Removal Action Work Plan
High Street Outfall and 40th Avenue Storm Sewer System

Vasquez Boulevard/Interstate 70 Site, Operable Unit #2

Prepared for:
City and County of Denver
Environmental Quality Division
200 West 14th Ave, Suite 310
Denver, Colorado  80204

Prepared by:
Engineering Management Support, Inc.
7220 W. Jefferson Ave., Suite 406
Lakewood, Colorado  80235

June 19, 2015
TABLE OF CONTENTS

1 INTRODUCTION .............................................................................................................. 1
  1.1 BACKGROUND ........................................................................................................... 1
  1.2 PROJECT ORGANIZATION ....................................................................................... 1
  1.3 PLAN ORGANIZATION ........................................................................................... 3

2 SITE CHARACTERIZATION .......................................................................................... 4
  2.1 WASTE MATERIAL .................................................................................................... 4
  2.2 GROUNDWATER ....................................................................................................... 4
  2.3 SOIL GAS .................................................................................................................. 5

3 SCOPE OF REMOVAL ACTION .................................................................................... 6
  3.1 DESIGN INVESTIGATION .......................................................................................... 6
  3.2 GENERAL LAYOUT .................................................................................................. 6
  3.3 MOBILIZATION PLAN ............................................................................................. 7
  3.4 SITE PREPARATION .................................................................................................. 8
  3.5 EXCAVATION OF SOLIDS ...................................................................................... 8
  3.6 SOLIDS TREATMENT PRIOR TO DISPOSAL .......................................................... 9
  3.7 SOLIDS DISPOSAL ................................................................................................. 9
  3.8 GROUNDWATER MANAGEMENT ........................................................................... 9
  3.9 STORMWATER MANAGEMENT .............................................................................. 9
  3.10 DUST CONTROL MEASURES ................................................................................ 10
  3.11 PERSONNEL AND EQUIPMENT MONITORING AND DECONTAMINATION ....... 10
  3.12 WORKER HEALTH AND SAFETY ......................................................................... 10
  3.13 PROCUREMENT STRATEGY ................................................................................ 10

4 PROJECT SCHEDULE ................................................................................................... 11

5 PROJECT REPORTING .................................................................................................. 12
  5.1 MONTHLY PROGRESS REPORTING ....................................................................... 12
  5.2 CONSTRUCTION COMPLETION REPORT .............................................................. 12

6 REFERENCES ............................................................................................................... 14

LIST OF FIGURES

Figure 1  Conceptual Plan View of Stormwater Drainage System
Figure 2  Conceptual Stormwater Channel Cross-section
Figure 3  Organization Chart
Figure 4  Waste Material Compounds of Concern
Figure 5  Groundwater Compounds of Concern
Figure 6  Removal Action Concept Plan
Figure 7  Removal Action Master Schedule
LIST OF APPENDICES

Appendix A: Resumes of Key Project Staff
Appendix B: Summary of Known Environmental Conditions
Appendix C: Sampling and Analysis Plan (FSP, QAPP, and RMP)
Appendix D: Materials Management Plan
Appendix E: Health and Safety Plan
Appendix F: Monthly Report Template
# LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACM</td>
<td>Asbestos-Containing Material</td>
</tr>
<tr>
<td>AoC</td>
<td>Agreement and Order on Consent</td>
</tr>
<tr>
<td>bgs</td>
<td>Below ground surface</td>
</tr>
<tr>
<td>BMPs</td>
<td>Best Management Practices</td>
</tr>
<tr>
<td>CCoD</td>
<td>City and County of Denver</td>
</tr>
<tr>
<td>CCR</td>
<td>Construction Completion Report</td>
</tr>
<tr>
<td>CDOT</td>
<td>Colorado Department of Transportation</td>
</tr>
<tr>
<td>CDW</td>
<td>Construction Dewatering</td>
</tr>
<tr>
<td>CERCLA</td>
<td>Comprehensive Environmental Response, Compensation, and Liability Act</td>
</tr>
<tr>
<td>COC</td>
<td>Compound of Concern</td>
</tr>
<tr>
<td>EMSI</td>
<td>Engineering Management Support, Inc.</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>ESD</td>
<td>Explanation of Significant Difference</td>
</tr>
<tr>
<td>FSP</td>
<td>Field Sampling Plan</td>
</tr>
<tr>
<td>HASP</td>
<td>Health and Safety Plan</td>
</tr>
<tr>
<td>LEL</td>
<td>Lower Explosive Limit</td>
</tr>
<tr>
<td>mg/kg</td>
<td>milligram per kilogram</td>
</tr>
<tr>
<td>MMP</td>
<td>Materials Management Plan</td>
</tr>
<tr>
<td>PAHs</td>
<td>Polynuclear-aromatic Hydrocarbons</td>
</tr>
<tr>
<td>% v/v</td>
<td>percent by volume</td>
</tr>
<tr>
<td>OU-2</td>
<td>Operable Unit #2</td>
</tr>
<tr>
<td>QAPP</td>
<td>Quality Assurance Project Plan</td>
</tr>
<tr>
<td>RACS</td>
<td>Regulated Asbestos-Contaminated Soil</td>
</tr>
<tr>
<td>RAWP</td>
<td>Removal Action Work Plan</td>
</tr>
<tr>
<td>RD/RA/O&amp;M</td>
<td>Remedial Design/Remedial Action /Operations and Maintenance</td>
</tr>
<tr>
<td>RMP</td>
<td>Records Management Plan</td>
</tr>
<tr>
<td>ROD</td>
<td>Record of Decision</td>
</tr>
<tr>
<td>RPM</td>
<td>Remedial Project Manager</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>RTD</td>
<td>Regional Transportation District</td>
</tr>
<tr>
<td>SAP</td>
<td>Sampling and Analysis Plan</td>
</tr>
<tr>
<td>SoW</td>
<td>Statement of Work</td>
</tr>
<tr>
<td>SVOCs</td>
<td>Semi-volatile Organic Compounds</td>
</tr>
<tr>
<td>TCRA</td>
<td>Time-Critical Removal Action</td>
</tr>
<tr>
<td>TSDF</td>
<td>Treatment, Storage, and Disposal Facility</td>
</tr>
<tr>
<td>VOCs</td>
<td>Volatile Organic Compounds</td>
</tr>
</tbody>
</table>
INTRODUCTION

This Removal Action Work Plan (RAWP) was prepared on behalf of the City and County of Denver (Respondent) pursuant to Section II.4 of the Statement of Work (SOW) attached to the Administrative Settlement Agreement and Order on Consent (AOC) for Removal Action in a Proceeding Under Sections 104, 106(a), 107 and 122 of the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§ 9604, 9606(a), 9607 and 9622 regarding the Vasquez Boulevard/Interstate 70 (VB/I70) Site Operable Unit 2 (OU2).

1.1 Background

Work under this Removal Action entails design and implementation of the “environmental components” of an open channel stormwater drainage feature to be constructed through a portion of Operable Unit 2 of the VB/I70 Superfund site. The open channel stormwater drainage feature is part of a larger project that is intended to reduce flooding in the Montclair Drainage Basin area and address stormwater management needs associated with projects being developed by Regional Transportation District (RTD), Colorado Department of Transportation (CDOT), and Respondent. A conceptual plan and cross-section of the segment of the stormwater channel of interest, which lies on property owned by the Respondent, are illustrated on Figures 1 and 2, respectively.

The “environmental components” to be addressed by this Removal Action consist of: 1) management and handling of waste material encountered during construction of the open channel stormwater drainage feature; 2) management and, if necessary treatment and/or disposal, of dewatering liquid during construction; and 3) design and construction of an impermeable barrier system to prevent any contaminants remaining within the boundaries of the stormwater feature from adversely impacting stormwater retained within and conveyed by the open channel system, as well as prevent stormwater infiltration into contaminated media remaining within the feature.

The purpose of this RAWP is to describe 1) management and disposal solid and liquid wastes that will be encountered or generated during design and construction, 2) investigative activities that will support design of the impermeable barrier system, 3) a general approach to barrier system construction, and 4) health and safety measures to be implemented during design and construction.

