acres located north and east of Gate 4 for storage space for magnesium ingots. ¹¹¹

Conveyances

The CRC subdivided the plant complex into parcels and proceeded to sell them, as follows:

Date	From	To	Area
4/28/1951	CRC	Stauffer	259.196 acres
6/28/1951	CRC	WECCO	Preparation Area ¹¹²
8/21/1951	CRC	Arrowhead Lime and Chemical Company (US Lime)	Preparation Area ¹¹³
11/6/1951	CRC	Hercules Powder Company	Land ¹¹⁴ approximately 36.65 acres
1/24/1952	CRC	OJ Scherer and Associates	Building T-3
1/31/1952	CRC	Stauffer	11.59 acres
3/31/1952	CRC	Stauffer	36.65 acres
8/1/1952	CRC	WECCO	Area subsequently purchased by Navy ¹¹⁵
9/8/1952	CRC	BMI	Common Areas
9/8/1953	CRC	Stauffer	16.517 acres

¹¹¹ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

¹¹² Agreement of Sale, CRC to BMI, May 23, 1952. [BR001627-644]

¹¹³ Agreement of Sale, CRC to BMI, May 23, 1952. [BR001627-644] See also BR002977.

¹¹⁴ Agreement of Sale, CRC to BMI, May 23, 1952. [BR001627-644]

¹¹⁵ Referred to in letter to GSA Regional Director, January 18, 1954. [BR002436-437]

In addition, the CRC indicated that several sales were in process as of May 23, 1952. However, the areas involved are unclear and it is unknown if the transactions were in fact completed.¹¹⁶ These transactions were identified as:

- W.O. Haynes, Inc., Agreement of Sale dated December 17, 1951.
- Molybdenum Corporation of America, Agreement of Sale dated December 31, 1951.
- Manganese Inc., the necessary legal documents relative to sale were in the process of being compiled on May 23, 1952.

With the sale of the parcels to individual companies and the sale of what became known as the Common Areas to a syndicate of tenants that had formed under the name BMI, the CRC had essentially achieved its objective. On January 21, 1953, as a part of its payment to the Federal Government, the CRC re-assigned six leases to the General Services Administration. The transaction thereby made the United States the owner of those facilities again.¹¹⁷

Ownership of the facility after the completion of the CRC conveyances is depicted in Figure 2-6.

Various transactions have occurred since the property was sold by the CRC. The following section is arranged by entity to show these land acquisitions, lessees, and conveyances.

2.1.3 United States Government

Acquisitions

As noted above, the CRC re-assigned six leases to the General Services Administration in January 1953, as a part of its payment to the Federal Government. The transaction made the

¹¹⁶ Agreement of Sale, CRC to BMI, May 23, 1952. [BR001627-644]

¹¹⁷ Assignment of Lease. [BR002880] "Leases" in Office Memorandum, Liquidation of the Colorado River Commission Activities at the Basic Magnesium Project, January 26, 1953. [BR002986-990] See also: Office Memorandum, Robert B. Bradford to Deputy Regional Director, Public Building Service, April 25, 1956. [BR002865] Lease and Option Agreements attached to Richard H. Greenburg, Regional Comptroller, GSA, to Robert J. Moore, BMI, January 30, 1953. [BR002975-983] Transmittal of Notes, Deeds and Leases Assigned to GSA, January 28, 1953. [BR002984-985] Richard H. Greenburg, Regional Comptroller, GSA, to Robert J. Moore, BMI, January 30, 1953. [BR002974] Elmo L. Buttle, Chief, Surplus Real Property Division, October 5, 1953. [BR002971]

United States the owner of those facilities again.¹¹⁸ The land acquisitions and conveyances involving the government are depicted in Figure 2-7.

Date	From	To	Area
1/23/1953	CRC	GSA	Assignment of Leases for Refineries J-1, J-2 and J-5, Metal Units 7-10, Peat Building B-5, Loading Platform J-12, Building S-14, Cafeteria Building S-11, Canteen S-12, Change House S-1 and the east half of S-7.
12/31/1953	WECCO	USA/US Navy	Two parcels 151.3689 and 138.9621 acres ¹¹⁹

Lessees

Company	Lease Area	Term
Pioche Manganese Company	Refinery Building J-2	1953 to 1967 This building was originally leased to predecessor Combined Metals Reduction Company. Pioche Manganese assigned and transferred Refinery Building J-2 to National Lead on July 5, 1956. ¹²⁰
National Lead	Refineries J-1 and J-5	1953 to 1962

¹¹⁸ Assignment of Lease. [BR002880] “Leases” in Office Memorandum, Liquidation of the Colorado River Commission Activities at the Basic Magnesium Project, January 26, 1953. [BR002986-990] See also: Office Memorandum, Robert B. Bradford to Deputy Regional Director, Public Building Service, April 25, 1956. [BR002865] Lease and Option Agreements attached to Richard H. Greenburg, Regional Comptroller, GSA, to Robert J. Moore, BMI, January 30, 1953. [BR002975-983] Transmittal of Notes, Deeds and Leases Assigned to GSA, January 28, 1953. [BR002984-985] Richard H. Greenburg, Regional Comptroller, GSA, to Robert J. Moore, BMI, January 30, 1953. [BR002974] Elmo L. Buttle, Chief, Surplus Real Property Division, October 5, 1953. [BR002971]

¹¹⁹ Agreement of Sale, CRC to BMI, May 23, 1952. [BR001627-644]

¹²⁰ See Letter from Richard Greenburg, GSA, to Robert Moore, BMI, January 30, 1953. [BR002974]

Company	Lease Area	Term
National Lead	Metal Units 7 through 9, Peat Building B-5 and S-14, Change House S-1, Cafeteria Building S-11 and approximately 62.12 acres of land.	1953 to 1967
National Lead	Metal Unit 10, Refinery Building J-2, East half of Change House S-7, Canteen S-12, and Loading Platform J-12.	1953 to 1967 Canteen S-12 and Loading Platform J-12 were originally leased to predecessor Combined Metals Reduction Company. Pioche Manganese assigned and transferred Canteen S-12 and Loading Platform J-12 to National Lead on July 5, 1956. ¹²¹

Conveyances

Date	From	To	Area
3/15/1962	USA	American Potash and Chemical Corporation	Two Parcels, 151.3689 and 138.9621 acres ¹²²
3/2/1962	GSA	National Lead Company	Refineries J-1 and J-5. ¹²³
4/27/1967	GSA	National Lead Company	Assignment of Leases for Refinery J-1, Metal Units 7-10, Peat Building B-5, Loading Platform J-12, Building S-14, Cafeteria Building S-11, Canteen S-12, Change House S-1 and the east half of S-7.

¹²¹ See Letter from Richard Greenburg, GSA, to Robert Moore, BMI, January 30, 1953. [BR002974]

¹²² Deed of Trust, March 15, 1962. [BR002931-940]

¹²³ Referred to in Memorandum by Fred Johnston to Chief, Real Property Division, November 25, 1966. [BR002993-994]

2.1.4 Stauffer Chemical Company of Nevada / Pioneer Chlor-Alkali Company, Inc.

Land acquisitions and conveyances involving Stauffer are depicted in Figure 2-8.

Acquisitions

Date	From	To	Area
11/28/1952	Hercules Powder Co.	Stauffer	114.65 acres
9/1953	BMI	Stauffer	19.70 acres
4/1972	BMI	Stauffer	15.314 acres
8/1984	BMI	Stauffer	7.386 acres
10/19/1988	Stauffer	Pioneer Chlor-Alkali Company (Pioneer)	All properties

Lessees¹²⁴

Company	Lease Area	Term
Chemada Corporation	Unspecified parcel for the purpose of installing a gas turbine power plant. ¹²⁵	September 1968
Chemical Properties, Inc.	Office and truck repair space	November 24, 1984, and for a short period thereafter. ¹²⁶
Montrose Chemical	A series of sub-parcels	1947 until 1983. ¹²⁷
Post Transportation, Bulk Transportation, and Nu-Bulk Transportation	A small portion of the site ¹²⁸	Unclear

¹²⁴ Leasing information from the Pioneer Chlor Alkali Company, Stauffer Management Company, ECA, March 22, 1993. Page numbers are referenced.

¹²⁵ See p. 3-9.

¹²⁶ See p. 3-9.

¹²⁷ See p.3-5. See Figure 3-4 in the ECA for a depiction of the leased area. See also Montrose ECA, p. 21. [B002332]

¹²⁸ See p. 3-5. See Figure 3-4 in the ECA for a depiction of the leased area.

Company	Lease Area	Term
Saguaro Power Corporation	6 acres for a 90-megawatt natural gas-fired cogeneration facility.	This lease was initiated in 1990 by Pioneer. ¹²⁹

Conveyances

Date	From	To	Area
3/18/1981	Stauffer	State of Nevada	41.47 acres for Interstate 515
10/1988	Stauffer	Pioneer	All properties [sale agreement executed 8/88; transaction closed 10/26/88]

In 2003, Bayer CropSciences, Inc. succeeded to certain assets and liabilities of the Stauffer Management Company, an affiliate of the Stauffer Chemical Company.

2.1.5 Western Electro Chemical Company

Land acquisitions and conveyances involving WECCO/American Potash and Chemical Corporation/Kerr-McGee Chemical Corporation (Kerr-McGee) are depicted in Figure 2-9.

Acquisitions

Date	From	To	Area
3/15/1962	USA	American Potash and Chemical Corporation	Two Parcels, 151.3689 and 138.9621 acres ¹³⁰

¹²⁹ See p. 3-9.

¹³⁰ Deed of Trust, March 15, 1962. [BR002931-940]

Lessees

Company	Lease Area	Term
Buckles Construction Company	Portion of Unit 1	August 1973 to June 1989 ¹³¹
Burriss Oil and Chemical Company (also doing business as Basic Resources Company [not affiliated with BMI])	Unclear	May 1979 to May 1983. ¹³²
Delbert Madsen and Estate of Delbert Madsen	Triangular shaped two acre parcel at the northeastern corner of the Kerr-McGee property	June 1976 to at least 1993. ¹³³
Dillon Potter	2 acres southeast of the Southern Nevada Auto Parts lease area ¹³⁴	Unknown
Ebony Construction Company	Portion of Unit 1	1977 and 1978. ¹³⁵
Green Ventures International	Office space	August 1980 to September 1981. ¹³⁶
J.B. Kelley	The area south of the Koch lease	Period of lease unknown. ¹³⁷
Koch Asphalt Company (aka Koch Materials Company)	The area surrounding Building B-3	May 1983 to at least 1993. ¹³⁸

¹³¹ KMCC ECA, p. 7-24. [B002133]

¹³² KMCC ECA, p. 7-21. [B002130]

¹³³ KMCC ECA, p. 7-26. [B002135]

¹³⁴ KMCC ECA, p. 7-28. [B002137]

¹³⁵ KMCC ECA, p. 7-24. [B002133]

¹³⁶ KMCC ECA, p. 7-23. [B002132]

¹³⁷ KMCC ECA, p. 7-21. [B002130] See Plate 7.3 for the location of the operations.

¹³⁸ KMCC ECA, p. 7-21. [B002130]

Company	Lease Area	Term
Nevada Precast Concrete Products	Office space	January 1973 to May 1978. ¹³⁹
Southern Nevada Auto Parts and related companies ¹⁴⁰	10 acres	1972 to at least 1993. ¹⁴¹
State Industries	Unit 1, Buildings T-4, T-5, and T-8	1969 to 1988 ¹⁴²

Conveyances

Date	From	To	Area
12/31/1953	WECCO	USA/US Navy	Two parcels 151.3689 and 138.9621 acres ¹⁴³
1971	Kerr-McGee	Chemstar	Small parcel ¹⁴⁴ See Figure 2-10
1988	Kerr-McGee	Chemstar	Small parcel ¹⁴⁵ See Figure 2-10

In 2006, Kerr-McGee became Tronox LLC.

2.1.6 National Lead Company/Titanium Metals Corporation

TIMET was formed by a joint venture agreement between Allegheny Ludlum Steel Corporation and National Lead Company in 1950.¹⁴⁶ Land acquisitions and conveyances involving the companies are depicted in Figure 2-11.

¹³⁹ KMCC ECA, p. 7-23. [B002132]

¹⁴⁰ Robert and William Ellis leased this area beginning in October 1972 doing business as SNAP-TOW, Southern Nevada Auto Parts, and Pick-A-Part. Ed Smith and Vern Christensen leaseholders since January 1990, doing business as Nevada Recycling (auto salvage yard) on the northern portion of this area.

¹⁴¹ KMCC ECA, pp. 7-26 to 7-28. [B002135-137]

¹⁴² Henderson Steering Committee ECA, p. 16. [B002484]

¹⁴³ Agreement of Sale, CRC to BMI, May 23, 1952. [BR001627-644]

¹⁴⁴ Chemstar Lime Company, ECA, April 15, 1993, p. 8. Site facility boundaries are shown on maps at B002640-2641.

¹⁴⁵ Chemstar Lime Company, ECA, April 15, 1993, p. 8. Site facility boundaries are shown on maps at B002640-2641.

Acquisitions

Date	From	To	Area
8/20/1957	BMI	TIMET	Portion of NW ¼ of Section 13 and Roadways around Building T-3
9/4/1957	A.T. and Mildred Newell	TIMET	Portion of NW ¼ of Section 13
3/2/1962	GSA	National Lead Company	Refineries J-1 and J-5. ¹⁴⁷
4/28/1967	GSA	National Lead Company	Metal Units 7, 8, 9, and 10. Refinery Building J-1, J-2 and J-5. Peat Building B-5 and S-14. Change House S-1 and the East half of Change House S-7. Cafeteria Building S-11 Canteen S-12, and Loading Platform J-12.
12/29/1967 and 1/20/1972	National Lead Company	TIMET	Fourteen parcels, Refinery Building J-2, Canteen S-12 and S-14, Loading Platform J-12, Peat Building B-5, Ingot Refinery J-1, Billet Foundry J-5 and additional land
4/17/1985 8/13/1980 4/13/1972	BMI	TIMET	Parcel 1, 62.8 acres Parcel 2, 204.02 acres Parcel 3, 197.6 acres

Lessees

Company	Lease Area	Term
1400 Corporation	T-52, storage vault. KBMI Radio Tower	1963

¹⁴⁶ Timet, ECA, April 15, 1993., p. 3-1

¹⁴⁷ Referred to in Memorandum by Fred Johnston to Chief, Real Property Division, November 25, 1966. [BR002993-994]

Company	Lease Area	Term
BMI	Fire Station Building S-10 and Building T-1	July 1961
Burriss Oil & Chemical Company	Canteen S-14 and 1.6 acres of vacant land (contiguous)	December 1978
Chemtec Corporation	Building K-55	1975 to 1978. Operations unknown. ¹⁴⁸
City of Henderson	TIMET ball park	April 1959
Coyote Construction (Wirthlin Trenching)	Building S-17 and one acre of land.	1978-1979 operations unknown. ¹⁴⁹
Frank Briscoe Company	B-5, including rail track #5	60 to 90 days in 1980. ¹⁵⁰
John Wiley Jones Company, Inc.	Building T-18 and Unit No. J-2	April 1960
Jones Chemicals, Inc.	Building T-11	January 1963 to at least January 1991
Jones Chemicals, Inc.	Building T-18	April 1964 to at least January 1991
Jones Chemicals, Inc.	Building T-16	Unknown to January 1966
Jones Chemicals, Inc.	Locomotive House Building P-1	January 1966 to at least January 1991
Magnesite Truck Company	Building T-30	Ca. 1951 to possibly late 1956. operations unknown. ¹⁵¹
Musical Arrangements, Inc.	Building K-3	April 1972
National Sound Corporation	Building K-55	1972, for a period of two months. ¹⁵²

¹⁴⁸ TIMET ECA, p. 4-56. [B002860]

¹⁴⁹ TIMET ECA, p. 4-57. [B002861]

¹⁵⁰ TIMET ECA, p. 4-57. [B002861]

¹⁵¹ TIMET ECA, p. 4-58. [B002862]

¹⁵² TIMET ECA, p. 4-56. [B002860]

Company	Lease Area	Term
Per Boy Associates	Southwest quarter Section 7	June 1965
Rosecrest Cabinets	Half of Building K-32	October 1973 to 1989
Skaggs Company, Inc.	Portion of T-2 warehouse	August 1972
State Industries	Outside, east end of Building T-3	1980 for storing non-polychlorinated biphenyls (PCBs)-containing transformers. ¹⁵³
State Stove and Manufacturing Company	Building T-2	1972-1980 for warehousing purposes. ¹⁵⁴
TIMET Employees Federal Credit Union	Building K-32	March 1968
Espy Construction	Areas within the Pabco Road Ponds	Since October 1980. ¹⁵⁵
Henderson Telephone Company	Building K-32	Until 1954. ¹⁵⁶
M. Zenoft (lease assigned to Television Company of America)	Portion of Building K-32	September 1953. ¹⁵⁷

2.1.7 Chemstar, Inc.

United States Lime Corporation leased property at the Basic Magnesium site and began operations in November 1948. In 1950, Arrowhead Lime and Chemical Company purchased the land and improvements on which US Lime was operating. The connection between Arrowhead Lime and US Lime is unclear. However, Chemstar, the current successor to US Lime, indicated that it acquired the rotary kiln building (B-1), the pellet storage bins (B-21) and the adjacent

¹⁵³ TIMET ECA, p. 4-57. [B002861]

¹⁵⁴ TIMET ECA, p. 4-57. [B002861]

¹⁵⁵ TIMET ECA, p. 4-55. [B002859]

¹⁵⁶ TIMET ECA, p. 4-55. [B002859]

¹⁵⁷ TIMET ECA, p. 4-55. [B002859]

open yard in 1950.¹⁵⁸ In 1971 and 1988, two additional parcels were acquired from Kerr-McGee. The three continuous parcels comprise 10.45 acres.¹⁵⁹ The Chemstar facility is depicted in Figure 2-10.

2.2 MANUFACTURING PROCESSES USED AT THE SITE

Information regarding the owners' and/or lessees' manufacturing processes is provided below. It is arranged alphabetically by company name.

1400 Corporation

The company leased facilities from TIMET and operated a radio station. No relevant manufacturing processes appear to have occurred.

Allied Productions, Inc.

Allied Productions leased facilities at the site from the US government. The company produced motion pictures. No relevant manufacturing processes appear to have occurred.

Amecco Chemicals, Inc.

Amecco Chemicals acquired the Hardesty Chemical lease of the electrolysis building #2 and the adjacent chlorination building on September 1, 1947, and began operations at the site on October 1 of that year.¹⁶⁰ In a monthly report on the status of lessees at the Basic Magnesium site, the WAA noted that Amecco had 70 employees at the site.¹⁶¹

Amecco purchased chlorine piped in from Stauffer and produced four chemical products:

- Monochlorobenzene
- Paradichlorobenzene

¹⁵⁸ Chemstar Lime Company, ECA, April 15, 1993, p. 11.

¹⁵⁹ Chemstar Lime Company, ECA, April 15, 1993, p. 8. Site facility boundaries are shown on maps at B002640-2641.

¹⁶⁰ Information from WAA, Washington Credit Division Report, April 30, 1948. [BR002381-391]

¹⁶¹ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

- Orthodichlorobenzene
- Arsenite

In conjunction with its assessment of how to collect on the delinquent rental and utility charges incurred by Hardesty Chemical, the government reported that Amecco was closely associated with Hardesty Chemical. The companies shared the same president; Amecco was a minority owner of Hardesty Chemical preferred stock; and, at least between October 1947 and March 1948, Hardesty Chemical financed Amecco operations. In addition, Raymond T. Heilpern, Vice President and counsel for Amecco, was also an officer, director, and counsel for Hardesty Chemical.¹⁶²

The government ascertained that Amecco was “practically bankrupt,” that Hardesty Chemical was financially able to pay rent and utility charges, legally liable for the rent, “and also for the utility charges on the theory that Amecco was acting in effect as [Hardesty Chemical’s] agent when it incurred the utility charges.”¹⁶³

The WAA also indicated that Raymond Heilpern (counsel for both Amecco and Hardesty Chemical) informed the WAA that Stauffer “was going to finance Amecco’s operations, supplying chlorine on memorandum invoice, even purchasing benzene with Stauffer funds, all in order to keep Amecco going as a consumer of Stauffer’s by-product chlorine.”¹⁶⁴ Stauffer, in a carefully worded letter to the WAA, noted that the company was not going to initiate action in order to obtain repayment of approximately \$22,000 that Amecco owed Stauffer. Moreover, Stauffer informed the WAA that it was working out arrangements for liquidation of the amount over an extended period of time. “We are making this arrangement in part because of our interest in seeing that Amecco Chemicals, Inc., maintains and if possible, increases the scope of its operation at Henderson.”¹⁶⁵

Basic Boat Builders

Basic Boat Builders leased facilities at the site from the US government in which it constructed boats.

¹⁶² WAA, Washington Credit Division Report, April 30, 1948, [BR002381-391]

¹⁶³ WAA, Washington Credit Division Report, April 30, 1948, p. 6. [BR002386]

¹⁶⁴ WAA, Washington Credit Division Report, April 30, 1948, p. 5. [BR002385]

¹⁶⁵ WAA, Washington Credit Division Report, April 30, 1948, Exhibit 2-A. [BR002388]

Basic Magnesium Inc.

The original development of the site was the construction of a magnesium plant and associated facilities. There were two major raw materials used to produce magnesium—magnesite and chlorine—and two primary components to the operations—a chlorine/caustic plant and a magnesium production plant. A flow chart of the operations can be found as Figure 2-12. The following provides a brief overview of the processes used to manufacture magnesium:

Chlorine/Caustic Plant

Sodium chloride (salt) was processed (dissolved) in the chlorine/caustic plant to form a saturated brine. The saturated brine was then purified by settling out the mud and solid material, and then treated with sodium carbonate. After the sodium carbonate reacted with the calcium and magnesium, those materials were then settled from the brine. The brine was cleaned up and put into a chlorine electrolytic cell where a direct electric current passed through the cell and formed chlorine gas, sodium hydroxide (caustic soda), and by-product hydrogen.

Magnesium Plant

The magnesium plant consisted of ten large buildings, Units 1 through 10, each of which were divided into two rooms—a chlorinator room and an electrolytic cell room.

The chlorinators produced the feed for the electrolytic cells by converting magnesium into magnesium chloride. In this process MgO was mixed together with coal, recycled magnesium chloride, and peat moss to form a pellet. The pellets were dried and fed to the chlorinator. The material was heated to the appropriate temperature, the reaction occurred, and then the molten magnesium chloride was drawn off and transported to the electrolytic cells.

Electrolytic cells contained a molten salt bath consisting of the chloride salts of sodium, potassium, calcium, and magnesium. The cells consisted of steel cathodes and graphite anodes contained in a refractory lined steel box. When a direct current passed through the cell, chlorine gas was drawn to the positively charged anode, and magnesium was drawn to the negatively charged cathode of the cell. The magnesium eventually broke off of the cathode and floated to the top of the cell. Periodically the magnesium was removed from the cell and then cast into ingots or mixed with other metals to make magnesium alloys.

Buckles Construction Company

Buckles Construction Company leased a portion of Unit 1 from Kerr-McGee. The company used the facility for steel fabrication and equipment storage.¹⁶⁶

Bulk Transportation

Bulk Transportation leased facilities from Stauffer. Bulk Transportation transported chlor alkali products from Stauffer, along with similar materials for other companies at the site. Other transportation companies, including Nu-Bulk Transportation and Post Transportation, have also leased the same area from Stauffer and have presumably conducted similar operations, which may have also included truck washing.¹⁶⁷

Bureau of Reclamation

The Bureau of Reclamation leased a portion of the site on which transformers were located and presumably used them for power generation. No manufacturing processes appear to have occurred. However, it is possible that the transformers owned by the Bureau of Reclamation may have leaked PCB's over time.

Burriss Oil and Chemical Company (also doing business as Basic Resources Company)

Burriss Oil/Basic Resources operated an asphalt emulsion batch plant for blending and packaging a variety of asphalt emulsions. The production process involves milling asphalt cement with soap emulsifiers.¹⁶⁸ The companies were Kerr-McGee Lessees.

Carter Printing & Engraving

Carter Printing & Engraving leased facilities from the US government and used them as a print shop.

¹⁶⁶ KMCC ECA, p. 7-24. [B002133]

¹⁶⁷ Stauffer/Pioneer ECA, p. 3-5. [B001671]

¹⁶⁸ KMCC ECA, p. 7-21. [B002130]

Chemada Corporation

Chemada Corporation leased an unspecified parcel from Stauffer for the purpose of installing a gas turbine power plant. Details regarding the company's operations are unknown.¹⁶⁹ The gas turbine was removed prior to 1988.

Chemical Properties, Inc.

Chemical Properties leased office and truck repair space from Stauffer. Details regarding the company's operations are unknown.¹⁷⁰

Chemstar Lime Company

Chemstar Lime Company's predecessors (United States Lime Corporation, United States Lime Division of the Flinkote Company, Genstar Corporation, Genstar Cement & Lime Company, Genstar Lime Company, and Chemstar Inc.) acquired a portion of the site from CRC and expanded operations with property acquired from Kerr-McGee. Production processes used by Chemstar are described in Section 4 of the Phase I Environmental Conditions Assessment (ECA), prepared in 1993. To briefly summarize, lime production encompasses three production stages:

- Mining and rock preparation
- Calcining to convert carbonate rock to calcium and/or magnesium oxides (quicklime)
- Hydrating the quicklime to hydroxides

Chemtec Corporation

Chemtec Corporation leased facilities from TIMET. Details regarding its operations are unknown.

City Mercantile Company

City Mercantile Company leased facilities from the US government. Its operations are unknown.

¹⁶⁹ See p. 3-9.

¹⁷⁰ See p. 3-9.

City of Henderson

The City of Henderson leases an area used as a municipal park from TIMET. No manufacturing processes appear to have occurred.

On September 28, 1992, through condemnation, the City of Henderson acquired from BMI 35.34 acres immediately to the south of the Upper Ponds as the site for a municipal wastewater injection facility (the RIBs), which was in operation from 1992 to at least 2002. On October 6, 2003, as a part of a land exchange, the City acquired approximately 101.638 acres generally located adjacent and west of the Lower Ponds from BMI. In turn, the City conveyed 73.157 acres (including the acreage associated with the RIBs) to LandWell. The City used the land it acquired for a municipal wastewater treatment facility (the City of Henderson WRF), which is presently under construction.

Combined Metals Reduction Company

Combined Metals Reduction Company leased facilities at the site from the CRC. The CRC conveyed the ownership of the property to GSA after the CRC had sold the bulk of its holdings. The Combined Metals Reduction Company assigned the lease to Pioche Manganese Company, which in turn assigned the leased facilities to National Lead Company. Details regarding operations conducted by Combined Metals Reduction Company are unclear, although there is some indication that the company produced ferro-manganese alloys and that its operations may have been similar to those of the Pioche Manganese Company.¹⁷¹

Coulter, Harden & Company

Coulter, Harden & Company leased facilities at the site from the US government. The company processed cell melt refuse.¹⁷²

Coyote Construction (Wirthlin Trenching)

Coyote Construction leased facilities from TIMET. Details regarding its operations are unknown.¹⁷³

¹⁷¹ Henderson Steering Committee ECA, p. 14. [B002482]

¹⁷² Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11] See also, WAA Sales Brochure, Plancor 201. n.d.

¹⁷³ TIMET ECA, p. 4-57. [B002861]

Daniel Furse and Dante Bagni

Daniel Furse and Dante Bagni leased cafeteria space from the CRC. No manufacturing processes appear to have occurred.

Delbert Madsen and Estate of Delbert Madsen

Delbert Madsen and subsequently the Estate of Delbert Madsen leased a triangular shaped 2-acre parcel at the northern most, eastern corner of the Kerr-McGee property.¹⁷⁴ The area was used as a storage and salvage yard for 1940s-vintage transportable government housing, used mobile homes, old vehicles and wrecked vehicles.¹⁷⁵

Desert Furniture & Carpet Company

Desert Furniture & Carpet Company leased warehouse facilities from the US government and used them for furniture storage. No manufacturing processes appear to have occurred.

Dillon Potter

Dillon Potter leased a 2-acre portion of the Kerr-McGee property southeast of the SNAP-TOW lease area. The area was used to maintain a limited number of livestock including horses, pigs, cattle, chickens, and peacocks.¹⁷⁶

Ebony Construction Company

Ebony Construction Company leased a portion of property center of the north side of Unit 1 in 1977 and 1978 from Kerr-McGee. It provided construction management and staging activities.¹⁷⁷ No relevant manufacturing processes appear to have occurred.

Espy Construction

Espy Construction has occupied areas within the Pabco Road Ponds area since October 1980. Espy was used by various plants within the industrial complex to demolish outdated process equipment, build berms for effluent control, and construct evaporation ponds. It is a TIMET lessee.

¹⁷⁴ See KMCC ECA, Plate 7-4.

¹⁷⁵ KMCC ECA, p. 7-26. [B002135]

¹⁷⁶ KMCC ECA, p. 7-28. [B002137]

¹⁷⁷ KMCC ECA, p. 7-24. [B002133]

Frank Briscoe Company

Frank Briscoe Company leased facilities from TIMET and used them for unloading filter media materials.¹⁷⁸

Gelatines, Inc.

Gelatines, Inc. leased facilities from the US government. The company's operations are unknown.

Green Ventures International

Green Ventures International leased facilities from Kerr-McGee and operated an alfalfa sprouts marketing office.¹⁷⁹ No manufacturing processes appear to have occurred.

Hardesty Chemical Company

Hardesty Chemical Company leased electrolysis building #2 and the adjacent chlorination building for operation of a chemical plant from the US government beginning in September 1946. The company produced synthetic detergents, muriatic acid, monochlorobenzene, paradichlorobenzene, and orthodichlorobenzene.¹⁸⁰

Hardesty Chemical sold or assigned its interest in the lease to Amecco Chemicals, Inc. on September 1, 1947, but apparently did not inform or consult the WAA. Amecco wrote to the WAA advising the government that it had "purchased the entire interest of the Hardesty Chemical Co., Inc. in it's (sic) Basic Magnesium Plant operation, including plant, machinery, and chemical stocks and will continue the operation here, commencing October 1st."¹⁸¹ The WAA did not recognize the assignment or purchase of the lease, and as of March 31, 1948, Hardesty Chemical was delinquent on its lease and utility charges and owed the government almost \$50,000. The WAA noted that since the government had agreed to dispose of the entire Basic Magnesium site to the CRC, they felt that the decision regarding Amecco's continuation of

¹⁷⁸ TIMET ECA, p. 4-57. [B002861]

¹⁷⁹ KMCC ECA, p. 7-23. [B002132]

¹⁸⁰ Sales Brochure, Plancor 201. n.d.

¹⁸¹ Information from WAA, Washington Credit Division Report, April 30, 1948. [BR002381-391]

operations should reside with the CRC.¹⁸² See the discussion under Amecco Chemicals, Inc. for additional information.

In its assessment of the delinquent rental and utility payments, the government ascertained that Amecco was “practically bankrupt,” that Hardesty Chemical was financially able to pay rent and utility charges, legally liable for the rent, “and also for the utility charges on the theory that Amecco was acting in effect as [Hardesty Chemical’s] agent when it incurred the utility charges.”¹⁸³ The government also noted that Hardesty Chemical was a subsidiary of W.C. Hardesty Company, Inc., which in turn was a subsidiary of Binney & Smith Company. W.C. Hardesty owned 75 percent of Hardesty Chemical’s preferred stock and Amecco owned the remaining 25 percent. W.C. Hardesty owned 51 percent and Bormar Corporation owned 49 percent of Hardesty Chemical’s common stock.¹⁸⁴

Henderson Riding Club

The Henderson Riding Club leased facilities from the CRC. No manufacturing processes appear to have occurred.

Henderson Telephone Company

The Henderson Telephone Company leased facilities from TIMET. No manufacturing processes appear to have occurred.

Hodsdon Brothers, Inc.

Hodsdon Brothers, Inc. leased facilities from the US government. Details about the company’s operations are unknown.

Industrial & Metallurgical Engineering Company

Industrial & Metallurgical Engineering Company leased facilities from the US government. Details about the company’s operations are unknown.

¹⁸² According to a WAA summary pertaining to Hardesty Chemical operations, Hardesty accepted the RFC’s Letter of Intent in December 1945. The property was delivered to the company in operating condition on September 1, 1946. Information from WAA, Washington Credit Division Report, April 30, 1948. [BR002381-391]

¹⁸³ WAA, Washington Credit Division Report, April 30, 1948, p. 6. [BR002386]

¹⁸⁴ WAA, Washington Credit Division Report, April 30, 1948. [BR002381-391]

J.B. Kelley

J.B. Kelley leased facilities from Kerr-McGee. Details regarding operations are unknown.

J.W. Conroy

J.W. Conroy leased facilities from the CRC. Details regarding operations are unknown.

John Wiley Jones Company, Inc.

John Wiley Jones Company leased facilities from TIMET. The company repackaged chlorinated chemicals for swimming pool maintenance and also manufactured sodium hypochlorite (bleach).

Jones Chemicals, Inc.

Jones Chemical is the successor to John Wiley Jones Company. It leases facilities from TIMET. The company repackages chlorinated chemicals for swimming pool maintenance.

Koch Materials Company (aka Koch Asphalt Company)

Koch Materials Company and/or Koch Asphalt Company leased facilities from Kerr-McGee and operated an asphalt emulsion batch plant for blending and packaging a variety of asphalt emulsions. The production process involved milling asphalt cement with soap emulsifiers.¹⁸⁵

Magnesite Truck Company

Magnesite Truck Company leased facilities from TIMET. Details regarding the company's operations are unknown.¹⁸⁶

Mainor, William

William Mainor leased facilities from the CRC. Details regarding operations are unknown.

Mendelsohn, William

William Mendelsohn leased warehouse space from the US government and used it to store furniture. No manufacturing processes appear to have occurred.

¹⁸⁵ KMCC ECA, p. 7-21. [B002130]

¹⁸⁶ TIMET ECA, p. 4-58. [B002862]

Miller, Haynes & Smith, Inc.

Miller, Haynes & Smith, Inc. leased facilities from the CRC. Details regarding the company's operations are unknown.

Montrose Chemical Corporation of California

In 1947, Stauffer sub-leased approximately 10 acres of land to Montrose Chemical Corporation (Montrose), on which Montrose built an organic chemical manufacturing plant. The company expanded its operations in 1954, when it built a hydrochloric acid (HCl) manufacturing plant to produce industrial grade HCl. Montrose expanded its facilities again in 1977, but ultimately dismantled its entire organic chemical manufacturing plant in 1983.¹⁸⁷ The area that Montrose leased from Stauffer between 1947 and 1983 changed, and ultimately involved twelve parcels totaling, at a maximum, approximately 20 acres.

Information regarding industrial processes and waste generation is presented in detail in Section 4 of the Montrose ECA, prepared in 1993. To briefly summarize, the company manufactured:

- Chloral, 1947-1983
- Chlorobenzene or MCB, 1947-1983
- Polychlorinated Benzenes, 1947-1983
- Dichlorobenzil, 1967-1983
- Muriatic acid, 1947-1983
- Ethyl chloride, 1958-1961

Musical Arrangements, Inc.

Musical Arrangements, Inc. leased facilities from TIMET. The company's operations consisted of making music tapes.¹⁸⁸ No relevant manufacturing processes appear to have occurred.

¹⁸⁷ Montrose ECA, p. 21. [B002332]

¹⁸⁸ TIMET ECA, p. 4-55. [B002859]

Myers-Thornton Gas Company

Myers-Thornton Gas Company leased facilities from the US Government. The company distributed propane. No relevant manufacturing processes appear to have occurred.

National Sound Corporation

National Sound Corporation leased facilities from TIMET. It is believed that no production activities occurred.¹⁸⁹

Nevada Clay Products Company

Nevada Clay Products Company leased facilities from the US government. Details regarding the company's operations are unknown.

Nevada Precast Concrete Products

Nevada Precast Concrete Products leased office space from Kerr-McGee.¹⁹⁰ No manufacturing processes appear to have occurred.

Nevada Wholesale Meat Company

Nevada Wholesale Meat Company leased cafeteria facilities from the US government. No manufacturing processes appear to have occurred.

Nevada, New York & Ohio Chemical Company

Nevada, New York & Ohio Chemical Company leased facilities at the site under a sub-lease obtained from Stauffer during the time that Stauffer was leasing its site from the US government. It appears that the Nevada, New York & Ohio Chemical lease began in January 1946 and the plant closed in July 1947 for renovation. As of October 1947 the plant was inactive due to market conditions.¹⁹¹ It is unknown if the Nevada, New York & Ohio Chemical operations resumed. Nevada, New York & Ohio Chemical produced aluminum chloride.¹⁹²

¹⁸⁹ TIMET ECA, p. 4-56. [B002860]

¹⁹⁰ KMCC ECA, p. 7-23. [B002132]

¹⁹¹ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

¹⁹² Sales Brochure, Plancor 201. n.d.

Nu-Bulk Transportation

Nu-Bulk Transportation leased facilities from Stauffer. Nu-Bulk Transportation transported chlor-alkali products from Stauffer, along with similar materials for other companies at the site. Other transportation companies, including Bulk Transportation and Post Transportation, have also leased the same area from Stauffer and have presumably conducted similar operations.¹⁹³

O.J. Scherer Company

O.J. Scherer Company initially leased Building T-3 until 1951, when it purchased it from CRC. The company subsequently sold it to TIMET. Scherer operated a machine shop, fabricated machinery, and conducted machinery and equipment repair activities.¹⁹⁴

Paraffine Companies, Inc.

Paraffine Companies, Inc. leased facilities from the CRC. Details regarding the company's operations are unknown.

Per Boy Associates

Per Boy Associates leased facilities from TIMET. Details regarding the company's operations are unknown.

Pioche Manganese Company

Combined Metals Reduction Company assigned its lease for facilities at the site to Pioche Manganese Company. Pioche Manganese used a portion of the leased area for manganese slag storage. Pioche processed ore supplied by the nearby Three Kids' Mine. The company operated an arc (carbon electrode) furnace for ore processing. The operations produced manganese and process slag, which was stockpiled in areas north and east of Building J-2.¹⁹⁵

Post Transportation Company

Post Transportation Company leased facilities from the CRC and thereafter from Stauffer Chemical. Post Transportation transported chlor alkali products from Stauffer, along with similar

¹⁹³ Stauffer/Pioneer ECA, p. 3-5. [B001671]

¹⁹⁴ Information from Memorandum John R. Reilly to Irving Gumbel, July 15, 1947. [BR002371-373]

¹⁹⁵ TIMET ECA, p. 3-3. [B002784]

materials for other companies at the site. Other transportation companies, including Bulk Transportation and Nu-Bulk Transportation, have also leased the same area from Stauffer and have presumably conducted similar operations.¹⁹⁶

Rosecrest Cabinets

Rosecrest Cabinets leased facilities from TIMET. Details regarding the company's operations are unknown.

Saguaro Power Corporation

Saguaro Power Corporation leased six acres from Pioneer for the construction and operation of a 90-megawatt natural gas-fired electrical cogeneration facility.¹⁹⁷ The plant was commissioned in 1991 and has been in operation since then. Pioneer receives the steam and Nevada Power Company purchases the electricity.

Sears Robuck & Company

Sears Robuck & Company leased warehouse space from the US government and used it for furniture storage. No manufacturing processes appear to have occurred.

Skaggs Company, Inc.

Skaggs Company, Inc. leased warehouse facilities from TIMET. Details regarding the company's operations are unknown.

Southern Nevada Auto Parts and related companies

Robert and William Ellis leased a 10-acre portion of the Kerr-McGee site doing business as SNAP-TOW, Southern Nevada Auto Parts, and Pick-A-Part. Ed Smith and Vern Christensen have been leaseholders since January 1990, doing business as Nevada Recycling (an auto salvage yard) on the northern portion of this area. Operations at the auto impound yard (SNAP-TOW) consist of storage of wrecked, police impounded, and repossessed vehicles. Activities at the auto

¹⁹⁶ Stauffer/Pioneer ECA, p. 3-5. [B001671]

¹⁹⁷ See p. 3-9.

salvage yard at the northern and western portions of the lease area include buyer dismantling and retrieval of parts.¹⁹⁸

State Industries, Inc.

State Industries leased space from Kerr-McGee for the production of commercial and domestic water heaters.¹⁹⁹ The company also leased a portion of the site from TIMET and used it to store non-PCB-containing transformers.²⁰⁰

State of Nevada, Employment Service Department

The Employment Service Department leased office space from the US government. No manufacturing processes appear to have occurred.

State Stove and Manufacturing Company

State Stove and Manufacturing Company leased warehouse space from TIMET. No manufacturing processes appear to have occurred.

Stauffer Chemical Company of Nevada

Stauffer Chemical Company of Nevada initially leased a portion of the site from the US government. The company subsequently purchased that portion of property as well as additional parcels. Pioneer acquired Stauffer's manufacturing facilities in October 1988.²⁰¹ Production processes used by Stauffer and Pioneer are described in depth in Section 4 of the Phase I ECA, prepared in 1993. To briefly summarize, the Stauffer used five industrial processes for the production of:

- Parachlorothiophenol/Thiophenol
 - Parachlorothiophenol, 1960-1984
 - Thiophenol, 1967-1982
- Trithion/Imidan process, 1958-1984
 - Trithion, 1958-1984 (intermittent)

¹⁹⁸ KMCC ECA, pp. 7-26 to 7-28. [B002135-137]

¹⁹⁹ Henderson Steering Committee ECA, p. 16 [B002484]

²⁰⁰ TIMET ECA, p. 4-57. [B002861]

²⁰¹ Henderson Steering Committee ECA, p. 13. [B002481]

- o Methyl Trithion, 1960-1963
- o O,O-diethylphosphorodithoioic acid (DTA), 1972-1975, 1977-1984
- o Imidan, 1964-1976 (intermittently)
- Benzene Hexachloride process (Lindane), 1946-1958
- Chlor Alkali process, 1945 to present (since October 1988 under Pioneer)
- HCl process, 1945 to present²⁰² (since October 1988 under Pioneer. The HCl unit was owned by Montrose until at least 1997 and leased to Pioneer.)

Operations subsequent to 1988 have been limited to the production of chlorine, sodium hydroxide (caustic soda), sodium hypochlorite (bleach), and muriatic (hydrochloric) acid.

TIMET

TIMET was formed by a joint venture agreement between Allegheny Ludlum Steel Corporation and National Lead Company in 1950.²⁰³ National Lead initially leased facilities at the site from the CRC, which assigned the leases to the GSA after the CRC has sold most of the Basic Magnesium property. TIMET ultimately obtained title to the leased property. Industrial processes and wastes generated are discussed in detail in Section 4 of the TIMET ECA. To summarize, the principal products manufactured by the company are:

- Titanium ingots
- Titanium tetrachloride
- Titanium sponge
- Titanium fines
- Neutralized leach liquor (magnesium chloride sold as a roadway dust suppressant)

The process used to produce titanium starts with the chlorination of rutile (titanium dioxide ore) to produce titanium tetrachloride. The titanium tetrachloride is then purified and reduced to titanium metal with elemental magnesium.

²⁰² Stauffer/Pioneer ECA, p. 1-2. [B001661]

²⁰³ Timet, ECA, April 15, 1993., p. 3-1

TIMET Employees Federal Credit Union

TIMET Employees Federal Credit Union leased office space from TIMET. No relevant manufacturing processes appear to have occurred.

True Gems

True Gems leased facilities from the US government. The company manufactured costume jewelry. No relevant manufacturing processes appear to have occurred.

Underwriters Salvage Company of New York

Underwriters Salvage Company of New York leased space from the US government. The company used the space for warehousing and processing salvaged groceries. No relevant manufacturing processes appear to have occurred.

Union Pacific Railroad Company

Union Pacific Railroad Company leased office space from the CRC. No manufacturing processes appear to have occurred.

United States Vanadium Corporation

United States Vanadium Corporation leased facilities at the site from the US government. The company's operations included chemical beneficiation of tungsten concentrates produced by itself and others in Nevada and California.²⁰⁴ Work as of October 1947 consisted of reclaiming concentrates from the settling ponds and re-running them for scheelite.²⁰⁵ The company produced synthetic scheelite, tungstic acid, molybdenum trisulphate, ammonia parathustate.

U.S. Lime Products Corporation

U.S. Lime Products Corporation appears to have initially leased facilities at the site from the CRC. The company's successors acquired the site. See the discussion under Chemstar Lime Company.

²⁰⁴ Information from WAA, Proposal of USVC lease, February 28, 1946. [BR002359-363]

²⁰⁵ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

U.S. Navy

In 1950, WECCO entered into an agreement with the Navy Department to set up and operate a sodium perchlorate plant in a part of the Basic Magnesium facility. In addition, WECCO agreed to operate a 50-ton per day ammonium perchlorate plant on 290 acres that the Navy acquired from WECCO.²⁰⁶

In 1954, WECCO was absorbed by American Potash & Chemical Corporation and took over all contract rights from WECCO in connection with the Navy facility. WECCO and American Potash & Chemical Corporation had no lease with the Navy; instead the company operated the plant, furnishing ammonium perchlorate on a supply contract for the Navy Department. The supply contract provided that sufficient money be included in the per pound charge of ammonium perchlorate to cover overhead, maintenance, profit, and production costs.²⁰⁷

Through most of its operation, the plant was the sole producer of ammonium perchlorate for defense purposes.²⁰⁸ According to a 1958 appraisal of the Naval Industrial Reserve Plant, the Government, “either directly or indirectly through defense contractors, was the sole purchaser of ammonium perchlorate in volume.”²⁰⁹

The industrial facilities associated with the government-owned WECCO/American Potash & Chemical Corporation facilities consisted of two parts:

- Production equipment situated in buildings owned by the company, which was covered under a Naval Bureau of Ordnance contract, NOrd (F) 1741 (DOD-217).
- Approximately 290 acres of land, plus buildings, equipment, and improvements, which were owned by the Navy Department and built adjacent to WECCO’s property. This portion of the

²⁰⁶ Deed of Conveyance, October 26, 1953. NARA San Bruno, RG 121, Box 23, Folder: N-Nev-5-415 US Naval Industrial Reserve Plant (DOD 473 and DOD 217). [BR002789-793] The Navy vested title to the property to the United States of America on December 31, 1953. Letter to Regional Director, GSA, January 18, 1954. NARA San Bruno, RG 121, Box 4, Folder: R-Nev-5, Basic Magnesium, Western Electrochemical Co. General through Final Disposition. [BR002436-437]

²⁰⁷ Appraisal of US Naval Industrial Reserve Plant (DOD 473 and DOD 217), October 31, 1958. NARA San Bruno, RG 121, Box 22, Folder: N-Nev-5-415 US Naval Industrial Reserve Plant (DOD 473 and DOD 217). [BR002535-537]

²⁰⁸ Appraisal of US Naval Industrial Reserve Plant (DOD 473 and DOD 217), October 31, 1958. NARA San Bruno, RG 121, Box 22, Folder: N-Nev-5-415 US Naval Industrial Reserve Plant (DOD 473 and DOD 217). [BR002583]

²⁰⁹ Appraisal of US Naval Industrial Reserve Plant (DOD 473 and DOD 217), October 31, 1958. NARA San Bruno, RG 121, Box 22, Folder: N-Nev-5-415 US Naval Industrial Reserve Plant (DOD 473 and DOD 217). [BR002584]

facilities was covered under a Naval Bureau of Ordnance contract, NOrd (F) 1740 (DOD-473).

US Treasury Department, Bureau of Federal Supply

The US Treasury Department leased storage space for magnesium ingots.²¹⁰ No manufacturing processes appear to have occurred.

Vadelite Corporation

Vadelite Corporation leased office space from the US government. The company designed prefabricated houses. No relevant manufacturing processes appear to have occurred.

Western Electro Chemical Company/Kerr-McGee Chemical Corporation

WECCO initially leased facilities from the US government. It subsequently purchased the property.

Industrial processes and wastes generated are discussed in the Kerr-McGee ECA, Section 4. To briefly summarize, the facility has three production areas:

- Chlorate/perchlorate-based compounds
 - Sodium chlorate, 1945 to at least 1990
 - Potassium chlorate, 1945-1975
 - Potassium perchlorate, 1945-1983
 - Sodium perchlorate production, 1945 to at least 1990
 - Ammonium perchlorate, 1951 to at least 1990
 - Magnesium perchlorate, 1969-1976
 - Tumbleaf Defoliant®, 1975-1985
- Electrolytic manganese dioxide, 1951 to at least 1990
- Boron and halogenated boron products,
 - Elemental boron, 1972 to the present
 - Boron Trichloride, 1972 to the present
 - Boron Tribromide, 1973 to the present

²¹⁰ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

Western Mineral & Development Corporation

Western Mineral & Development Corporation leased facilities at the site from the US government. The company reportedly processed gypsum and conducted truck repair activities.²¹¹ The company was unable to secure financing, and the extent of its operations is unclear.²¹²

Zenoft, M.

M. Zenoft leased facilities from TIMET for a radio station. The lease was assigned to Television Company of America. No relevant manufacturing processes appear to have occurred.

2.3 DISPOSAL PRACTICES ON TO BMI COMMON AREAS

Information regarding the owners' and/or lessees' disposal practices on to the BMI Common areas is provided below. It is arranged alphabetically by company name. An overview of the source characterization for the Eastside and CAMU areas, based on data collected from investigations conducted since 1996, is presented in Section 4.2.

Amecco Chemicals Inc.

Amecco Chemicals reportedly disposed of wastes in the BMI Landfill. Types and volume of wastes are unknown.²¹³

Basic Magnesium Inc.²¹⁴

All of the wastes deposited in or discharged to the BMI Common Areas from the Basic Magnesium operation can be classified as either: (1) solid material which would go to a landfill, (2) total suspended solids (TSS) and total dissolved solids (TDS) which would go to evaporation ponds, or (3) trace impurities which would be discharged with the dissolved and suspended solids. These wastes can be characterized as salts from the production process (chloride salts of magnesium, sodium, calcium, etc.) and organic and inorganic solids of various types. The solids would have consisted of impurities in the magnesite, compounds formed from the impurities in

²¹¹ Monthly Report of Status of Lessees for October 1947. [NARA, San Bruno, RG 121, WAA Property Disposal Files, Box 11]

²¹² Sales Brochure, Plancor 201. n.d.

²¹³ Henderson Steering Committee ECA, p. 40. [B002508]

²¹⁴ In addition to cited sources, see Expert Report of Clifford B. Wilson on Wastes Produced by Basic Magnesium, Inc., March 18, 2004, and Supplemental and Rebuttal Expert Report, Clifford B. Wilson on Wastes Produced by Basic Magnesium, Inc., April 19, 2004.

the acid neutralization process, sodium carbonate formed by the reaction of excess caustic with carbon dioxide, and chlorinated organics formed by the reaction of chlorine with carbon at elevated temperatures. These materials would have left behind a residual evaporite in the soils of the evaporation ponds on the Common Areas. This following briefly examines the types of wastes likely produced by each of the major process steps.

Chlorine/Caustic Plant

In the Chlorine/Caustic plant there were several ways in which wastes occurred:

- The salt arrived in the plant in solid form. To use the material it was necessary to dissolve the salt in water to form a saturated brine solution. Solid impurities in the salt needed to be removed. As a result, mud and other insoluble material were settled out of the brine and were eventually washed, presumably to the Basic Magnesium settling ponds.
- Before the salt brine could be used in the chlorine cells, it had to be purified. Sodium carbonate was introduced into the brine and precipitated calcium as calcium carbonate and magnesium as magnesium carbonate. The material (sludge) was settled out of the brine and discharged to the settling ponds. In addition to the carbonates, the sludge material carried a significant amount of salt with it.
- A certain amount of asbestos waste was generated from this operation. The Hooker electrolytic chlorine cell used an asbestos membrane. Every time the cell was rebuilt, the old membrane was discarded. The total quantity of this was small (100 to 200 tons).
- There is indication that, at least in the early days of the plant, all of the caustic from the chlorine/caustic plant was wasted.²¹⁵ The caustic, when combined with the discharge from the magnesium portion of the operation, precipitated magnesium hydroxide, which resulted in a solution leaving the plant with a pH in the range of 11 and would have resulted in white solids being deposited in the ponds. It appears that through May or June of 1943 all of the caustic was used as cell effluent from the chlorine cells. The caustic that was used for neutralization up through May 1943 was wasted as sodium carbonate. Because this material was cell effluent it also contained a significant amount of salt (15 percent). Beyond that point (*i.e.*, May 1943), the caustic was wasted as a 50 percent caustic solution in water and went to

²¹⁵ Phase I Environmental Conditions Assessment Report, Pioneer Chlor Alkali Company, Inc. Stauffer Chemical Company Site, Weston Managers Designers/Consultants, March 22, 1993, p. 5-4. [B001722]

the evaporation ponds.²¹⁶ It is probable that the wasted caustic was either carbonated by the addition of CO₂ or by the reaction with CO₂ from the atmosphere and was ultimately deposited as sodium carbonate in the pond.

- The caustic evaporator plant began operations in the summer of 1943 and sales of caustic soda from the plant first occurred in August 1943. There would have been losses from this plant, mainly in the form of a “sulfate purge” stream. The sulfate purge stream was generated when sulfate was removed from the caustic that was being evaporated. This stream was purged from the plant and most probably went to the Basic Magnesium ponds. The sulfate purge stream contained sodium sulfate, caustic and salt. The estimate of losses assumes that the caustic soda that was not sold and utilized as a commercial product was wasted. According to hearings conducted after the plant shut down, 45,314 tons of caustic was shipped from the plant at a value of \$775,920.
- The chlorine liquefaction process produced at least two waste streams:
 - A small chlorinated organic stream was generated by the chlorine drying step. Indications are that this was discharged to a small impoundment near the plant.
 - Cleaning up the tail gas from the liquefaction process generated a sodium hypochlorite stream. It was estimated that the loss of chlorine with the tail gas was two percent,²¹⁷ but considering the low pressure (30 pounds per square inch [psi])²¹⁸ used in the liquefaction process, it is likely that the losses were much higher.

The Chlorinators

The chlorinator furnaces were a major source of losses from the magnesium process. Some of these sources include the following:

- The chlorination reaction does not proceed with 100 percent efficiency. As a result, there was a loss of chlorine from the chlorinators.

²¹⁶ Phase I Environmental Conditions Assessment for The Basic Management, Inc. Industrial Complex Clark County, Nevada, Geraghty & Miller, Inc., April 14, 1993, p. 33. [B002501]

²¹⁷ Chlorine & Caustic Plants and Henderson Plant Services, Description of Process and Equipment, Chlorine Plant – Liquefaction quantity flow sheet. [BR002266].

²¹⁸ Chlorine & Caustic Plants and Henderson Plant Services, Description of Process and Equipment, p. 4. [BR002220]

- HCl was generated in the chlorinator. This was a result of the reaction of chlorine and water at the high temperature to form HCl.
- Because of the high temperature in the chlorinator, some of the magnesium chloride evaporated and was carried out of the chlorinator as a vapor.²¹⁹
- The temperatures in the chlorinator along with the presence of chlorine with large amounts of carbon led to the formation of relatively low levels of chlorinated organics.²²⁰ These organics were carried as a vapor out of the chlorinator and most would condense in the chlorinator scrubbers. They were eventually discharged with the cooling water from the scrubbers. In general, these devices are known to produce hexachlorobenzene and chlorinated dibenzofurans as byproducts.
- Impurities coming in with the magnesite (iron oxides, silica, etc.) and the coal tended to build up in the chlorinators. It was necessary to remove the chlorinator from service approximately every three weeks in order to remove this material.²²¹
- Flow sheets indicate that magnesium chloride was recycled from the chlorinators to the pellet production operation. However, because these pellets were dried at high temperature²²² (about 1,800 degrees F), this material can be considered to be a total loss. This is because at that temperature the magnesium chloride break downs and forms HCl.²²³ The acid was discharged through the scrubbers in the pellet production plant.

The Magnesium Cells

The magnesium cells were the heart of the process. This was the point where everything came together to produce the product of the plant. Only minor amounts of waste would have been generated from the cells themselves. Most of the waste materials were in solid form, although there were probably minor amounts of liquid wastes. These wastes included:

²¹⁹ Kh. L. Strelets, *Electrolytic Production of Magnesium*, TT76-50003, U.S. Dept. of Commerce, Technical Information Service, Springfield, Va., translated by J. Schmorak, Keter Publishing House Jerusalem Ltd., 1977, p. 193.

²²⁰ Reference document submitted by the Experts of the European Community and Member States of the European Union on Best available techniques (BAT) and best environmental practices (BEP) for reducing and/or eliminating emissions of by-products POPs to the First Session of the UNEP Expert Group on BAT and BEP, 10-14 March 2003, USA, p. 39.

²²¹ *Engineering and Mining Journal*, October 1943, p. 66.

²²² *Metallurgical Operation at Basic Magnesium, Inc. Las Vegas, Nevada*, April 23, 1942, p. 4. [R004807]

²²³ K. K. Kelly, *Energy requirements and Equilibria in the Dehydration, Hydrolysis, and Decomposition of Magnesium Chloride*, technical paper 676, U.S. Dept. of Interior, Bureau of Mines, Washington, D. C., 1945.

- Cell Mud (sludge) was the material that settled to the bottom of the cell and had to be removed before it caused a deterioration of cell performance. The cell mud generally contained MgO, some magnesium metal, acidic insoluble material and the remainder being cell bath.²²⁴ The material came out as a solid (even though much of it was soluble) and, in all probability, it ended up in the Basic Magnesium landfill.
- Cell Melt had to be periodically removed from the cell. This was typically done to control the composition of the cell melt in the cell. The material also came out as a solid. Most of this material went to make flux. The flux, in turn, went to the casting operation and then eventually ended up as a waste from the casting operation.
- Some waste associated with the gas handling system was probably generated. The chlorine gas coming from the cell was sent to the chlorinator. A certain amount of cell melt salts were present in the cell gas (due to evaporation of the salts from the cell). These would be lost either as a solid in the gas handling system or eventually as an aqueous discharge to the evaporation ponds. There is also indication that gas from the cathode compartment of the cells was scrubbed in a water scrubber. This gas would have contained HCl.
- In addition to the wastes listed above, Magnesium cells are known to produce trace quantities of chlorinated organics. The conditions in the electrolytic cell (*i.e.*, strong chlorine, graphite and a temperature of 700 °C) provide conditions that are capable of producing highly chlorinated organics such as hexachlorobenzene.²²⁵

Magnesium Casting

Essentially all the wastes generated from the casting operations were in solid form. When magnesium is handled in the molten form, a certain amount of burning takes place. Fluxes were used to minimize this burning by protecting the surface of the melt. Fluxes were also utilized to settle impurities out of the metal. The MgO from burning and the fluxes were all heavier than the metal and eventually settled to the bottom of the holding crucible. The sludge from the casting operation was removed from the casting crucibles and most probably went to the landfill.

²²⁴ Kh. L. Strelets, Electrolytic Production of Magnesium, TT76-50003, U.S. Dept. of Commerce, Technical Information Service, Springfield, Va., translated by J. Schmorak, Keter Publishing House Jerusalem Ltd., 1977, p. 302-303.

²²⁵ Zero Toxics, Sources of by-product POPs and their Elimination, Darryl Luscombe and Pat Costner, Greenpeace International Toxics Campaign, May 2001, p. 14-15.

Typically the losses from the casting of magnesium run in the order of six percent or more of the magnesium metal handled.²²⁶

Flux Plant

The wastes from the flux plant would have been minimal. There are, in general, two types of fluxes. The first of these are blended fluxes, which were made by mixing solid materials (chloride salts) together and then packaging them. The second type of flux is a fused flux, which was made by melting the salts and then grinding (after solidification) or flaking the materials to provide the flux in a form that can be used in the casting operation. Neither of these types of operations produce a significant amount of waste either in solid or liquid form. There were dust collectors associated with the operation that would have captured dusts and discharged them with the liquid effluent from the plant.

TSS and TDS Discharges

There were extensive discharges of suspended solids. A Basic Magnesium internal report generated before the plant started up predicted discharge of an estimated 300 tons per day.²²⁷ Since the plant management's only concern with waste was where they could put it, this number was used to estimate the TSS discharge. Although parts of the operation probably operated and discharged waste more than just during the time of the production magnesium, the estimate of the discharge has been made only on the basis of a stabilized full production capacity. Some portion of these TSS discharges would have been due to impurities contained in the magnesite feed to the plant.

The composition of the TSS and TDS from the Basic Magnesium process would have been a varied mix of materials that included, but were not limited to, the following:

- Arsenic
- Asbestos
- Calcium carbonate

²²⁶ Hearing of the Sub-committee on Light Metals and Aviation of the Special Committee Investigating the War Program, Held in the Office of Mr. F. O. Case, General Manager Basic Magnesium on May 11, 1943 at 2:30 P.M., p. 41. [BR032205]

²²⁷ Basic Magnesium Incorporated Engineering Department, History of Civil Engineering, by E. H. Clary, BMI Internal Report No. 18, Date: April 1, 1942, p. 18. [BR33900]

- Chlorinated hydrocarbons containing hexachlorobenzene, chlorinated dibenzofurans, octachlorostyrene, PCBs, and others
- Magnesium chloride
- Magnesium hydroxide
- Muds
- Other chlorides such as calcium chloride and potassium chloride
- Sodium carbonate
- Sodium chloride
- Sodium hydroxide
- Sodium hypochlorite
- Sodium sulfate
- Sulfuric acid (H₂SO₄)
- Wastes from the magnesite

There were numerous places where these materials entered the waste streams leaving the Basic Magnesium process. The following is a partial list of the places where these wastes entered the streams that eventually ended up in the Basic Magnesium evaporation ponds:

- Cooling water from numerous sources
- Cooling tower blow down
- Dust collector at the Flux Plant
- Dust from chlorine filters and chlorine mains
- Filters and surge tanks at the Brine Preparation plant
- Slurry from the Recovery and Neutralization plant

- Wash Tower at the Preparation Plant
- Wash Tower for cathode exhaust
- Water from the Henderson Sewer treatment plant

Cell Demolition

After the plant operations ceased, the magnesium cells would have eventually been demolished and put into the landfill. The debris from this would have consisted of the bath in the cells, the refractory used in the cell, the anodes and the cathodes used in the cell. The steel shell might have been recovered as recycled steel.

Calculated Waste Totals

Basic Magnesium, Inc

Portion of the Process	Total Tons of Wastes
Liquid Losses	
Material lost to Trade Effluent Ponds	90,429
Magnesium plant losses to Upper Ponds	230,127
Chlorine/caustic plant losses to Upper Ponds	104,803
Chlorine/caustic plant losses to Lower Ponds	10,982
Losses going to Landfill	
Cell Mud	14,824
Solids lost in the chlorinator	24,545
Losses of casting sludge	26,520
Magnesium Cells going to landfill	20,730
Landfill Total	86,619

City of Henderson²²⁸

Sewage treatment facilities (HSTP1) operated by the City of Henderson were constructed in 1958. HSTP1 continued operations until 1985, when it was closed.

HSTP1 received and treated domestic and light industry sewage from the Henderson/Pittman area. It did not receive or treat BMI sewage effluent.

A sewage treatment plant constructed in 1942 received and treated sewage effluent from the BMI industries and the City of Henderson until it closed in or about 1985. BMI operated the plant until 1974, at which time the City of Henderson assumed ownership and control. Sewage at HSTP2 underwent minor treatment and was discharged as raw sewage into the upper ponds. Unlined infiltration basins located near HSTP2 continue to receive treated effluent from the City of Henderson.

Sewage from the Henderson/Pittman area is currently treated through HSTP3, which began operations in November 1983. Sewage is treated and passes through microscreens at HSTP3 before discharge into the infiltration basins. Treated effluent is periodically pumped into the lower ponds whenever the discharge from HSTP3 exceeds its capacity.²²⁹

As noted earlier, the City of Henderson also operated RIBs as injection points for municipal waste water on a portion of the site from 1992 to at least 2002.

Hardesty Chemical Company

Hardesty Chemical Company reportedly disposed of wastes in the BMI Landfill. Types and volume of wastes are unknown.²³⁰

Jones Chemical Company

Jones Chemical Company disposed of wastes to the:

- BMI Landfill

²²⁸ In addition to the cited sources, see Expert Report of Paul D. Fahrenthold, Ph. D., March 18, 2004, and Fahrenthold Supplemental and Rebuttal Expert Report, April 19, 2004.

²²⁹ See Henderson Steering Committee ECA, p. 58-60. [B002526-528]

²³⁰ Henderson Steering Committee ECA, p. 40. [B002508]

- o Wastes included general trash and floor sweeping, sodium carbonate, sodium bicarbonate, diatomaceous earth, tri-sodium phosphate, Borax, Vermiculite clays, sodium chloride, and sodium sulfate.²³¹
- BMI Upper Ponds
 - o Rinse and wash water containing small amounts of chlorides.²³²

Montrose Chemical Corporation of California²³³

Process waste streams generated from the manufacture of all the products produced by Montrose can be classified as H₂SO₄ waste, HCl waste, sodium hypochlorite waste, and sulfonated organics waste. Specific information describing the wastes discharged to the BMI Ponds as of 1971 is provided in the Montrose ECA.²³⁴

Wastes discharged from the Montrose operations were commingled with wastes from Stauffer's operations in plant sewers.²³⁵ Stauffer reports that historically, stormwater and wastewaters from the Stauffer and Montrose operations areas were conveyed to off-site impoundments via a system of ditches.²³⁶ In 1970-1971, the combined effluents were diverted from the Lower to the Upper Ponds through the Beta Ditch Extension.²³⁷

The Montrose ECA indicates that the company disposed of wastes to the:

- Basic Magnesium Landfill
 - o Wastes included still bottom residues, empty DDT paper bags, and miscellaneous equipment and scrap²³⁸

²³¹ Henderson Steering Committee ECA, p. 45. [B002513]

²³² Henderson Steering Committee ECA, p. 58. [B002526]

²³³ In addition to the cited sources, see Expert Report of Paul D. Fahrenthold, Ph. D., March 18, 2004, and Fahrenthold Supplemental and Rebuttal Expert Report, April 19, 2004.

²³⁴ See Montrose ECA, pp. 78-79. [B002389 and B002390] The information is further summarized on individual pages BR 013616 and labeled H-01. Page H-01 also provides information on a non-process stream, demineralizer wastes, also discharged to the BMI Ponds. The Montrose process flow diagrams included in the ECA [B0001623, B0001629, and B0001630] and the data from BR013616 provide the basis for a material balance calculation of the wastewater quantities discharged to the BMI Ponds.

²³⁵ See Montrose ECA, p. 77. [B002388]

²³⁶ The ditches can be found in the Montrose ECA, Figure 5-1 [B001720] and 5-3 [B0001726]

²³⁷ Pioneer/Stauffer ECA, p. 5-7. [B001725]

²³⁸ See Montrose ECA, Section 5.10, p. 76. [B002387]

- Basic Magnesium Ponds via process sewers
 - Wastes included chloride wastes, H₂SO₄ wastes, and process washwaters containing sulfonated metabolites of DDT.²³⁹

Historical records provide additional information about waste disposal practices:

- In September 1957, Stauffer identified sources of contaminants in its and Montrose's effluent. Those items specifically identified as belonging to Montrose are:
 - Dilute HCl from Montrose included all HCl that could not be sold.
 - Spent H₂SO₄ from Montrose Chloral stills – 860 tons per month. The H₂SO₄ content was about 70 percent by weight and thus was equivalent to about 600 tons per month of 100 percent H₂SO₄.
- A November 1970 Stauffer Chemical Company Industrial Waste Survey identified six separate discharge lines from the Stauffer and Montrose facilities.²⁴⁰ Those items specifically identified as belonging to Montrose are:
 - Montrose discharge to the American Potash ponds: consisted principally of a Montrose chemical waste stream and a smaller stream from a H₂SO₄ tank overflow. The total stream was estimated to be 600,000 gallons per day.
 - Main Sewer discharge was a blend of eight streams going to the storm sewer at an estimated 2.4 million gallons per day. The streams included:
 - Once-through cooling water from the Montrose building
 - Caustic waste and Montrose Water: once-through cooling water from Montrose Building 5A. The water was contaminated with the effluent from the caustic sump, which handled waste from the filter and floor washings. The estimated discharge rate was 1.7 million gallons per day.

²³⁹ See Montrose ECA, Section 5.11 and 5.12, pp. 77-83. [B002388-394]

²⁴⁰ Montgomery Research, Inc., Stauffer Chemical Company Industrial Waste Survey, November 1970. [ST013797-830]

Additional information regarding the combined Stauffer and Montrose waste stream can be found in the Stauffer Chemical section.

Calculated Waste Totals

Montrose Chemical Corporation of California

Process Operation	Dates Operation Occurred (Years)	Volume of Waste (Tons)	TDS Concentration in Waste (Percent)	Volume of TDS Waste (Tons)	Distribution of Wastes	
					Upper Ponds (Jan. 1971- Dec. 1975)	Lower Ponds (May 1945- Dec. 1970)
Oliver Filtrate	1/67-12/75	55,232	0.10%	55	31	25
HCl Wastes	1/47-12/75					
Final vent scrubber		1,271,216	0.50%	6,356	1,096	5,260
Acid plant main sewer		317,804	0.50%	1,589	274	1,315
HCl Gas demister		88	35.00%	31	5	26
Benzene wash water		11,035	2.18%	241	41	199
Sulfonated Organics	1/67-12/75					
Sulfonated organics		236,709	2.00%	4,734	2,630	2,104
H ₂ SO ₄ waste		236,709	6.00%	14,203	7,890	6,312
Demineralizer Wash Water	1/47-12/75	235,174	1.50%	3,528	608	2,919
Chloral drying vent scrubber	1/47-12/75	127,122	0.60%	763	132	631

Process Operation	Dates Operation Occurred (Years)	Volume of Waste (Tons)	TDS Concentration in Waste (Percent)	Volume of TDS Waste (Tons)	Distribution of Wastes	
					Upper Ponds (Jan. 1971- Dec. 1975)	Lower Ponds (May 1945- Dec. 1970)
P-1 condensate	1/47-12/75	50,849	0.04%	20	4	17
Poly column & P-10 evactor	1/47-12/75	1,271,216	0.10%	1,271	219	1,052
MCB column evactor	1/47-12/75	1,271,216	0.10%	1,271	219	1,052
Totals				34,062	13,149	20,912

Pioche Manganese Company

Pioche Manganese Company reportedly disposed of wastes in the Basic Magnesium Landfill. Types and volume of wastes are unknown.²⁴¹

State Industries, Inc.²⁴²

State Industries discharged wastes to the:

- Basic Magnesium Ponds, 1970 to 1974
 - The composition of the waste was steel cleaning and preservation wash liquids. Individual components of the waste included borax, soda ash, phosphate chemicals, and H₂SO₄.²⁴³ Wastewater discharge to ponds at a rate of 35,000 gallons per month.²⁴⁴
 - Liquid wastes periodically discharged to the Beta Ditch through the acid drain system included neutralized and unneutralized waste cyanide solutions, pickling process wastes, spent H₂SO₄, borax, soda ash, and phosphate chemicals. In addition, State Industries

²⁴¹ Henderson Steering Committee ECA, p. 40. [B002508]

²⁴² In addition to the cited sources, see Expert Report of Paul D. Fahrenthold, Ph. D., March 18, 2004, and Fahrenthold Supplemental and Rebuttal Expert Report, April 19, 2004.