1.2 Project Organization

A project Organization Chart is shown on Figure 3. Overall, the project is managed by its project coordinator, Ms. Lisa Farrell, from the City and County of Denver. Ms. Farrell represents the interests of the Respondent and is responsible to ensure that all aspects of the work described in the SOW are implemented in accordance with the AOC. She has
direct reporting responsibility to the EPA and other entities involved with the barrier system design and construction.

The Respondent has retained Engineering Management Support, Inc. (EMSI) as the Managing Contractor. All aspects of the work to be performed by the Respondent pursuant to the AOC will be under the direction and supervision of EMSI. Accordingly, EMSI will direct and supervise all aspects of the Removal Action work. To facilitate this, the Project Coordinator has authorized EMSI to communicate directly with EPA or other regulatory entities on her behalf.

As a vice-president and principal engineer of EMSI, Mr. Timothy C. Shangraw, PE., will serve as Project Manager. He has BS and MS degrees in Civil Engineering, is a registered professional engineer in Colorado, and has 32 years of professional experience, most of which has been in hazardous waste management. Since 1984, Mr. Shangraw has been involved with CERCLA activities at Colorado Superfund Sites including, but not limited to, managing design and construction Removal Actions and RD/RA/O&M of the sitewide remedy for the Lowry Landfill Superfund Site. His resume is included in Appendix A.

Key members of the project team reporting directly to Mr. Shangraw include the QA Official and Health and Safety Officer, the Technical Director, and Technical Discipline Leads. Professionals serving those roles are listed on Figure 3. Their resumes are also included in Appendix A.

Key contractors retained by EMSI consist of CTL Thompson (Geotechnical Engineer and Testing); R.K Frobel and Associates (Barrier Design Engineer); Test America (Analytical Laboratory); Aquifer Technology (Certified Asbestos Building Inspector); Aerobiology (Asbestos Analyses); Site Services Drilling, LLC (Drilling services); Waste Management of Colorado, Inc. (disposal of non-hazardous solid waste and asbestos-containing material); Clean Harbors (treatment and disposal of hazardous and industrial wastes); Foresight West Surveying, Inc. (surveying); and CADD Services (drafting and GIS services). From time to time, additional contractors may be procured to support the work. The technical work provided by these contractors is supervised by the Technical Discipline Leads, who report to the Project Manager.

The project team includes personnel with requisite certifications. The Project Manager or Health and Safety Officer will inspect certifications prior to team members working the project. Documentation of certifications will be provided in the Subcontractor files for professional certifications, and in the Project Files for OSHA certifications. Training will be provided as necessary to maintain current certifications.

Over time, the named key team individuals or contractors may change. In such an event, the Project Manager, with approval from the Project Coordinator, will replace the Team member with an equally-qualified individual or company. Should the Project Manager, QA Official, or Technical Director need to be replaced, the Project Coordinator will notify EPA and present a new candidate for review and approval by EPA.
This Removal Action is a time-critical removal action. All of the resources identified above will be assigned to the project, as necessary, to meet the critical path schedule presented on Figure 7.

1.3 Plan Organization

This RAWP contains six sections, including this introduction. A description of the Site characteristics is presented in Section 2. The Removal Action approach, including a design investigation, general layout of construction features anticipated during implementation, environmental controls, traffic patterns, and health and safety measures are presented in Section 3. A project schedule is presented in Section 4, project reporting procedures are discussed in Section 5, and references are listed in Section 6.

The text and figures are followed by six appendices that contain:

Appendix A: Resumes of Key Project Staff
Appendix B: Summary of Known Environmental Conditions
Appendix C: Sampling and Analysis Plan
Appendix D: Materials Management Plan (draft final)
Appendix E: Health and Safety Plan
Appendix F: Monthly Report Template
2 SITE CHARACTERIZATION

2.1 Waste Material

Waste material beneath and west of the Denver Coliseum parking lot have been characterized by EMSI, 2009; Brown and Caldwell, 2010; and CTL Thompson, 2011. Summary results from their investigations are presented in Appendix B.

Where the barrier system study area crosses the Coliseum parking lot (Figure 1), waste material are present from approximately two feet below the ground surface (bgs) to as much as 20 feet bgs. Additional waste material may be present in the Globeville Landing Park area located west of the parking lot, but its areal extent, thickness and depth are not known at this time.

Compounds of potential concern in waste material consist of volatile organic compounds (VOCs), polynuclear-aromatic hydrocarbons (PAHs), arsenic, lead, and asbestos. Concentrations of VOCs, PAHs and metals in the material within and adjacent to the channel alignment are posted on Figure 4. Based on available information these concentrations are not characteristically hazardous, nor TCLP toxic.

Asbestos was detected in material collected from HS-02 (Figure 3) at a concentration of 0.5 percent of the total sample analyzed (CTL Thompson, 2011). This may be considered a trace amount, but its presence raises concern that asbestos may be randomly present in the material. If encountered, the ACM may need to be handled separately.

Additional Site characterization information is necessary to support design of the barrier system, and to manage handling and disposal of material that will be disturbed. Specific objectives and details of the additional data collection are discussed in Section 3.1 of this RAWP and in Appendix C.

2.2 Groundwater

Groundwater quality along the barrier system alignment has also been characterized by EMSI, 2009; Brown and Caldwell, 2010; and CTL Thompson, 2011. Summary results from their investigations are also presented in Appendix B.

In the vicinity of the barrier system, groundwater depths were measured in 2010 (Brown and Caldwell, 2010) and 2011 (CTL-Thompson, 2011). Their single-point readings indicate depths of approximately 10.7 feet bgs at HS-02; 11.5 feet bgs at CTL MW-4; 12.6 feet bgs at CTL MW-5; 13.7 feet bgs at HS-08; 23.5 feet bgs at MW-1; 23.8 feet bgs at HS-01; and 23.9 feet bgs at CTL MW-6. These depths will likely vary over time, but the single-point data provide a general indication of the depth to groundwater for planning purposes.
As shown on Figure 5 compounds of potential concern in groundwater consist of volatile organic compounds (VOCs), arsenic, cadmium, copper, lead, manganese, and zinc. If these concentrations are representative of waters that will be encountered during barrier system construction, treatment will likely be required before the water can be released to a receiving surface water body such as the South Platte River or nearby Sand Creek. Constituents that may require removal are discussed in a draft final Materials Management Plan (MMP), presented in Appendix D.

Similar to waste material, additional groundwater characterization information is necessary to support barrier system design, and to manage handling, treatment, and discharge of the groundwater encountered during construction. Objectives and details of the additional data collection are presented in Section 3.1 of this RAWP and in Appendix C.

2.3 Soil Gas

Soil gas monitoring was conducted during the advancement of borings HS-01, HS-02, HS-08, located on Figure 5 (Brown and Caldwell, 2010). Methane concentrations ranged from 0.5 percent by volume in air (% v/v) at HS-01, to 9.8 % v/v at HS-08, to 43.4 % v/v at HS-02. Additional measurements upstream (to the southeast) of the Coliseum parking lot detected methane concentrations up to 56.7 % v/v (see Appendix B, Soil Gas). In addition, well-head gas at the ground surface was measured during advancement of the CTL-MW-series well borings. Lower Explosive Limits (LELs) of 100% were recorded at many of the well-heads (CTL-Thompson, 2011). For reference, an LEL reading of 100% equates to a methane content of approximately 5% v/v.
3 SCOPE OF REMOVAL ACTION

3.1 Design Investigation

The first phase of the Removal Action will be a Design Investigation to better characterize subsurface conditions through which the barrier system will be constructed. Specific objectives of the Design Investigation consist of:

1) Determine the areal extent and depth of waste material along the footprint of the proposed alignment;
2) Sufficiently characterize the waste material for offsite disposal. Non-hazardous, solid waste disposal at the Denver Arapahoe Disposal Site (DADS) will require a) demonstration that the material will pass RCRA characteristic screens for ignitability, corrosivity, reactivity (cyanide and sulfide screen), oxidizers, and paint filter test, and TCLP toxicity for VOCs, PAHs, lead, and arsenic. In addition, samples that might visually appear to contain asbestos will be assessed for friable asbestos;
3) Determine the potentiometric surface of groundwater beneath and adjacent to the barrier system;
4) Characterize the quality of groundwater that may be encountered during construction to determine the need for and type of treatment required during construction; and
5) Assess the methane and total VOC concentrations of soil gas that may be encountered during excavation and materials handling.