²⁴³ State Industries to W.M. Tebeau, March 23, 1982. [BR014200-203]

²⁴⁴ State Industries to H. LaVerne Rosse, May 18, 1982. [BR014285] J.A. Westphal and W.E. Nork, "Reconnaissance Analysis of Effects of Waste Water Discharge on the Shallow Groundwater Flow System Lower Las Vegas Valley Nevada," April 1972. [BR023990]

discharged surface impoundment contents to the acid drain system on three occasions to facilitate liner repairs.²⁴⁵

- Basic Magnesium landfill: approximately 50 pounds of asbestos pipe wrapping.²⁴⁶

Stauffer Chemical Company of Nevada/Pioneer Chlor-Alkali Company, Inc.²⁴⁷

Stauffer/Pioneer provided information regarding waste disposal to the BMI Common Areas in Section 5.3 of the Stauffer/Pioneer ECA. To briefly summarize, Stauffer/Pioneer disposed of wastes to the:

- Basic Magnesium Landfill, 1945-1979
 - Wastes included concrete cell parts, asbestos shavings, asbestos sludge, graphite anodes, chlorine liquefaction sludge, carbon tetrachloride, and high paraffin fuel oil.
- Basic Magnesium Upper and Lower Ponds and associated conveyance ditches, 1946-1976
 - Wastes included asbestos, industrial effluent, and stormwater. Stormwater (but not industrial effluent) disposal to the Basic Magnesium Ponds continued at least until 1981.

Historical records provide additional information about waste disposal practices:

- In March 1952, Stauffer wrote to the CRC asking permission to “use the one large Northwest evaporation pond inside the BMP fenced area...” The company needed to use the additional pond because the caustic evaporation ponds that it leased from the CRC were “full almost to the point of overflow into the main storm sewer drain ditch.”²⁴⁸
- In September 1957, Stauffer identified sources of contaminants in its and Montrose’s effluent:
 - Sludge from brine area – an average of 380,000 pounds per month.
 - Dilute HCl from Montrose included all HCl that could not be sold.

²⁴⁵ KMCC ECA, p. 7-3 [B002112]

²⁴⁶ Henderson Steering Committee ECA, p. 45. [B002513]

²⁴⁷ In addition to the cited sources, see Expert Report of Paul D. Fahrenthold, Ph. D., March 18, 2004, and Fahrenthold Supplemental and Rebuttal Expert Report, April 19, 2004.

²⁴⁸ A.T Newell to R.J. Moore, March 7, 1952. [ST011629]

- o Spent H₂SO₄ from Montrose Chloral stills – 860 tons per month. The H₂SO₄ content was about 70 percent by weight and thus was equivalent to about 600 tons per month of 100 percent H₂SO₄.
- o Caustic plant sewers – 100 tons of 100 percent sodium hydroxide per month, 50 tons sodium chloride per month, 10,000 pounds of Filter-Aid (based on 400 filter runs), and 7,500 pounds per month MgO (based on 1,500 tons of 100 percent low iron sodium hydroxide at 5 pounds of MgO per ton).
- o Chlorine Area – 1,000 pounds per month of asbestos from cell renewal and 100 percent H₂SO₄ equivalent in H₂SO₄ (dilute), which was on average 52,000 pounds per month for 1957.²⁴⁹
- A November 1970 Stauffer Chemical Company Industrial Waste Survey identified six separate discharge lines from the Stauffer and Montrose facilities.²⁵⁰
 - o Montrose discharge to the American Potash ponds: consisted principally of a Montrose chemical waste stream and a smaller stream from a H₂SO₄ tank overflow. The total stream was estimated to be 600,000 gallons per day.
 - o Chlorine water stream to the East Pond: consisted of three streams from the liquefaction plant. The pH varied on these combined waste stream. The total volume discharged was 80,000 gallons per day.
- Main Sewer discharge was a blend of eight streams going to the storm sewer at an estimated 2.4 million gallons per day. The streams included:
 - o Once-through cooling water from the Montrose building
 - o Effluent from the Cell-Renewal Building, containing asbestos fibers from the cell diaphragms
 - o Effluent from the Brine Plant
 - o Effluent from the Caustic Plant

²⁴⁹ Inter-Office Correspondence, from George R. Stewart to J.F. Orr, September 24, 1957. [ST031129]

²⁵⁰ Montgomery Research, Inc., Stauffer Chemical Company Industrial Waste Survey, November 1970. [ST013797-830]

- o East & West Cooling Tower blowdown
- o Effluent from the Sludge Tank, consisting of contaminated saturated brine solution
- o Effluent from the Boiler Plant
- o Effluent from the Power Plant
- o Effluent from floor drains
 - Power Plant Blowdown: condensate water and blowdown from the #3 cooling tower, which was discharged at a rate of 65,000 gallons per day.
 - Caustic waste and Montrose Water: once-through cooling water from Montrose Building 5A. The water was contaminated with the effluent from the caustic sump, which handled waste from the filter and floor washings. The estimated discharge rate was 1.7 million gallons per day.
 - Agricultural Plant: was excluded from the study, but the report indicated that the waste stream from the agricultural plant flowed into the West Pond.
- Analyses of the wastes streams in this 1970 survey indicated the following:
 - o All samples showed a small concentration of mercury
 - o All samples showed traces of arsenic
 - o All samples showed cadmium
 - o All samples showed chromium 6
 - o Cell renewal samples showed 587 milligrams per liter (mg/L) lead
 - o A combined sample from the Main Sewer, Power Plant Blowdown, and Montrose Water showed <0.05 mg/L lead

Additional information regarding laboratory analyses can be found in Table IV-1 and V-1 of the 1970 report.

- Sometime between 1969 and 1975, Stauffer constructed a series of trenches in an area approximately 2,000 feet west of the BMI landfill. There is no documentation concerning disposal to these “slit trenches,” although anecdotal information (confirmed by field observation) indicates that the features were dug with a backhoe to depths of 15 to 20 feet. Wastes were deposited to approximately 10 feet below ground surface (bgs) and the trenches were then backfilled. Aerial photographs indicate that the trenches were closed in or about 1980.

Wastes generated by Stauffer have been categorized as follows:

Thiophenol/p-Chlorothiophenol Waste

The initial process wastes evaluated were generated by the thiophenol/p-chlorothiophenol process. That process generated phosphoric acid waste, caustic waste and process aqueous waste. The Stauffer Process Flow Diagram, Figure 4-2 of the ECA (B001717) indicates the origin of the waste streams. Their volume is defined on pages B001689-B001691. Phosphoric acid waste stream data were provided for the time period of 1960 to 1970. Those data were used to derive an average waste volume value for each year of production. Those data were used to make the calculations presented below. A further calculation was made that the total mass of the waste stream, including the organic phase, should be counted as non-volatile solids entering the BMI Ponds.

The quantity and composition of aqueous waste from thiophenol/p-chlorothiophenol production was reported in the ECA at B001691. The composition was reported as three percent “other,” interpreted as solids, and 97 percent water.

There are no data on the quantity of or dissolved solid content of the caustic stream generated by the process.

Trithio/Imidan Waste

The Trithio/Imidan waste streams are identified on B001697 as an organic waste, an aqueous waste and a dithio acid, identified previously as DTA. The quantity of aqueous waste was presented on B001698 as 24,700 Tons from the time period 1961-1974. These data were used to calculate the waste generated from the 1958-1975 production time frame.

The organic wastes were buried on-site in the Basic Magnesium Landfill.

The DTA wastes were produced from 1958 through 1975. Data exist which indicate that the waste stream volume was 2,259,000 pounds (B001699) from December 1977 through June 1978. These data were extrapolated to the entire production period.

Chlorine and Caustic Soda Waste

Chlorine and caustic soda were produced at the Magnesium Plant Site from 1942 through the present. While there are a number of waste streams from the process operations, only three were sent to the Basic Magnesium Ponds. In 1976, the chlor-alkali plant became a “zero-discharge” facility, meaning that all wastes were thereafter handled and stored on-site.

The first stream is brine sludge. This stream, shown on Figure 4-6 of the ECA (B001704) is generated from the purification of the brine fed to the electrolysis cells. The volume of the stream is presented in the ECA at B001741 as 113,000 Tons from the period 1946-1980. This value was adjusted for the 1946-1975 time frame.

The second waste from the process discharged to the BMI Ponds was the hypochlorite waste stream. According to Stauffer’s ECA (B001711), hypochlorite waste totaled 8,300 Tons during the 1963-1974 time frame. Extrapolating this value to the 1946-1975 time frame, combined with the concentration of solids in the stream as presented on B001742 produced a value for the waste stream to the BMI Ponds.

The third waste stream is sulfate slurry. This stream is generated by the removal of solids from the ~50 percent caustic soda solution produced in the caustic evaporation process. The destination of this stream in the post 1976 time frame was to CAPD Pond 6 (B001711). The volume of this stream is given at B001745 for the years 1983 and 1987. The sulfate concentration of seven percent is at B001711. The quantity of waste for 1983 and 1987 was used to calculate the production quantity for the entire production time frame at the concentration provided at B001711.

Calculated Waste Totals

Stauffer Chemical Company of Nevada/Pioneer Chlor Alkali Company, Inc.

Process Operation	Dates Operation Occurred (Years)	Volume of Waste (Tons)	TDS Concentration in Waste (Percent)	Volume of TDS Waste (Tons)	Distribution of Wastes	
					Upper Ponds (Jan. 1971- Dec. 1975)	Lower Ponds (May 1945- Dec. 1970)
thiophenol/ p-chlorothiophenol	1/60-12/75					
Phosphoric acid waste		19,636	~100%	0*	-	-
Aqueous process waste		1,206,400	3%	36,192	11,310	24,882
Caustic wastewater		No data			-	-
Trithion/Imidan	1/58-12/75					
Aqueous waste	1/58--12/74	29,992	10%	0**	-	-
Organic waste	Buried on site				-	-
Dithio acid salt	1/58-12/75 (18)	2,259,000 pounds produced from 12/77 to 6/78	27.35%	9,532	2,648	6,884
Chlor-alkali	1/46-12/75 (30)					
Brine sludge				519,842	86,640	433,202

Process Operation	Dates Operation Occurred (Years)	Volume of Waste (Tons)	TDS Concentration in Waste (Percent)	Volume of TDS Waste (Tons)	Distribution of Wastes	
					Upper Ponds (Jan. 1971- Dec. 1975)	Lower Ponds (May 1945- Dec. 1970)
Hypochlorite waste					-	-
Sulfate slurry					-	-
Fume scrubber					-	-
Total				565,566	100,598	464,968

“-” Signifies that this waste stream was not distributed to the Upper or Lower Ponds, or that data were not available.

* According to the Fahrenthold Supplemental and Rebuttal Expert Report, 19 April 2004, these wastes were sent to on-site trenches and pond, and were not distributed to the Upper or Lower Ponds.

** According to the Fahrenthold Supplemental and Rebuttal Expert Report, 19 April 2004, these wastes were sent to on-site leach beds, and were not distributed to the Upper or Lower ponds.

TIMET²⁵¹

TIMET provided detailed information regarding waste disposal to the BMI Common Areas in Section 5 of the TIMET ECA. To briefly summarize, the company discharged wastes to the:

- BMI Landfill
 - Wastes included combustible and non-combustible trash, sludge dryer residue, scrap titanium fines, magnesium cell smut, dust collectors residues, and chlorinator bed dump materials.²⁵²

²⁵¹ In addition to the cited sources, see Expert Report of Paul D. Fahrenthold, Ph. D., March 18, 2004, and Fahrenthold Supplemental and Rebuttal Expert Report, April 19, 2004.

²⁵² Henderson Steering Committee ECA, pp. 45-46. [B002513-514]

- BMI Ponds, 1951 to 1977
 - Wastes included leach liquor, caustic waste, and other process wastes. All discharges from the TIMET plant were commingled with other BMI facilities waste effluents and conveyed in unlined and lined channels to the BMI ponds.²⁵³
 - TIMET disposed of large quantities of its CSD solids in the “OPW” ponds located south of the Spray Wheel and capped this with soils scraped from the southern portions of the Spray Wheel.
 - TIMET Active Ponds, 1976 to 2005 – BMI conveyed to TIMET, property within the BMI Common Areas occupied by several rows of the Upper Ponds. TIMET regraded this property and constructed thereupon lined-evaporation ponds, into which it flowed effluent from its titanium manufacturing process from 1983 to 2005. In 2005, a wastewater treatment plant was constructed by TIMET and BRC within the TIMET plant, which allowed TIMET to terminate effluent discharge to the TIMET Active Ponds. These Ponds were formally taken out of service in June 2005, and the land reconveyed back to an affiliate of BMI.
 - TIMET Spray Wheel, 1983 to 1991 – BMI conveyed property within the BMI Common Areas occupied by a number of Upper and Lower Ponds, transected by the Beta Ditch. TIMET regraded this property and installed an evaporative agricultural-type “Spray Wheel” for the evaporative disposal of aqueous salt waste. The Spray Wheel was in operation from 1983 to 1991, after which it was permanently taken out of service, dismantled, and removed. The property was reconveyed by TIMET to an affiliate of BMI in 2005.

**United States Lime Corporation/ United States Lime Division of the Flinkote Company/
Genstar Corporation/Genstar Cement & Lime Company/Genstar Lime
Company/Chemstar Inc./Chemstar Lime Company²⁵⁴**

Chemstar identified three waste streams that have been discharged to the BMI Ponds:

- Hydrator start-up waste

²⁵³ TIMET ECA, p. 5-1. [B002895]

²⁵⁴ In addition to the cited sources, see Expert Report of Paul D. Fahrenthold, Ph. D., March 18, 2004, and Fahrenthold Supplemental and Rebuttal Expert Report, April 19, 2004.

- Hydration process waste
- Hydrator dust collector waste²⁵⁵

United States Vanadium Company

United States Vanadium Company reportedly disposed of wastes in the BMI Landfill. Types and volume of wastes are unknown.²⁵⁶

Western Electro Chemical/American Potash and Chemical/Kerr-McGee²⁵⁷

Kerr-McGee provided detailed information regarding waste disposal to the BMI Common Areas in Section 5 of the Kerr-McGee ECA. To briefly summarize, WECCO/AP&CC/Kerr-McGee disposed of wastes to the:

- BMI Landfill
 - Wastes included sodium chlorate filter cake, asbestos, elemental carbon powder, dried residues from cleaning of the Kerr-McGee surface impoundments, as well as materials such as paper, cartons, bags, pallets, drums, and plastics²⁵⁸
- Upper and Lower Ponds via the Beta Ditch
 - Chlorate (including sodium chlorate filter cake), perchlorate, and boron process wastes and related waste streams from cooling tower blowdown, boiler blowdown, and housekeeping washings (by Kerr-McGee, predecessors, and tenants) between 1945 and 1976²⁵⁹

In addition to Kerr-McGee's production facilities at the BMI complex, the U.S. Navy owned land and equipment required for the production of ammonium perchlorate. The Navy's ownership began in January 1954 and lasted until February 1962. The ECA for Kerr-McGee

²⁵⁵ See Chemstar ECA, Sections 4-5, pp. 18-66. [B002647-97]

²⁵⁶ Henderson Steering Committee ECA, p. 40. [B002508]

²⁵⁷ In addition to the cited sources, see Expert Report of Paul D. Fahrenthold, Ph. D., March 18, 2004, and Fahrenthold Supplemental and Rebuttal Expert Report, April 19, 2004.

²⁵⁸ KMCC ECA, pp. 7-8 and 7-9 [B002117-118]

²⁵⁹ KMCC ECA, pp. 5-66 [B002038] and 5-68 to 5-69. [B002040-2041] See also Section 7.

reports that during the Navy's period production of ammonium perchlorate, ammonium perchlorate wastes were discharged to the Basic Magnesium Ponds.²⁶⁰

2.4 CORPORATE SUCCESSION

The following section presents an overview of corporate succession from the founding of Basic Magnesium, Inc. to the present:

Basic Magnesium Incorporated

BRI was formed on May 29, 1931, as Basic Dolomite, Inc. an Ohio corporation. The company acquired the raw and clinkered dolomite business of Dolomite Inc. and of Basic Products Company.²⁶¹ On October 15, 1936, Basic Dolomite formed a subsidiary called Basic Ores, Inc., whose operations included mining brucite ore in Nye County, Nevada.²⁶² Basic Dolomite changed its name to BRI in March 1941.²⁶³

BRI changed its subsidiary's name from Basic Ores, Inc. to Basic Magnesium Inc. on November 14, 1941,²⁶⁴ and the parent company took over the former mining operations.

The authorized capital for Basic Magnesium was \$100,000, of which BRI owned 55 percent and MEL 45 percent.²⁶⁵ BRI transferred its magnesite holdings in Nye County in exchange for its 55 percent interest in Basic Magnesium. In exchange for its 45 percent interest in Basic Magnesium, MEL donated its technical skill and expertise and agreed to supply the "know how" for the construction and operation of the magnesium plant project.²⁶⁶ Subsequently, 2.5 percent of the interest held by BRI was transferred to George Thatcher.²⁶⁷

²⁶⁰ KMCC ECA, p. 7-6. [B002215]

²⁶¹ Basic Refractories, Inc., Corporate Background, n.d. NARA I, RG 46, Box 476, Folder: Basic Magnesium Corporate History. [BR032651-657]

²⁶² Articles of Incorporation of Basic Ores, Inc., October 15, 1936. Nevada Secretary of State. [BR039109]

²⁶³ Basic Refractories, Inc., Corporate Background, n.d. NARA I, RG 46, Box 476, Folder: Basic Magnesium Corporate History. [BR032651-657]

²⁶⁴ Certificate of Amendment to Articles of Incorporation, November 14, 1941. Nevada Secretary of State. [BR039125]

²⁶⁵ Dun & Bradstreet report, April 25, 1942. NARA I, RG 46, Box 476, Folder: Basic Magnesium Corporate History. [BR032668-675] Certificate of Amendment to Articles of Incorporation, November 14, 1941. Nevada Secretary of State. [BR039125] Officers, Directors, and Designation of Resident Agent, December 6, 1941. Nevada Secretary of State. [BR039131]

²⁶⁶ "Magnesium," circa 1943. NARA I, RG 46, Box 478, Folder: Las Vegas Basic Magnesium. [BR032509-561, @BR032536]

²⁶⁷ Investigation of Industrial Centralization (Basic Magnesium Plant), Hearings before a Special Committee, 78th Congress, Second Session, Part 5, November 27 and 28, 1944, p. 522. [BR038448]

When it became apparent to the U.S. government in mid-1942 that the operations of the magnesium plant could not succeed under the management of the existing Basic Magnesium Inc., the government approached the Anaconda Copper Company and implored them to take over the operations of Basic Magnesium. Anaconda evaluated the situation and on September 30, 1942, Basic Magnesium, BRI, MEL, and Anaconda reached an agreement.²⁶⁸ The DPC agreed to purchase the mining claims in Nye County for \$450,000 and Anaconda agreed to pay \$75,000 for 52,500 shares of Basic Magnesium stock.²⁶⁹

Anaconda purchased the MEL share holdings in Basic Magnesium in 1951. Anaconda dissolved Basic Magnesium Inc. in November 1974. The Anaconda Company was merged into a wholly-owned subsidiary of the Atlantic Richfield Company on January 12, 1977. Atlantic Richfield Company was purchased by the British Petroleum Company (BPC) in 1999.

Basic Management, Inc.

BMI was formed in 1952 for the purpose of providing utility and other services to companies in the BMI Complex. Basic Environmental Company LLC (BEC) is a limited liability company organized and existing under the laws of the State of Nevada. BEC was formed in March 1999. BEC owns property at issue within or near the BMI Complex. BMI's original shareholders were Stauffer, National Lead, Combined Metals Reduction Company, WECCO and U.S. Lime. BMI is the sole member of BEC.

BMI is a corporation organized and existing under the laws of the State of Nevada. BMI was previously known as Basic Investment Inc. (BII) and was formed in 1993 as a holding company for separate operations of several subsidiaries and/or affiliates (*i.e.*, BEC, The LandWell Company LP, BRC, Basic Land Company, Basic Water Company, and Basic Power Company). BII's original shareholders were Kerr-McGee, TIMET, Pioneer, and Chemical Lime Company of Arizona. In March 1999, BII's name was changed to BMI. In 2000, Pioneer Partners 2000, LLC succeeded to the shares owned by Pioneer. Treco, Inc. succeeded to TIMET's interest in BMI.

Chemstar Lime Company

United States Lime Products Corporation was formed in 1926. The company was purchased by Flintkote Company on June 30, 1958, and became the United States Lime Division of the

²⁶⁸ Agreed upon procedures, September 30, 1942. [YBD15102-106]

²⁶⁹ Excerpt from Minutes of Meeting of Board of Directors of Basic Refractories, October 20, 1942. [YBD15642-646]

Flinkote Company. The Genstar Corporation purchased Flintkote in December 1979. Genstar incorporated the Henderson lime plant into the Genstar Cement & Lime Company on July 22, 1981, and into Genstar Lime Company in October 1983. Imasco purchased the parent company, Genstar Corporation, in 1983. Imasco proceeded to sell off the production subsidiaries, and Chemical Lime Company of Forth Worth, Texas and Lime Holding Company purchased Genstar Lime Company on December 6, 1986. Genstar Lime Company changed its name to Chemstar, Inc. in 1986, and to Chemstar Lime Company in 1991.²⁷⁰

Kerr-McGee Chemical Corporation/Tronox LLC

WECCO was formed in 1941. American Potash and Chemical Company merged with WECCO in 1955. Kerr-McGee purchased American Potash and Chemical Company in 1967. In 2005, Kerr-McGee became Tronox LLC.

Montrose Chemical Corporation of California

Montrose was formed in 1946. The company still exists. Stauffer Management Company and Chris-Craft Industries, Inc. each own a 50 percent share in Montrose.²⁷¹

Stauffer Chemical Company of Nevada/Pioneer Chlor-Alkali Company, Inc.

Stauffer Chemical Company of Nevada (a Nevada corporation) was formed sometime prior to 1944, and was owned by Stauffer Chemical Company (a California corporation). Pioneer acquired Stauffer's chlor-alkali manufacturing facilities in October 1988.

TIMET

Titanium Metals Corporation, also known as TIMET was formed from a joint venture agreement between Allegheny Ludlum Steel Corporation and National Lead Company in 1950. TIMET still exists.

²⁷⁰ Chemstar Lime Company ECA, p. 13. [B002644]

²⁷¹ SEC Filing, Annual Report to Stockholders, March 23, 1990.

2.5 REGULATORY ACTIVITIES

2.5.1 Introduction

As described in Section 2.0, the BMI Complex has been the site of many industrial activities including production of magnesium, pesticides, other organic chemicals, titanium, acids, caustics, chlorine and rocket propellants.²⁷² From the 1940's until the 1970's, operating companies in the complex made extensive use of unlined evaporation ponds located adjacent to the plants in the BMI Common Areas.²⁷³ A landfill, reportedly on the site of the war-time Trade Effluent Ponds, accepted organic and inorganic wastes from the operating companies until it ceased operation in 1980.²⁷⁴ Much of this activity went unregulated until the advent of federal and state environmental laws in the 1970's.

In the early 1970's, under the federal National Pollutant Discharge Elimination System (NPDES) program, the industries at the Basic Magnesium Complex curtailed waste discharges to the Basic Magnesium ponds, and lined ponds were constructed by individual companies.²⁷⁵ Later in 1976, the operating companies discontinued the use of the original Lower and Upper ponds in compliance with zero discharge waste requirements.²⁷⁶ Beginning around this time, the USEPA and the NDEP began requiring regular environmental sampling at the Basic Magnesium Complex.²⁷⁷ This sampling resulted in various regulatory actions involving the operating companies and a three phase environmental investigatory process that continues today.

Both the USEPA and the NDEP have been active in environmental regulation of the Basic Magnesium Complex. The principal regulator has been the NDEP. The Bureaus of Water Pollution Control and Solid and Hazardous Waste Management, the Chemical Accident Prevention Program and the Bureau of Corrective Action in the NDEP provide the day-to-day regulation and permitting of environmental activities at the Basic Magnesium Complex. This has

²⁷² NDEP Memorandum "Environmental Studies at the BMI Complex, Henderson, Nevada, December 1998." [BR034398-34401]

²⁷³ Id.

²⁷⁴ Id.

²⁷⁵ Id.

²⁷⁶ Id.

²⁷⁷ Aerial Reconnaissance of Hazardous Waste and Pollution Sources – BMI Industrial Complex – Henderson, Nevada, 1943 – 1979. [B000001-50]

included overseeing of closure of liquid waste disposal ponds, addressing spills and releases and insuring that contaminated groundwater and soils are cleaned up.²⁷⁸

Beginning in 1990, NDEP initiated a three phase environmental investigation and corrective action program for each operating company and for the BMI Common Areas. NDEP entered into consent agreements with each operating company in 1991 covering the plant sites in the complex, and with all the operating companies covering the BMI Common Areas. Phase I, completed in 1993, was a data gathering activity that focused on historical information and liquid and solid waste management practices. The results of these investigations identified data gaps and areas requiring more intensive study during Phase II. Phase II, reflected in a second round of consent agreements, was intended to provide additional information and data and evaluation of remediation alternatives.²⁷⁹ Phase III (*i.e.*, the AOC3) will involve the remediation of the contaminated areas.

2.5.2 BMI Common Areas

The Phase I consent agreement for the BMI Common Areas originally included a definition of the “site” which included areas previously used for waste disposal plus other BMI properties beyond the commonly understood Basic Magnesium complex. BMI, which was not a party to this consent agreement, soon realized that the “site” definition was overly broad, and sought to exclude areas unaffected by waste disposal activities. In April 1992 the NDEP began excluding certain parcels from the 1991 Consent Agreement because they had not been used for waste disposal. These excluded properties include Victory Village, the Henderson Water Treatment Plant with associated easements, a section of Major Avenue, Opportunity Village,²⁸⁰ the BMI properties west of Interstate 95,²⁸¹ “the Storm Channel Easement” and portions of parcel 1A.²⁸² In addition, during the 1990s BMI performed corrective action on particular parcels, leading to NDEP issuance of NFA letters for areas 4A, 4B, 5, 6, 9 North, Warm Springs and Pabco Roads

²⁷⁸ NDEP Memorandum “Environmental Studies at the BMI Complex, Henderson, Nevada, December 1998.” [B018551-18554]

²⁷⁹ Environmental Conditions Investigation Report, BMI Common Areas, Henderson, Nevada (ERM-West, Inc., August 1996). [B011708-11952]

²⁸⁰ Letter from Robert Ritchey to Verne Ross, November 1, 1991, acknowledged by NDEP on January 23, 1992.

²⁸¹ Letter from Jeffrey Denison of NDEP to Mark Paris of BMI, June 19, 1992. [A000640]

²⁸² Letter from Robert Kelso to Gregory Schlink, November 2, 1993.

Right-of-Ways and the Pioneer Detention Basin, excluding them from the Consent Agreement and further remedial action.²⁸³

In 1993, the Henderson Industrial Site Steering Committee (HISSC), a coalition of Basic Magnesium Complex companies, conducted a Phase I investigation that included a review of existing documents and past practices. The results of this investigation were presented in its Phase I ECA, which was submitted to the NDEP in April 1993.²⁸⁴ Based upon its review of the Phase I ECA, the NDEP determined that a Phase II Environmental Conditions Investigation (ECI) was necessary. In an August 1994 Letter of Understanding (LOU), the NDEP identified several study items that, in its opinion, required additional study and investigation during the second phase.²⁸⁵ In February 1996, HISSC entered into a Phase II Consent Agreement, in which a work plan was submitted and approved by the NDEP.²⁸⁶

In 1996, HISSC completed a field investigation. These results were presented in August 1996 in a Draft ECI for the BMI Common Areas.²⁸⁷ Based on the draft ECI, the NDEP requested that HISSC conduct a RAS for the BMI Common Areas. NDEP approved the RAS work plan in July, 1999.

In December 1999, BMI and NDEP entered into a Liability Transfer and Assumption Agreement with the other HISSC parties.²⁸⁸ This agreement gave a BMI subsidiary – BRC – primary responsibility for the cleanup and remediation for soils in the BMI Common Areas. The agreement also gave BRC the power to be the primary negotiator with the NDEP with regard to the clean up of contaminated soil in the BMI Common Areas. In December 2002, a similar agreement was reached between BMI, Montrose, and NDEP with respect to groundwater contamination.

²⁸³ September 30, 1997, Letter from Allen Biaggi to Dan Stewart re: No Further Action for Exclusion Area 6 [A000694-98]; August 18, 1998, Letter from Allen Biaggi of NDEP to Dan Stewart of BMI re: No Further Action for Exclusion Area 5 [A000699]; October 6, 1998, Letter from Allen Biaggi of NDEP to Dan Stewart of BMI re: No Further Action on Pabco/Warm Springs Parcel 4c [A000519-520]; August 19, 1999, Letter from Allen Biaggi of NDEP to Crowley of BMI re: No Further Action for 12.692 acre parcel and 4.99 acre parcel [G006619-6620]

²⁸⁴ Phase I Environmental Conditions Assessment for the Basic Management, Inc. Industrial Complex (Geraghty & Miller, April, 1993). [B002294-2628]

²⁸⁵ NDEP Memorandum “Environmental Studies at the BMI Complex, Henderson, Nevada, December 1998.” [B018551-18554]

²⁸⁶ Consent Agreement between NDEP and BMI, et. al., dated February 23, 1996. [A000285-394]

²⁸⁷ Environmental Conditions Investigation Report, BMI Common Areas, Henderson, Nevada (ERM-West, Inc., August 1996). [B011708-11952]

²⁸⁸ The BMI et. al. Liability Transfer and Assumption Agreement, December 30, 1999. [BR049347-49363]

In 2000 and 2001, BMI submitted a draft RAS, a proposed Corrective Action Plan (CAP) and a Draft Closure Plan for the BMI Common Areas. NDEP issued a ROD for Soils in the BMI Common Areas in November 2001.²⁸⁹ In February 2003, NDEP, BRC and other parties executed the AOC3. All current submittals, including this Closure Plan, are being provided in response to the AOC3.

2.5.3 Pioneer Chlor Alkali Company and Stauffer Management Company

Soon after the USEPA and the NDEP began the requirement for environmental sampling at the BMI Complex, the NDEP issued an August 1979 Violation and Order against Stauffer for groundwater contamination.²⁹⁰ In February 1982 both the NDEP and the Clark County Health District requested data and information regarding environmental conditions at the Stauffer site. In 1983, Stauffer entered into a Consent Agreement with NDEP. In July 1984, the USEPA issued their findings of a Toxic Substances Control Act dioxin investigation.²⁹¹

Pioneer and Stauffer are parties to a 1991 Consent Agreement with the NDEP. Pioneer and Stauffer submitted their Phase I ECA in April 1993. Based upon the ECA, a LOU was executed with the NDEP in August 1994 that identified study areas at the Pioneer facility for further investigation. In a subsequent Consent Agreement, Pioneer and Stauffer agreed to conduct a Phase II ECI of the study areas.²⁹² Pioneer and Stauffer submitted its Phase II ECI in June 1996.²⁹³ In addition, Pioneer and Stauffer have submitted a number of documents to the NDEP regarding various supplemental Phase II environmental studies at the site.

2.5.4 Titanium Metals Corporation

The NDEP began requesting groundwater information from TIMET in 1982.²⁹⁴ The NDEP issued a Finding of Alleged Violation and Order against TIMET in December 1990.²⁹⁵ This was followed by the NDEP revoking TIMET's authority to discharge from their Spray Wheel in

²⁸⁹ Record of Decision, Remediation of Soils and Sediments in the Upper and Lower Ponds at the BMI Complex, Henderson, Nevada, November 2, 2001. [BR005787]

²⁹⁰ Letter from Marvin Tabeau of NDEP to James Wiseman of Stauffer, August 28, 1979. [ST090880]

²⁹¹ USEPA Preliminary TSCA Dioxin Investigation at BMI Complex, Henderson, Nevada, July 10, 1984. [C000784-846]

²⁹² Draft Phase I Environmental Conditions Assessment.

²⁹³ NDEP Memorandum "Environmental Studies at the BMI Complex, Henderson, Nevada, December 1998." [B018441-18554]

²⁹⁴ Id.

²⁹⁵ Letter from Joseph Livak of NDEP to Tom Buck of Timet, December 31 1990. [B021736-21749]

September 1991.²⁹⁶ TIMET also received a Notification of Penalties for Water Pollution Violation in December 1997.²⁹⁷

TIMET signed a Consent Agreement with the NDEP in 1991. TIMET submitted its Phase I ECA in April 1993.²⁹⁸ The NDEP issued a LOU in August 1994 that identified 54 study items at the TIMET facility. The Draft Phase II ECI Work Plan was submitted to the NDEP in June 1996, and the Final Phase II Consent Agreement was signed in June 1996.²⁹⁹ After review and comment, TIMET submitted its final ECI in February 1998.³⁰⁰ This was later approved with conditions in June 1998.³⁰¹ Phase II environmental studies continue at the site.

2.5.5 Kerr-McGee Chemical Corporation (Tronox)

Kerr-McGee signed a 1991 Consent Agreement with the NDEP. Based upon the information found in its Phase I ECA, which was submitted in April 1993, a LOU between Kerr-McGee and the NDEP was established in August 1994.³⁰²

Kerr-McGee signed Consent Agreement in August 1996 that defined the process required for additional study.³⁰³ Kerr-McGee's Work Plan, which included both field activities and file searches, was approved by the NDEP in August 1997.³⁰⁴ The NDEP later approved their Phase II ECI in June 1998 with conditions for further study. Kerr-McGee entered into another Consent Agreement with the NDEP in July 1999 that involved additional sampling toward the development of a RAS.³⁰⁵ Kerr-McGee (now Tronox) has also worked with the NDEP on

²⁹⁶ Letter from John Nelson of NDEP to R.J. Allinger of Timet, September 5, 1991. [B021662]

²⁹⁷ Letter from Joseph Livak of NDEP to John Sanderson of Timet, December 29, 1997. [G002748]

²⁹⁸ Titanium Metals Corporation Phase I Environmental Conditions Assessment, April 1993. [B002758-2984]

²⁹⁹ NDEP Memorandum "Environmental Studies at the BMI Complex, Henderson, Nevada, December 1998." [B018551-18554]

³⁰⁰ Draft Environmental Conditions Investigation Report, Titanium Metals Corporation Facility, Henderson, Nevada (Tetra Tech EM, Inc. February 20, 1998). [B013059-14214]

³⁰¹ NDEP Memorandum "Environmental Studies at the BMI Complex, Henderson, Nevada, December 1998." [B018551-18554]

³⁰² Letter of Understanding between NDEP and Kerr-McGee dated August 14, 1994.

³⁰³ Consent Agreement between Kerr McGee and NDEP dated June 28, 1996. [G013903-13915]

³⁰⁴ NDEP Memorandum "Environmental Studies at the BMI Complex, Henderson, Nevada, December 1998." [B018551-18554]

³⁰⁵ Consent Agreement between Kerr McGee and NDEP, July 26, 1999. [B021792-21884]

perchlorate issues, including a 1999 temporary permit to discharge perchlorate “seep.”³⁰⁶ Phase III remedial and Phase II environmental studies continue at the site.

2.5.6 Montrose Chemical Corporation

Montrose signed a 1991 Consent Agreement with the NDEP. Montrose submitted its Phase I ECA in April 1993.³⁰⁷ Montrose completed its Phase II ECI in August 1997, which covered issues regarding soil contamination at their property.³⁰⁸ Montrose, Pioneer and Stauffer are working jointly with regard to groundwater contamination. A joint report regarding groundwater was submitted to the NDEP in 1998.³⁰⁹ Phase II environmental studies continue at the site.

2.5.7 City of Henderson

The City of Henderson has been involved in many environmental issues regarding the Basic Magnesium Complex. In December 1990, Henderson entered into a LOU with the NDEP regarding contamination of the BMI Complex.³¹⁰ In March 1992, the NDEP issued a violation against Henderson’s wastewater discharge permit.³¹¹ Later that year Henderson entered into an environmental monitoring agreement with BMI.³¹² In June 2001, Henderson was involved in selecting alternative 4B of the RAS for the BMI Common Areas.³¹³

BMI Complex Regulatory Timeline

Date	Action
1972-1973	Under the NPDES program, the industries at BMI curtailed waste discharges to the BMI ponds; lined ponds were constructed by individual companies.
1976	Industries at BMI discontinued the use of the original lower and upper ponds in compliance with zero discharge waste requirements.

³⁰⁶ Letter from Catherine Pool of NDEP to Patrick Corbett of Kerr McGee, November 10, 1999. [G014288-14306]

³⁰⁷ Montrose Chemical Company Phase II Environmental Conditions Assessment, August 11, 1997. [B011953-13058]

³⁰⁸ NDEP Memorandum “Environmental Studies at the BMI Complex, Henderson, Nevada, December 1998.” [B018551-18554]

³⁰⁹ Id.

³¹⁰ Id.

³¹¹ Letter from Joseph Livak of NDEP to Philip Speight of the City of Henderson, March 20, 1992. [A000773-778]

³¹² Monitoring Agreement between the City of Henderson and BMI, December 15, 1992. [B015287-15302]

³¹³ Letter from Monica Simmons of City of Henderson to Alan Biaggi of NDEP, June 14, 2001. [BR005661]

Date	Action
May 1979 – September 1989	USEPA conducts sampling at complex.
August 1979	NDEP issues Violation and Order against Stauffer for organic pollutants found in the groundwater [C000458-460].
March 1980	USEPA requests hazardous waste records for BMI complex [C000482-499].
July 1980	USEPA issues report of hazardous waste and pollution sources at BMI complex [BR001884-1939].
August 1980	USEPA conducts a site inspection of the BMI complex [C000622-631].
June 1981	USEPA issues findings of its “Henderson Industrial Complex Hazardous Waste Investigation” [C001645-1774].
February 1982	NDEP issues order requesting data and information from BMI complex [C000667-670]. Clark County Health District requests asbestos information from Stauffer [A000963-964].
May 1982	NDEP issues order requesting TIMET produce data regarding groundwater.
June 1982	NDEP begins sampling at BMI complex [ST032143-32161].
June 1983	Stauffer enters Consent Agreement with NDEP.
July 1984	USEPA issues findings of TSCA Dioxin Investigation of Stauffer and Montrose [C000784-846].
September 1987	Montrose submits Closure/Post Closure Plan for RCRA ponds [C002068-2095].
December 1990	LOU between NDEP and the City of Henderson regarding BMI contamination [A000942-950]. NDEP issues Finding of Alleged Violation and Order to TIMET for “unlawful discharge of a pollutant without a permit” [B021736-21749].
January 1991	NDEP stays previous order against TIMET.
April 1991	Consent Agreement with NDEP and HISSC companies [A000039-79].

Date	Action
September 1991	NDEP revokes TIMET's authority to discharge from Spray Wheel [B021662].
March 1992	Phase I ECA submitted for BMI Common Areas. NDEP issues a violation to The City of Henderson's wastewater discharge permit [A000773-778].
June 1992	NDEP agrees to exclude BMI properties west of Interstate 95 from the 1991 Consent Agreement [A000640].
January 1992	NDEP agrees to exclude Victory Village, the Henderson Water Treatment Plant and associated easements, a section of Major Avenue and Opportunity Village from the 1991 Consent Agreement.
December 1992	Monitoring Agreement entered into between the City of Henderson and BMI [B015287-15292].
April 1993	Phase I ECA's submitted for Stauffer [B001646-1841], Chemstar Lime [B002629-2713], Kerr-McGee [B001842-2293], Montrose [B002301-2459] and TIMET [B002758-3191].
May 1993	LOU between NDEP and Chemstar regarding environmental assessment activities [A001013-1015].
June 1993	LOU between NDEP and TIMET regarding assessment/remediation activities [A000191-203].
November 1993	NDEP holds a public hearing regarding the ECA for BMI Common Areas [NDEP0003281-3282]. NDEP agrees to exclude the Storm Channel Easement and parts of parcel 1A.
August 1994	NDEP identifies items requiring additional study during the Phase II investigation in LOU with Pioneer and Stauffer. NDEP identifies items requiring additional study during the Phase II investigation in the LOU with TIMET. NDEP identifies items requiring additional study during the Phase II investigation in the LOU with Kerr-McGee [ST039340-39351].
February 1996	Phase II Consent Agreement with HISSC companies [A000284-394].
March 1996	NDEP holds public hearing regarding Phase II Consent Agreement [A000105-142].

Date	Action
June 1996	Phase II ECI submitted for Stauffer [ST047243-47865]. Final Phase II Consent Agreement between NDEP and TIMET [B021792-21884].
July 1996	Phase II Consent Agreement between Kerr-McGee and NDEP [G003514-3515].
August 1996	Phase II ECI for BMI Common Areas submitted to NDEP [B020361-20605] Phase II Consent Agreement between NDEP and Kerr-McGee [G003380-3483].
March 1997	NDEP determines soil characterization in ECI for BMI Common Areas is complete [A001218-1219].
April 1997	NDEP approves Kerr-McGee Work Plan [G003559-3562]
December 1997	NDEP approves RAS work plan for BMI Common Areas [B019962-19963]. NDEP issues Notification of Penalties for Water Pollution Violation against TIMET [G002748].
August 1997	Montrose submits Phase II ECI to NDEP [B011953-13058]. Kerr-McGee submits Phase II ECI to NDEP [B008447-9113].
September 1997	NDEP issues NFAD for Exclusion Area 6 [A000894-900]
February 1998	TIMET submits Phase II ECI to NDEP [B013226-14214]
May 1998	Consent Decree entered in Clark County, Nevada, District Court between NDEP and TIMET [G002697-2699].
June 1998	NDEP approves final Phase II ECI Report with TIMET [NDEP0003084-3090]. NDEP approves final Phase II ECI Report with Kerr-McGee.
August 1998	NDEP issues NFAD for Exclusion Area 5 [A000487-488].
October 1998	NDEP issues NFAD for Warm Springs and Pabco Roads Right-of-Ways [A000519-520].
December 1998	NDEP holds public hearing regarding Phase II ECI investigation for BMI Common Areas [B019551-19554].

Date	Action
July 1999	NDEP issues NFAD to Pioneer for the Pioneer Detention Basin [G006608-6609]. Consent Agreement entered into between NDEP and Kerr-McGee [G013903-13915].
August 1999	NDEP issues NFAD to Kerr-McGee for a 12.692 acre portion of Section 13 and a 4.99 acre portion of Section 12 [G006619-6620].
November 1999	NDEP issues temporary permit for the discharge of perchlorate treated “seep” to Kerr-McGee [G014288-14306].
December 1999	Liability Transfer and Assumption Agreement between BMI <i>et al.</i> (Soils) [BR049347-49363]
January 2000	RAP, Permit for CAMU for BMI Common Areas is submitted to NDEP [G003048-3283].
March 2000	RAS for Soils for BMI Common Areas submitted to NDEP [S003093-3275]. NDEP issues NFAD for Nevada Power Substation Property [BR055966-55976].
April 2000	NDEP holds a public hearing regarding the RAS for BMI Common Areas [BR035143].
June 2000	Presentation of CAP for BMI Common Areas [BR005615-5641].
June 2001	City of Henderson approves Alternative 4B of the RAS [BR005661].
February 2001	BMI submits Site Closure Plan to NDEP (revised July 2001 [S000540-711].
November 2001	NDEP issues ROD for Soils at BMI Common Areas [BR005787-5853].
February 2002	NDEP issues Draft Closure Plan for BMI Common Areas [S0045535620].
December 2002	Liability Transfer and Assumption Agreement between BMI <i>et al.</i> (Groundwater) [BR049507-49515].
August 2003	NDEP proposes Phase III Administrative Order on Consent [BR052900-52791].
February 2006	NDEP, BRC, and others execute the AOC3.
September 2006	NDEP approves BRC’s <i>Corrective Action Plan</i>

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SECTION 3

3 SITE RELATED CHEMICALS LIST

Based on a thorough review of the various chemicals (including likely by-products and degradation products) produced, used, handled, generated, or disposed by the manufacturing companies and BMI, BRC has, with the NDEP's oversight, created a comprehensive Site Related Chemicals (SRC) List for the BMI Common Areas. In creating this list, BRC considered:

- All historical uses at the Site;
- The multiplicity of plant source processes and chemicals that have or may have been discharged into the ponds via the conveyance ditches;
- The lack of certainty and specificity of these discharges into known ditches and ponds; and
- Anticipated future uses.

The SRC submittal (BRC Common Areas Site Related Chemicals Tables, 2006) documents the information used in the development of the SRC list, including the lists themselves. Table 3-1 contains the broad suite analytical list for the project, based on the SRC list. This analytical program (or appropriate subsets, based on the NDEP's approval) will be applied to all characterization and confirmation sampling conducted as part of Closure of this Site.

It should be noted that on-going investigations are currently being performed by various companies associated with historical operations at the BMI Complex under the NDEP's supervision. If those investigations identify additional SRCs that might have been discharged to the Upper and Lower Ponds and Ditches, the analytical program and the SRC list itself will be updated as needed to include additional chemicals. Conversely, if investigations show that some chemicals do not occur at the Site, they may be removed, with the NDEP's permission. Or, if subsequent sampling and analysis demonstrates to the NDEP's satisfaction that certain analytical suites can be eliminated without adversely affecting risk assessment reliability, those suites may be eliminated from the analytical program.

As later discussed in Section 9, it is permissible following USEPA's current guidance to eliminate various chemicals from the SRC list, leaving a smaller number of chemicals of potential concern (COPCs) that are analyzed and used in risk assessments. BRC expects that some number of the analytes in the SRC list will be eliminated for risk assessment purposes (*i.e.*,

not be carried over as COPCs) in accordance with this guidance as the project progresses. The selection of COPCs is a function of the risk assessment process. COPC selection will not be conducted prior to initiating a sub-area-specific risk assessment.

SECTION 4

4 SITE-WIDE CONCEPTUAL SITE MODEL OVERVIEW

This section of the Closure Plan presents an overview of the CSM for the Eastside Area and the CSM for the CAMU Area of the Site. The Site boundaries were set and are described by the AOC3. A history of the Site and adjacent industrial plants situated to the southwest is provided in Section 2 of this plan.

Pursuant to the Scope of Work set forth in the AOC3, two comprehensive and detailed CSMs for the Site are to be prepared as separate stand-alone reports. These stand-alone CSMs are for the Eastside Area and for the CAMU Area (as further defined, below). The CAMU Area CSM was submitted to the NDEP in February 2007 and BRC has received requests for certain additional data in this regard from the NDEP. The Eastside Area CSM is under development and will be submitted to the NDEP after various current investigations are implemented and the data thereby collected and incorporated. Both CSMs will be “living documents” and will be updated periodically as new data are collected and analyzed.

The American Society for Testing and Materials (ASTM) guidance E 1689-95, *Standard Guide for Developing Conceptual Site Models for Contaminated Sites* (2003) states the basic activities associated with the development of a CSM, and these include:

- Brief Site Summary
- Site Description, including a description of the limits of the study area
- Source Characterization
- Background Levels for each media of interest
- Migration Pathway Descriptions
- Environmental Receptor Identification
- Discussion of Data Gaps
- Maps, Tables, and Figures

The activities called for in the ASTM guidance are summarized in this section of the Closure Plan.

4.1 SITE SUMMARY

The area known as the “BMI Common Areas” is delineated in Appendix A of the AOC3. The subject Site is near the BMI Industrial Complex, in Clark County, Nevada, approximately 13 miles south of the city of Las Vegas and approximately two miles northeast of the City of Henderson (Figure 2-1). The total extent of the Site, including the Eastside Area (Figure 1-2) and the CAMU Area (Figure 1-3), as delineated in Appendix A of the AOC3, is discussed in Section 1 of this Closure Plan. The Eastside Area (including relevant portions of Parcel 9) covers approximately 2,321 contiguous acres, and the CAMU Area covers approximately 114 acres. The Eastside Area lies to the east of Boulder Highway (except for Parcel 9, which is adjoining and to the west of Boulder Highway) and to the north of Lake Mead Parkway and consists of:

- Land on which unlined wastewater effluent evaporation/infiltration ponds (and associated conveyance ditches) were built and into which various plant wastewaters were discharged from 1942 through 1976;
- Land on which effluent from the TIMET plant was disposed through the use of a spray irrigation wheel;
- Land on which lined wastewater effluent ponds were constructed and into which effluent from the TIMET plant was discharged from 1976 to 2005;
- Land on which the City of Henderson constructed municipal wastewater infiltration basins (*e.g.*, the Southern RIBs);
- Land on which unlined wastewater effluent ponds were constructed but which were never used; and,
- Land that has remained desert.

The CAMU Area consists primarily of land which contains:

- The closed BMI Landfill;
- Land on and under which Stauffer constructed a line of groundwater extraction wells and their associated piping, treatment, and reinjection apparatus;

- Land across which traversed the former Western Ditch that carried effluent from the Plants to the Western Ditch Extension and from there towards the Las Vegas Wash;
- A series of trenches (the "Slit Trenches") into which various wastes and trash were deposited; and,
- Land that appears to have had no historical use.

The CAMU Area will continue to be used as a waste disposal facility. The Eastside Area will be redeveloped to a mixed use, including residential use, in accordance with a master plan.

4.1.1 Site Description

The Site represents a portion of the property known as the BMI Common Areas. The total extent of the property is approximately 2,435 acres and is comprised of: 1) the Eastside Area of approximately 2,321 contiguous acres located east of Boulder Highway and including Parcel 9 (Figure 1-2) and, 2) the CAMU Area of approximately 114 acres (within the 369 acre Parcel 5/6) to the west of Boulder Highway (Figure 1-3). The Site contained a network of ditches, canals, flumes, and unlined ponds that were used for the disposal of aqueous waste from the original magnesium plant and, later, other industrial plants and the municipality adjacent to it. The ponds are sometimes referred to as the "BMI Ponds" or the "evaporation ponds of the BMI Common Areas" or the "Upper Ponds" and "Lower Ponds." The Lower Ponds are topographically lower and located to the north; the Upper Ponds are topographically higher and located to the south. This disposal network comprised less than half of the Site.

This overview of the CSMs describes:

- The entire 2,321 acres of the Eastside Area, bounded on the south by Lake Mead Parkway, on the west by Boulder Highway (except for Parcel 9) and the community of Pittman, and on the north by the Tuscany and Weston Hills communities; and
- The 114 acres which comprises the CAMU Area within the footprint of the property located east of Eastgate Road, west of 4th Street, approximately 1400 feet south of West Warm Springs Road, and north of the properties operated by Pioneer, Stauffer, and Montrose.

Effluent wastes discharged to the ponds of the BMI Common Areas from the war-time Basic Magnesium operations can be characterized as salts from the production process (chloride salts of a variety of metals and radionuclides); organic solids; and inorganic solids and dissolved

components of various types. Chlorinated organic chemicals were included in the effluent. Notable processes that contributed to the waste stream from the plants that succeeded Basic Magnesium included effluents from the manufacture of the following types of products: chlorine and sodium hydroxide (caustic soda); a variety of chlorate, perchlorate compounds, and halogenated boron compounds; manganese dioxide; titanium and related compounds; and a variety of pesticides. Among these wastes were salts; organic and inorganic chemicals; and metals. A more detailed description of these processes and their effluents is found in Section 2. An overview of the contaminants now found on Site is also found below in Section 4.2, "Source Characterization."

Due to the size of the Site and its various historical, present, and prospective uses, BRC has subdivided the 2,321 acre Eastside Area into sub-areas. The rationale for this subdivision is to divide the Site into sub-areas in which acreages of reasonably similar geography, geology, past use, and future use are grouped together. By dividing the Site into various sub-areas, the Site restoration and reclamation can be more focused, and thus achieved in a more precise, cost effective and timely manner. Figure 1-2 depicts the sub-areas that are the focus of this CSM summary for the Eastside Area. These Eastside Area sub-areas are:

- Western Hook (227 acres);
- Trails & Recreation sub-area (151.4 acres);
- City of Henderson WRF Expansion (101.3 acres);
- Galleria North (135.6 acres);
- Sunset North Commercial (57.9 acres);
- Upper Ponds (284.5 acres);
- Spray Wheel (128.7 acres);
- TIMET Ponds (209.9 acres);
- First Eight Rows (208.2 acres);
- Mohawk (49.2 acres);
- Southern RIBs (245.1 acres); and

- No-Further-Action (NFA) Areas (522.2 acres).

With two exceptions (the City of Henderson WRF sub-area and the sub-area named NFA Areas), the sub-areas listed above are included in the Closure Plan as it addresses impacts to soils. The City of Henderson has received a NFA determination from the NDEP for its City of Henderson WRF Expansion sub-area relative to soil impacts, and the owner of the NFA Areas sub-area has received NFA determinations for this sub-area relative to soil impacts.

As noted, all of the Eastside Area sub-areas are planned for redevelopment according to a mixed-use master plan, which will include above- and below-ground utilities (potable water, sewerage, power, gas), roadways, trails, parks, homes, schools, shops, and municipal buildings. Some of the Eastside Area sub-areas will be primarily residential (*e.g.*, Mohawk), some will be primarily commercial (*e.g.*, Sunset North Commercial), one will be exclusively dedicated to trails and parks (*i.e.*, Trails & Recreation sub-area), and some will be a mixture (*e.g.*, Southern RIBs).

Figure 1-3 depicts the sub-areas that are the focus of this CSM summary for the CAMU Area. These CAMU Area sub-areas are:

- Eastern W. Ditch (6.1 acres);
- Northern Landfill Lobe (51.7 acres);
- Northern Lobe of the Borrow Area (9.3 acres);
- Slit Trench Area (27.7 acres);
- Southern Landfill Lobe (8.2 acres);
- Southern Lobe of the Borrow Area (8.5 acres); and
- Western W. Ditch (2.3 acres).

As mentioned above, it is anticipated that the CAMU Area will continue use as a waste disposal area.

All of the sub-areas listed above, including the two in the Eastside Area excluded from the Closure Plan relative to soil impacts, are covered by the AOC3 and are included in the Closure Plan for groundwater impacts.

4.1.2 Geology

4.1.2.1 Regional Geology

Southern Nevada regional geology is typical of the Basin and Range Province morphology of the Western Cordillera of North America. In this region, Cenozoic tectonic extension has resulted in one of the world's most extensive systems of fault-bounded mountains separated by sediment-filled valleys, extending across Idaho, Oregon, Nevada, Utah, Arizona, New Mexico, California, and northern Mexico.

The Basin and Range Province is typified by elongated north-south-trending arid valleys bounded by mountain ranges that also bound adjacent valleys. Basins consist of down-dropped blocks of crust, and the ranges are upthrust slabs with a regional tilt to the east. The normal arrangement in the Basin and Range system is that each valley is bounded on each side by a normal fault that runs parallel to the range. Upthrown sides of Basin and Range normal faults form mountains that rise abruptly and steeply, and the down-dropped sides create low valleys. The fault plane, along which the two sides of the fault move, extends deep in the crust, usually at a nominal angle of 60 degrees. In places, the relief or vertical difference between the two sides is as much as 10,000 feet.

The mountain range rock types in this region consist primarily of consolidated sedimentary and volcanic rocks of Proterozoic and Mesozoic age, with some Precambrian Era rocks. A lesser percentage of the mountain rock types are metamorphic and intrusive igneous rocks. Following uplift, sediments originating from the mountain sources began filling the valleys, with sedimentary rocks of the Cenozoic Era forming the basin stratigraphy. Cenozoic volcanic rocks also comprise portions of selected mountain ranges in the Basin and Range Province.

4.1.2.2 Local Geology

The geology of the Las Vegas Valley has been mapped and described by several researchers, most recently by Page *et al.* (2005). As is common throughout the Las Vegas Valley, Site soils are primarily sand and gravel, with occasional cobbles. This is consistent with the depositional environment of an alluvial fan. The Site is located on alluvial fan sediments, with a surface that slopes to the north-northeast at a gradient of approximately 0.02 foot per foot (ft/ft) towards the Las Vegas Wash. These uppermost alluvial sediments were deposited within the last two million years and are of Quaternary age. The alluvial soils on the Site were deposited from the

McCullough and the River Mountain ranges, located to the southwest and southeast of the Site, respectively. Regional drainage is generally to the east.

The uppermost strata beneath the Site, at the CAMU Area and the Eastside Area, consist primarily of alluvial sands and gravels derived from the River Mountains and from the volcanic source rocks in the McCullough Range. These deposits are of Quaternary age, and are thus mapped and referred to as the Quaternary alluvium (Qal; Carlsen *et al.* 1991). The Qal is typically on the order of 50 feet thick at the Site with variations due, in part, to the non-uniform contact between the Qal and the underlying Tertiary Muddy Creek Formation (TMCf).

The TMCf underlies the Qal. The Muddy Creek formation, of which the TMCf is the uppermost part, is a lacustrine deposition from the Tertiary Age, and it underlies much of the Las Vegas Valley. It is more than 2,000 feet thick in places. The lithology of the TMCf underlying the Site is typically fine-grained (sandy silt and clayey silt), although layers with increased sand content are sporadically encountered. These TMCf materials have typically low permeability, with hydraulic conductivities on the order of 10^{-6} to 10^{-8} centimeters per second (Weston 1993).

The contact between the Qal and the underlying TMCf is not a planar surface (Figure 4-1). The unconformity between these two geologic units is a result of uplift and erosion of the TMCf prior to the deposition of the alluvial sediments that comprise the Qal. As the TMCf was eroded, shallow channels were incised into its surface and filled with the relatively coarse-grained alluvium, resulting in the development of southwest-to-northeast trending paleochannels. Figure 4-2 depicts the relationships between the Qal and the TMCf at the Site.

4.1.3 Surface Water

Surface water flow occurs for brief periods of time during periodic precipitation events and drains to the Las Vegas Wash, which is to the north of the Site's northern border. Four jurisdictional wetlands are present in the northern portion of the Site that contain water during portions of the year. These four wetlands are near larger wetlands associated with the Las Vegas Wash and occupy approximately 13 acres (Figure 4-3). Groundwater seeps have been observed at various locations in the northern portions of the Site closer to the Las Vegas Wash and at nearby off-Site locations. In recent years, the observed seeps have been restricted to the wetland areas. An evaluation of historical aerial photos indicates that seeps have appeared in association with past effluent infiltration at the Eastside Area ponds and with infiltration of municipal wastewater at municipal RIBs on the Eastside Area.

4.1.4 Groundwater

The logs of more than 500 borings installed at the Site were reviewed to evaluate the primary Site geologic units, including their lithology, geometry, and stratigraphy. More than 15 miles of geophysical transects have been shot across the 3.6 square mile Site (Figure 4-4), and these transects have also been evaluated. This evaluation has yielded a good understanding of the depositional environments of the various strata, which control the flow of groundwater and the distribution of chemicals that are found in both soils and groundwater at the Site.

Groundwater is primarily encountered in two distinct layers (shallow and deep) at both the CAMU Area and at the Eastside Area. The shallower layer of groundwater is unconfined and typically encountered in the Qal and the upper portion of the TMCf. The deeper groundwater occurs in the TMCf. The potentiometric surface in the Upper Unconfined Water Bearing Zone generally follows topography, sloping towards the Las Vegas Wash. The depth to groundwater at the Site ranged from approximately eight feet bgs at the northern perimeter of the Eastside Area to 65 feet bgs at the southern border when water level data were collected in 2004 (Eastside Area) and 2005 (CAMU Area). More recent groundwater data from quarterly monitoring in 2006-2007 is under analysis at the present time; however some of these data are also discussed later.

On the eastern side of the Eastside Area, groundwater is not found in the Qal. The shallowest groundwater in this portion of the Eastside Area is encountered within the uppermost fine-grained sediments of the upper TMCf, just below the contact between the Qal and the TMCf (Figure 4-5).

Wells completed in both the Qal and the TMCf water-bearing zones, at both the CAMU Area and the Eastside Area, are generally low producing, as indicated by recovery rates of less than five gallons per minute (gpm) observed after purging monitoring wells installed in 2004 and 2005. (A notable exception is an Eastside Area Upper Unconfined Water Bearing Zone, also referred to as the alluvial aquifer [Aa], groundwater well on the west side of the first eight rows of Upper Ponds, AA-09, just downgradient of the closed TIMET Ponds, that recovered at a rate of 52 gpm during 2004.)

Deep groundwater occurs within the TMCf and is encountered between 335 and 395 feet bgs, as encountered while drilling at the Site during Summer 2004 (Figure 4-6). There is no indication that deep groundwater, which is confined and under pressure, is in contact with the Las Vegas Wash to the north of the Site. To the east of the Site, faulting has been identified that may

provide a pathway of hydraulic connectivity between Deep Zone groundwater and the Las Vegas Wash. The shallower groundwater presents evidence of contact with the Las Vegas Wash gravels. With the exception of the wetlands discussed previously, the potentiometric surface does not emerge as surface water prior to flowing into the Las Vegas Wash. Stiff diagrams for the Aa and the Deep Zone (Figure 4-7) graphically depict cation/anion constituent data. The similarity or dissimilarity of the Aa and the Deep Zone groundwater is a data gap that will be addressed through future investigations.

Between shallow and deep groundwater occur several hundred feet of dry to moist, fine-textured, silts to silty clays comprising the TMCf. This unit, between the Upper Unconfined Water Bearing Zone and the Deep Zone, has been designated as the Middle Zone. Thin sand lenses were sporadically and unpredictably encountered in this upper portion of the TMCf during drilling. Many of the sand lenses were saturated; others were unsaturated. These lenses are typically less than one foot in thickness and the borings studied (through the construction of project cross-section and fence diagrams) do not appear to establish lateral interconnection between Middle Zone lenses observed in individual borings. The lenses were encountered at depths ranging from 55 feet bgs to more than 300 feet bgs (Figure 4-8 and Figure 4-9).

Shallow groundwater quality is classified as brackish, with TDS concentrations averaging approximately 4,090 mg/L. A number of contaminant chemicals are also present.

Figures 4-10 through 4-14 are block diagrams that summarize the features of the Eastside Area depicted between circa 1943 and circa 2005. Figure 4-15 depicts the future scenario following redevelopment of the Site. Figures 4-16 through 4-18 are block diagrams that summarize the features of the CAMU Area circa 1943, 1976, and 2005. Figure 4-19 depicts the future scenario with the CAMU in place.

Water level measurements in monitoring wells in the vicinity of the Site indicate that groundwater in the deep TMCf is under pressure, which causes an upward groundwater gradient. Where the potentiometric head in the shallow zone is lower than the head in the deeper zone, the upward gradient can inhibit downward groundwater flow and contaminant transport from the Qal. However, where the potentiometric head in the shallow zone is greater than the head in the deeper zone, downward groundwater flow and contaminant transport can still occur from the Qal.

In the vicinity of the CAMU Area, groundwater is typically encountered first in the Qal under unconfined conditions. The Qal is unsaturated toward the east, with saturation first noted in the

uppermost TMCf, close to the contact between the Qal and the TMCf. It is thought that the Qal has been dewatered in this area as a result of operation of the Tronox remediation system, located on the property east and adjacent to the CAMU Area. Groundwater extraction has been conducted immediately east of the CAMU Area, at the Tronox facility, since 1987 (Tronox 2006).

As a part of this system, groundwater is extracted and treated for chromium, nitrate, chlorate, perchlorate, and other chemicals present in the influent water. The majority of this treatment occurs on the Tronox plant site at the BMI Complex, east of and adjacent to the CAMU Area. Ferrous sulfate is also added approximately 8,700 feet downgradient at the location known as the Athens Road Lift Station. Approximately 5,500 feet farther downgradient toward the Las Vegas Wash, a line of nine extraction wells, oriented orthogonal to flow of groundwater, captures groundwater that is subsequently treated to remove perchlorate. Water from the perchlorate treatment system is treated to remove solids, disinfected with an ultraviolet (UV) system, and then discharged via pipeline to the Las Vegas Wash. Based on the most recent reporting from Tronox (2006), the maximum groundwater level fluctuation induced by groundwater pumping and downgradient injection of water has been approximately 10 feet.

Another line of remediation extraction wells, known as the Pioneer/Stauffer/Montrose Groundwater Treatment System (GWTS), is installed north and downgradient of the CAMU Area. The GWTS is an 1,800-foot long line of 13 remediation extraction wells installed north and downgradient of the CAMU Area, oriented orthogonal to the flow of groundwater. The GWTS was originally designed to only remove volatile organic compound (VOCs) from groundwater. In correspondence dated January 2005, NDEP noted that the GWTS was to be modified to remove pesticides and semi-volatile organic compounds (SVOCs). NDEP stated that there might be chemicals not treated by the GWTS and that the GWTS might not be capturing all of the impacted groundwater moving through the Pioneer/Stauffer/Montrose facilities area. In this scenario, it is likely that groundwater and contaminants continue to flow north towards the Las Vegas Wash. Subsequent to this January 2005 letter, there has been a substantial and continuing dialogue between the NDEP and Pioneer/Stauffer/Montrose concerning the efficacy of the current GWTS, various operational and design inadequacies, and proposed upgrades to remedy these inadequacies. It is anticipated that this dialogue will lead within the next 36 months to a modification of the GWTS.

The CAMU CSM report presents a full summary of additional features relating to the historical and current groundwater recharge in the Site area.

4.2 SOURCE CHARACTERIZATION

Historical operations and chemical disposal at both the CAMU Area and Eastside Area have resulted in chemical impacts to soil and groundwater. Site investigations to collect and summarize historical operational information (Section 2), and to collect and analyze soil and groundwater quality data, have been conducted 30 times since 1996. All data collected from investigations conducted since 1996 have been subjected to a data validation process to insure that the data are of sufficient quality for use in interpreting Site conditions.

A detailed discussion of the analytical data and impacts to the CAMU Area is presented in the CAMU CSM. The Eastside Area CSM, in preparation, will present a similar detailed discussion of the Eastside Area analytical data and impacts. An overview of the source characterization for each of the two Site Areas is presented below.

A SRC list of laboratory analytes was developed to include every chemical known (including potential chemical byproducts and degradation products) to have been manufactured or used by any of the entities at the BMI industrial site from inception to present. This is discussed in Section 3.

A subset of these analytes have been detected at the Site. Detected analytes were grouped into chemical classes and compared to regulatory-established screening levels in order to put relative concentrations at the Site into a context that has been established by regulatory precedence. In order to provide a manageable, useful, and accurate discussion of the chemical impacts to the Site, the chemicals were grouped into the following classes:

- Aldehydes, asbestos, dioxins and furans, herbicides, metals, organic acids, organochlorine pesticides, organophosphate pesticides, perchlorate, PCBs, radionuclides, SVOCs, and VOCs.

Because asbestos only occurs as a solid, and owing to the fact that there is not a mechanism to transport this compound to greater depths, only surface soils were analyzed for its presence.

Detected pre-remedial Site chemical concentrations are screened against USEPA Region 9 Residential preliminary remediation (PRGs), and soil screening levels (SSLs) using a dilution attenuation factor (DAF) of 1. Except in the Mohawk sub-area, where contaminated soils have been excavated, the data represent pre-remedial conditions. Dioxins/furans toxic equivalency (TEQ) concentrations were compared to the Agency for Toxic Substances and Disease Registry

(ATSDR) screening value of 50 parts per trillion (ppt). The analytical results for naturally occurring constituents, including arsenic, radium-226, and radium-228, were compared to shallow soil background concentrations. Finally, the reporting limits for all reported non-detects in soils were compared with the screening levels noted above in order to evaluate the usefulness of the “non-detect” data.

4.2.1 Summary of Eastside Area Source Characterization

Historical waste disposal practices at the Eastside Area ditches, canals, flumes, and unlined ponds have impacted soil and groundwater in this Area. Table 4-1 presents BRC’s estimate of volumes deposited into the Upper and Lower Ponds from 1942 until 1976, based on a review of historical operating reports, memoranda, and other data.

4.2.1.1 Eastside Area Soil

The analytical data collected during the Site investigations conducted in this Area since 1996 were organized into a relational database that forms the basis of the Eastside Area source characterization. The data were sorted, screened, and statistically analyzed. Table 4-2 presents the screening levels that were used in the data summary tables and figures. Table 4-3 presents the following for each soil analyte on the SRC list:

- Screening levels;
- Maximum background levels;
- Range of detections;
- Number of detections exceeding the screening level;
- Range of non-detections; and
- Number of non-detections exceeding the screening level.

Tables 4-4 through 4-7 present these data categorized by the following soil horizons.

- Surficial soil (one foot bgs or less) (Table 4-4);
- Near-surface soils (between one foot bgs and 15 feet bgs) (Table 4-5)
- Middle zone soils (between 15 feet bgs and the Qal/TMCf interface) (Table 4-6); and

- Deep zone soils (within the TMCf) (Table 4-7).

Figures 4-20 through 4-23 present the soil data showing locations where chemicals exceed screening levels.

Shallow soil chemical data indicate that asbestos was deposited in the sub-areas of Sunset North Commercial, Spray Wheel, First Eight Rows, Mohawk, and the Southern RIBs. For the samples collected and analyzed, the greatest frequency of asbestos detection occurred in the First Eight Rows sub-area.