Characterization and testing procedures designed to address these Design Investigation objectives are described in a Sampling and Analysis Plan (SAP), presented in (Appendix C). Results from the Design Investigation will be presented in a Data Summary Report that will support design of the barrier system and finalization of the draft final MMP (Appendix D).

3.2 General Layout

A conceptual layout of the Removal Action is illustrated on Figure 6. Solids excavated from the drainage channel will be staged along the north side of the excavation. Drainage from the excavated material will flow back to the open excavation via a swale excavated around the north, east, and west sides of the stockpile, and via direct southward flow into the open excavation. From the open excavation, liquids will be pumped and treated, as discussed below.

Solids will be visually screened prior to placement in the stockpile for evidence of hazardous material and ACM. To the extent that either is identified, the suspect material will be staged in the same general area, but separate from the non-hazardous and non-ACM material. Testing of the potentially hazardous and/or friable ACM will be performed in accordance with the MMP.
Transport of non-hazardous solids, hazardous waste, and ACM will be performed by licensed haulers under appropriate DOT manifests. As shown on Figure 6, transport vehicles will enter the Site via McFarland Drive, turn around in the Coliseum parking lot, be loaded from the north side of the Solids Staging Area, then depart via the eastbound lane of McFarland Drive. During loading of the trucks, a Site inspector will monitor the solids for evidence of free liquids and if observed, he/she will direct the material to be placed back on the stockpile for further drainage. Similarly, a Site inspector will monitor the stockpiled solids for emissions of VOCs, methane, odor, and fugitive dust. Threshold VOC and methane levels are discussed in the Health and Safety Plan presented in Appendix E. Malodors and visible fugitive dust will be monitored by the Site inspector monitoring the work. If VOC or methane threshold levels are exceeded, the material is excessively malodorous, or visible fugitive dust is observed at the Site boundary, appropriate mitigation measures will be performed, such as spraying the material with a fine mist of water, or slowing down excavation or loading operations. These and other mitigative measures will be detailed in the Removal Action design.

Before each loaded vehicle leaves the Site, it will be inspected for evidence of free liquids leaking from the vehicle, loose material not contained within the truck trailer, and a properly positioned screen over the top of the loaded trailer. With the Site inspector’s approval, the loaded transport truck will be allowed to depart the Site.

Liquids from the channel excavation will likely be generated from dewatering operations, gravity-draining of stockpiled solids, direct precipitation onto the open excavation and stockpiled soils, and decontamination activities. In accordance with the MMP any or all of these liquids may require treatment. Dewatering and water treatment details will be developed during Removal Action design. For planning purposes, treatment and pumping equipment will be located south the of the drainage channel as shown on Figure 6. Vehicle access to and from the treatment facilities will be via Arkins Court, as shown on the Figure 6.

Support areas that will accommodate a field trailer, equipment storage, and staff parking will be located along the northern boundary of the Coliseum parking lot, as shown on Figure 6. Security will be provided by fencing that surrounds working areas.

### 3.3 Mobilization Plan

A mobilization plan will be developed by contractors who will be implementing the Removal Action. For planning purposes, contractors will be directed to set their trailers, heavy equipment, and construction materials in the Field Trailer and Equipment Storage areas, respectively, as shown on Figure 6.
3.4 Site Preparation

A temporary on-Site field office will be established for on-Site management of Removal Action implementation. The field office will be equipped with potable bottled water, fire extinguisher, safety door, and fire and smoke detectors. Electric service will be provided from a Coliseum power supply designated by the Respondent. Distribution boxes and circuit wiring will be provided by the Respondent to meet the required power needs. All circuits throughout the Site will be protected either by a ground fault interrupter or an approved grounding system.

Lighting will be provided for all work areas when night work is required, or natural light is inadequate to perform the work safely. Work areas will be lighted to not less than the minimum illumination intensities listed in OSHA Standard 29 CFR 1910.120.

The Respondent will provide access to an adequate water supply for construction water. Non-potable water outlets will be clearly identified so as not to be used for drinking or cooking purposes. Water for suppression of VOCs, odor, or dust, and for soil moisture will be supplied by the Respondent at locations indicated during Removal Action design. Potable water such as bottled drinking water for use by Contractor's employees will be provided by the Contractor.

Contractors will provide temporary toilet facilities, which will be the chemical type, insofar as possible, to minimize water requirements. Contractors will be responsible for servicing and maintaining these facilities.

All vehicular traffic control will conform to the traffic patterns illustrated on Figure 6 and be in conformance with Site Rules (discussed below) to promote safe and efficient operations. Parking areas will be designated by the On-Site Manager. Site Rules are as follows:

- Maximum speed limit for all vehicles/equipment on-Site is 15 miles per hour.
- Vehicle and pedestrian traffic must yield to heavy equipment at all times.
- Contractor's vehicles must have orange survey flagging wrapped around interior rear view mirror to distinguish them as Superfund Site activity-related vehicle traffic.
- No vehicle will be allowed to idle for more than 5 minutes (Title II – Revised Municipal Code, Chapter 4, Article IV, Sec 4-43) unless it is required to perform a specific construction function.

Equipment storage will be in the Equipment Storage Area shown on Figure 6. Storage will be in accordance with the individual Contractor’s Work Plans, as approved by the Respondent.

3.5 Excavation of Solids

An excavation plan will be developed as part of the Removal Action design.
3.6 Solids Treatment Prior to Disposal

Visual screening, segregation, and additional testing (if needed) of solids are addressed in the MMP.

3.7 Solids Disposal

Solids disposal options are addressed in the MMP.

3.8 Groundwater Management

If groundwater, which includes perched water within the excavated material, is encountered the excavation will require dewatering. Two management scenarios are considered in the MMP. The first is treatment followed by release to the South Platte River or Sand Creek under Colorado’s Construction Dewatering (CDW) general permit or Remediation permit. The second is disposal of the water offsite as an industrial or hazardous waste in a licensed RCRA treatment, storage, or disposal facility (TSDF).

At completion of the Removal Action, a permanent groundwater monitoring well will be installed at a location that meets data quality objectives that will be determined in consultation with EPA.

3.9 Stormwater Management

A stormwater control plan will be developed as part of Removal Action design. It will include measures used to divert stormwater around the open excavation, solids storage area, and water treatment areas. Diversions may consist of diversion terraces or interceptor channels that route stormwater to the South Platte River with minimal erosion impact. To the extent that the diverted stormwater may contain suspended solids contributed from Removal Action activities, the diverted water will be treated using Best Management Practices (BMPs) prior to release to the South Platte River. Such BMPs may consist of sediment barriers such as hay/straw bales or silt fencing composed of geotextile.

Stormwater that contacts waste material will require collection and possible treatment prior to release. Collection mechanisms, treatment, and release will be developed as part of the Removal Action design. Release of the water to the South Platte River or Sand Creek will require a discharge permit, as discussed in the MMP.

3.10 Dust Control Measures

Dust control measures will be developed as part of the Removal Action design.
3.11 Personnel and Equipment Monitoring and Decontamination

Contractors and subcontractors performing work at the Site will decontaminate all tools, heavy equipment, and other equipment prior to arrival on-Site. Tools and heavy equipment that are used on-Site that contact waste material or contaminated groundwater will be pressure-washed until visually-clean, prior to departing from the Site. Trucks transporting waste material or contaminated groundwater from the Site will not require pre-Site decontamination, nor departure decontamination unless the Site inspector observes visual contamination on trucks entering the Site, or Site materials on vehicle tires or transport equipment exiting the Site.

Decontamination of personnel will occur as necessary prior to leaving the Site. Visibly-stained personal protective equipment (PPE) will be collected and disposed as a non-hazardous solid waste unless there is reason to believe the PPE is hazardous or is contaminated with ACM.