Soil chemical impacts on the Eastside Area were compared to USEPA Region 9 Residential PRGs, USEPA SSLs (using a DAF of 1), ATSDR TEQs for dioxins/furans, and the provisional background dataset for metals and radiochemicals. The chemical groups and significant individual chemicals detected most often and most frequently at concentrations above screening levels (“exceedances”) were arsenic, dioxins and furans, organochlorine pesticides, perchlorate, and radium-226 and radium-228.

Arsenic concentrations exceeded PRGs in almost all samples at all intervals, as do the activities of radium-226 and radium-228. Comparison of arsenic and the radium-226 and radium-228 isotopes sample concentrations to the background dataset indicates that these chemicals generally occur at concentrations not substantially different from background concentrations in the Site vicinity. However, the existing data indicate that some areas appear to be relatively elevated in concentration compared to background. BRC will continue to evaluate and address these areas, as appropriate, and update the CSM as needed.

Chemical groups that demonstrated a relatively low (and in some cases, no) frequency of exceedance of the soil screening levels included VOCs, SVOCs, PCBs, aldehydes, asbestos, herbicides, organophosphate pesticides, radionuclides (other than radium isotopes), organic acids, and polycyclic aromatic hydrocarbons (PAHs).

As measured by the quantity and type of soil sample chemical analytic results that exceeded the soil screening values, the greatest soil impact on the Eastside Area occurred in the First Eight Rows sub-area, with lesser impacts observed in the remaining sub-areas.

As indicated by frequency of chemical analyte exceedances above the PRG screening level, soil chemical impact is greatest in surface soil samples and decreases with depth into the Qal soils above the Upper Unconfined Water Bearing Zone. Preliminary evaluation of the Eastside Area

soil data has not addressed the potential for leaching of soil chemical constituents to the Upper Unconfined Water Bearing Zone. That evaluation will be reported in the detailed CSM for the Eastside Area. The decline in concentration of detected chemicals with increasing depth in the TMCf soil suggests that the extent of contamination in the unsaturated sediments below the Upper Unconfined Water Bearing Zone is low.

4.2.1.2 Eastside Area Groundwater

Evaluation of Eastside Area groundwater is based on data derived from groundwater monitoring and sampling events conducted in July 2004; as well as more recently in April-June 2006, July-August 2006, and October-November 2006.

Groundwater chemical results were statistically analyzed and compared to (1) maximum contaminant limits (MCLs) where they have been established, (2) secondary water treatment standards, and (3) the USEPA Region 9 PRGs for tap water for a residential water use scenario. Table 4-2 lists the screening levels, and Table 4-8 presents the following for each groundwater analyte on the SRC list, using the most recent 2006 data:

- Screening levels;
- Range of detections;
- Number of detections exceeding the screening level;
- Range of non-detections; and
- Number of analyses with reported detection levels exceeding the screening level.

Tables 4-9 through 4-11 present these data categorized by the following groundwater zones.

- Upper unconfined water-bearing zone (Table 4-9);
- Intermediate water-bearing zone (Table 4-10); and
- Deep water-bearing zone (Table 4-11).

Figures 4-24 through 4-26 present the most recent 2006 groundwater data showing locations where chemicals exceed screening levels.

Generally, water in the Upper Unconfined Water Bearing Zone is classified as brackish, with average TDS concentration of 4,090 mg/L. The Aa water can be further classified as being of calcium-chloride to calcium-sulfate in chemical character. Groundwater within the Upper Unconfined Water Bearing Zone has been impacted by the chemicals historically used in the Plants Area to the west as a result of wastewater disposal to the effluent ditches and ponds. In addition, off-Site sources have been identified for impacted groundwater flowing west of Pabco Road and beneath the Lower Ponds. In addition to perchlorate, groundwater in the Upper Unconfined Water Bearing Zone has been impacted with elevated levels of certain dioxins and furans, certain metals (total chromium, selenium, and copper), certain organochlorine pesticides, certain radionuclides as well as certain SVOCs, and VOCs. Groundwater samples collected from Upper Unconfined Water Bearing Zone groundwater do not exhibit detectable concentrations of PCBs, PAHs, herbicides, organophosphorus pesticides, or organic acids.

4.2.2 Summary of CAMU Area Source Characterization

The revised CAMU CSM document was submitted to the NDEP February 16, 2007. Recently BRC has received comments on this CSM. The following summary is based on this revised draft report, taking into consideration considering NDEP's comments.

4.2.2.1 CAMU Area Soil

Impacts to soil on the CAMU Area have been documented to exist in the North Landfill Lobe, beneath the Western Drainage Ditch (beneath pieces of Western W. Ditch Area and the Eastern W. Ditch Area), and in the Slit Trench Area. These impacts include VOCs, SVOCs, pesticides, metals, Aroclors, PCBs, radiochemicals, and dioxins/furans. Though specific information does not exist on historical waste disposal activities or subsurface investigations at the South Landfill Lobe, it is logical to assume that similar impacts exist here that exist beneath the North Landfill Lobe. Investigations and studies have indicated that limited soil impacts have occurred in the North Borrow Pit Lobe and the South Borrow Pit Lobe. A formal risk assessment has been performed on the soils in these two Borrow Pit Lobes (ERM 2007) and has been approved by the NDEP. The risk assessment indicates that the soils in these two lobes present minimal hazard to human health. An NFAD (with conditions) for these soils has been obtained by BRC. These soils are to be excavated to make room for the below-grade portion of the CAMU. The excavated soils will be used as underlayment with an overlying, approved cap. Excluding the portion of land through which the Western Drainage Ditch traversed and based on the absence of historical waste disposal activities, no impacts to soil are known at the Eastern W. Ditch Area.

4.2.2.2 CAMU Area Off-Site Soil

A variety of chemical manufacturing, storage, handling, distribution, and waste disposal facilities historically operated at facilities south and upgradient of the CAMU Area. Environmental investigation reports document that activities at these facilities have resulted in soil impacts beneath the facilities. These impacts include VOCs, SVOCs, pesticides, and metals; and additional impacts may exist. However, a complete interpretation comparable to the one given the CAMU Area is not possible because of the limited analyte list used for analyzing samples collected from the upgradient locations. It is BRC's understanding that a CSM is in preparation by others covering both upgradient and downgradient areas of the CAMU. BRC will provide the CAMU CSM for this effort.

4.2.2.3 CAMU Area Groundwater

The current data for groundwater within the CAMU Site boundary include:

- Historical one-time groundwater grab samples collected from borings (HLA 1998), performed for Montrose;
- Data collected from groundwater monitoring wells installed in the past (ERM 1999);
- Data collected from groundwater monitoring wells installed during the 2005 CAMU investigation performed for BRC.

Impacts to groundwater have occurred in the Aa beneath and upgradient of the CAMU Area. Chemicals detected in this groundwater in the CAMU Area perimeter wells during the 2005 CAMU investigation include VOCs, SVOCs, pesticides, metals, PCBs, dioxins/furans, TDS, and radionuclides. Chemicals that exceed MCLs in the Aa in both the CAMU Area upgradient and downgradient wells are significantly fewer in both number and type. These exceedances include VOCs, SVOCs, pesticides, dioxins (only in the upgradient wells), and metals. Fewer chemicals were found in the CAMU Area downgradient wells than in the upgradient wells. Notable chemicals detected at concentrations above MCLs in the upgradient wells that were not detected above MCLs in the downgradient wells include vinyl chloride, uranium-238, and PCBs.

Trichloroethylene (TCE) was detected above the MCL in a downgradient well but not in the upgradient wells. Further investigation of upgradient groundwater is needed (and is being conducted by offsite property owners) to characterize upgradient groundwater quality and evaluate the source of the detected TCE. Because it is well-documented that PCE can degrade to

TCE in anaerobic groundwater, it is suspected that TCE may be the biodegradation daughter product of PCE originating from upgradient sources or originating from the BMI Landfill or the CAMU Slit Trench Area.

Based on comparison of soil sample results from the Qal depth interval greater than 10 feet bgs to the DAF-1 soil screening criteria for representative chemicals, impacts to groundwater beneath the CAMU may have resulted from historical disposal of wastes in the CAMU Area in the North Landfill Lobe, the South Landfill Lobe, the Slit Trench Area, the Eastern W. Ditch Area, and the Western W. Ditch Area. These impacts include metals, organochlorine pesticides, PCBs, perchlorate, radiochemicals, SVOCs, and VOCs.

BRC has conducted work to evaluate background levels of metals and radiochemicals in shallow soil. The work is under review, as noted further below. Based on a statistical comparison of the data collected to date with the provisional shallow background soils dataset, the detected metals and radiochemicals may be attributable, in whole or in part, to natural sources and may be representative of background levels. BRC is developing a study to evaluate background concentrations of deeper (greater than 10 feet bgs) Qal and TMCf soils. Additional evaluation of the data will be conducted when this study is completed.

Historically, all of the chemicals found in any of the wells downgradient or cross-gradient from the CAMU Area were also found in the upgradient wells. For chemicals found at the highest concentrations, such as benzene, chlorobenzene, polychlorinated benzenes, and chloroform, historical CAMU Area well concentrations upgradient of the CAMU were typically high. Historical isoconcentration plots indicate that significant groundwater sources exist for these chemicals at off-site, upgradient locations. Isoconcentration plots of the boundary wells based on contemporaneous data collected in 2005 show a repeated pattern that likewise indicates that significant upgradient sources exist for these chemicals.

Impacts to groundwater occurring in the TMCf sand lenses have also occurred. In samples collected from wells located upgradient of the CAMU Area, 21 chemicals were detected at concentrations above the MCLs in TMCf groundwater lenses. These chemicals included VOCs, SVOCs, a pesticide, metals, and a radionuclide (uranium-238). All of the chemicals detected above MCLs in the TMCf groundwater samples were also detected above MCLs in samples collected from CAMU Area upgradient perimeter wells. Many were also detected above MCLs in CAMU Area downgradient perimeter wells.

4.3 SOIL BACKGROUND LEVELS

4.3.1 Surficial Soil

A background soil summary report (for metals, radionuclides, and other inorganics) was completed for the Site by BRC and TIMET in 2007 (BRC and TIMET 2007). The report is currently in review with NDEP, and the data are thus currently considered “provisional” until the report is approved. BRC is also currently considering the applicability and value of a shallow background soils evaluation of pesticides and other compounds that have been detected in Site soils but may be due to offsite sources. BRC will address these issues with NDEP.

The general scope of work included the collection of soil samples from background areas at higher topographic elevations than the Site industrial areas and analysis of these samples for site-related metals, radionuclides, general chemistry ions, and soil characteristics. The definition of “background” for this report is based upon that of the USEPA (2002), which states:

“Substances or locations that are not influenced by the releases from a site and are usually described as naturally occurring or anthropogenic: (1) Naturally occurring substances present in the environment in forms that have not been influenced by human activity. (2) Anthropogenic substances are natural and human-made substances present in the environment as a result of human activities...”

The main objective of this study was the development of a representative background soil data set that could be used to evaluate whether concentrations of site-related chemicals detected in Site soil samples statistically exceed concentrations of these chemicals in background soil.

Soil samples were collected from 11 sampling locations located on undeveloped properties close to the Site. A total of 33 borings were installed at the 11 locations, and 104 independent soil samples were collected for analysis. Soil samples were collected from three depth intervals at each sampling location:

- Surface soil (0 to 0.5 feet bgs); and
- Two subsurface depths (four to six feet and nine to 11 feet bgs).

In addition to data collected for Site-related metals, radionuclides, and anions, data for soil characteristics (soil texture, pH, conductivity, cation exchange capacity [CEC], salinity, total

organic carbon [TOC], and percent moisture) were also collected to evaluate whether the background soil locations are representative of characteristics of Site soils.

Specific goals and comparisons proposed for the background soils study included the collection of data such that:

- The data from the sampled soil units are representative of Site soils;
- The data form a sufficient sample population that can be used to support statistical comparison of on-Site and background data sets;
- The data are sufficient to form more than one background data set, if required based on statistical comparisons of data from different geologic settings;
- The data could be used to evaluate the comparability of background data collected during this study to data collected by Environ for the City of Henderson (Environ 2003); and
- The data could be used to evaluate the comparability of soil originating from geologic units in the northern McCullough Range and the River Mountains.

The background study concluded that the 11 sampling locations represent the range of soils found within the vicinity of the Site. It was also considered reasonable to conclude that the background samples collected reflect background conditions for soils at the Site based on sample location characteristics obtained from published documentation, site inspection, and sample collection. Key results include:

- **Metals and Anions** - A total of 43 metals and anions were analyzed in each sample. Although there were some statistically significant differences, the results of statistical tests comparing groupings of the BRC/TIMET metals data by depth suggest that data for two intervals of subsurface soil (4 to 6 feet bgs, and 9 to 11 feet bgs) can be combined for all metals. Significant differences were found for 24 metals and anions when comparing BRC/TIMET sample results from the surface to the subsurface. These differences are likely the result of background differences associated with the difference in soil type with depth. Because of this difference, surface soil sample results may constitute a different background dataset from deeper subsurface soil sample results. This possibility is being investigated by BRC. A work plan, as discussed below, to investigate background for the deep Qal and TMCf soils is in review and will be submitted to NDEP for review and acceptance.

- Radionuclides - Results of statistical tests comparing radionuclide activities for the different sampling depths indicate that the data for radionuclides from all depths can be pooled and treated as a single data set.
- Other Parameters - Parameters such as pH, conductivity, TOC, and soil texture provide additional insights into the comparability of soil samples collected from site and background areas or different areas within a site. Because the concentrations of metals in solid media (*e.g.*, soils and sediments) may be correlated with grain size or TOC, and because pH can radically affect the mobility of metals, data for these supporting parameters will be collected and used to assist in data evaluation.
- Comparability of McCullough Range and River Mountains Data - The source rocks and soil types for the McCullough Range and River Mountains are similar, and the main factors for soil formation are the same for the alluvial fans derived from both ranges. The heterogeneity of the samples collected on alluvial fan materials from the northern McCullough Range generally encompass the range of concentrations found in the mixed alluvial fan locations, and the River Range alluvial fan locations. Based on a comparison of the BRC/TIMET data set in areas downgradient from the McCullough Range and the River Mountains, with a few exceptions, the concentrations of metals and radionuclides in soil samples are comparable.
- The BRC/TIMET data set will be used for background comparisons in future investigations after approval by NDEP.
- These background locations were not impacted by Site operations.

Table 4-12 presents the range of concentrations of metals, radionuclides, and other parameters that resulted from the background study.

4.3.2 Deep Soil

At present, insufficient background data exist to evaluate whether concentrations of certain Site-related chemicals detected in deeper Site samples statistically exceed concentrations of these chemicals in deeper (as compared to shallow) background soil. In order to address this data gap, in April 2007, a work plan for the evaluation of deeper background soil chemistry was submitted to the NDEP for review and approval (DBS&A 2007). NDEP has provided comments and the plan is in revision by BRC as of this writing. The soil portion of the work plan was written to evaluate deep soil background ranges for metals, radionuclides, general chemistry anions, and

certain soil characteristics. The purpose of the soil component of the work plan is to collect data for metals and radionuclides in deep background soils that are comparable to deep Site soils. These data will be used in Site-to-background statistical comparisons.

This soil portion of the work plan scope will provide the following information needed for soil Site-to-background comparisons:

- Soil chemical data for various depth intervals (*e.g.*, starting at 20 feet bgs and proceeding down at 10-foot intervals for the alluvial soils and for two depth intervals into the shallow Muddy Creek formation). Actual depths will depend on particular locations.
- Soil chemical data for a representative range of soil map units applicable to the Site (*e.g.*, Natural Resources Conservation Service [NRCS] mapped Soil Units 117, 182, and 184).
- Soil chemical data to form an adequate sample population to support future statistical comparison of Site and background sample data sets.
- Soil chemical data to form more than one background data set, if required, based on statistical comparisons of data from different soil mapping units.

As noted, the deeper soil background work plan is currently in revision by BRC.

4.4 UPGRADIENT AND DEEPER GROUNDWATER

The April 2007 work plan for the evaluation of deeper background soil chemistry (Section 4.3.2) also includes well installation for the evaluation of shallow upgradient groundwater conditions along the perimeter of the Eastside Area (DBS&A 2007). Six monitoring wells are proposed to be installed in first-encountered groundwater.

As discussed with NDEP, an evaluation of deeper groundwater conditions will be completed once the evaluation of shallow groundwater, and other related and supporting tasks in progress such as the aquifer testing and numerical modeling, are complete.

4.5 MIGRATION PATHWAYS

4.5.1 Eastside Area

Figures 4-10 through 4-14 were prepared to summarize changes in site operations that occurred over time. By the spring of 1943, the Upper and Lower Ponds were constructed to aid in the

disposal of wastewater as Basic Magnesium's Trade Effluent Ponds, west of present-day Boulder Highway, reached capacity. Wastewater was conveyed to the unlined Upper and Lower Ponds Areas via a series of four unlined ditches. The Western Ditch and Northwest Ditch both conveyed effluent waters to the Lower Ponds. During 1942 until 1976, wastewater was conveyed to the Upper and Lower ponds via the Alpha and Beta Ditches. Once wastewater entered the Alpha or Beta Ditches, it was transferred to the east for management in the Upper Ponds via the Beta Ditch or to the north for management in the Lower Ponds via the Alpha Ditch. Effluent liquids containing chemicals deposited sediment in the pond and ditch bottoms. The Upper Ponds were constructed first, followed by the Lower Ponds to the north shortly thereafter. The ponds were designed in a cascade fashion such that as the nearer (southerly) ponds were filled, the next row (to the north) would fill. Evaporation left evaporative sediments and non-volatile chemicals in the pond cells.

Chemicals not evaporated likely leached from pond and ditch sediments and bottoms through the Eastside Area soils to the underlying groundwater. Rainwater is presumed to have also created a leaching mechanism for dried evaporite sediment. In 1976, the Upper and Lower Ponds were permanently removed from service.

Although more than 100 ponds were built in 1942-43 and have been identified on plans and aerial photographs, there is no documentary, photographic, or visual indication that more than the first eight rows of the Upper Ponds were ever directly in service (*i.e.*, filled with effluent). It appears from the documentary evidence that the large number of ponds constructed resulted from an erroneous assumption made in 1941 or early 1942 when trying to rectify an earlier miscalculation of the evaporative area needed for the magnesium plant's effluent (Clary 1944). The assumption neglected to account for percolation (thus assuming that only evaporation would occur) when considering the fate of effluent discharged to the ponds. As a result, a lesser number of ponds were directly used and filled with effluent than was originally envisioned when the ponds were designed and constructed. The Lower Ponds were in service between 1943 and 1970. The Upper Ponds were in service between 1943 and 1976, when both Upper and Lower Ponds were permanently taken out of service. TIMET operated its lined ponds on-site between 1976 and 2005.

Soluble chemicals leached with percolating waters into the Upper Unconfined Water Bearing Zone where chemical impacts are currently detected in groundwater. Impacts to the Eastside Area groundwater also occurred as the result of the dispersion of chemicals (*e.g.*, perchlorate) in the Tronox groundwater plume to the west and from chemicals (*e.g.*, tetrachloroethylene) from

sources to the southwest of the Eastside Area. Chemicals moved in groundwater in the Upper Unconfined Water Bearing Zone northward toward the Las Vegas Wash with the prevailing groundwater gradient and flow. Site geologic and hydrologic data indicate that the Upper Unconfined Water Bearing Zone is in communication with sediments beneath the Las Vegas Wash and that the Site is contributing chemicals to groundwater in the sediments immediately beneath the Las Vegas Wash.

The less retarded chemicals, such as perchlorate, traveled in groundwater farther, faster, and in greater mass than more retarded chemicals. More sorptive and more retarded chemicals (for example, organochlorine pesticides) migrated less and are currently less widespread in groundwater. Non-soluble chemicals, such as asbestos, moved very little and did not leach.

The distribution of chemicals in groundwater beneath the Eastside Area is consistent with percolation through the unlined ponds and subsequent travel in the groundwater within the Upper Unconfined Water Bearing Zone. However, it is suspected that the observed decline in chemical concentrations with depth in the TMCf is due to minimal leaching of chemicals from the Upper Unconfined Water Bearing Zone to the underlying TMCf. Existing soil data collected from the unsaturated fine-grained sediments of the TMCf beneath the Upper Unconfined Water Bearing Zone reveal limited chemical impact to soil. BRC posits that the existing Site data indicate that the limited impact to the TMCf soils by Site chemicals is indicative of limited leaching into the fine-grained Deep (*i.e.*, TMCf) soils from the overlying perched Aa. As posited by BRC, the limited impact to the Deep soils, the currently observed upward groundwater gradient from the Deep Zone groundwater, and the off-Site, upgradient chemical impacts (*e.g.*, perchlorate) in the Deep Zone groundwater suggest that the Deep Zone confined aquifer (found at a depth of more than 380 feet bgs) may not have been significantly impacted by direct downward leaching of chemicals beneath the Site effluent disposal ponds. However, some downward leaching of chemicals from Site effluent ponds cannot be ruled out. It is possible that some percolation from the Site ponds, along with pathways from upgradient sources, as well as natural sources can, singly or in combination, explain the observed concentrations of contaminants (including very high levels of TDS) in the deep groundwater.

Initial analytical modeling of infiltration into the Upper Unconfined Water Bearing Zone (using historical measurement of pond disposal as calibration), indicate that a mound of significant areal extent and head builds up quickly under a percolation scenario. This suggests the possibility that groundwater flow direction could have been other than northerly when the ponds were in use,

and that significant downward gradients could also have existed, during the time effluent was being disposed to the Eastside Area ponds.

BRC performed interim remedial measures (IRMs), consisting of excavation and removal, transport, and subsequent stockpiling of shallow impacted soils in a secured holding area, within the First Eight Rows sub-area. The IRM excavations were performed as shown in Figure 4-27. The stockpiled soils were placed in secure holding areas and treated with an application of a binding agent to resist the erosive potential of heat, wind, and water. BRC plans to transport and dispose stockpiled soil at the CAMU planned at the former BMI Landfill Site west of Highway 95. Permit applications have been made to the NDEP and other regulatory agencies with jurisdiction for the planned CAMU and are under review and refinement.

4.5.2 CAMU Area

At the CAMU Area, the BMI Landfill received wastes from 1942 until 1980, at which time it was closed and capped (Weston 1993). The North and South Landfill Lobes were covered and capped in order to reduce the potential for chemicals to leach to groundwater. Aerial photographs and historical data reveal that the routing of process effluents from the Pioneer/Stauffer/Montrose site occurred through the Western Drainage Ditch, an unlined surface channel that drained west to the Western Ditch Extension. This practice lasted from 1946 to 1970. The Western Ditch, which is now closed and all liquids removed, eventually flowed north to the Lower Ponds. Periodically, between 1970 and 1980, a variety of process and office wastes were reportedly disposed of in the Slit Trench Area, located immediately south of the BMI Landfill. There appear to be ten slit trenches that were excavated along east-west trends. Aerial photographs show the slit trenches to range in length from approximately 450 to 900 feet. Based on direct field observations during drilling and sampling operations, the trenches vary in depth between approximately 25 and 32 feet. Trench width is estimated to be eight to 10 feet. Anecdotal evidence and soil sampling results that reveal the presence of dioxins and furans suggest that burning of waste occurred in the Landfill Lobes and the Slit Trench Area.

Directly upgradient of the CAMU Area, four companies have operated industrial chemical production facilities since 1942: Basic Magnesium, Stauffer, Montrose, and Pioneer. Basic Magnesium operated a chlor-alkali plant incident to the manufacture of magnesium. Stauffer operated chlor-alkali facilities and an agricultural chemical plant. Montrose operated a hydrochloric acid and an agricultural chemical plant. Pioneer operated (and still operates) chlor-alkali and hydrochloric acid facilities. These operations have been documented to have resulted

in soil and groundwater impacts with TDS, VOCs, SVOCs, pesticides, and metals. Additional upgradient soil impacts may exist.

Chemicals were disposed of in soils and mixed soils/waste in the Northern and Southern Landfill Lobes and in the Slit Trench Area and resulted in direct impacts to soil. Soluble chemicals leached with percolating waters into the Upper Unconfined Water Bearing Zone where chemical impacts are currently detected in groundwater. Volatile chemicals (*e.g.*, tetrachloroethylene) have migrated in the vapor phase to larger volumes of soil, though impacts to groundwater are not widespread. Step-out soil borings in the Slit Trench Area suggest that chemicals have preferentially migrated along the line of trench excavations (nominally east-west) when compared to migration in a direction transverse to the trench lines (nominally north-south).

Soil impacts on the CAMU Area have been documented to exist in the North Landfill Lobe, beneath the Western Drainage Ditch (beneath segments of the Western W. Ditch Area and the Eastern W. Ditch Area), within the Slit Trench Area, and inferred to exist in the South Landfill Lobe because of its similar history to the Northern Landfill Lobe. These impacts include VOCs, SVOCs, PCBs, pesticides, metals, and dioxins/furans. PCBs were detected in four samples in two borings in the Slit Trench Area. Investigations and studies have indicated that only limited soil impacts have occurred in the North Borrow Pit Lobe and the South Borrow Pit Lobe, and as noted above reports of investigations for these areas were submitted by BRC for NFAD issuance by the NDEP, which reviewed the reports and has now issued the NFAD. Because waste disposal activities were not conducted at other locations within the Eastern W. Ditch Area, known soil impacts are limited to the Western Drainage Ditch in this area.

Impacts to the CAMU Area groundwater also occurred as the result of contaminant transport (*e.g.*, perchlorate) from the Tronox groundwater plume to the east and from the American Pacific Corporation (AMPAC) plume (*i.e.*, perchlorate) to the southwest (Figure 4-28). CAMU Area groundwater is also impacted by chemicals detected in groundwater from sources to the south. Chemicals transported with the prevailing groundwater gradient in the Upper Unconfined Water Bearing Zone northward from the upgradient sources at the plants site, beneath the CAMU Area, and towards the Las Vegas Wash.

Operations at the upgradient plants site have impacted soil and groundwater with VOCs, SVOCs, pesticides, and metals. Soil sources that may continue to impact groundwater may still exist at the upgradient plants. Upon entering the groundwater, the chemicals from these off-site locations migrate north beneath the CAMU Area. Data indicate that CAMU Area sources likely

contributed to groundwater impacts. Because detected chemical concentrations are elevated in both upgradient and downgradient CAMU Area monitoring wells, with concentrations being typically higher in the upgradient wells, it is difficult to discern with certainty whether groundwater has been impacted, and to what degree, by releases from the CAMU Area. For chemicals found at the highest concentrations in groundwater, such as benzene, chlorobenzene, polychlorinated benzenes, and chloroform, CAMU Area upgradient wells typically had high concentrations as well. Historical groundwater iso-concentration plots indicate that significant groundwater sources exist for these chemicals at off-site upgradient locations. Iso-concentration plots of the 2005 contemporaneously collected data from the CAMU Area boundary wells show a repeated pattern that likewise indicates that significant upgradient sources exist for these chemicals.

After exiting beneath the CAMU Area, groundwater flows northward from the CAMU Area towards the Pioneer/Stauffer/Montrose GWTS described in Section 4.1.4.

4.6 ENVIRONMENTAL RECEPTOR IDENTIFICATION AND DISCUSSION

Exposures to current receptors are being managed through site access control. Under the prospective redevelopment plan, the Eastside Area of the Site will be used for a variety of purposes, including residential housing, parks, schools, places of worship, commercial and/or light industrial development, and streets. The entire Site will be enhanced by restoration and redevelopment once remediation is complete. Therefore, exposures to ecological receptors will be mitigated or removed. Future receptors identified as “on-site receptors” are defined as receptors located within the current Site boundaries (Figure 1-2), while future “off-site receptors” are those located outside the current Site boundaries. Many potential human receptors are possible at the Site in the period during and after redevelopment. The potentially exposed populations and their potential routes of exposure are discussed in Section 9 of this Closure Plan.

4.7 DISCUSSION OF SITE DATA NEEDS (GAPS)

The CSM represents a functional working description of historical Site operations, potential chemical release sources, chemical impacts to Site soils, the occurrence of groundwater beneath the Site, groundwater flow, chemical impacts to Site groundwater, and the connectivity of Site groundwater to the Las Vegas Wash. This summary of the CSM presents an overview of the Site data that have been gathered over the years by BRC and others. The CSM Summary outlines the present understanding of the Site and the physical processes that have resulted in the observed Site chemical impacts.

It is recognized that data gaps remain, including, for example, those pertaining to off-site sources as potential release mechanisms of chemicals to Site groundwater, and to the quantification of soil and aquifer parameters that control Site groundwater flow and chemical transport. Table 4-13 presents the data that need to be collected and analyzed to further support and update the CSM.

All work will be used to continually update and refine the CSM. As stated at the beginning of this section, two separate, more-detailed CSM documents are in preparation that elaborate upon this CSM summary for each of the Eastside and CAMU areas. The CAMU CSM has been submitted for review to NDEP, comments have been received from NDEP by BRC, and this CSM is being updated. The Eastside Area CSM will be updated upon conclusion of the several field investigations (*e.g.*, aquifer testing, numerical modeling, north-east area investigation, deep soil background investigation, upgradient Qal investigation) presently being formulated/conducted.

As discussed in Section 1, in the future, remediation utilizing soil excavation is planned to remove chemically-impacted soils from the Eastside Area which will then be placed in the CAMU. Subsequent to the excavation, confirmation sampling will be conducted that will compare the resulting spatial distribution of soil impacts to remediation clean-up goals. Based on the results of the confirmatory sampling, the Eastside Area CSM will be updated in the future.

SECTION 4 REFERENCES

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SECTION 5

5 DATA VERIFICATION AND VALIDATION

Data verification and validation are key steps in the assessment phase for any environmental data collection project. As defined in USEPA (2002), data verification is the process of evaluating the completeness, correctness and conformance/compliance of a data set against requirements set forth. Data validation is an analyte- and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance (data verification) to determine the analytical quality of a specific data set. Both verification and validation are necessary and are best performed in the order described here. The descriptions are brief, providing guidance on the basic intent of data verification and validation, and forming the basis for more detailed descriptions that will be presented in each sub-area or decision specific closure plans. Data verification will be performed against the analytical methods and operating procedures, at the laboratories that perform the analyses. Individuals designated by the Project Program Manager will perform data validation. Section 1 discusses the project staffing in this regard. Data validation will evaluate the data against the measurement quality objectives described in this Closure Plan and the Quality Assurance Project Plan (QAPP; BRC and MWH 2006). Data reporting from the field and laboratory operations will follow the requirements specified in the QAPP.

5.1 FIELD DATA VERIFICATION

All field personnel will be responsible for following the sampling and documentation procedures described in the work plan so that defensible data are obtained. Project Team Personnel will verify field notes and records against field procedures and data sets to identify any inconsistencies, non-conformance or anomalous data. The quality control (QC) steps required during field operation will also be checked against the applicable procedure. Chain-of-Custody, field logbooks, instrument calibration, and sampling records will be reviewed. The field team will be interviewed to reconcile any inconsistencies as soon as possible after the fieldwork is completed. A systematic effort to identify inconsistencies will be performed before field data are reported. Inconsistencies may result from improper sampling or measurement methodology, data transcription and calculation errors, and loss of data due to natural causes. Anomalies that are identified as a result of sampling, measurement or transcription errors will be identified and corrected; anomalies that cannot be attributed to these causes will be identified in the sample reports but not excluded from the sample sets.

5.2 LABORATORY DATA VERIFICATION

Laboratory personnel will verify analytical data at the time of analysis and reporting and through subsequent reviews of the raw data for any non-conformance to the requirements of the analytical method and laboratory QA/QC procedures. Verification will include reviewing positive and negative control results including method blanks, laboratory control samples, matrix spikes, duplicate, surrogate, tracer, carrier and internal standards. Results will be verified against the Method Detection Limits (MDLs), Minimum Detectable Activity, and Practical Quantitation Limits as well as the method or laboratory established recovery and variability requirements. Analysts may be required to evaluate the selectivity of the results for identification purposes. Laboratory personnel will make a systematic effort to identify any errors before they report the data. Outliers that result from errors found during data verification will be identified and corrected; outliers that cannot be attributed to errors in analysis, transcription, or calculation will be clearly identified in the case narrative section of the analytical data package, but will not be excluded from the data set. Laboratory reports will include certification and signature by lab director along with all additional USEPA Level IV requirements, or, alternatively, the laboratory reports must have sufficient detail to allow the level of review/validation that is required as specified in a sub-area or decision specific QAPP.

5.3 LABORATORY DATA VALIDATION

One or more experienced chemists, who have sufficient background in inorganic and radiochemistry methods and are independent from the activities of this project, will validate all laboratory data. The chemist(s) will be selected by the Project Program Manager. Section 1 discusses the project staffing in this regard. The organic and inorganic data will be validated in accordance with current USEPA National Functional Guidelines (USEPA 1999 and 2004). National Functional Guidelines do not include the radiochemistry anion analysis but this data will undergo a similar review. Radiochemistry data validation will use the U.S. Department of Energy (USDOE) reference document, *Evaluation of Radiochemistry Data Usability* (USDOE 1997). The laboratory will provide data reports at USEPA Level IV so that the raw data is available for full validation. In accordance with the QAPP for this project, 100 percent of the data will undergo Level III data validation, and 10 to 20 percent will undergo Level IV data validation. Full data validation includes all review requirements, thus 100 percent of the data will undergo at least a review. Requirements for cursory (review) and full validation are listed below.

5.4 DATA REVIEW

Data review will be completed on 100 percent of the summary data packages for SRC analyses. No data will be eliminated from this review unless it is selected for full validation. All data will be qualified as necessary in accordance with established criteria. Data review will entail evaluation of USEPA Level III documentation including:

- Narrative, cross-reference, chain-of-custody, and method references;
- Analytical results;
- Surrogate recoveries (as applicable);
- Blank results;
- Laboratory control sample recoveries;
- Duplicate sample results and/or duplicate spike recoveries; and
- Sample spike recoveries.

In cases where the data review indicates uncertainties that require investigation, a full data validation will be performed. The data review process is described in the QAPP and requires verifying the completeness, correctness, and conformance/compliance of the data against acceptance criteria.

5.5 FULL DATA VALIDATION

Full validation will be completed on 10 to 20 percent of the data packages. To perform full data validation, data summary packages of Level IV are required. Level IV data packages consist of the Level III requirements provided above, plus summary of internal standards, initial and continuing calibration recoveries and raw data, initial and calibration blank concentrations and raw data, analytical run logs, sample and standard preparation logs, and all instrument raw data. The data will be validated against the laboratory method requirements and project or work plan specific quality objectives. At a minimum the USEPA National Functional Guidelines steps will be followed.

5.6 DATA VALIDATION REPORT

Based on the outcome of the data verification and data validation procedures, individual sample records may be qualified. Qualifiers (flags) indicate if results are inconsistent, anomalous, outside of tolerance limits, estimated, or rejected. Only rejected data will be considered unusable for decision-making. Flags will follow the National Functional Guidelines, or where none are available (*e.g.*, radiochemistry) will be clearly defined. Data validation reports will include a complete list of applicable Sample Delivery Group (SDG) designations and the number of samples within each SDG along with reconciliation between each sample and SDG. All sensitivity indicators (*e.g.*, Practical Quantitation Limit) will be clearly defined.

5.7 RECONCILIATION WITH USER REQUIREMENTS

After environmental data have been reviewed, verified, and validated in accordance with the procedures described above and in the QAPP, the data must and will be further evaluated to determine whether the Data Quality Objectives (DQOs) have been met. Data will be evaluated according to USEPA's data quality assessment (DQA) process to verify that the type, quality, and quantity of data collected are appropriate for their intended use. DQA methods and procedures are outlined in USEPA *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (USEPA 2000). The DQA process includes five steps: (1) review the DQOs and sampling design; (2) conduct a preliminary data review; (3) select a statistical test; (4) verify the assumptions of the statistical test; and (5) draw conclusions from the data.

SECTION 5 REFERENCES

- Basic Remediation Company (BRC) and MWH. 2006. BRC Quality Assurance Project Plan. April.
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SECTION 6

6 DATA USABILITY EVALUATION

This section describes the procedures used to evaluate the acceptability of data for use in the risk assessment. Overall quality of sample results is a function of proper sample management. Management of samples begins at the time of collection and continues throughout the analysis process. The collection of environmental data will follow the quality assurance/quality control (QA/QC) procedures identified in the QAPP (BRC and MWH 2006a) prepared for the Site. Standard Operating Procedures (SOPs) that are wholly consistent with the risk assessment will be followed to ensure that samples are collected and managed properly and consistently and to optimize the likelihood that the resultant data are valid and representative. Field methods are discussed in the Field Sampling and Standard Operating Procedures (FSSOP) document (BRC and MWH 2006b) and adhere to practices consistent with the policies of the NDEP. All relevant site characterization data will be reviewed for applicability and usability following procedures in USEPA's (1992a,b) *Guidance for Data Usability in Risk Assessment (Parts A and B)* and USEPA's (1989) *Risk Assessment Guidance for Superfund*.

6.1 CRITERION I: REPORTS TO RISK ASSESSOR

Data will be reported in a format that provides adequate data summaries and data documentation for the risk assessment. This criterion is limited to identification of the specific site characterization reports that comprise the site database, and the documentation of the report contents. The report components include:

- a. Site description with detailed map indicating site location (including site boundaries), surrounding structures, terrain features, population or receptors, air and water flow, and information regarding operative industrial processes (*i.e.*, source locations).
- b. Site map with sample locations identified.
- c. Description of sampling design and procedures including rationale.
- d. Description of analytical methods used and detection limits including sample quantitation limits (SQL) and detection limits for non-detect data.
- e. Results given on a per-sample basis, qualified for analytical limitations and error, and accompanied by SQLs. Estimated quantities of compounds/tentatively identified compounds.

- f. Field conditions and physical parameter data as appropriate for the environmental media of interest.
- g. Narrative explanation of qualified data on an analyte and sample basis, indicating direction of bias.
- h. QC data results for audits, blanks, replicates, and spikes from the field and laboratory.
- i. Definitions and descriptions of flagged data.
- j. Hardcopy of diskette results.
- k. Raw data (instrument output, chromatograms, spectra) (laboratory report sheets are usually adequate).

6.2 CRITERION II: DOCUMENTATION

The objective of the documentation review is to ensure that each analytical result can be traced to a sample location and that the procedure(s) used to collect the environmental samples were appropriate. The three acceptable types of documentation used to trace samples and analytical methods are chain-of-custody forms, SOPs, and field and analytical records. All three types will be employed by BRC in this Closure Plan.

The minimum requirement of Criterion II is that sample results must be related to a specific geographic location and documentation of the sample location versus sample result (*i.e.*, chain-of-custody records, SOPs, field and analytical records) must be provided. BRC will comply with this requirement, at a minimum.

6.3 CRITERION III: DATA SOURCES

The objective of the data source review is to ensure that the analytical techniques used for the investigation are appropriate to identify COPCs for each exposure area and environmental medium of interest. Comparability of data from different sources (*e.g.*, different investigations, different analytical methods, etc.) will be evaluated.

The minimum requirements for this criterion are:

- a. Analytical sample data results are produced for each medium within an exposure area,

- b. A broad spectrum analysis is available for at least one sample per medium per exposure area,
- c. [where relevant] Field measurement data for physical characteristics of the Site, medium, or contamination source where deemed critical to the quantitative evaluation of risk (*i.e.*, needed for fate/transport modeling). Examples include particle size, pH, soil porosity, soil moisture content, soil organic carbon content, wind direction/speed, topography, percent vegetative cover.

BRC will comply with these requirements.

6.4 CRITERION IV: ANALYTICAL METHODS AND DETECTION LIMITS

For a chemical result to be usable for assessing risks, the analytical method must appropriately identify the chemical form or species, and the sample detection limit must be at or below a concentration that is associated with risk benchmark levels. When a COPC is reported as not detected, the result can only be used with confidence if the quantitation limits reported are lower than the corresponding concentration of concern. (Note: USEPA provides a minimum recommended requirement that the MDL be no more than 20 percent of the concentration of concern). The minimum requirement for this evaluation step is that documentation that routine (*e.g.*, USEPA or ASTM) methods were used to analyze COPCs in critical samples. BRC will comply with this requirement.

6.5 CRITERION V: DATA REVIEW

This step consists of the assessment of the quality of analytical results, performed by a professional knowledgeable in the necessary analytical procedure(s). The requirement for risk assessment is that only data that have been reviewed according to a specified level or plan (usually specified in DQOs) will be used. Any analytical errors, potential data gaps, and/or limitations in the data to be used must and will be addressed; an explanation for data qualifiers must be included.

All site data must have a sufficient level of review. The appropriate level of review, for each data source, must and will be identified, applied, and documented. The minimum requirement for this data usability evaluation criterion is that there be a “defined level of data review for all data” (USEPA 1992). The level and depth of the data review must and will include and examination of laboratory and method performance for the samples and analytes involved. This examination will include:

- a. Evaluation of data completeness,
- b. Verification of instrument calibration,
- c. Measurement of laboratory precision using duplicates; measurement of laboratory accuracy using spikes,
- d. Examination of blanks for contamination,
- e. Assessment of adherence to method specifications and QC limits, and
- f. Evaluation of method performance in the sample matrix.

6.6 CRITERION VI: DATA QUALITY INDICATORS

The data quality indicators (DQI) address field and analytical data quality aspects as they relate to uncertainties in selection of COPCs, exposure point concentrations, and risk characterization. The DQIs are briefly discussed below.

Completeness is measured, for risk assessment purposes, by the total number of data points available and acceptable for each COPC for each medium of interest. For risk assessment purposes, the adequacy of the number of samples is evaluated in terms of: (1) acceptable uncertainty regarding the identification of COPCs in each environmental medium of interest and within each exposure area; and (2) acceptable uncertainty regarding the estimation of exposure point concentration of each COPC within each exposure area.

Comparability is a critical parameter when considering the combination of data sets from different analyses for the same COPCs. Only comparable data sets can readily be combined for the purpose of generating a single risk assessment decision/calculation. The use of standard sampling and analytical methods simplifies the determination of comparability. All non-routine methods will be specifically evaluated for comparability in the data usability evaluation.

Representativeness of data used in risk assessment will be documented. The results of the risk assessment will be biased to the degree that the data do or do not reflect the chemicals and concentrations present in the exposure area of interest. In cases where sampling was not specifically designed to characterize representative COPCs and exposure concentrations for all potential sub-areas of the Site, it is critical to evaluate what the impact on the risk assessment results may be. In addition to sampling strategy issues, analytical data quality will be assessed in

regard to representativeness. Holding time, sample preservation, extraction procedures, and results from analyses of blanks affect the representativeness of analytical data.

Precision is determined by evaluating: (1) the sampling variability; and (2) the measurement error. Assessment of sampling variability is critical to identifying the appropriate statistical measures and the number of required samples (USEPA 1992). Assessment of measurement error is accomplished by using the results of field duplicate samples. Field duplicates determine total within-batch measurement error (including analytical error if the samples are also analyzed (as laboratory duplicates). The laboratory limits for precision, as measured by the relative percent difference between laboratory control sample analyses, are the laboratory control limits, based on historical data calculated, as specified in the analytical methods.

Accuracy is a measure of overestimation or underestimation of reported concentrations and is evaluated from the results of spiked samples. Accuracy is controlled primarily by the analytical process and is reported as bias. Bias is estimated for the measurement process by calculating the percent recovery (%R) for the spiked or reference compound.

The minimum requirements for the assessment of DQIs are:

- a. Sampling variability must be quantitated for each analyte,
- b. QC samples must be evaluated to identify and quantitate precision and accuracy,
- c. Sampling and analytical precision and accuracy must be quantitated.

BRC will comply with these requirements.

SECTION 6 REFERENCES

Basic Remediation Company (BRC) and MWH. 2006a. BRC Quality Assurance Project Plan, BMI Common Areas, Clark County, Nevada. April.

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SECTION 7

7 DATA QUALITY OBJECTIVES

This section first provides a general overview of USEPA and NDEP's 7-step DQO process. After that it discusses one of the key decision inputs to the DQO process, namely the Step 2 Principal Study Questions (PSQs) that this closure process will address before Closure is complete for the Eastside Area. The PSQs are the central Eastside Area-wide questions that provide a basis for the overall closure effort. Per discussions with the NDEP, the other steps of the DQO process will be addressed, on an Eastside Area sub-area by sub-area basis (for soils), in the respective sub-area Sampling and Analysis Plans that BRC plans on developing for each sub-area (Figure 1-4) relating to the soils cleanup. It is also possible that there may be other sub-area specific PSQs that may be developed. These too will be addressed in the respective sub-area Sampling and Analysis Plans. Similarly, the other steps of the DQO process for groundwater or other media will be discussed in subsequent Sampling and Analysis plans for those media as they are developed.

7.1 OVERVIEW OF THE DQO PROCESS

The DQO process is a strategic, systematic process for planning scientific data collection efforts. The DQO process helps investigators and decision makers answer the following basic questions:

- Why do we need data?
- What must the data represent?
- How will we use the data?
- How much uncertainty is tolerable?

By using the DQO process, BRC will ensure that the data collected for decision making are of the right type, quantity, and quality. In addition, the DQO process:

- Ensures that limited resources are spent on collecting only those data that will support defensible decisions;
- Allows flexibility in planning because of its iterative nature (sometimes new information or conclusions cause the planning team to cycle back to earlier steps in the process); and

- Promotes multidisciplinary group consensus-building methodology that ensures buy-in from key participants and critical stakeholders.

The DQO process has been widely applied to environmental problems, such as investigating contamination in soil or water, and is set forth in USEPA guidance.

The DQO process, as defined by USEPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4*, consists of seven steps:

Step 1 - State the problem

Step 2 - Identify the decision

Step 3 - Identify the inputs to the decision

Step 4 - Define the study boundaries

Step 5 - Develop decision rules

Step 6 - Specify limits on decision errors

Step 7 - Optimize the process for obtaining data.

Each of these steps, along with sub-activities that comprise each step, are outlined below:

Step 1. State the Problem

The first step in the DQO process is to define the problem that initiated the study. Often, problems can be very complex, requiring investigators to examine a variety of political, economic, scientific, technical, legal, and social factors. This step allows the decision-making team to recognize multiple facets of the problem and consider the perspectives of key stakeholders to ensure all issues are addressed properly and adequately. This includes gathering all available relevant information so that a CSM can be developed and the needs of the site actions can be better defined.

There are four basic activities in this step:

- Identify members of the planning team. The planning team is the group of people who will develop the DQOs for the study. Generally, the team consists of representatives from key groups with a role in data collection or use, and often those with a critical interest or stake in

the problem; the size of the team depends on the scope and complexity of the problem. An example of a team for a Superfund site might be the Remedial Project Manager, a soil scientist, a hydrogeologist, a chemist, a risk assessor, representatives from the site's potentially responsible party, a QA specialist, and a statistician.

- Identify the primary decision maker of the planning team and define each member's role and responsibility during the DQO process. The planning team should have a leader (often the person with the most authority over the study) who is responsible for making final decisions based on the recommendations of the planning team. In the example provided above, the Remedial Project Manager would be the logical choice for the primary decision maker for the study.
- Develop a concise description of the problem. This description provides background information about the problem and allows the team to focus on the fundamental issue to be addressed by the study. Some elements to include for the description might be study objectives, regulatory context, groups who are involved or who have an interest in the study, political issues, funding, previous study results, land usage, and any obvious existing sampling design constraints.
- Specify the available resources and relevant deadlines for the study. The planning team needs to determine the budget, personnel, and resources available for the study, as well as list intermediate and final deadlines that may need to be met.

Step 2. Identify the Decision

The second step in the process is to define the decision statement that the study will attempt to resolve. There are four basic activities in this step:

- Identify the PSQ(s). The PSQ(s) helps the planning team narrow the often complex issues of a problem so that the team may focus their study. The question(s) identifies the unknown conditions or unresolved issues to the problem being investigated. The PSQs identified for this project in order to affect ultimate closure of the Site are discussed later in this section.
- Define the alternative actions that could result from resolution of the PSQ. The planning team identifies what possible actions may be taken to solve the problem. The types of actions also include the alternative that no action will be taken. For example, if the PSQ is "Is the

soil in a particular site contaminated?,” the alternative actions might be to take corrective action or to take no action.

- Combine the PSQ and the alternative actions into a decision statement. The planning team combines the actions and PSQ developed earlier in this step. A standard format for drafting decision statements is: “Determine whether or not [unknown environmental conditions/issues/criteria from the PSQ] require (or support) [taking alternative actions].” For the example used above, the decision statement would be “Determine whether or not the soil is contaminated and requires corrective action.”
- Organize multiple decisions. If several separate decision statements are to be addressed, the planning team must identify the relationships among the decisions, such as the order in which they should be resolved.

Step 3. Identify Inputs to the Decision

In this step, the planning team identifies the different types of information needed to resolve the decision statement. One of the purposes of the DQO process is to assist in new data collection. Historic data are considered in the CSM and new data needs are identified (potentially iteratively) via the CSM data gaps and DQO process. There are four activities in this step:

- Identify the information that will be required to resolve the decision statement. The team determines what environmental variables and other information are needed to resolve the decision statement. They may consider whether they should use modeling or monitoring approaches or a combination of the two. For example, the information may be variables such as levels of arsenic or radium 226 or even pH.
- Determine the sources for each item of information identified. The team identifies the sources of information they need to collect. The team may be able to use data from previous studies or investigations, or they may need to collect new data, or some combination of both.
- Identify the information that is needed to establish action levels. The team defines the basis for the action level, which defines a threshold value for determining which alternative action will be taken. Action levels may be based on regulatory standards, or they may be derived from site- and contaminant-specific criteria such as risk analyses. (This step identifies the basis of the action level; the actual numerical value of the action level is set in Step 5.)

- Confirm that appropriate analytical methods exist to provide the necessary data. The team ensures that there are methods available to provide them with acceptable environmental measurements. The team should list each method with its appropriate MDL and limit of quantitation (LOQ), as well as method performance data. If acceptable methods do not exist, the planning team may need to reconsider the approach for providing inputs, or perhaps reformulate the decision statement in Step 2.

Step 4. Define the Boundaries of the Study

In this step, the planning team defines the spatial and temporal boundaries of the problem. There are five activities in this step:

- Specify the characteristics that define the population of interest. The team defines the attributes of the population so that the focus of the study is unambiguous. Some examples of key attributes of interest in the target population are “concentrations of perchlorate in groundwater” or “arsenic concentrations in soil.”
- Define the spatial boundary of the decision statement. There are two steps to this activity. First, the team defines the geographic area to which the decision applies, such as “a property or site boundary.” Second, by using previously existing information, the team divides the population into strata that have relatively homogeneous characteristics (such as contaminant concentrations). By dividing the population, the team reduces the variability within subsets of data and makes the problem more manageable.
- Define the temporal boundary of the problem. There are two steps to this activity. First, the team determines the time frame to which the decision applies. This means that the team decides the time frame for which they wish to make a decision about using the data to be collected. For example, the data might be used to make a decision about possible contaminant exposures to local residents over a 30-year period. Second, the team needs to decide when they can collect data. The team must consider factors such as seasonal or daily variations in the population to be sampled, as well as weather and temperature conditions that may affect the data collected.
- Define the scale of decision making. The team determines the smallest, most appropriate subsets of the population for which they will make a decision. For example, a population might be the concentrations of arsenic in soil at a 100-acre sub-area of the Site, but the scale

of decision-making might be the top 10 feet of soil in a 1/8th acre area (*e.g.*, the area based on the size of a future residential lot).

- Identify practical constraints on data collection. The team identifies obstacles to data collection, such as the availability of sampling equipment or personnel or gaining permission to investigate private property.

Step 5. Develop a Decision Rule

In this step, the planning team summarizes the attributes of the problem and how the information collected will guide the team to choose a course of action that will solve the problem. There are four main elements to the decision rule: the parameter of interest, the scale of decision making, the action level, and the alternative actions.

The three activities involved in this step are as follows:

- Specify the statistical parameter that characterizes the population (the parameter of interest). The planning team determines the parameter of interest (such as a mean, median, or percentile) whose true value the team would like to know and that the data will estimate. For example, at many Superfund sites, investigators often choose the mean as the parameter of interest when the action level is based on long-term, average health effects.
- Specify the action level for the study. The decision maker chooses the numerical value that would cause one to choose between alternative actions. In some cases, the action value is determined by regulatory standards.
- Develop a decision rule. The decision rule is an “if ... then ...” statement that incorporates the parameter of interest, the scale of decision making, the action level, and the actions that would result from the decision. For example, at a site undergoing remediation, the decision rule might be as follows: “If the mean concentration of lead in a 1/8th -acre plot of soil is less than 400 milligrams per kilogram (mg/kg), then remediation is complete; otherwise, continue remediation.”

Step 6. Specify Tolerable Limits on Decision Errors

In this step, the decision maker chooses tolerable limits on decision errors. These limits are used to establish performance goals for the data collection design. BRC recognizes that this Step may be difficult to implement on a complex site such as BRC. BRC will minimize decision errors by

considering data adequacy in the DQA process. However, in the event that BRC may attempt to minimize decision errors using a typical Step 6 analysis, there are four activities in this step:

- Determine the possible range of the parameter of interest. The team establishes the likely upper and lower bounds of the parameter. To determine the range, the team may examine historical and documented analytical data. For example, previous studies may indicate that the range of PAH concentrations in soil undergoing remediation might be from 50 to 1,000 mg/kg.
- Identify the decision errors and choose the null hypothesis. There are four steps in this activity:
 1. The team determines the two types of decision errors and establishes the true state of nature for each decision error. A decision error occurs when the data erroneously lead the decision maker to conclude that the parameter of interest is on one side of the action level, when in fact the true value of the parameter is on the other side of the action level—in other words, a false positive or a false negative.
 2. The team specifies and evaluates the potential consequences of each decision error.
 3. The team then establishes which decision error has more severe consequences near the action level.
 4. The team defines the null hypothesis (baseline condition) and the alternative hypothesis and assigns the terms “false positive” and “false negative” to the appropriate decision error. Sometimes the choice of a baseline condition is determined by regulations. Other times, there may be a preponderance of evidence or logical reasons why one condition should be chosen as the baseline. If none of these circumstances hold, then the baseline is chosen to be the “worst case” so that the data must show convincing evidence to the contrary, leading to a “better safe than sorry” stance.
- Specify a range of possible parameter values where the consequences of decision errors are relatively minor, a gray region. The gray region is a range of possible parameter values where the consequences of a false negative decision error are relatively minor. The gray region is bounded on one side by the action level and on the other side by that parameter value where the consequences of making a false negative decision error begin to be significant. The decision maker establishes this boundary by examining the consequences of

not rejecting the null hypothesis when it is false. Then, the decision maker places this edge of the gray region where these consequences are severe enough to set a limit on the magnitude of this false negative decision error. Specifying a gray region is necessary because variability in the population and unavoidable imprecision in the measurement system combine to produce variability in the data such that a decision may be “too close to call” when the true parameter value is very near the action level. Therefore, the gray region (or “area of uncertainty”) establishes the minimum distance from the action level where the decision maker would like to begin to control false negative decision errors.

- Assign probability limits to points above and below the gray region that reflect the tolerable probability for the occurrence of decision errors. These limits reflect the decision maker’s tolerable limits to making an incorrect decision. The decision maker selects a possible value of the parameter and then chooses a probability limit based on the evaluation of the seriousness of the potential consequences of making the decision error if the true parameter value is located at that point. At a minimum, the decision maker should specify a false positive decision error limit at the action level and a false negative decision error limit at the other end of the gray region.

The outputs of Step 6 may be shown graphically on a Decision Performance Goal Diagram (which is essentially a statistician’s power curve).

Step 7. Optimize the Design

In this final step, the planning team selects a resource-effective data collection design for collecting data that will satisfy the DQOs. There are six activities in this step:

- Review the DQO outputs and existing environmental data. The team reviews the outputs of the six previous steps and ensures that they are consistent.
- Develop general data collection design alternatives. The team decides what kinds of data collection designs are feasible and appropriate for the Site. In this activity, the team also determines what each design will cost and what types of information will be provided by using the design.

Formulate the mathematical expressions needed to solve the design problems for each data collection design alternative. Three mathematical expressions are needed to optimize the design:

1. A method for testing the statistical hypothesis and for defining the sample size formula (*e.g.*, Student's *t*-test)
 2. A statistical model that describes the relationship of the measured value to the “true” value
 3. A cost function that relates the number of samples to the total cost of sampling and analysis.
- Select the optimal sample size that satisfies the DQOs for each data collection design alternative. Using the equations developed in the previous activity and limits placed on decision errors, the team determines the optimal sample size. If no design fits the specified criteria, the team may have to relax the constraints (such as false negative or false positive error rates or the size of the gray region in Step 6) placed upon the design.
 - Select the most resource-effective data collection design that satisfies all of the DQOs. The team evaluates the design options based on cost and the ability to meet the specified DQOs.
 - Document the operational details and theoretical assumptions of the selected design in the sampling and analysis plan. These details are needed to allow for efficient and valid statistical interpretation of the data which is conducted as part of the DQA, before the data are used in subsequent analyses such as risk assessments.

It is unlikely that BRC will attempt a rigorous, quantitative Step 7 analysis for this project in all instances. If suitable alternatives are available, BRC will evaluate the cost of collecting the requisite data in different ways. For example, typically, soil data will be collected via sampling per the approved SOP followed by fixed laboratory analysis; however, it is possible that for some compounds or in certain situations, alternatives such as field screening may also provide valid data. In such cases, the Step 7 analysis will be based on cost considerations without compromising data objectives.

7.2 PRINCIPAL STUDY QUESTIONS FOR THE PROJECT

This subsection discusses the PSQs that are fundamental to the DQO process. These PSQs are identified below at in 7.2.1. Note that it is possible that additional PSQs could be developed in the future or some of the current PSQs could be combined, as needed. For the purposes of these PSQs, the word “current” is defined as pre-development. This can be any point in time from the present time through the remediation phase, but prior to development. Similarly, “future” is defined as post-remediation. The word “incremental” can mean two different things. In one

context, “incremental” means over background or over upgradient conditions. For example, if risks due to the background level for a particular pollutant in soil is X, then incremental in this context would mean that “risk value over X.” In a second context, “incremental” may mean over some prevailing ambient value. For example, if the US average cancer risk is Y due to all causes, then incremental in this case is “cancer risk over Y.” It will be clear, by context, which meaning of incremental is intended.

In general, each study question concerns the existence of contamination in various media, the remediation that has occurred, the confirmation sampling that has followed, and the desire to clean up the Site to background levels so that incremental risk is small. The decision that will be made could be stated with the following question:

Example PSQ 1 – Are the current incremental risks to human health in sub-area X sufficiently low that they are acceptable? If the incremental risks are not sufficiently low then reasonable further action will be taken, otherwise, no further action will be taken.

It should be noted that this approach to PSQs makes it clear that the final decisions are based on incremental risks, as discussed earlier in the first context. Background comparisons are the essential context to the main and final decisions that are based on incremental human health risk over background. The term “reasonably” used in the example PSQ above recognizes that there is uncertainty, that there are consequences to making an incorrect decision and that there are costs involved in mitigation (soil removal in this case). That is, there is a trade-off between reducing uncertainty (via more data collection requiring more time and money and also prolonging present unremediated conditions) and reduction in decision risk, or between mitigation (which also requires more time and money) and putative reduction in human health risk. BRC may refine this example PSQ, if needed, to handle specific risk endpoints such as 10^{-6} excess cancers risk, a Hazard Index (HI) of 1.0, or a lead threshold of 400 mg/kg, etc., or make the PSQ relate to a specific medium (*e.g.*, surface soil, groundwater, etc.). While this example PSQ could be aimed at the whole Eastside Area rather than a sub-area, it is BRC’s intention to focus the PSQs on each discrete sub-area of the Site.

7.2.1 Site Principal Study Questions

There are six (6) PSQs. These are:

PSQ 1 – Are the current incremental risks to human health in the sub-area under investigation sufficiently low that they are acceptable? If the incremental risks are not sufficiently low, then reasonable further action will be taken; otherwise, no further action will be taken.

PSQ 2 – Are the current concentrations of contaminants associated with groundwater under the Site (*e.g.*, under the Eastside Area), after consideration of groundwater quality upgradient of the Site, sufficiently low that they are acceptable? If the concentrations are not sufficiently low, then reasonable further action will be taken; otherwise, no further action will be taken.

PSQ 3 – Are the current concentrations of contaminants associated with offsite groundwater downgradient of the Site, after consideration of groundwater quality upgradient of the Site, sufficiently low that they are acceptable? If the concentrations are not sufficiently low, then reasonable further action will be taken; otherwise, no further action will be taken.

PSQ 4 – Are the incremental human health risks associated with groundwater at the Site after development is completed (*i.e.*, post-development and under steady state conditions) sufficiently low that they are acceptable? If the incremental risks are not sufficiently low, then reasonable further action will be taken otherwise; no further action will be taken.

PSQ 5 – Are the current incremental ecological risks in the Trails & Recreation sub-area sufficiently low that they are acceptable? If the incremental risks are not sufficiently low, then reasonable further action will be taken; otherwise, no further action will be taken.

PSQ 6 – Are there current incremental ecological risks offsite that are attributable to migration of contaminants from the Site? If so, are these incremental risks sufficiently low that they are acceptable? If the incremental risks are not sufficiently low, then reasonable further action will be taken; otherwise, no further action will be taken.

It should be noted that a PSQ for off-site soils locations has not been developed at this time. BRC is in the process of determining via surface soil sampling in suitable offsite locations, whether any offsite migration of site contaminants may have occurred via the air entrainment and dust deposition pathway. BRC has previously conducted sampling and demonstrated that contaminated sediments have not impacted offsite locations via surface water and attendant sediment flows via the ditches. BRC does not believe that surface water sheet flow can transport site soils and sediments offsite since such water is typically contained in the various ponds and cannot flow downgradient.

Finally, it should be noted, for PSQ6, that this evaluation of incremental offsite ecological risks cannot be conducted by BRC alone since offsite migration of contaminants may have occurred due to the actions of numerous parties. Therefore, PSQ6 will likely be addressed via multi-party investigations, as needed.

SECTION 8

8 REMEDIAL ALTERNATIVE STUDIES

Once site characterization investigations are complete (generally pursuant to NDEP-approved work plans), it is customary, based on the findings of such investigative efforts, to develop a RAS in order to address remedial strategies that may be necessary in order to reduce or eliminate contamination in the study area for the particular media (soils, groundwater, vadose zone, etc.) under evaluation. The RAS, once approved, is documented via issuance of a ROD by the NDEP. The ROD, therefore, chooses among the various alternatives evaluated in the RAS. Alternatives can range from the “No Action” alternative to progressively more involved *in-situ* or *ex-situ* remedial actions, depending on the specifics of the study area and the media in question as well as intended future uses of the study area.

Each RAS alternative is evaluated against all of the criteria consistent with the USEPA guidance (USEPA 1988) for conducting a Feasibility Study. These criteria are as follows:

- a. Overall protection of human health and the environment;
- b. Compliance with ARARs;
- c. Long-term effectiveness and permanence;
- d. Reduction of toxicity, mobility or volume;
- e. Short-term effectiveness;
- f. Implementability;
- g. Cost;
- h. State acceptance; and
- i. Community acceptance.

BRC has followed and intends to follow the same approach for this project.

8.1 EASTSIDE AREA SOILS

As part of the Eastside Area Soils RAS (ERM 2000), various remedial options were identified to achieve the remedial action objectives and site-specific soil cleanup goals. Those remedial options that best addressed the soil conditions and mitigation of future exposures were combined to form remedial alternatives. The remedial alternatives considered in the RAS were as follows:

Alternative 1 - No action

Alternative 2 - Institutional controls / limited action

Alternative 3 - On-Site capping of soils

Alternative 4 - Excavation and disposal of soils at an on-site landfill (located within the Site [Alternative 4A] or at the BMI Complex [Alternative 4B])

Alternative 5 - Excavation and disposal of soils at an off-site landfill

These alternatives were evaluated to assess the relative performance of each alternative with respect to the criteria discussed earlier.

Based on the evaluation of alternatives, Alternative 4B was identified as the preferred remedial alternative to eliminate the potential health risks posed by the presence of chemical constituents in Eastside Area soils. Because of the rapidly expanding residential development surrounding the Eastside Area, and with the input from community stakeholders and the state, Alternative 4B was proposed by BRC as best fitting the USEPA criteria of overall protection of human health and the environment, compliance with ARARs, long-term effectiveness and permanence, reduction of toxicity, mobility or volume, short-term effectiveness, implementability, cost, state acceptance, and community acceptance. The NDEP approved this proposed remedial alternative in its ROD (NDEP 2001), and the Henderson City Council unanimously affirmed it.

8.2 CAMU AREA SLIT-TRENCH WASTES

BRC is currently preparing a RAS for the wastes located in the slit-trench sub-area in the CAMU portion of the Site. Since the CAMU is proposed to be located on this sub-area, BRC is evaluating, with guidance from the NDEP, whether some or a portion of the wastes located in this sub-area should be excavated prior to the construction of the CAMU in this sub-area.

8.3 EASTSIDE AREA SHALLOW GROUNDWATER AND VADOSE ZONE

BRC is currently conducting characterization of shallow (*i.e.*, Aa) groundwater in the Eastside Area as discussed previously in Section 4. Upon completion of these characterization efforts as well as related groundwater modeling studies and studies relating to evaluation of groundwater conditions upgradient of the Eastside Area, BRC will prepare a RAS for shallow groundwater and associated vadose zone for the Eastside Area.

8.4 EASTSIDE AREA DEEPER GROUNDWATER

BRC is currently conducting characterization of deeper groundwater (*i.e.*, TMCf) in the Eastside Area as discussed previously in Section 4. Upon completion of these characterization efforts, BRC will discuss the need to prepare a RAS for deeper groundwater with the NDEP.

8.5 CAMU AREA GROUNDWATER

BRC has conducted an evaluation of groundwater in the CAMU Area in 2005. This is discussed in the *Draft CAMU Area Conceptual Site Model*. Groundwater in this area is contaminated upgradient of the CAMU Area and is presently being remediated (for certain contaminants) by others, downgradient of the CAMU Area. BRC will conduct additional evaluations of impacts to groundwater from the CAMU Area and then discuss RAS options with the NDEP and others presently conducting groundwater remediation in this area.

8.6 OTHER STUDY AREAS OR MEDIA

As noted in Section 4, BRC is in the process of conducting additional evaluations in order to better understand site conditions and to close data gaps. As BRC continues these evaluations, it may become necessary for BRC to address remediation of particular study areas or particular media. If needed, BRC will follow the same basic procedure discussed above. BRC will first complete appropriate characterization pursuant to NDEP-approved work plans, followed by discussions with the NDEP relating to the findings. Finally, if needed, the necessary RAS will be developed.

SECTION 8 REFERENCES

- Environmental Resources Management (ERM). 2000. Remedial Alternatives Study for Soils and Sediments in the Upper and Lower Ponds at the BMI Complex. Henderson, Nevada. March 1.
- Nevada Division of Environmental Protection (NDEP). 2001. Record of Decision, Remediation of Soils and Sediments in the Upper and Lower Ponds at the BMI Complex. Henderson, Nevada. November 2.
- U.S. Environmental Protection Agency (USEPA). 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final. Office of Emergency and Remedial Response, Washington, DC. EPA/540/G-89/004. October.

SECTION 9

9 RISK ASSESSMENT METHODOLOGY – HUMAN HEALTH

As presented in Section 1.1, BRC proposes that risk assessments at the Site be performed after remediation is completed, with the status of completion to be based upon confirmatory field observations and laboratory analyses. By performing risk assessments after remediation, environmental conditions will form a baseline for post-remediation exposures and risks, then and into the future.

9.1 PURPOSE

The purpose of the human health risk assessment is to evaluate the potential for adverse human health impacts that may occur as a result of potential exposures to residual concentrations of chemicals in soil, groundwater, surface water, and air following remediation. Findings of the human health risk assessment are intended to support the site closure process.

This section describes the technical approach, guiding principals, and tasks that will be employed to complete the post-remediation human health risk assessment. BRC's proposed baseline risk assessment approach for the Site follows basic procedures outlined in the USEPA's *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual* (USEPA 1989) and *Draft Risk Assessment Guidance for Superfund: Volume 3—Part A, Process for Conducting Probabilistic Risk Assessment* (USEPA 2001a). Other guidance documents consulted by BRC in formulating its risk assessment methodology include:

- *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual. Supplemental Guidance: Standard Default Exposure Factors*. USEPA. 1991a.
- *Guidelines for Exposure Assessment*. USEPA. 1992A.
- *Exposure Factors Handbook*. USEPA. 1997.
- *Soil Screening Guidance for Radionuclides*. USEPA. 2000a.
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. USEPA. 2002a.
- *Technical Support Document for a Protocol to Assess Asbestos-Related Risk. Final Draft*. USEPA. 2003a.

- Nevada Administrative Code Chapter NAC 445A. Adopted Permanent Regulation of the Nevada State Environmental Commission. LCB File No. R119-96. NDEP. 1996.

A full list of guidance documents consulted is provided in the Reference section at the end of this document. It is anticipated that this human health risk assessment methodology will be the primary tool used to guide discussions with the NDEP with regard to the content and level of detail of the human health risk assessment that is needed to support decision-making for the Site.

9.1.1 Human Health Protection

For human health protection, BRC's goal is to remediate the Site soils such that they are suitable for unrestricted residential uses, assuring health protective conditions at 1/8th-acre exposure areas. The 1/8th-acre area corresponds to the size of a typical residential lot size, as presented in USEPA (1989) and is applicable to future Site conditions. There are only two exceptions to this general goal of residential end use, specifically, the areas within the Site that are designated as wetlands, and the adjoining areas where no development is planned (see delineation of Trails & Recreation sub-area on Figure 1-2).

It should be noted that although 1/8th-acre areas are the target for exposure, sampling will not occur on many of these 1/8th-acre exposure areas, instead assumptions of similar populations across the site (or areas larger than 1/8th-acre, as supported by the data) will allow estimates to be applied to 1/8th-acre exposure areas. The decision can hence be made simultaneously for many 1/8th-acre exposure areas based on the data and documentation that the exposure areas can be aggregated.