3.12 Worker Health and Safety

Hazardous levels of VOCs and explosive gases may be present during drilling, excavation, materials handling, or when working near an open excavation or stockpiled material. Applicable regulations include, but may not be limited to, the confined space standard (Part 1926.21(b)(6)(i) and (ii) in Subpart C); gases, vapors, fumes, dusts and mists (Part 1926.55 in Part 1926 Subpart E); fire protection and prevention (Part 1926 Subpart F); and trenching and excavation (Part 1926 Subpart P). Site-specific threshold values, mitigation measures, PPE, and recommended personnel field procedures are presented in the Project Health and Safety Plan (HASP), which is presented in Appendix E.

At a minimum, contractors and subcontractors will abide by a HASP for their employees. A contractor or subcontractor may choose to apply the Project HASP as a guide to develop its own HASP, or may choose to adopt the Project HASP in full. In either case, the Project HASP will be considered the primary HASP for all project-related activities. If another HASP is provided by a contractor or subcontractor, it will be considered an attachment to the Project HASP. All contractors and subcontractors will, at a minimum, follow all provisions of the Project HASP and/or applicable OSHA guidelines; whichever is more stringent or appropriate. In addition, all organizations performing oversight will be responsible for their own employee’s health and safety and for providing and verifying that each person present at the Site has the appropriate health and safety training.

3.13 Procurement Strategy

A procurement strategy will be developed as part of Removal Action design.
4 PROJECT SCHEDULE

A Master Schedule is presented on Figure 7.

Project plans consisting of this RAWP, the SAP (including the Field Sampling Plan, Quality Assurance Project Plan, and Records Management Plan), MMP, and HASP are scheduled to be prepared during the months of May and June, and finalized in early July, 2015. The Design Investigation field work is scheduled for July. Laboratory analyses and geotechnical testing will occur during July and August followed by preparation of a draft Data Summary Report and Preliminary Removal Action Design. The latter two documents are scheduled to be completed in mid-September, 2015. Finalization of the Data Summary Report, MMP, and Design documents will occur between October and December, 2015.

Procurement of material suppliers and contractors is scheduled between December, 2015 and late February, 2016. Contracts will be awarded in early March 2016, followed by mobilization, setup, and application for a Construction Dewatering and/or Remediation Permits between March and April 2016. Removal Action construction is scheduled to commence in May and be completed in November, 2016.
5 PROJECT REPORTING

5.1 Monthly Progress Reporting

Monthly progress reports will contain most of the information specified in Superfund Removal Procedures, Removal Response Reporting: POLREP and OSC Reports (EPA, 1994). The monthly report will include the following sections:

Section 1 - Heading
Section 2 - Background,
Section 3 - Site Information,
Section 4 - Removal Information, and
Section 5 - Disposition of Wastes.

Section 1 will include date of report, Site name, author of report, recipient of report, and number of report.

Section 2 will the Site number, response authority, CERCLIS number, NPL status, Action Memorandum date, actual start date, demobilization date, and completion date.

Section 3 will include incident category (e.g., time critical, fund-lead, etc.), description of the Site, description of the threat, and removal Site investigation results.

Section 4 will include a description of contamination, cleanup standards, actions to date, and planned actions.

Section 5 will include a description of the waste, treatment process required prior to disposal, volume of treated waste, temporary storage, and final disposition of the waste.

The template included as Appendix F will be followed for the monthly reports. Monthly reports will be submitted to EPA no later than 30 calendar days after the end of the reporting period.

5.2 Construction Completion Report

At completion of the Removal Action, a Construction Completion Report (CCR) will be prepared. It will include the following 10 sections:

Section 1 - Introduction: Include a brief description of the location, size, environmental setting, and operational history of the Site. Describe the operations and waste management practices that contributed to contamination of the Site. Describe the major findings and results of Site investigation activities.
Section 2 - Operable Unit Background: Summarize requirements specified in the ROD, ESD, and TCRA Memorandum for OU2. Include information on the cleanup goals, institutional controls, monitoring requirements, and other parameters applicable to the design, construction, operation, and performance of the removal action.

Section 3 - Construction Activities: Provide a step-by-step summary description of the activities undertaken to construct and implement the remedy e.g., mobilization and Site preparatory work; construction of the treatment system; associated Site work, such as fencing and surface water collection and control; system operation and monitoring; and sampling activities).

Section 4 - Chronology of Events: Include significant milestones and dates, such as, design submittal and approval; ROD amendments or ESDs; mobilization and construction of the remedy; significant operational events such as treatment system/application start-up, monitoring and sampling events, system modifications, operational down time, variances or non-compliance situations, and final shut-down or cessation of operations; final sampling and confirmation-of- performance results; required inspections; demobilization; and completion or startup of post- construction operation & maintenance activities.

Section 5 - Performance Standards and Construction Quality Control: Describe the overall performance of the technology in terms of comparison to cleanup goals. For treatment remedies, identify the quantity of material treated, the strategy used for collecting and analyzing samples, and the overall results from the sampling and analysis effort.

Section 6 - Final Inspection and Certifications: Report the results of the various inspections to include the pre-Final inspection, and identify noted deficiencies. If implemented, summarize details of the institutional controls (e.g., the type of institutional control, who will maintain the control, who will enforce the control).

Section 7 - Summary of Project Costs: Provide the actual final costs and applicable year for the project. If actual costs are not available, provide estimated costs.

Section 8 - Observations and Lessons Learned: Provide Site-specific observations and lessons learned from the project, highlighting successes and problems encountered and how resolved.

Section 9 - Operable Unit Contact Information: Provide contact information (names, addresses, phone numbers, and contract/reference data) for the major design and remediation contractors, EPA oversight contractors, and the respective RPM and project managers for EPA, the State, and the Respondent, as applicable.
6 REFERENCES

CTL Thompson, Inc., 2011. Limited Phase II Environmental Site Assessment, 40th Street Outfall, South Platte River to Blake Street, Denver, CO, prepared for WHPacific, Inc. May 10, 2011.


FIGURES
Figure 1
CONCEPTUAL PLAN VIEW OF STORMWATER DRAINAGE SYSTEM
OPERABLE UNIT #2, VB 170 SUPERFUND SITE
EMSI Engineering Management Support, Inc.
Figure 2
CONCEPTUAL STORMWATER CHANNEL CROSS-SECTION
OPERABLE UNIT #2, VB I70 SUPERFUND SITE
EMSI Engineering Management Support, Inc.
Figure 3
Organizational Structure
VB/I70 Operable Unit #2 Response Action

On-Scene Coordinator
D. Zinner (USEPA)

Project Coordinator
L. Farrell (Denver)

QA Official and
Health and Safety Manager
R. Jelinek, PE (EMSI)

Managing Contractor
T. Shangraw, PE (EMSI)

Technical Director
P. Rosasco, PE (EMSI)

Technical Discipline Leads
Solids Management (T. Shangraw, PE)
Water Treatment (R. Jelinek, PE)
Regulatory Compliance (P. Rosasco, PE)
Geotechnical Engineering (D. Glater, PE)
Barrier Design (R. Frobel, PE)
CABI (N. Fisher)

Key Contractors
Geotechnical Engineer and Testing
CTL Thompson
Barrier Design Engineer
R.K Frobel & Associates
Analytical Laboratory
Test America (water and solids)
Certified Asbestos Building Inspector
Aquifer Technology
Asbestos Laboratory
Aerobiology
Drilling
Site Services Drilling, LLC
Solid Waste and ACM Disposal
Waste Management, DADS
Hazardous/Industrial Waste Disposal
Clean Harbors
Surveying
Foresight West Surveying
Graphics and GIS
CADD Services

On-Scene Coordinator
D. Zinner (USEPA)

Project Coordinator
L. Farrell (Denver)

QA Official and
Health and Safety Manager
R. Jelinek, PE (EMSI)

Managing Contractor
T. Shangraw, PE (EMSI)

Technical Director
P. Rosasco, PE (EMSI)

Technical Discipline Leads
Solids Management (T. Shangraw, PE)
Water Treatment (R. Jelinek, PE)
Regulatory Compliance (P. Rosasco, PE)
Geotechnical Engineering (D. Glater, PE)
Barrier Design (R. Frobel, PE)
CABI (N. Fisher)