Project-specific risk level and remediation goals consistent with USEPA precedents and guidelines for residential uses have been established, as summarized later in this section. It should be noted that: 1) all comparisons to risk or chemical-specific goals will be made on an exposure area basis consistent with likely exposure assumptions, and 2) these comparisons shall be demonstrated through the use of statistical modeling to apply to each 1/8th-acre exposure area. The project-specific risk levels and remediation goals are presented below.

9.1.1.1 Risk Level Goals

The following target risk goals have been established for the Site in conjunction with additional chemical-specific goals discussed in Section 9.1.1.2:

1. Post-NFAD chemical and radionuclide concentrations in Site soils are targeted to have an associated residual, cumulative theoretical upper-bound incremental carcinogenic risk level point of departure of 10^{-6} . This is the target risk goal for the project. For cases where NDEP identifies this goal to be unfeasible, it is BRC's understanding that the NDEP will re-evaluate the goal in accordance with USEPA guidance [USEPA 1991b]). In no case will the residual, cumulative theoretical upper bound carcinogenic risk levels exceed those allowed per USEPA guidance.
2. Post-NFAD chemical concentrations in Site soils are targeted to have an associated cumulative, non-carcinogenic HI of 1.0 or less. If the screening HI is determined to be greater than 1.0, target organ-specific HIs will be calculated for primary and secondary organs (see discussion in Section 9.9). The final risk goal will be to achieve target organ-specific non-carcinogenic HIs of less than 1.0.
3. Where background levels exceed risk level goals or chemical-specific remediation goals, metals and radionuclides in Site soils are targeted to have risks no greater than those associated with background conditions.

9.1.1.2 Chemical-Specific Remediation Goals

In addition to the risk goals discussed above, a chemical-specific remediation goal has been established for lead. The target goal for lead is 400 mg/kg for residential land use, which is a residential soil concentration identified by USEPA (based on the Integrated Exposure Uptake Biokinetic Model [IEUBK] model) as protective of a residential scenario (USEPA 2004a).

9.2 OVERVIEW OF THE HUMAN HEALTH RISK ASSESSMENT PROCESS

Pursuant to NAC 445A and consistent with USEPA (2001a), and the National Academy of Science (1994) guidance, BRC proposes to follow a "tiered," or iterative, approach. The tiered approach focuses risk assessments on specific objectives, such as identifying potential areas of concern that need further investigation and/or remediation, and eliminating from further consideration areas that do not pose a risk to human health or the environment. BRC proposes to employ this tiered process for the post-remediation risk assessments, including specifically all pathways identified in Section 9.7.1. Therefore, references in this Closure Plan to "the risk assessment" pertain to each of these iterative risk assessments as they may be conducted at the Site.

The risk assessment process described herein consists of two tiers based on USEPA (2001a) recommendations. The first tier of the risk assessment process is a deterministic risk assessment approach, while the second tier is a probabilistic risk assessment approach. The deterministic risk assessment methodology is described comprehensively in this section. Specific details regarding proposed probabilistic risk assessment methodology will be described in a separate submittal to NDEP following the determination that a probabilistic risk assessment is warranted for a particular site. In preparing the human health risk assessment methodology, every effort has been made to take full advantage of available information to clarify the proposed technical approach. This human health risk assessment methodology is a “living” document—some portions of this document (*e.g.*, probabilistic distributions) will be submitted for insertion into a supplemental human health risk assessment methodology (as needed) as input from the NDEP is incorporated into the document prior to conducting the risk assessment for each sub-area.

9.3 SUMMARY OF CONCEPTUAL SITE MODEL AND DATA USABILITY EVALUATION

9.3.1 Summary of Conceptual Site Model

The CSM is a tool used in risk assessment to describe relationships between chemicals and potentially exposed human receptor populations, thereby delineating the relationships between the suspected sources of chemicals identified at the Site, the mechanisms by which the chemicals might be released and transported in the environment, and the means by which the receptors could come in contact with the chemicals. The CSM provides a basis for defining DQOs, guiding site characterization, and developing exposure scenarios. The site history, land uses, climate, physical attributes, including geology and hydrogeology, and various field investigations are fully described in Section 4, and in the Site-Wide CSM (in preparation).

9.3.1.1 Potential Current Exposure Pathways and Receptors

The Site is currently vacant except for the area of the City of Henderson southern RIBs. The potential on-site and off-site receptors are currently trespassers, occasional on-site workers, and off-site residents.

Risks to current receptors are being managed through site access control. In addition, although current exposures exist at the Site, the risk assessments will be performed after soils remediation is performed, therefore only potential future land-use conditions will be quantitatively evaluated.

9.3.1.2 Potential Future (Redevelopment and Post-Redevelopment) Exposure Pathways and Receptors

Under the current, prospective redevelopment plan, the Site will be used for a variety of purposes, including residential housing, parks, schools, places of worship, commercial and/or light industrial development, and streets. The entire Site will be enhanced by restoration and redevelopment once remediation is complete. To construct parks, civic structures and residences, the land will be cut and/or filled, paved with roads or foundations, and nurtured with imported top soils¹ as needed.

The Site will be redeveloped in several phases. Throughout the redevelopment process, one sub-area of the Site will be redeveloped while another sub-area is redeveloped sequentially. Future receptors identified as “on-site receptors” are defined as receptors located within the current Site boundaries (Figure 1-2), while future “off-site receptors” are those located outside the current Site boundaries. “On-site receptors” are those future receptors that will be located within the sub-area under evaluation. “Off-site receptors” are those future receptors that will be located outside of the sub-area under evaluation that may have complete exposure pathways associated with sources within the sub-area.

Many potential human receptors are possible at the Site in the period during and after redevelopment. The potentially exposed populations and their potential routes of exposure are presented in Figure 9-1 and summarized in Section 9.7.1. Because the background general water quality (*i.e.*, high salt concentrations) of the groundwater beneath the Site and in the surrounding area is poor and because BRC will place institutional controls in the form of a deed restriction to prevent future users from utilizing groundwater beneath the Site, the use of private water wells by residents, businesses, or parks for drinking water, irrigation water, or other non-potable uses (*e.g.*, washing cars, filling swimming pools) will not occur in the post-redevelopment phase. Therefore, exposure pathways relating to this type of use are incomplete.

9.3.2 Summary of Data Usability Evaluation

Section 6 describes the procedures to be used to evaluate the acceptability of data for use in the risk assessment.

¹ Note: Imported soil data will not be included in risk assessment calculations.

In addition to data validation, a QA/QC review of the analytical results will be conducted during the post-remediation field sampling effort. The analytical data will be reviewed for applicability and usability following procedures in the *Guidance for Data Usability in Risk Assessment (Parts A and B)* (USEPA 1992b,c) and USEPA (1989).

9.3.2.1 Overview of the Data Evaluation Process

The primary objective of the data usability evaluation is to identify appropriate data for use in the risk assessment. All relevant site characterization data will be reviewed for applicability and usability following procedures in USEPA's (1992b,c) *Guidance for Data Usability in Risk Assessment (Parts A and B)* and USEPA's (1989) *Risk Assessment Guidance for Superfund*. The USEPA data usability evaluation framework provides the basis for identifying and evaluating uncertainties in the human health risk assessment in regard to the site characterization data. Data usability is the process of assuring or determining that the quality of data generated meets the intended use. USEPA has established a specific guidance framework to provide risk assessors a consistent basis for making decisions about the minimum quality and quantity of environmental analytical data that are sufficient to support risk assessment decisions (USEPA 1992b,c). The USEPA data usability guidance provides an explicit set of data quality criteria that are used to determine the usability of site characterization data in the risk assessment process.

The six USEPA evaluation criteria by which data are judged for usability in risk assessment are:

- Availability of information associated with Site data;
- Documentation;
- Data sources;
- Analytical methods and detection limits;
- Data review; and
- DQIs, including precision, accuracy, representativeness, comparability, and completeness (PARCC).

A summary of these six criteria for determining data usability in the present risk assessment is described in this section. In addition, further details related to data evaluation are described in Section 6.

9.3.2.2 Data Adequacy

The concept of data adequacy incorporates: (i) an analytical program that seeks to quantify all relevant Site chemicals that have the potential to affect risk calculations, and (ii) a spatial density of sampling points that provides confidence that the Site has been sufficiently characterized and that areas requiring remediation have not been missed. The risk assessment analytical program for the Site represents a broad suite of analyses that cover all chemicals that might be conceivably expected to be present at elevated levels at the Site as a result of historical operations on the Site or adjacent to the Site.

An evaluation of the adequacy of the sampling for use in risk assessment will be presented in the risk assessment report. The evaluation may incorporate the results from three analyses. The first qualitatively evaluates whether the sample collection appears to be adequately representative in relation to the CSM. The second analysis addresses data quality using traditional classical statistics-based process. The third analysis presents a probabilistic analysis of the data.

9.4 SELECTION OF COPCs FOR HUMAN HEALTH RISK ASSESSMENT

COPCs will be selected for each exposure area evaluated. The broad suite of analytes presented in the SRC list (Section 3) is considered to be the current list of potential COPCs at the Site, based on site characterization conducted to date. However, in order to ensure that each risk assessment focuses on those substances that contribute the greatest to the overall risk (USEPA 1989); two procedures will be used to identify the COPCs for quantitative evaluation in the risk assessment:

- Identification of chemicals with detected levels which are greater than background concentrations (where applicable), and
- Identification of chemicals that are frequently detected at the Site.

As to the latter, chemicals that are infrequently detected within an area will be discussed on a case-by-case basis with NDEP. The procedure for evaluating COPCs relative to background conditions is presented below.

9.4.1 Evaluation of Site Concentrations Relative to Background Conditions

USEPA (1989, 2002b,c) guidance allows for the elimination of chemicals from further quantitative evaluation if detected levels are not elevated above naturally occurring levels.

Typically for purposes of selecting COPCs for risk assessment, COPCs are chemicals that are shown to be elevated above naturally occurring levels based on statistical analyses. For the purpose of selecting COPCs for each sub-area risk assessment, appropriate statistical methods will be applied for the background analyses. When the results of the statistical analyses indicate that a particular chemical is within background levels, then the chemical will not be identified as a COPC and will not be quantitatively evaluated in the risk assessment. That is, a chemical is selected as a COPC based on background conditions if it is determined to be above background levels based on a weight-of-evidence evaluation of the results of the individual background comparison tests. A chemical will be excluded as a COPC if it is determined to be at or below background levels based on a collective weight of evidence approach. The chemical will, however, be addressed qualitatively in the uncertainty analysis section of the risk assessment report (USEPA 2002b). Also consistent with USEPA guidance (2002b), for chemicals that exceed their respective background levels, risks will be calculated considering both background and site-related risks. In addition, risks associated with background levels will also be presented for comparison purposes.

The comparison of site-related soil concentrations to background levels will be conducted using the existing, provisional soils background data set presented in the *Background Shallow Soil Summary Report, BMI Complex and Common Area Vicinity* (BRC and TIMET 2007, currently in review by the NDEP), which includes both the Environ (2003) dataset and the BRC/TIMET dataset collected in 2005.

Background comparisons will be performed using the Quantile test, Slippage test, the *t*-test, and the Wilcoxon Rank Sum test with Gehan modification. The Quantile test, Slippage test, and Wilcoxon Rank Sum test are nonparametric. That is, the tests are distribution free; thus an assumption of whether the data are normally or lognormally distributed is not necessary. The computer statistical software program, Guided Interactive Statistical Decision Tools (GISdT[®]; Neptune and Company 2007), will be used to perform all statistical comparisons, with a decision error of $\alpha = 0.025$.

The Wilcoxon Rank Sum test performs a test for a difference between the sum of the ranks for two populations. This is a nonparametric method for assessing differences in the centers of the distributions that relies on the relative rankings of data values. Knowledge of the precise form of the population distributions is not necessary. The Wilcoxon Rank Sum test has less power than the two-sample *t*-test when the data are normally distributed, but the assumptions are not as

restrictive. The GISdT[®] version of the Wilcoxon Rank Sum test uses the Mantel approach which is equivalent to using the Gehan ranking system.

The Quantile test addresses tail effects which are not addressed in the Wilcoxon rank-sum test. The Quantile test looks for differences in the right tails (upper-end of the data set) rather than central tendency like the Wilcoxon rank-sum test. The Quantile test will be performed using a defined quantile = 0.80.

The Slippage test looks for a shift to the right in the extreme right-tail of the background data set versus the extreme right-tail of the site data set. This is equivalent to asking if a set of the largest values of the site distribution are significantly larger (in a statistical sense) than the maximum value of the background distribution.

Typically an $\alpha = 0.05$ is used to evaluate a statistically significant result. Since several correlated tests will be conducted, a lower alpha is selected. As more tests are performed, it is more likely that a statistically significant result will be obtained purely by chance. Given the use of multiple statistical tests, an $\alpha = 0.025$ is selected as a reasonable significance level for the COPC selection. Generally, any chemical that resulted in a p value less than 0.025 in one of four tests will be retained as a COPC. Additionally, these tests are set up with one-sided hypotheses. Consequently, not only are differences between the two samples able to be detected, a directional determination can be made as well (*e.g.*, Site is greater than background).

Cumulative probability plots and side-by-side box-and-whisker plots will also be prepared to evaluate whether the Site data and background data are representative of a single population. These plots are qualitatively used in the selection of COPCs. These plots give a visual indication of the similarities between the Site and background data sets. A determination to eliminate a chemical as a COPC on the basis of these visual indications will be made on a case-by-case basis with the NDEP.

9.4.2 Further Selection of COPCs

The COPC selection criteria described in this section will be applied to metals and radionuclide COPCs that are present above background levels, and all other detected chemicals. Initially, as discussed above, the broad-suite analytes will be considered to be potential COPCs at the Site. From this list, a preliminary list of COPCs will be derived for purposes of risk assessment that includes chemicals that are:

- Positively identified in at least one sample in a given medium, including: (1) chemicals with no qualifiers attached (excluding non-detect results with unusually high detection limits, if warranted), and (2) chemicals with qualifiers attached that indicate known identities but estimated concentrations (*e.g.*, J-qualified data);
- Detected at levels significantly elevated above levels of the same chemicals detected in associated blank samples (this protocol includes an analyte if it is known to be site-related and its concentration is greater than five times the maximum amount detected in any blank; if the chemical is a common laboratory contaminant [as defined by USEPA 1989], it is included only if its concentration is greater than 10 times the maximum amount detected in any blank);
- Tentatively identified but presumed to be present because of association with the Site based on historical information; and
- Transformation (*e.g.*, degradation) products of chemicals demonstrated to be present.

In deriving the preliminary list of COPCs, the following criteria established by USEPA (1989) will also be considered:

Historical Information – Chemicals likely to be associated with site activities, based on historical information, will not be eliminated, even if the results of other “COPC reduction” steps indicate that such elimination is warranted.

Concentration and Toxicity - Aspects of concentration and toxicity will be considered prior to eliminating a chemical as a COPC. For example, weight-of-evidence for human toxicity will be considered in conjunction with site exposure concentrations. Thus, Class A carcinogens will be retained as COPCs.

Consistent with ATSDR guidance (De Rosa *et al.* 1997), if the dioxins/furans TEQ concentration does not exceed the ATSDR screening value of 50 ppt for any sample within a sub-area, dioxins/furans will generally not be retained as COPCs for the sub-area. Elimination of dioxins/furans as COPCs based on the ATSDR screening criterion will be subject to NDEP approval on a case-by-case basis. Although the ATSDR screening value was published in 1997 as an interim policy guideline, the value is consistent with a current range of residential cleanup levels identified in a recent review of the scientific evidence for the risks posed by dioxins (Paustenbach *et al.* 2006).

Availability of Toxicity Criteria – Some chemicals have not been assigned toxicity criteria (*i.e.*, cancer slope factor [CSF] or reference dose [RfD]). Prior to eliminating such chemicals, structure-activity relationship (SAR) analysis and applicability of surrogate toxicity values will be considered.

Mobility, Persistence and Bioaccumulation – Chemicals that are highly mobile, are persistent or tend to bioaccumulate will generally be retained as COPCs.

Special Exposure Routes – For some chemicals under special site-specific scenarios, certain exposure routes need to be considered carefully before eliminating COPCs.

Treatability – Chemicals that are difficult to treat should remain as COPCs because of their importance during the selection of remedial alternatives if needed.

Documentation of Rationale – Rationale for the exclusion of any chemicals from the risk assessment will be documented in the risk assessment report.

Need for Further Reduction of COPCs – The need for further reduction of COPCs will be considered prior to applying reduction criteria. It may be appropriate to narrow the number of COPCs included in fate and transport modeling by grouping COPCs with similar fate and transport properties. That is, the modeled behavior of a given COPC will likely reflect that of other COPCs with similar properties. The selection of appropriate COPCs to be included in fate and transport modeling will be discussed with, and approval sought from, NDEP prior to modeling. A discussion of the COPCs that are not included in fate and transport modeling will be presented in the uncertainty section of the risk assessment report.

Approval by the NDEP – NDEP approval will be sought prior to the elimination of any potential COPCs from the risk assessment.

Frequency of detection (FOD) is another criterion that may warrant COPC reduction. Chemicals exhibiting a low FOD within a specific exposure area generally will not contribute significantly to risk and hazard estimates when hot spots are not present. USEPA (1989) suggests that chemicals with a FOD less than or equal to five percent, with the exception of metals and known human carcinogens, may be considered for elimination. Prior to eliminating a COPC based on the FOD criteria, (1) any elevated detection limits will be addressed, and (2) data distributions within sub-areas will be considered (*e.g.*, potential hot spots will be assessed). Additionally, the detection of the COPC in all sampled media will be considered. For example, USEPA

recommends that a chemical infrequently detected in soil should not be eliminated if it is frequently detected in groundwater and exhibits mobility in soil. As stated above, chemicals that are infrequently detected within an exposure area will be addressed on an exposure area-specific basis and will be discussed on a case-by-case basis with NDEP.

9.4.3 Summary and Presentation of COPCs

For each exposure area, a summary of the site COPC data (*i.e.*, chemical, range of concentration, background levels, FOD, retained/eliminated as COPC, and rationale for elimination) will be presented in table form.

9.5 DETERMINATION OF REPRESENTATIVE EXPOSURE CONCENTRATIONS

A representative exposure concentration is a COPC-specific and media-specific concentration value used in the dose equation for each receptor and each exposure pathway. As described below, the methods, rationale, and assumptions employed in deriving the representative exposure concentrations will be consistent with USEPA guidance and will reflect site-specific conditions.

9.5.1 Soil

The risk assessment will incorporate representative exposure concentration estimates (*e.g.*, 95 percent upper confidence limit of the mean [UCL] [USEPA 2002d, Singh *et al.* 1997] as presented below) that specifically relate to potential site-specific human exposure conditions. Representative exposure concentrations may vary across the Site, consistent with the statistical approach presented in the *Statistical Methodology* document (BRC and NewFields 2006).

Under a deterministic risk assessment framework, two approaches for developing representative exposure concentrations for soil in a particular exposure area may be used: 1) 95 percent UCL concentration approach; and 2) geostatistical (block kriging) approach. Both of these methods result in use of a 95 percent UCL of the mean concentration, by either 1) assuming randomness (no spatial correlation) or 2) assuming a spatial correlation structure. Each of these approaches is discussed below. The use of each of these approaches for a particular COPC within an exposure area will be dependent on whether the data are spatially correlated or not, as determined through COPC-specific correlation analyses. Results of correlation analyses will be provided to NDEP for review and comment prior to calculation of representative exposure concentrations.

If the data are spatially uncorrelated for a particular COPC, the 95 percent UCL will be computed to represent the sub-area-wide exposure point concentration. Based on USEPA (1989)

guidance and NDEP's recommendation, non-detects will be assigned a random number between zero and the detection limit. For radionuclide censored data, the actual reported value will be used. Data identified in the data usability evaluation as unusable due to elevated reporting limits will not be used in the calculation of representative exposure concentrations. The formulas for calculating the 95 percent UCL COPC concentration (as the representative exposure concentration) are presented in USEPA (2002d, Singh *et al.* 1997).² The 95 percent UCL statistical calculations will be performed using the computer statistical software program GISdT[®] (Neptune and Company 2007).

For normally distributed data, the normal 95 percent UCL will be used. For non-normal data, the maximum of the three bootstrap 95 percent UCLs will be selected. If the selected 95 percent UCL does not exceed the maximum value (including detects and detection limits) it will be selected as the exposure point concentration, otherwise the maximum value will be used as the exposure point concentration.

If the data are spatially correlated³ for a particular COPC, representative exposure concentrations will be determined on the basis of sub-areas. The size of the exposure area is dependent on the receptor (that is, 1/8th-acre will be used for residential receptors, while 1/2-acre will be used for worker receptors). For this purpose, the sub-area will be covered by a 1/8th-acre or 1/2-acre cell grid network, *i.e.*, each 1/8th-acre or 1/2-acre exposure area is defined as a cell, respectively. The geostatistical block estimation process (known as the block kriging) will be used to estimate the average COPC concentration over each cell along with its standard error. These statistics can be used to calculate the cell-specific UCLs. Under a deterministic risk assessment framework, the maximum UCL across all cells, or block kriging will be applied to the entire sub-area to estimate an overall mean, standard error, and UCL for the sub-area.⁴ One of the advantages of the block kriging is the fact that cells in sparsely sampled locations will have higher standard deviations, even when their estimated average values are low. The UCL at these cells will be elevated. This kriging property provides a further safety factor against not discovering previously unknown hotspots. Subsequent samplings around such cells will confirm the actual status of their contamination.

² Under a probabilistic risk assessment framework, the computed mean concentration and standard error will be used to define the distribution of representative exposure concentration.

³ Upon a thorough inspection of computed omni-directional and directional variograms, the status of spatial correlation of a chemical in a given soil layer will be determined (BRC and NewFields 2006).

⁴ Under a probabilistic risk assessment framework, the mean concentration and standard error from representative cells will be considered for defining the distribution of representative exposure concentration.

Representative exposure concentrations for soil will be based on the potential exposure depth interval for each of the receptors. For commercial workers, maintenance workers, and trespassers or recreational users, who are exposed to surface soils, data from the top two feet of soil will be used (USEPA 2002a). For construction workers and residents exposed to on-site surface and sub-surface soils, data from the surface to ten bgs will be used, unless representative exposure concentrations are greater for the top two foot depth interval. For external radiation exposures, data from the surface to ten feet bgs will be used for all receptors.

9.5.2 Indoor Air

Concentrations of volatile constituents (VOCs, certain SVOCs, and radon) in soil and groundwater that may infiltrate buildings to be constructed at the Site through cracks in the foundations will be estimated using USEPA surface emission isolation flux chamber (flux chamber) measurements collected at the Site in accordance with USEPA guidance (USEPA 1986) and the Flux Chamber SOP (BRC and MWH 2006). The flux chamber is used to measure the emission rates from surfaces emitting gas species. Use of the flux chamber reduces the need for modeling surface flux rates which reduces the uncertainty in the air representative exposure concentrations and the risk characterization. Because the flux chamber measurements will be conducted outdoors on open soil, an “infiltration factor” will be applied to the outdoor flux data to generate data supporting the inhalation of indoor air exposure pathway. The infiltration factor is based on the ASTM *Standard Guide for Risk Based Corrective Action* (2000). The indoor air concentrations will be determined from the following:

$$C_a = \frac{J \times \eta}{L \times ER}$$

where:

- Ca = indoor air concentration (milligram per cubic meter [mg/m³])
- J = measured flux of chemical (mg/m²-min)
- η = foundation crack fraction (unitless)
- L = enclosed space volume/infiltration area ratio (meter [m])
- ER = enclosed space air exchange rate (1/min)

Default parameter values from ASTM (2000) for residential and commercial buildings, where appropriate, will be used where site-specific data are unavailable. These default parameters are presented in Table 9-1. Radon testing will be conducted using static outdoor chambers

in addition to the USEPA surface flux chamber following the procedures presented in the Flux Chamber SOP (BRC and MWH 2006). Maximum flux rates for samples collected from a particular exposure area (*i.e.*, flux chamber sample resulting in the highest risk for the exposure area) will be used in the above equation. The number of surface flux samples and their locations will be proposed in a site-specific work plan for each sub-area.

9.5.3 Outdoor Air

Long-term exposure to COPCs bound to dust particles will be evaluated using the USEPA's Particulate Emission Factor (PEF) approach (USEPA 2002a). The PEF relates concentrations of a chemical in soil to the concentration of dust particles in the air. The Q/C (Site-Specific Dispersion Factor [USEPA 2002a]) values in this equation will be for Las Vegas, Nevada (Appendix D of USEPA 2002a; see Table 9-1). The USEPA guidance for dust generated by construction activities (USEPA 2002a) will be used for short-term construction worker exposures. Input soil concentrations for the model will be the exposure point concentrations as described above.

For exposures to VOCs, volatile SVOCs, and radon in outdoor air, the flux chamber measurements as described above will be used. Outdoor flux data will be divided by the dispersion factor for volatiles (Q/Cvol for Las Vegas; from USEPA 2002a; see Table 9-1) for use in the outdoor air exposure pathway. The same dispersion factor will be used for all scenarios. The dispersion factor for the construction worker will not be adjusted to account for soil intrusion activities. Uncertainties associated with using the default dispersion factor for the construction scenario will be discussed in the uncertainty analysis.

9.5.4 Groundwater

For direct contact with groundwater exposures, the representative exposure concentration will be the lower of the maximum detected concentration or the 95 percent UCL concentration for each detected chemical. Data available from all wells within or immediately adjacent to a particular sub-area will be used in the determination of representative exposure concentrations in groundwater. As noted above at Section 9.5.1, non-detects for COPCs are assigned a random value between zero and the detection limit (except for radionuclide censored data, where the actual reported value will be used).

9.5.5 Plant Uptake

As indicated in Section 9.7.1, and consistent with USEPA guidance (USEPA 1996, 2000a), the consumption of homegrown produce is applicable and will be evaluated for metals, dioxins/furans, PCBs, relevant SVOC, and radionuclide COPCs. In their *Soil Screening Guidance* document (USEPA 1996), USEPA presents generic plant SSLs for six metals (arsenic, cadmium, mercury, nickel, selenium, and zinc), based on plant uptake-response slopes from the *Technical Support Document for the Land Application of Sewage Sludge* (USEPA 1992d). USEPA has not developed plant SSLs for other metals or for organic chemicals. For the six metals assigned a plant uptake SSL, USEPA has concluded that the other soil exposure pathways (*e.g.*, soil ingestion, dermal contact, inhalation) are likely to be adequately protective of the soil-plant-human exposure pathway (USEPA 1996) for mercury, nickel, selenium, and zinc, but not for arsenic and cadmium. Therefore, risks associated with plant uptake will be addressed using USEPA plant SSLs (USEPA 1996) for arsenic and cadmium and mercury, nickel, selenium and zinc will not require quantitative evaluation for the plant uptake pathway. For other metals and organic COPCs, USEPA (2005) guidance will be used, and for radionuclides, USEPA (2000a) guidance will be used. On a site-by-site basis, BRC and the NDEP will mutually agree on which of the soil COPCs will warrant quantitative evaluation for the plant uptake pathway.

9.6 METHODOLOGY FOR EVALUATING POTENTIAL IMPACTS TO GROUNDWATER AND SURFACE WATER

Several vadose zone fate and transport models are available to evaluate the potential for chemicals to migrate from the unsaturated zone (or vadose zone) to groundwater beneath a site. BRC will not use groundwater in its subsequent redevelopment of the Site and will accept a restriction on groundwater use at the Site. As discussed in Section 9.6.3, as a first level screen, surface water concentrations will be considered equal to groundwater concentrations. The following approach and assumptions will be employed for appropriate fate and transport modeling at the Site.

9.6.1 Soil/Water Partition Equation for Migration to Groundwater

In order to determine the potential impacts of residual levels of COPCs in soil on groundwater quality, a simple, yet conservative, approach is used. The modeling consists of a simple soil/water partitioning and groundwater dilution model provided in the USEPA's *Soil Screening Guidance* (1996). The model consists of a series of calculations used to determine COPC concentrations in groundwater that result from their presence in the unsaturated zone. The model

simulates non-dispersive mass transport in soil from an infinite source. It assumes steady-state flow conditions, that all sources will infiltrate and desorb contaminants from the soil, and that the infiltrate will mix completely within the mixing zone (see equation below) beneath the Site resulting in an equilibrium groundwater concentration.

The model used is conservatively simplistic in that it does not account for numerous physical and chemical processes in the calculation of chemical transport that in general tend to retard and reduce chemical concentrations as they move down the soil column. The model and equations presented in this section can be used either to (1) predict groundwater concentrations from measured soil concentrations, or (2) establish target soil concentrations protective of groundwater quality (*e.g.*, values below which leachate hypothetically generated from the soils can not cause groundwater concentrations to become elevated above applicable criteria [*e.g.*, MCLs]). The equations as presented below are designed to predict groundwater concentrations from measured soil concentrations. The equations merely need to be solved in terms of C_p to establish target soil concentrations protective of groundwater quality. Calculated groundwater concentrations will then be added to existing groundwater concentrations to determine compliance with allowable groundwater concentrations.

As part of predicting groundwater concentrations from measured soil concentrations, one first calculates a soil leachate concentration using site-specific input parameters (Sections 9.6.1.1 and 9.6.1.2). The partitioning (or distribution) equation from the USEPA's *Soil Screening Guidance* (Equation 10 from USEPA 1996 [rearranging the guidance document equation]) for migration to groundwater will be used:

$$C_p = \frac{C_t}{\left(K_d + \frac{\theta_w + \theta_a H'}{\rho_b} \right)}$$

where:

- C_p = soil leachate concentration (mg/L)
- C_t = soil concentration (mg/kg)
- K_d = soil-water partition coefficient (L/kg)
- θ_w = water-filled soil porosity ($L_{\text{water}}/L_{\text{soil}}$)
- θ_a = air-filled soil porosity ($L_{\text{air}}/L_{\text{soil}}$)
- H' = Henry's Law Constant (dimensionless)
- ρ_b = dry soil bulk density (kilogram per liter [kg/L])

For organic chemicals, soil organic matter is the primary sorbing component of the soil matrix. For organic compounds, the K_d is estimated using the following equation:

$$K_d = f_{oc} \times K_{oc}$$

where:

- f_{oc} = fraction of organic carbon in soil (mg/mg)
- K_{oc} = organic carbon-water partition coefficient (L/kg)

Chemical property values will be obtained from the USEPA literature (1996, 2000a, 2002a), as well as the National Library of Medicine's on-line Hazardous Substances Database. Where available, soil properties (*e.g.*, fraction of organic carbon, porosity, and dry soil bulk density) will be based on laboratory results associated with soil samples collected from the Site. Model default values (USEPA 1996, 2000a) will be used where site-specific data are unavailable. These default parameters are presented in Table 9-1. For inorganics, K_d values will be selected to represent a range of soil pH (pH = 8 and 6.5), where available. While current soil pH conditions are in the range of 5.9 to 9.3, the lower pH will be evaluated anticipating some decrease in pH after redevelopment.

9.6.1.1 Groundwater Parameters

The groundwater input parameters used in this evaluation will be based on site-specific data. These data will be collected as part of the overall groundwater characterization program for the Site (see Section 4). The hydraulic gradient, or any other parameter, used in any specific area will be based on the most current data set for that area. The input parameter values will be provided to NDEP for review and comment prior to conducting modeling.

The depth of the groundwater mixing zone will be calculated for each exposure area using the following equation provided in the USEPA's *Soil Screening Guidance* (Equation 12 from USEPA 1996):

$$d = (0.0112L^2)^{0.5} + d_a \{1 - \exp[(-L \times I)/K \times i \times d_a]\}$$

where:

- d = depth of mixing zone (m)
- K = hydraulic conductivity (meter per year [m/yr])

- i = hydraulic gradient (meter per meter [m/m])
- d_a = thickness of the aquifer (m)
- I = infiltration rate (m/yr)
- L = source length parallel to groundwater flow (m)

The thickness of the aquifer (d_a) value will be based on stratigraphic data noted in the lithologic map of the Site (prepared as part of the CSM process described in Section 4). The site-specific term representing source length parallel to groundwater flow (L) will be selected based on the known areal extent of a given COPC within a particular exposure area. Each COPC will be modeled separately. The source length parallel to groundwater flow (L) will be dependent on the particular COPC being modeled. The infiltration rate will be based on the water balance that is being developed as part of the groundwater model for the Site.

9.6.1.2 Predicted Groundwater Concentrations

The equation used for estimating groundwater concentrations is (from USEPA 1996 [shown as solved in terms of C_{gw}, below]):

$$C_{gw} = \frac{C_p}{1 + (Kid / IL)}$$

where:

- C_p = chemical concentration in the soil leachate (mg/L)
- C_{gw} = chemical concentration in groundwater (mg/L)
- K = hydraulic conductivity (meters per year [m/yr])
- i = hydraulic gradient (m/m)
- d = depth of mixing zone (m)
- I = infiltration rate (m/yr)
- L = source length parallel to groundwater flow (m)

Where available, site-specific conditions will be incorporated in the model. The input parameters associated with the model are discussed above.

For the purposes of screening analysis, the resultant predicted groundwater concentrations of COPCs from post-remediation soils will be compared to applicable environmental- and health-based standards (e.g., MCLs and ambient water quality criteria for the protection of freshwater organisms). Results of this modeling will be evaluated separately as well as combined with

existing groundwater concentrations to evaluate whether post-remediation COPC concentrations in soil (if any) could potentially impact groundwater to a cumulative extent greater than applicable standards, or--if existing groundwater concentrations are already above these standards--to determine the incremental increase in concentrations.

9.6.1.3 Determination Whether to Proceed to a More Refined Vadose Zone Modeling Effort

The decision of whether the screening level vadose zone modeling results indicate that final Site conditions are protective of groundwater protection will be made based on the predicted groundwater COPC concentrations:

- If predicted COPC concentrations from the modeling and in combination with existing groundwater concentrations are determined to be below applicable environmental- and health-based standards, it will be concluded that additional modeling will generally not be warranted.
- If predicted COPC concentrations from the modeling and/or in combination with existing groundwater concentrations are determined to be above their respective applicable environmental- and health-based standards, a decision will be made to: (1) proceed with additional vadose zone modeling utilizing more refined modeling tools (*e.g.*, VLEACH vertical migration model), (2) re-evaluate the risk goal in accordance with USEPA guidance, or (3) perform additional soil removal and sampling.

The final determination of whether to conduct more refined vadose zone modeling will be made by the NDEP.

9.6.2 Surface Runoff Modeling

Migration of COPCs to surface water bodies by overland flow is quantified by the estimation of surface runoff. Surface runoff is the potential mass of surface soil that is eroded by precipitation and carried via runoff water to a site of deposition. Factors that can affect the amount of soil erosion taking place include type of soil, intensity of rainfall, steepness of the ground slope, amount of vegetative cover, size of the site subjected to erosion, erosion control practices, and distance to the surface water body or wetland where deposition is expected to occur. For the purposes of this assessment, the revised Universal Soil Loss Equation (USLE) will be used to estimate the mass of COPCs in surface soils eroded and transported to the Las Vegas Wash (USEPA 1988; USDA 2004 as referenced by USEPA 2004b). The revised USLE calculates annual soil loss using the following equation:

$$Y(S)_A = R \times K \times ls \times C \times P \times A \times S_d$$

where:

- $Y(S)_A$ = annual soil loss in runoff tonnes/year [1 tonne = 1,000 kilograms]
R = rainfall and runoff factor (in 10^2 m-ton-cm/ha-hour; USDA 1991)
K = the soil erodibility factor (tonnes/hectare per unit R)
ls = topographic factor (unitless)
C = dimensionless cover/management factor (1.0 for no appreciable plant cover)
P = dimensionless erosion control practice factor (1.0 for uncontrolled sites)
A = area of site (ha)
 S_d = dimensionless sediment delivery ratio

For each parameter, site specific information will be incorporated where available. Where data for parameters are not available, default assumptions based upon available information and databases (USDA 2004) will be incorporated. The annual mass of a particular chemical eroded from an area can be calculated based on the soil concentration and the resultant amount of eroded soil.

$$C_m = C_o \times Y(S)_A$$

where:

- C_o = soil concentration (mg/kg)
 C_m = the mass of chemical eroded from a site (mg/yr)

Surface water concentrations for each chemical from surface runoff can then be estimated using the following equation:

$$C_{sw} = \frac{C_m}{V_{sw}}$$

where:

- V_{sw} = annual surface water volume (L/yr)
 C_{sw} = surface water concentration (mg/L)

For each parameter, site specific information will be incorporated where available. Where data for parameters are not available, default assumptions based upon available information and

databases (USDA 2004) will be incorporated. The annual mass of a particular chemical eroded from an area can be calculated based on the soil concentration and the resultant amount of eroded soil.

9.6.3 Impacts on Las Vegas Wash

Potential impacts on the Las Vegas Wash will be evaluated by predicting the impact of groundwater migration and surface runoff, using the equations above. Applicable or Relevant and Appropriate Requirements (ARARs), protective of human health and ecological risk will be identified by BRC and the NDEP and employed by the NDEP as the basis for managing potential risk to Las Vegas Wash. The analysis will initially apply the conservative assumption that predicted groundwater concentrations at the point of infiltration will proceed undiluted and unattenuated up to the point of entry into the Las Vegas Wash. If more refined analyses are warranted, approval from NDEP will be sought prior to conducting those analyses.

Example models that may be considered for refined analyses include MODFLOW, a three dimensional, saturated flow model developed by the U.S. Geological Survey (USGS) with a comprehensive graphical interface, VLEACH, a one-dimensional, finite difference unsaturated (vadose) zone model developed by USEPA, and SESOIL, a one-dimensional vertical transport model for the vadose zone originally developed for USEPA, which can simulate seasonal climatic variations and varying soil properties with depth.

BRC fully recognizes the importance of this pathway, and the need to protect surface water quality from potential Site-related impacts, including those associated with redevelopment of the Site. Therefore, BRC will work closely with the NDEP to ensure the adequate evaluation and mitigation of these potential impacts. Potential impacts on the Las Vegas Wash are being further evaluated by the pending groundwater characterization and modeling program at the Site. The risk assessment will incorporate information obtained by this program when it becomes available.

9.7 TIERED HUMAN HEALTH RISK ASSESSMENT APPROACH

A tiered approach is proposed for the post-remediation risk assessments. The tiered, or iterative, approach for the risk assessments follows the USEPA recommendations (USEPA 2001a). The tiered risk assessment approach is applicable for all COPCs, with the exception of lead and asbestos. As discussed in Section 9.1.1.2, site-specific remediation goals have been established for lead. Because USEPA guidance for probabilistic risk assessment methods for asbestos is not

well established, and because it is not clear how to apply the current asbestos risk assessment approach into a probabilistic assessment, the use of a probabilistic approach for asbestos is too uncertain to use at this time. Therefore, asbestos risks will be evaluated through a deterministic risk assessment only.

9.7.1 Identification of Potentially Exposed Populations and Pathways

The identification of potentially exposed populations and exposure pathways is supported by the CSM. A summary CSM is presented in Section 4. For a complete exposure pathway to exist, each of the following elements must be present (USEPA 1989):

- A source and mechanism for chemical release;
- An environmental transport medium (*i.e.*, air, water, soil);
- A point of potential human contact with the medium; and
- A route of exposure (*e.g.*, inhalation, ingestion, dermal contact).

Figure 9-1 and the following present the primary exposure pathways for each of the potential receptors following remediation at the Site. These populations and complete/potentially complete exposure pathways for each of the receptors will be evaluated in the post-remediation risk assessments, as summarized below.

- Adult and child residents (except at the Trails & Recreation sub-area [as shown on Figure 9-1])
 - incidental soil ingestion*
 - external exposure from soil[†]
 - dermal contact with soil
 - consumption of homegrown produce*
 - outdoor inhalation of dust*[‡]
 - indoor inhalation of dust*[‡]
 - outdoor and indoor inhalation of VOCs and radon from soil and groundwater
- Indoor commercial workers (except at the Trails & Recreation sub-area)
 - incidental soil ingestion*
 - external exposure from soil[†]
 - indoor inhalation of VOCs and radon from soil and groundwater

- Park and landscape maintenance workers (equivalent to outdoor commercial/industrial workers)
 - incidental soil ingestion*
 - external exposure from soil[†]
 - dermal contact with soil
 - outdoor inhalation of dust*[‡]
 - outdoor inhalation of VOCs and radon from soil and groundwater

- Construction workers
 - incidental soil ingestion*
 - external exposure from soil[†]
 - dermal contact with soil
 - outdoor inhalation of dust*[‡]
 - outdoor inhalation of VOCs and radon from soil and groundwater
 - incidental ingestion of groundwater during construction activities*
 - dermal contact with groundwater during construction activities

- Trespassers and recreational users (for potential exposures at the Trails & Recreation sub-area)
 - incidental soil ingestion*
 - external exposure from soil[†]
 - dermal contact with soil
 - outdoor inhalation of dust*[‡]
 - outdoor inhalation of VOCs and radon from soil and groundwater
 - incidental ingestion of surface water*
 - dermal contact with surface water

*Includes radionuclide exposures.

[†]Only radionuclide exposures.

[‡]Includes asbestos exposures.

9.7.2 Deterministic Human Health Risk Assessment Methodology

The deterministic risk assessment will follow procedures outlined in the USEPA's *Risk Assessment Guidance for Superfund: Volume I--Human Health Evaluation Manual* (USEPA 1989). Other guidance documents that will be relied on include:

- *Guidelines for Exposure Assessment*. USEPA. 1992a.
- *Soil Screening Guidance: Technical Background Document*. USEPA 1996.
- *Exposure Factors Handbook, Volumes I-III*. USEPA 1997.
- *Soil Screening Guidance for Radionuclides*. USEPA. 2000a.
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. USEPA 2002a.
- *Technical Support Document for a Protocol to Assess Asbestos-Related Risk. Final Draft*. USEPA. 2003a.
- *Child-Specific Exposure Factors Handbook*. USEPA 2006.
- Nevada Administrative Code Chapter NAC 445A. Adopted Permanent Regulation of the Nevada State Environmental Commission. LCB File No. R119-96. NDEP 1996.

9.7.2.1 Deterministic Exposure Parameters

The exposure parameters proposed to be used in the deterministic risk assessment are presented in Tables 9-2 through 9-5. These generally conservative default values are based on standard USEPA guidance values. Exposure parameters that have significant impact on the results will be discussed in the uncertainty section of the risk assessment.

9.7.2.2 Deterministic Exposure Assessment

Reasonable maximum exposure levels to chemicals will be calculated for each receptor of concern, using the exposure parameters identified in Tables 9-2 through 9-5. Because the risk assessment may also be conducted probabilistically, a deterministic central tendency exposure will not be evaluated. The methodology used to estimate the average daily dose (ADD) of the chemicals via each of the complete exposure pathways will be based on USEPA (1989, 1992a) guidance. For carcinogens, lifetime ADD (LADD) estimates are based on chronic lifetime exposure extrapolated over the estimated average 70-year lifetime (USEPA 1989). This is performed in order to be consistent with cancer slope factors, which are based on chronic lifetime exposures. For non-carcinogens, ADD estimates will be averaged over the estimated exposure period. The generic equation for calculating the ADDs and LADDs is:

$$Dose = \frac{C \times IR \times ED \times EF \times BIO}{BW \times AT \times 365 \text{ d/yr}}$$

where:

- Dose = ADD for non-carcinogens and LADD for carcinogens (in mg/kg-day)
- C = chemical concentration in the contact medium (*e.g.*, mg/kg soil)
- IR = intake rate (*e.g.*, mg/day soil ingestion and dermal contact; m³/day for inhalation)
- ED = exposure duration (years of exposure)
- EF = exposure frequency (number of days per year)
- BW = average body weight over the exposure period (kilograms)
- BIO = relative bioavailability (unitless)
- AT = averaging time; same as the ED for non-carcinogens and 70 years (average lifetime) for carcinogens

With the exception of arsenic, the relative oral bioavailability (BIO) of all COPCs will be 100 percent. For arsenic, consistent with scientific literature recommendations on arsenic bioavailability (Roberts *et al.* 2001; Ruby *et al.* 1999; USEPA 2001b), an arsenic oral bioavailability of 30 percent will be used. The actual oral bioavailability of arsenic (as well as other metals at the Site, for which an oral bioavailability of 100 percent will be used) is likely to be lower than this value. Chemical-specific dermal absorption values from USEPA guidance (USEPA 2004c [Part E RAGS]) will be used in the risk assessments.

Exposure levels of potentially-carcinogenic and non-carcinogenic chemicals will be calculated separately because different exposure assumptions apply (*i.e.*, ADD for non-carcinogens and LADD for carcinogens). Exposure levels will be estimated for each relevant exposure pathway (*i.e.*, soil, air, and water), and for each exposure route (*i.e.*, oral, inhalation, and dermal). For non-carcinogens, ADDs will be derived for both child (zero to six years of age) and adult (seven to 30 years of age) receptors. For chemical carcinogens, LADDs will be derived for both child (zero to six years of age) and adult (seven to 30 years of age) receptors. These age classes are consistent with USEPA (1991a) guidance. Daily doses for the same route of exposure will be summed. The total dose of each chemical is the sum of doses across all applicable exposure routes.

The results of the exposure assessment will be used with information on the toxicity of the COPCs in the risk characterization step of the risk assessment to estimate the potential risks to human health posed by exposure to the COPCs. This process is discussed in Section 9.9.

9.7.2.3 Determination Whether to Proceed to a Probabilistic Risk Assessment

The decision of whether the deterministic risk assessment results indicate that final Site conditions are protective of human health and the environment will be made based on the non-cancer HI and total cancer risk.

- If both the non-cancer HI and the total cancer risk are below their respective acceptable levels (*i.e.*, a target organ HI of 1.0 and a cancer risk point of departure of 10^{-6}), and no hot spots are determined to exist, it will be concluded that probabilistic risk assessment will generally not be warranted.
- If either the non-cancer HI or the total cancer risk is above their respective acceptable levels, a decision will be made to: (1) proceed to a probabilistic risk assessment, (2) re-evaluate the risk goal in accordance with USEPA guidance, or (3) perform additional soil removal and sampling.

In order to assist in the decision to proceed to a probabilistic risk assessment, a quantitative sensitivity analysis will be performed if BRC considers performance of a probabilistic risk assessment warranted. If a probabilistic risk assessment is performed then a global numerical sensitivity analysis will be performed, which will be described in more detail in a separate probabilistic risk assessment methodology submittal to the NDEP. The final determination of whether a probabilistic risk assessment is warranted will be made by the NDEP. If a probabilistic risk assessment is conducted for a particular exposure area, all chemicals will be included (*i.e.*, no further reduction of COPCs will be conducted).

9.7.3 Probabilistic Human Health Risk Assessment Methodology

The probabilistic risk assessment will follow the procedures outlined in USEPA guidance (1989 and 2001a). It should be noted that the use of probabilistic risk assessment methodology is intended to more explicitly identify and quantify the uncertainty and variability that can be expected in the exposure assessment, and consequently, the risks associated with these exposures. As discussed above, specific details regarding proposed probabilistic risk assessment methodology will be described in a separate submittal to the NDEP.

9.7.4 Radionuclide Risk Assessment Methodology

Risks associated with radionuclides will be evaluated separately from chemical contaminants. Recently available USEPA risk assessment methodologies for radionuclides will be used (USEPA

2000a). There are several important differences between evaluating risks pertinent to radionuclides and those pertinent to chemical contaminants. These differences include:

- Exposure estimates are based on units of activity (*e.g.*, pCi) instead of units of mass (*e.g.*, mg) in soil;
- Only the carcinogenic effects of radionuclides due to ionizing radiation are considered. A radionuclide may also have a chemical toxicity (*e.g.* uranium or lead). These risks are addressed separately by using the concentration of mass of chemical in soil, rather than activity; and
- CSFs are based on the total theoretical age-averaged incremental lifetime cancer risk per intake of the radionuclide, or per unit external radiation exposure to gamma-emitting radionuclides. A soil ingestion CSF for adults will be used for all receptors except the resident and trespasser. For residents and trespassers the age-averaged soil ingestion CSF will be used as presented in the radionuclide PRG table (USEPA 2007a). Except for external CSFs, which are presented as risk/year per pCi/g_{soil}, CSFs for radionuclides are not expressed as a function of body weight or time, as are CSFs for chemical contaminants.

Exposure equations and parameter values to be used are the standard deterministic risk assessment exposure parameters based on typical USEPA (2000a, 2007a) default values. The exposure equations will be modified to include radionuclide decay as used in USEPA's radionuclide PRG equations (USEPA 2007a). For exposures not included in this guidance document (*e.g.*, construction worker and trespasser or recreational user exposures to groundwater and surface water, respectively), standard USEPA equations for these pathways will also be used for radionuclide exposures. Default parameter values are presented in Tables 9-2 through 9-5. These factors will also be used in the calculation of a site-specific background radionuclide risk level. The potential risks associated with exposure to radon will be evaluated using the approach for inhalation exposures to radon described in Section 9.5.2 (the equation presented in Section 9.5.2 for VOCs will also be applied for radon). In addition to inclusion in the radionuclide risk estimates, results of the estimated radon indoor air concentrations will be compared to USEPA's recommended action level of 4 picocuries per liter (pCi/L).

9.7.5 Asbestos Risk Assessment Methodology

Although final guidance is unavailable at this time, USEPA recommends that site-specific risk assessments be performed for asbestos (USEPA 2004d). Risks associated with asbestos in soil

will be evaluated using the most recent draft methodology proposed by USEPA (2003a). This methodology is an update of the method described in *Methodology for Conducting Risk Assessments at Asbestos Superfund Sites-Part 1: Protocol* and *Part 2: Technical Background Document* (Berman and Crump 1999a,b). Because the risk assessment methodology for asbestos is unlike that for other COPCs, and the preliminary guidance documents do not include probabilistic methods, asbestos risks will be evaluated using deterministic methods only. Exposure pathways, equations, and parameters to be used will be those presented in USEPA (2003a). Adjustments for exposure duration and exposure intensity, consistent with the methodology, will be made for each of the receptor populations, based on the respective exposure parameters presented in Tables 9-2 through 9-5.

The exposure point concentration for asbestos are based on the pooled analytical sensitivity of the dataset. The pooled analytical sensitivity is calculated as follows:

$$\text{Pooled Analytical Sensitivity} = 1 / \left[\sum_i (1 / \text{analytical sensitivity for trial } i) \right]$$

Two estimates of the asbestos concentration will be evaluated, best estimate and upper bound as defined in the draft methodology (USEPA 2003a). The best estimate concentration is similar to a central tendency estimate, while the upper bound concentration is comparable to a reasonable maximum exposure estimate. The best estimate asbestos concentration is the number of asbestos fibers detected multiplied by the pooled analytical sensitivity:

$$\text{Estimated Bulk Conc. (} 10^6 \text{ s/gPM10)} = \text{Long fiber count} \times \text{Pooled analytical sensitivity}$$

The upper bound estimate is the 95 percent upper confidence bound of the mean of the assumed underlying Poisson distribution used to model the number of structures found, multiplied by the pooled analytical sensitivity. In Microsoft® Excel, the 95 percent upper confidence bound of the mean may be calculated utilizing the following equation:

$$95\% \text{ UCL of Poisson Distribution (} 10^6 \text{ s/gPM10)} = \text{CHIINV}(1 - \alpha, 2 \times (\text{Long fiber count} + 1) / 2)$$

The intent of the risk assessment methodology is to predict the amount of airborne asbestos which can be inhaled by a receptor. In order to quantify the airborne asbestos concentration, the estimated dust levels or PEFs are used:

$$\text{Est. Airborne Conc. (s/cm}^3 \text{)} = \text{Est. Bulk Conc. (} 10^6 \text{ s/gPM10)} \times \text{Est. Dust Level (} \mu\text{g/cm}^3 \text{)}$$

In addition, it will be assumed that asbestos only occurs at the soil surface (zero to two inches), unless it is plausible that it exists at deeper depths based on available sample data or information for a particular exposure scenario. This will be determined on a case-by-case basis with NDEP.

For assessing asbestos risks, Table 8-2 (Based on Optimum Risk Coefficients) of USEPA (2003a) will be used. Table 8-2 presents best estimate risks optimized based upon separation of fiber type, size and endpoint (mesothelioma/lung cancer), thereby reducing apparent variation between the studies utilized. The values in Table 8-2 will be used because they are the authors “best” estimates of potency based upon all the available data (whereas the “conservative values” presented in Table 8-3 present only the most conservative, and best “behaved” data). As described in USEPA (2003a), because the asbestos risks to male and female smokers/non-smokers are different, population averaged risks will be evaluated based on Eqn. 8-1 of USEPA (2003a):

$$URF = 0.5 \times ((0.786 \times (NSM + NSF)) + ((0.214 \times (SM + SF)) \times CF)$$

where:

- URF = Population Averaged Unit Risk Factor [s/cm^3]⁻¹; *g.*, mg/kg, milligrams per cubic meter [mg/m^3])
- NSM = risk for male non-smokers
- NSF = risk for female non-smokers
- SM = risk for male smokers
- SF = risk for female smokers
- NFM = risk for female non-smokers
- CF = factor to convert risk from risk per 100,000 to risk per 1,000,000

This equation considers male smokers, male non-smokers, female smokers, and female non-smokers. In addition, because both chrysotile and amphibole have been detected in the general area (for example, from the City of Henderson WRF sampling), both could be expected to occur at the Site. Therefore, both amphibole and chrysotile fibers will be evaluated in the risk assessments, regardless as to whether either is detected within an exposure area (as calculated using the 95 percent UCL of the mean of the assumed underlying Poisson distribution).

To interpret measurements of asbestos in soils, it is necessary to establish the relationship between the asbestos concentrations observed in soils and concentrations that will occur in air when such soil is disturbed by natural or anthropogenic forces. This is because asbestos is a

hazard when inhaled (see, for example, Berman and Crump 2001). In fact, the Modified Elutriator Method (Berman and Kolk 2000), which will be the method employed to perform the risk assessments, was designed specifically to facilitate prediction of airborne asbestos exposures based on bulk measurements (see, for example, Berman and Chatfield 1990).

9.8 TOXICITY ASSESSMENT

This section identifies how toxicity values to be used for the risk assessment will be obtained. Toxicity values are published by the USEPA in the on-line Integrated Risk Information System [IRIS]; USEPA 2007b). CSFs are chemical-specific and experimentally derived potency values that are used to calculate the risk of cancer resulting from exposure to potentially carcinogenic chemicals. A higher value implies a more potent carcinogenic potential. RfDs are experimentally derived “no-effect” levels used to quantify the extent of toxic effects other than cancer due to exposure to chemicals. With RfDs, a lower value implies a more potent toxicant. These criteria are generally developed by USEPA risk assessment work groups and listed in the USEPA risk assessment guidance documents and databases. Toxicity criteria will not be developed *de novo* by BRC for elements or compounds that do not have criteria published in the above sources. Should COPCs be found which do not have established toxicity criteria; these will be discussed on a case-by-case basis with NDEP and qualitatively addressed in the uncertainty analysis of the risk assessment report. Where appropriate, and only as approved by NDEP, non-carcinogenic surrogate RfDs may be applied.

Like any biological reaction, the toxicity of a chemical on humans can be described as a range of possible outcomes (severities and levels that cause an endpoint of concern). The uncertainty in the toxicity outcomes or values is an important source of uncertainty in most risk assessments and would be an appropriate parameter to be modeled probabilistically. However, for the purposes of both the deterministic and probabilistic assessments, the toxicity values used will be point estimates (deterministic). Available toxicity values for all Site COPCs to be used in the risk assessment will be obtained from the USEPA. The following hierarchy for selecting toxicity criteria will be used (based on USEPA 2003b):

1. IRIS
2. USEPA’s Provisional Peer Reviewed Toxicity Values (PPRTVs)
3. National Center for Environmental Assessment (NCEA, or other current USEPA sources)

4. Health Effects Assessment Summary Tables (HEAST)
5. USEPA Criteria Documents (*e.g.*, drinking water criteria documents, drinking water Health Advisory summaries, ambient water quality criteria documents, and air quality criteria documents)
6. ATSDR toxicological profiles
7. USEPA's Environmental Criteria and Assessment Office (ECAO)
8. Peer-reviewed scientific literature

For carcinogens, the USEPA weight-of-evidence classification will be identified for each carcinogenic COPC. Available RfDs will be obtained for all COPCs, including carcinogens. A list of COPC-specific non-carcinogenic and carcinogenic toxicity criteria, current at the time of the post-remediation risk assessment, will be submitted to NDEP for approval prior to initiation of each risk assessment. Radionuclides toxicity criteria will be obtained from the USEPA's *Preliminary Remediation Goals for Radionuclides* (USEPA 2007a). For some radionuclides, two different toxicity criteria are available: for that radionuclide only, and for the radionuclide and associated short-lived radioactive decay products (*i.e.*, those decay products with radioactive half-lives less than or equal to six months). To be conservative, the toxicity criteria that include radioactive decay products will be used, even though toxicity criteria are available for some of their respective radioactive decay products, which are also assessed separately.

Although route-to-route extrapolation is generally inappropriate without adequate toxicological information, in this case route-to-route extrapolation will be applied based on USEPA's approach (USEPA 2004e). The uncertainties associated with this approach will be addressed in the risk assessment report. CSFs that account for risks from associated short-lived radioactive decay products (*i.e.*, radon) will be used in the risk assessment.

Although USEPA has developed toxicity criteria for the oral and inhalation routes of exposure, it has not developed toxicity criteria for the dermal route of exposure. Typically, a simple route-to-route (oral-to-dermal) extrapolation is assumed such that the available oral toxicity criteria are used to quantify potential systemic effects associated with dermal exposure. However, as noted in USEPA's *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (USEPA 2004c), there is uncertainty associated with this approach because the oral toxicity criteria are based on an

administered dose and not an absorbed dose. In general, USEPA (2004c) recommends an adjustment to the oral toxicity criteria to convert an administered dose into an absorbed dose. The adjustment accounts for the absorption efficiency of the chemical in the “critical study” that is the basis of the oral toxicity criterion. If the oral absorption in the critical study is 100 percent, then the absorbed dose is equivalent to the administered dose and no adjustment is necessary. If the oral absorption of a chemical in the critical study is poor (less than 50 percent), then the absorbed dose is much smaller than the administered dose. In this situation, an adjustment to the oral toxicity criteria is recommended.

For the dioxins/furans, the USEPA toxicity equivalency procedure, developed to describe the cumulative toxicity of these compounds, will be applied. This procedure involves assigning individual toxicity equivalency factors (TEFs) to the 2,3,7,8 substituted dioxin/furan congeners. TEFs are estimates of the toxicity of dioxin-like compounds relative to the toxicity of 2,3,7,8-TCDD, which is assigned a TEF of 1.0. Calculating the TEQ of a mixture involves multiplying the concentration of individual congeners by their respective TEF. One-half the detection limit will be used for calculating the TEQ for individual congeners that are non-detect in a particular sample. The sum of the TEQ concentrations for the individual congeners is the TEQ concentration for the mixture. TEFs from USEPA (2000b) will be used in the risk assessment.

For carcinogenic PAHs, provisional USEPA guidance for estimating cancer risks will be used (USEPA 1993). The procedure uses information from the scientific literature to estimate the carcinogenic potency of several PAHs relative to benzo(a)pyrene. These relative potencies may be used to modify the CSF developed for benzo(a)pyrene for each PAH, or to calculate benzo(a)pyrene equivalent concentrations for each of the PAH’s (which would then be used with the benzo(a)pyrene CSF). The former approach will be used in the risk assessment. If one carcinogenic PAH is considered a COPC then all seven carcinogenic PAHs will be considered COPCs, regardless of whether or not they are detected at the Site. Although route-to-route extrapolation is inappropriate without adequate toxicological information, route-to-route extrapolation will be applied based on USEPA’s approach.

The USEPA has not derived toxicity criteria to evaluate the potential non-cancer health hazards associated with exposure to the carcinogenic PAH COPCs. For the human health risk assessment, a toxicological surrogate (*i.e.*, pyrene) will be used to quantify the potential non-carcinogenic effects of the carcinogenic PAHs. This surrogate was selected from a list of six PAHs for which non-cancer oral toxicity criteria have been assigned by the USEPA based on a careful consideration of their relevant toxicity data, target organ(s), dose-response information,

and structure-activity relationships. From the available oral non-cancer toxicity data reported by the USEPA, the most sensitive target organs are the liver, kidney, and blood (hematological effects) (IRIS, USEPA 2007b; ATSDR 1990, 1995; ORNL 1993). For the carcinogenic PAHs, the non-cancer target organs were found to be the same and the reported toxicological thresholds for these effects are generally in the range for those reported for the non-cancer PAHs (ATSDR 1995). Although naphthalene (2-ring structure) has the most stringent oral non-cancer toxicity criterion (0.02 mg/kg day), pyrene (4-ring structure; oral RfD of 0.03 mg/kg-day) was selected to be the best surrogate due to (1) non-cancer toxicity endpoints are more consistent with those for carcinogenic PAHs and (2) the greater number of rings in the pyrene chemical structure.

The National Research Council of the National Academies published its technical review of the *Health Implications of Perchlorate Ingestion* in January 2005. From this review USEPA has established a final RfD of 0.0007 mg/kg-day, which is currently contained in the IRIS database (USEPA 2007b). This value will be employed in the risk assessment.

9.9 RISK CHARACTERIZATION

In the last step of a risk assessment, the estimated rate at which a person intakes a COPC is compared with information about the toxicity of that COPC to estimate the potential risks to human health posed by exposure to the COPC. This step is known as risk characterization. In the risk characterization, cancer risks will be evaluated separately from non-cancer adverse health effects. The methods used for assessing cancer risks and non-cancer adverse health effects are discussed below.

9.9.1 Methods for Assessing Cancer Risks

In the risk characterization, carcinogenic risk will be estimated as the incremental probability of an individual developing cancer over a lifetime as a result of a chemical exposure. Carcinogenic risks will be evaluated by multiplying the estimated average exposure rate (*i.e.*, LADD calculated in the exposure assessment) by the chemical's CSF. The CSF converts estimated daily doses averaged over a lifetime to incremental risk of an individual developing cancer. According to USEPA (1989), this approach is appropriate for theoretical upper-bound incremental lifetime cancer risks of less than 1×10^{-2} . The following equations will be used to calculate chemical-specific risks and total risks:

$$Risk = LADD \times CSF$$

where:

LADD = lifetime average daily dose (mg/kg-d)
CSF = cancer slope factor (mg/kg-d)⁻¹

and

$$\text{Total Carcinogenic Risk} = \Sigma \text{Individual Risk}$$

It will be assumed that cancer risks from various exposure routes are additive. Thus, the result of the assessment is necessarily a high-end estimate of the total carcinogenic risk. High-end carcinogenic risk estimates will be evaluated by NDEP in light of site-specific risk management decision criteria.

The equation used to calculate asbestos risks, which will be evaluated separately, is:

$$\text{Risk} = \text{Estimated Airborne Concentration (s/cm}^3\text{)} \times \text{Adjusted URF (s/cm}^3\text{)}^{-1}$$

9.9.2 Methods for Assessing Non-Cancer Health Effects

Non-cancer adverse health effects are estimated by comparing the estimated average exposure rate (*i.e.*, ADDs estimated in the exposure assessment) with an exposure level at which no adverse health effects are expected to occur for a long period of exposure (*i.e.*, the RfDs).

ADDs and RfDs are compared by dividing the ADD by the RfD to obtain the ADD:RfD ratio, as follows:

$$\text{Hazard Quotient} = \frac{\text{ADD}}{\text{RfD}}$$

where:

ADD = average daily dose (mg/kg-d)
RfD = reference dose (mg/kg-d)

The ADD-to-RfD ratio is known as a hazard quotient. If a person's average exposure is less than the RfD (*i.e.*, if the hazard quotient is less than 1), the chemical is considered unlikely to pose a significant non-carcinogenic health hazard to individuals under the given exposure conditions. Unlike carcinogenic risk estimates, a hazard quotient is not expressed as a probability. Therefore, while both cancer and non-cancer risk characterizations indicate a relative potential for adverse

effects to occur from exposure to a chemical, a non-cancer adverse health effect estimate is not directly comparable with a cancer risk estimate.

If more than one pathway is evaluated, the hazard quotients for each pathway, for all COPCs, will be summed to determine whether exposure to a combination of pathways poses a health concern. This sum of the hazard quotients is known as an HI.

$$\text{Hazard Index} = \Sigma \text{Hazard Quotients}$$

A total HI that includes all COPCs and all exposure pathways will be presented in the risk assessment. The NDEP non-cancer risk management target is an HI value of less than or equal to 1.0.

For any HI that exceeds 1.0, the potential for adverse health effects will be further evaluated by considering the target organs upon which each chemical could have an adverse effect. Target organ-specific HIs will be assessed only after approval by NDEP. The target organ specific HIs will be summed for all relevant COPCs. The segregation of HI by target organ is consistent with USEPA guidance for non-carcinogens, including metals (USEPA 1989, 2001c, 2005).

9.10 UNCERTAINTY ANALYSIS

Consistent with USEPA (1989) guidance, for the deterministic risk assessment, a qualitative discussion of the uncertainties associated with the estimation of risks for the Site will be presented in the risk assessment report. The uncertainty analysis will discuss uncertainties associated with each step of the risk assessment, including site characterization data, data usability, selection of COPCs, representative exposure concentrations, fate and transport modeling, exposure assessment, toxicity assessment, and risk characterization. For both non-carcinogens and carcinogens, the relative contribution of specific COPCs and pathways to total risk and HI will be identified. If a probabilistic risk assessment is performed the uncertainty analysis will be performed quantitatively. Details will be provided in a separate probabilistic risk assessment methodology submittal to the NDEP.

9.11 INTERPRETATION OF FINDINGS

The risk characterization results will be presented in tabular format in the risk assessment report. Key exposure (*e.g.*, estimated intakes, important modeling assumptions, summary of exposure pathways for each receptor) and toxicity information (*e.g.*, CSFs, RfDs, target organs) will be provided. In addition, the risk characterization results will be placed into proper perspective,

including a discussion of the concept of *de minimis* risk. The cancer risk assessment results will be presented for both total cancer risk and background cancer risk estimates, as well as presentation of the percent contribution of the background cancer risk to the total cancer risk. In addition, those COPCs and exposure pathways having the greatest influence on the risk assessment results will be identified. As appropriate, graphical presentation of the results will also be included in the risk assessment report. In addition, the format and content of risk assessment reports will follow the guidelines presented in USEPA's *Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual—Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments* (USEPA 2001c) and USEPA's Reviewers Checklist (USEPA 1989) to ensure that essential issues are adequately addressed in each risk assessment.

In addition to the above, upon completion of the final cycles of cleanup and sampling, the updated site geographic information system (GIS) database will be used to generate area-wide, layer-specific 1/8th-acre cell average concentrations and their corresponding estimation standard deviations. This process will be performed for the risk-driver chemicals that represent 90 percent of the total cancer risk and non-cancer HI based on the methodology provided in Section 9.9 above.

Having the mean and standard deviation of concentrations of the risk-driver chemicals within each cell, large number of sets of chemical concentrations of targeted contaminants will be randomly selected. For this purpose, each concentration will be selected from a normal distribution, associated with the given risk driver. Having a complete set of selected chemical concentrations of risk drivers, the cumulative cancer risks and non-cancer hazards are calculated for each set. After an appropriately large number of these parametric Monte Carlo simulated sets (*e.g.*, 1,000 simulated sets), the upper 95-percentile of the total cancer risks and non-cancer hazards will be determined for each cell. The results of these computations will be provided as area-wide, layer-specific mosaic-colored maps of the upper 95-percentile total cancer risks and non-cancer hazards. These maps will provide a comprehensive depiction of extent of risks over various depths of the entire area.

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SECTION 10

10 RISK ASSESSMENT METHODOLOGY – ECOLOGICAL

The purpose of an ecological risk assessment (ERA) is to evaluate the potential for adverse ecological impacts that may occur as a result of potential exposures to residual concentrations of chemicals following remediation. The biotic setting is important for determining if an ERA is necessary, placing the findings of the ERA in perspective, and, given the number of species and the complexity of biological communities, scoping the ERA effort. A current habitat map is provided in Figure 10-1.

The Las Vegas Wash is located north of the Site and has been identified as a key regional conservation priority (Audubon International's 2000 *Ecological Design for Village East, North of Sunset Road, Henderson, Nevada*. Prepared for the Landwell Company). The primary source of the perennial surface water for the Las Vegas Wash is treated wastewater. The Wash supports both desert riparian and perennial freshwater aquatic/emergent habitats that provide refuge and foraging habitat for a variety of wildlife species (Figure 10-1). In addition, the Las Vegas Wash serves as the major wildlife movement corridor in the area because of its dependable water source, visual shielding from surrounding development, and vegetation structure.

In addition to the Las Vegas Wash, the City of Henderson's Birding Preserve is the only other permanent surface water in the vicinity of the Site. As with the Las Vegas Wash, the primary source of the perennial surface water for the Henderson Birding Preserve is treated wastewater. The City of Henderson's Birding Preserve supports freshwater aquatic/emergent wetland habitat and will likely continue to support minimally disturbed wetland communities. This birding preserve supports abundant and diverse bird populations.

Much of the area surrounding the Site currently supports or is planned to support residential, commercial, or industrial uses. These areas are not intended to and do not support habitat attractive to support native plant and wildlife populations. These areas are landscaped with a variety of native and non-native ornamental plants. Wildlife that may be observed in these areas are likely to be transient, introduced species that are tolerant of human activity and typical of highly disturbed areas (*e.g.*, European starling, rock dove).

The entire Site is to be developed to support residential and mixed commercial and civic land use. The current development plans for the Site indicate that the Trails & Recreation sub-area will receive a substantial amount of fill material and be developed for non-residential uses after

remediation is complete. Based on discussions between BRC and NDEP, it is currently the belief that these developments do not constitute suitable habitat in this sub-area or in any of the other sub-areas and hence an ERA is not necessary. An ERA work plan will be developed if and when impacts and receptors are identified. For example, if it is discovered that off-Site impacts are adversely affecting ecological receptors it may be necessary to develop an ERA work plan. This work plan will incorporate appropriate USEPA ecological risk guidance documents, as well as those that the NDEP may develop.