Key Contractors
Geotechnical Engineer and Testing
CTL Thompson
Barrier Design Engineer
R.K Frobel & Associates
Analytical Laboratory
Test America (water and solids)
Certified Asbestos Building Inspector
Aquifer Technology
Asbestos Laboratory
Aerobiology
Drilling
Site Services Drilling, LLC
Solid Waste and ACM Disposal
Waste Management, DADS
Hazardous/Industrial Waste Disposal
Clean Harbors
Surveying
Foresight West Surveying
Graphics and GIS
CADD Services
LEGEND

Monitoring Well
Soil Boring
Limits of Fill Material Within the Coliseum Parking Area as Defined During the OU2 Remedial Investigation (EMSI, 2009)
Thickness of Fill Material Based on EMSI 2009 Remedial Investigation
Option 2 - High Street Outfall Alignment
Drainage Channel Sampling Area
Sanitary Sewer

Note: Results presented in milligrams per kilogram (mg/kg).
TCLP results presented in milligrams per liter (mg/L)

Figure 4
WASTE MATERIAL
COMPONDES OF CONCERN
OPERABLE UNIT #2, VB I70 SUPERFUND SITE
EMSI Engineering Management Support, Inc.
Figure 5
GROUNDWATER COMPOUNDS OF CONCERN
OPERABLE UNIT #2, VB I70 SUPERFUND SITE

Note: Results presented in micrograms per liter (ug/L).

EMSI Engineering Management Support, Inc.
Appendix A

Resumes
TIMOTHY C. SHANGRAW, P.E.

Mr. Shangraw has over 34 years of technical and management experience relevant to hazardous waste site investigations and remediation, water and wastewater treatment, mine dewatering, stormwater planning, and environmental studies. His expertise is particularly strong in managing complex remediation programs from conceptual design through detailed design, construction, and operations.

For the past 20 years, Mr. Shangraw has managed remedial design, remedial action, and O&M of the Lowry Landfill Superfund Site near Denver, Colorado. This has been a $100M+ project involving groundwater cutoff walls, pump and treatment systems, capping, waste pit remediation, landfill gas collection and treatment, and extensive environmental monitoring. Unique challenges included development and application of emerging technologies to oxidize and biodegrade 1,4-dioxane and other organic compounds and to sequester inorganic compounds. Such technologies involved both in-situ and above-ground treatment methods. Case studies were published in technical journals and/or presented to national technology-transfer organizations.

Throughout his career, Mr. Shangraw has managed and technically directed regulatory closur

EDUCATION

M.S., Civil/Environmental Engineering, University of Colorado, Boulder, 1979
B.S., Civil Engineering, University of Massachusetts, Dartmouth, 1977

REGISTRATION

Registered Professional Engineer (Colorado, 1981, No. 19853)
DOE "Q" Clearance (retired)

EMPLOYMENT HISTORY

1998-Present Engineering Management Support, Inc.
            Vice President and Principal Engineer

            Senior Associate and Program Manager. Directed, managed, and performed hazardous waste studies, design, and construction projects from the Denver, Salt Lake City, and Richland, Washington offices. Projects included restoration programs under RCRA and CERCLA for industry, PRP groups, Department of Defense, and Department of Energy. Also assessed potential hydrogeologic impacts from water storage and supply projects in the Denver metro area.
Project Engineer. Performed RCRA compliance studies for wood preserving sites throughout the United States. Conducted field investigations, prepared landfill siting studies, and designed lagoon closures. Also prepared drainage reports for land development projects utilizing HEC-2 flood plain model.

Staff Engineer. Conducted remedial evaluations of abandoned mine reclamation sites, prepared environmental baseline studies for coal gasification plants and underground mines, and participated in cleanup of a Superfund Site in Philadelphia, Pennsylvania. Also participated in geotechnical studies for surface water impoundments and mine subsidence evaluations.

Staff Engineer/Hydrologist. Responsible for design of dewatering systems for a large open pit uranium mine. Performed aquifer tests, supervised computer modeling studies, and integrated dewatering system into mine development plans. Also provided conceptual designs for treatment of radioactive mine water.

MEMBERSHIPS
Willowbrook Water and Sanitation District – Director
Water Environment Federation

PUBLICATIONS AND PRESENTATIONS


PAUL V. ROSASCO, P.E.

Mr. Rosasco has over 38 years of experience in providing supervision, management, and technical review for geological, hydrogeological, and engineering projects. He has designed and implemented geological, hydrogeological and geophysical investigations and environmental monitoring programs for sites ranging from 0.5 acres to over 300 square miles. Mr. Rosasco has extensive project management and technical experience in a wide variety of waste disposal and environmental contamination projects. He has provided design, site engineering, and construction management services and acted as owner’s representative for surface and subsurface remediation projects. He has also been involved in a variety of geotechnical, geologic hazard, and water supply evaluation projects.

Mr. Rosasco has 32 years of experience with all aspects of CERCLA and National Priorities List (NPL) site projects where he has worked at over 40 Superfund Sites. His experience includes evaluation of existing data and development of scopes of work, negotiation of scopes of work, administrative orders and consent decrees, implementation and supervision of remedial investigations, feasibility studies, remedial designs, remedial actions, removal actions and performance and effectiveness evaluations of operation and maintenance of removal and remedial actions.

Mr. Rosasco also has 30 years of experience with Resource Conservation and Recovery Act (RCRA) facilities where he has performed characterizations of generator, treatment, storage, disposal sites, assessed the nature and extent of contamination, and evaluated and designed corrective measures. He has participated in the development and review of RCRA Part B applications, ground-water monitoring and corrective measure programs and closure plans. Mr. Rosasco has also developed operations plans and designed and facilitated permitting for solid and liquid waste disposal sites.

Mr. Rosasco has provided expert testimony related to groundwater occurrence, flow and chemical transport, the nature, extent and sources of environmental contamination, the necessity and appropriateness of various remedial actions, consistency of response actions with the National Contingency Plan (NCP) and other environmental regulations, and allocation of response costs. He has been qualified by several federal courts as an expert in the areas of hydrogeology, contaminant occurrence, fate and transport, remedial actions, cost allocation and NCP consistency. He has also provided expert testimony on the role of environmental issues and site remediation related to property valuation and condemnation proceedings. He has testified at numerous regulatory hearings and public meetings on issues ranging from site selection and the design and operations of waste disposal facilities, environmental contamination and remediation, and water quality standards. He has had his deposition taken 38 times, testified at trial 13 times and at formal administrative or agency hearings seven times. He has also provided expert assistance related to construction claims and disputes.

In addition to expert testimony, Mr. Rosasco has provided expert assistance in support of litigation in a wide variety matters including hydrogeological characterization, nature, extent and causation of contamination, and remedial actions at regional groundwater contamination sites such as the San Gabriel Valley – Baldwin Park Operable Unit, the Suburban Operable Unit and
the former Fairchild Industries facility in southern California, and the former Lockheed facility in Redlands, CA; regional mining districts including Leadville, CO, Bunker Hill, ID, Crede, CO, and Jamestown CA; petroleum refineries, bulk plants, and retail outlets; and various manufacturing and commercial facilities throughout the country. Mr. Rosasco served as an independent arbiter during settlement negotiations for a leaking underground storage tank site in Colorado and served as the 30-B6 representative relative to the claimed releases from adits, tunnels and portals in the upper portion of the Coeur d’Alene Basin.

EDUCATION

M.E., Engineering Geology, Colorado School of Mines, 1985
B.S., Geology, University of Oregon, 1976

REGISTRATIONS

Registered Professional Engineer in Colorado, Washington, and Illinois (retired status)

EMPLOYMENT HISTORY

  President and Principal Engineer

1985 - 1994 Harding Lawson Associates
  Member of Board of Directors
  Senior Vice President
  Director of Program Development
  Consulting Vice President
  Director of RCRA and CERCLA Services
  Northeast Regional Manager
  Mid-continent Operating Officer
  Rocky Mountain Regional Manager
  Principal in Charge - Denver Office
  Associate in Charge - Denver Office

  Hydrogeology group manager
  Project geological engineer and Rock mechanics supervisor

  Project geologist and Assistant project manager
1978 - 1979: Colorado School of Mines
    Research assistant

1977 - 1978: Kennicott Copper Co./Bear Creek Mining Co.
    Assistant geologist

1976 - 1977 Lane County Community College
    Mathematics Instructor

COMMUNITY SERVICE

Former Member - Jefferson County, Colorado Planning Commission (member and former
    Chairman [twice] and Vice-Chairman [twice] 1994 - 2004)

AFFILIATIONS AND MEMBERSHIPS

American Society of Civil Engineers
Association of Groundwater Scientist and Engineers

PUBLICATIONS

1995    Weaver, Jeffrey, D., Digel, Robert, K., and Rosasco, Paul V., Performance of a Post-
    audit of Groundwater Flow Models Used in Design of a Groundwater Capture/Containment
    System, in Symposium on Subsurface Fluid Flow (Ground-Water) Model, American Society for
    Testing and Materials.

1985    Rosasco, Paul, V., Geometric Continuity of Structural Discontinuities, CSM-ONWI
    Test Site, Idaho Springs, Colorado. Masters of Engineering report, Colorado School of Mines,
    Golden, Colorado.

1984    Rosasco, Paul, V. and Curry, John, A Cooperative Agreement to Investigate and
    Remedy Chemical Contamination at the Boulder/Marshall Landfills, Colorado. Prepared for the
Mr. Jelinek has over 34 years of experience specializing in engineering alternatives evaluations, cost estimating, and designs for groundwater and soil remediation and water/wastewater treatment systems projects. He has been involved both in technical and managerial positions on a wide range of engineering projects. Mr. Jelinek formerly managed the corporate-wide Remedial Design Center for a major consulting firm. In this role, he provided oversight, design review, value engineering review, and quality control (QC) review of all remedial design projects world-wide. In addition, he served as a lead author for their Design Procedures Manual and prepared the company's standard technical specifications and standard drawings.

Mr. Jelinek has prepared CERCLA feasibility studies (FS) and Engineering Evaluation/Cost Analyses (EE/CAs) as well as RCRA corrective measures studies (CMS). He has prepared engineering design evaluations; remedial action plans; drawings and specifications for construction of remedial actions and removal actions as well as water and wastewater treatment facilities for industrial and municipal application; construction quality assurance plans; facilities plans; construction cost estimates, and scheduling. He is also experienced in bench- and pilot-scale treatability studies, water and sewer utility rate studies, plans of operation, operation and maintenance (O&M) manuals, industrial pretreatment evaluations and program development, sewer use ordinances, water quality evaluations, and infiltration/inflow analyses.

Mr. Jelinek has conducted process, civil, and mechanical design and design review for metals and other inorganics, VOC, semivolatile organic compound (SVOC), and radionuclide removal, as well as side-stream and sludge treatment facilities at industrial, military, and municipal sites. He has experience at 40 hazardous waste sites and on 24 industrial or municipal water/wastewater-related projects and has provided regulatory interface, management of multiple-client relationships, project management, engineering services during construction at both contaminated and uncontaminated sites, and onsite inspection/construction management.

EDUCATION

M.S., Environmental Engineering, University of Colorado - Boulder, 1979
B.S., Civil Engineering, Lehigh University, Pennsylvania, 1978

REGISTRATIONS

Registered Professional Engineer in Colorado, Texas, New Jersey, New York, Pennsylvania, and Illinois

EMPLOYMENT HISTORY

1996-Present        Engineering Management Support, Inc.
                   Vice President and Principal Engineer

1989-1996        Harding Lawson Associates
                   Vice President
                   Manager of the corporate-wide remedial design center and chief engineer. 
                   Responsible for preparation and QC review of all drawings and specifications
for construction of ground water and soil remedies at contaminated sites. Also preparation of O&M manuals. Responsible for coordination of designs of three internal Remedial Construction Divisions.

Principal Engineer
Project manager for large remedial action projects. Deputy Program Manager for $40M of remedial investigation, endangerment assessment, feasibility study, remedial design, and remedial action programs at the Rocky Mountain Arsenal. Company-wide resource for remedy conceptualization and implementation.

Associate Engineer
Manager of engineering group. Prepared CERCLA feasibility studies and RCRA Corrective Measures Studies, bench and pilot-scale hazardous waste treatability studies, and remedial designs. Project Manager for several design and design/build projects. Also provided engineering services during construction.

Managed industrial and municipal water and wastewater conveyance, treatment and residuals disposal engineering projects, including facility audits, evaluations, design, and engineering services during construction under the CWA. Designed water and wastewater treatment, distribution, and storage facilities. Also served as Town Engineer.

1980-1983  Project Engineer, Henningson, Durham & Richardson (HDR)
Prepared drawings and specifications for construction of expansions to numerous municipal wastewater treatment facilities in Colorado and Wyoming under the CWA. Also developed industrial pretreatment programs and prepared utility rate studies.

1978-1979  Research Associate, Union Carbide Corporation
Operated pilot-scale ion exchange tertiary treatment systems for conversion of municipal wastewater to potable water (through the University of Colorado at Boulder).

1974-1978  Field Engineer, Stearns & Wheler Engineers
Conducted several sanitary and combined sewer system infiltration/inflow and sewer system evaluation surveys. Prepared 201 Facilities Plans under the Clean Water Act.

AFFILIATIONS AND MEMBERSHIPS

American Water Works Association
Water Environment Federation (formerly Water Pollution Control Federation), Rocky Mountain Section (Colorado, New Mexico, and Wyoming)-President, 1990-91

PUBLICATIONS AND PRESENTATIONS

1994. Field optimization of groundwater extraction and recharge: Design reevaluation during system construction and startup, Rocky Mountain Arsenal. Presented at the National


Resume

David A. Glater, P.E., C.P.G.
Principal Engineer

Mr. Glater has over 30 years of experience in geological engineering. He joined CTL|Thompson, Inc. in 1997 and currently serves as a Principal Engineer based in our Denver branch office. He is responsible for client service, project engineering, technical review, and the supervision of staff professionals related to geotechnical and geological engineering studies. Mr. Glater’s expertise in engineering and staff supervision includes small to large buildings, parks and recreational structures, infrastructure, planned residential developments, commercial and industrial developments and mines. His career encompasses diverse skills in engineering, staff management, and project management.

Mr. Glater’s knowledge and background includes work on deep, drilled pier foundations, geotechnical hazards, engineered fills, soil improvement, construction material recycling, pavements and floor slabs on expansive soils, and soil-related structure damage forensics. He has also been published in several industry publications and served as president for the Colorado Association of Geotechnical Engineers.

**Educaiton**

- B.S., Geological Engineering
- Colorado School of Mines, 1977

**Professional Registration**

- Registered Professional Engineer
- Colorado No. 20204
- Registered Professional Engineer
- Kansas No. 18321
- Registered Professional Geologist
- Wyoming No. 3508

**Professional Societies**

- American Society of Civil Engineers
- Association of Engineering Geologists
- American Institute of Professional Geologists, C.P.G. No. 6583
- Colorado Association of Geotechnical Engineers, Past President

**Project Experience**

- Fortune Dam, Arvada, Colorado
  Geological Engineer

- 6th Avenue West Estates, Jefferson County, Colorado
  Project Manager and Geological Engineer

- Castle Pines North, Douglas County, Colorado
  Project Manager

- Castlewood Ranch Subdivision, Castle Rock, Colorado
  Project Manager

- University of Colorado Williams Village Bear Creek Apartments, Boulder, Colorado
  Project Manager

- The Canyons South, Douglas County, Colorado
  Project Manager
RONALD K. FROBEL, MSCE, P.E.

CIVIL ENGINEERING
GEOSYNTHETICS
EXPERT WITNESS
FORENSICS

FIRM: R. K. FROBEL & ASSOCIATES
Consulting Civil / Geosynthetics Engineers

TITLE: Principal and Owner

PROFESSIONAL AFFILIATIONS:

American Society for Testing and Materials (ASTM) -
  Founding member of Committee D 35 on Geosynthetics
  Chairman ASTM D35 Subcommittee on Geomembranes 1985-2000
ASTM Award of Merit Recipient/ASTM Fellow - 1992
ASTM D18 Soil and Rock - Special Service Award - 2000
Transportation Research Board (TRB) of The National Academies
  Appointed Member A2K07 Geosynthetics 2000 - 2003
National Society of Professional Engineers (NSPE) - Member
American Society of Civil Engineers (ASCE) - Member
Colorado Section - ASCE - Member
International Society of Soil Mechanics and Foundation Engineers
  (ISSMFE) - Member
International Geosynthetics Society (IGS) - Member
North American Geosynthetics Society (NAGS) - Member
International Standards Organization (ISO) - Member TC 221
  Team Leader - USA Delegation Geosynthetics 1985 - 2001
European Committee for Standardization (CEN) - USA Observer
EPA Advisory Committee on Geosynthetics (Past Member)
Association of State Dam Safety Officials (ASDSO) – Member
U. S. Committee on Irrigation and Drainage (USCID) - Member
Technical Advisory Committee - Geosynthetics Magazine
  Editorial Board - Geotextiles and Geomembranes Journal
  Editorial Board - Geotechnical Testing Journal (ASTM)
Co-Chairman International Conference on Geomembranes
Co-Chairman ASTM Symposium on Impermeable Barriers
U.S. Naval Reserve Officer (Inactive)
Registered Professional Engineer – Civil (Colorado)
Mine Safety Health Administration (MSHA) Certified

ACADEMIC BACKGROUND:

University of Arizona: M.S. - Civil Engineering - 1975
University of Arizona: B. S. - Civil Engineering - 1969
Wentworth Institute of Technology: A.S. Architecture – 1966
PROFESSIONAL EXPERIENCE:

R. K. Frobel & Associates - Consulting Engineers
Evergreen, Colorado, Principal and Owner, 1988 - Present

Chemie Linz AG and Polyfelt Ges.m.b.H., Linz, Austria

U.S. Bureau of Reclamation, Engineering and Research Center

Water Resources Research Center (WRRC), University of Arizona
Tucson, AZ, Associate Research Engineer, 1975 - 1978

Engineering Experiment Station, University of Arizona
Tucson, AZ, Research Assistant, 1974 - 1975

United States Navy, Commissioned Naval Officer, 1970 - 1973

REPRESENTATIVE EXPERIENCE:

R. K. Frobel & Associates: Civil engineering firm specializing in the fields of geotechnical, geoenvironmental and geosynthetics. Expertise is provided to full service civil/geotechnical engineering firms, federal agencies, municipalities or owners on a direct contract, joint venture or sub-consultant basis. Responsibilities are primarily devoted to specialized technical assistance in design and application for foreign and domestic projects such as the following: Forensics investigations into geotechnical and geosynthetics failures; providing expert report and testimony on failure analysis; providing design and peer review on landfill lining and cover system design, mine waste reclamation, water treatment facilities, hydro-technical canal, dam, reservoir and mining projects, floating reservoir covers; oil and gas waste containment; design of manufacturers technical literature and manuals; development and presentation of technical seminars; new product development and testing; MQA/CQA program design and implementation.

Polyfelt Ges.m.b.H., Linz, Austria and Denver Colorado: As U.S. technical manager, primary responsibilities included technical development for the Polyfelt line of geosynthetics for the U.S. civil engineering market as well as world wide applications.
U.S. Bureau of Reclamation, Denver, Colorado: As technical specialist, responsibilities included directing laboratory research, design and development investigations into geosynthetics and construction materials for use on large western water projects such as dams, canals, power plants and other civil structures. Included were material research, selection and testing, specification writing, large scale pilot test programs, MQA/CQA program design and supervision of site installations. Prime author or contributor to several USBR technical publications incorporating geosynthetics.

University of Arizona, Tucson, Arizona: As research engineer at the Water Resources Research Center, responsibilities included research, design and development of engineering materials and methods for use in construction of major water projects including potable water reservoirs, canals and distribution systems. Prime author or contributor to several WRRC technical publications.

Northeast Utilities, Hartford, Connecticut: As field engineer for construction at Northeast Utilities, responsibilities included liaison for many construction projects including additions to power plants, construction of substations, erection of fuel oil pipe lines and fuel oil storage tanks. Responsibilities also included detailed review, inspection and reporting on numerous construction projects.

U.S. Navy: Commissioned Naval Officer – Nuclear Program

PUBLICATIONS: Over 85 published articles, papers and books.

CONTACT DETAILS:

Ronald K. Frobel, MSCE, P.E.
R. K. Frobel & Associates
Consulting Civil/Geosynthetics Engineers
32156 Castle Court
Suite 211/M240
Evergreen, Colorado 80439 USA
Ph 303-679-0285
M 720-289-0300
Email: geosynthetics@msn.com
NICK FISCHER

PROFESSIONAL EXPERIENCE

AQUIFER TECHNOLOGY
Environmental Engineer
Denver, CO/Clovis, NM
 Designing remediation systems including construction supervision, overseeing equipment installation and startup, and conducting the operation and maintenance of those systems.
 Conducting asbestos and mold surveys.
 Completing quarterly reports for PRPs, impacted property owners, legal counsel, and state/federal agencies.
 Industrial plant operator for treatment facilities in Colorado.
 Completed acid mine drainage and waste stabilization studies for the Bureau of Reclamation.
 Providing emergency response oversight for highway spills, collecting soil / groundwater samples, and providing cleanup documentation to CDOT and CDPHE.
 Conducting Phase I and II ESAs.
 Oversight of underground storage tank (UST) removals and cleanups.

HIGGINS AND ASSOCIATES, LLC
Environmental Denver, CO
 Project manager for oil and gas remediation facilities.
 Performed Phase I & II ESAs, UST removals / investigations / remediation, and asbestos surveys.

TERRACON
Environmental Engineer
Denver, CO
 Performed Phase I & II ESAs, UST removals, Risk Management Plans, and site investigations and remediation.

TEXAS EMPLOYERS INSURANCE ASSOCIATION
Safety Engineer
Denver, CO
 Performed safety inspections at industrial facilities and construction sites.

EDUCATION/CERTIFICATIONS

B.S. Chemical Engineering, New Mexico State University
Environmental Masters Courses CSU, UCD
OPS Registered Consultant # 5419
Senior Corrosion Technologist, NACE #3682
EPA-Approved AHERA Asbestos Building Inspector and Colorado State Certification
Industrial Plant Operator “A” 1960
Water Plant Operator “C” # 3030
Waste Water Plant Operator “D” # 7437
OSHA Hazardous Operations Training (both 40-hour and 8-hour refreshers)
Health Care Provider
Appendix B

Summary of Known Environmental Conditions

- Waste Material
- Groundwater
- Soil Gas
WASTE MATERIAL
Figure 12
Arsenic Soil Sample Concentrations
5 to 10 feet
VB/I-70 Remedial Investigation

Legend
- 2008 Drilling
- BH Soil Samples
- Barn Samples
- MW Holes
- Pepsi Area 3 Soil Samples
- O&O Samples
- Pepsi Area 5 Soil Samples
- SB Soil Samples
- Pepsi Area 6 Soil Samples
- CDOT Holes
- BB-BB-xx Holes
- Pepsi UT (Utility Trench) Soil Locations

As concentrations exceeding 15 ppm background limit (red)
Depth (ft) - Concentration (ppm)
Figure 11
Lead Soil Sample Concentrations
0 to 5 feet
VB/I-70 Remedial Investigation
EMSI Engineering Support Management, Inc.
Figure 15
Lead Soil Sample Concentrations
10 feet and Greater Depth
VB/I-70 Remedial Investigation

Pb concentrations exceeding 400 ppm background limit (red)
Depth (ft) - Concentration (ppm)
FIGURE 2 - SOIL SAMPLE EXCEEDANCES

CITY AND COUNTY OF DENVER

LEGEND

SOIL AND GROUNDWATER SAMPLE LOCATION

EXISTING MONITORING WELL LOCATION

CSEV COLORADO SOIL EVALUATION VALUES

mg/kg MILLIGRAMS PER KILOGRAM

REFERENCE STANDARD TABLE

CONSTITUENT CSEV EXCEEDANCE (mg/kg)

Benzo(a)anthracene 3.9
Benzo(a)pyrene 0.39
Benzo(b)fluoranthene 3.9
Dibenzo(a,h)anthracene 0.39
Indeno(1,2,3-cd)pyrene 3.9
Arsenic 1.6

BOLD RED TEXT INDICATES EXCEEDANCE

TABLE

CONSTITUENT WORKER CSEV EXCEEDANCE (mg/kg)

Benzo(a)anthracene <0.0069
Benzo(a)pyrene <0.0069
Benzo(b)fluoranthene <0.0069
Dibenzo(a,h)anthracene <0.0069
Indeno(1,2,3-cd)pyrene <0.0069
Arsenic <2.1

HS-01
Benzo(a)anthracene <0.0076
Benzo(a)pyrene 0.0054
Benzo(b)fluoranthene 0.0064
Dibenzo(a,h)anthracene <0.0076
Indeno(1,2,3-cd)pyrene <0.0076
Arsenic 3.5

HS-02
Benzo(a)anthracene 0.688
Benzo(a)pyrene 0.625
Benzo(b)fluoranthene 0.599
Dibenzo(a,h)anthracene 0.155
Indeno(1,2,3-cd)pyrene 0.358
Arsenic 3.7

HS-03
Benzo(a)anthracene <0.0074
Benzo(a)pyrene <0.0074
Benzo(b)fluoranthene <0.0074
Dibenzo(a,h)anthracene <0.0074
Indeno(1,2,3-cd)pyrene <0.0074
Arsenic <2.1

HS-04
Benzo(a)anthracene <0.0071
Benzo(a)pyrene <0.0071
Benzo(b)fluoranthene <0.0071
Dibenzo(a,h)anthracene <0.0071
Indeno(1,2,3-cd)pyrene <0.0071
Arsenic <2.1

HS-05
Benzo(a)anthracene <0.008
Benzo(a)pyrene <0.008
Benzo(b)fluoranthene <0.008
Dibenzo(a,h)anthracene <0.008
Indeno(1,2,3-cd)pyrene <0.008
Arsenic <2.4

HS-06
Benzo(a)anthracene 0.0441
Benzo(a)pyrene 0.0423
Benzo(b)fluoranthene 0.0431
Dibenzo(a,h)anthracene 0.0054
Indeno(1,2,3-cd)pyrene 0.023
Arsenic 4.3

HS-07
Benzo(a)anthracene <0.0068
Benzo(a)pyrene <0.0068
Benzo(b)fluoranthene <0.0068
Dibenzo(a,h)anthracene <0.0068
Indeno(1,2,3-cd)pyrene <0.0068
Arsenic <1.9

HS-08
Benzo(a)anthracene 1.45
Benzo(a)pyrene 1.65
Benzo(b)fluoranthene 1.55
Dibenzo(a,h)anthracene 0.267
Indeno(1,2,3-cd)pyrene 0.936

HS-09
Stormwater Sewer Alignment

LEGEND:

HS-01 SOIL AND GROUNDWATER SAMPLE LOCATION INSTALLED BY BROWN AND CALDWELL 2010
MW-1 SOIL AND GROUNDWATER SAMPLE LOCATION INSTALLED AS PART OF VB/170 OU2 ASSESSMENTS
MW-1 CTL MONITORING WELL LOCATION
5170 EXISTING GROUND SURFACE ELEVATION (FEET)

NOTES: RESULTS PRESENTED IN mg/kg MILLIGRAMS/KILOGRAM
TCLP LEAD RESULTS PRESENTED IN mg/L MILLIGRAMS/LITER

Summary of Soil Sample Results
FIGURE 3  GROUNDWATER SAMPLE EXCEEDANCES

CITY AND COUNTY OF DENVER

LEGEND
SOIL AND GROUNDWATER SAMPLE LOCATION
EXISTING MONITORING WELL LOCATION
CDPHE COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT, REGULATION 41, BASIC STANDARDS FOR GROUNDWATER

(Mg/L) MICROGRAMS PER LITER

REFERENCE STANDARD TABLE

<table>
<thead>
<tr>
<th>CONSTITUENT</th>
<th>CDPHE EXCEEDANCE (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>3.5</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>5</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>5</td>
</tr>
<tr>
<td>Cadmium</td>
<td>5</td>
</tr>
</tbody>
</table>

BOLD BLUE TEXT INDICATES EXCEEDANCE

HIGH STREET STORM DRAINAGE PROJECT

MW-1
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>12.7</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>4.6</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

HS-1
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>24.8</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>5.8</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

HS-01
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

HS-08
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

HS-05
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>2.9</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

HS-07
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>0.73</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

HS-02
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>1.1</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>1.0</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

HS-06
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>6.0</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>109</td>
</tr>
</tbody>
</table>

HS-04
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>2.1</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

HS-03
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>3.1</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>2.8</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>18.2</td>
</tr>
</tbody>
</table>

HS-07
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>2.1</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

MW-6
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>2.1</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

MW-6
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>2.1</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>
LEGEND:

HS-01 SOIL AND GROUNDWATER
  ○ SAMPLE LOCATION
  INSTALLED BY BROWN AND
  CALDWELL 2010

MW-1 SOIL AND GROUNDWATER
  ◦ SAMPLE LOCATION INSTALLED
  AS PART OF V6/L-70 OU2
  ASSESSMENTS

MW-1 CTL MONITORING WELL
  ◦ LOCATION

5170 EXISTING GROUND
  SURFACE ELEVATION (FEET)

NOTES:

(5185.96) APPROXIMATE GROUND
  WATER ELEVATIONS
  MEASURED APRIL 5, 2011

Ground Water
Elevations  Fig. 5
SOIL GAS
Appendix C

Sampling and Analysis Plan

- Field Sampling Plan
- Quality Assurance Project Plan
- Records Management Plan
Appendix C
Design Investigation
Sampling and Analysis Plan

For the

Removal Action
High Street Outfall and 40th Avenue
Storm Sewer System

Vasquez Boulevard/Interstate 70 Site,
Operable Unit #2

Prepared for:

City and County of Denver
Environmental Quality Division
200 West 14th Ave, Suite 310
Denver, Colorado 80204

Prepared by:

Engineering Management Support, Inc.
7220 W. Jefferson Ave., Suite 406
Lakewood, Colorado 80235

June 19, 2015

REVIEWED AND APPROVED BY:

USEPA Remedial Project Manager
and Quality Assurance Reviewer: ______________________     ____________
Dania Zinner             Date
# TABLE OF CONTENTS

1 INTRODUCTION .................................................................................................................. 1  
2 PURPOSE AND OBJECTIVES .............................................................................................. 2  
3 DATA ANALYSIS, INTERPRETATION, AND REPORTING .................................................... 4  

APPENDICES

- Appendix C-1  Field Sampling Plan  
- Appendix C-2  Quality Assurance Project Plan  
- Appendix C-3  Records Management Plan
### LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACM</td>
<td>Asbestos-Containing Material</td>
</tr>
<tr>
<td>COC</td>
<td>Compound of Concern</td>
</tr>
<tr>
<td>DADS</td>
<td>Denver Arapahoe Disposal Site</td>
</tr>
<tr>
<td>DVRs</td>
<td>Data Validation Reports</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>FSP</td>
<td>Field Sampling Plan</td>
</tr>
<tr>
<td>PAHs</td>
<td>Polynuclear-aromatic Hydrocarbons</td>
</tr>
<tr>
<td>OU-2</td>
<td>Operable Unit #2</td>
</tr>
<tr>
<td>QA/QC</td>
<td>Quality Assurance/Quality Control</td>
</tr>
<tr>
<td>QAPP</td>
<td>Quality Assurance Project Plan</td>
</tr>
<tr>
<td>RAWP</td>
<td>Response Action Work Plan</td>
</tr>
<tr>
<td>RMP</td>
<td>Records Management Plan</td>
</tr>
<tr>
<td>SAP</td>
<td>Sampling and Analysis Plan</td>
</tr>
<tr>
<td>TCLP</td>
<td>Toxicity Characteristic Leaching Procedure</td>
</tr>
<tr>
<td>VOCs</td>
<td>Volatile Organic Compounds</td>
</tr>
</tbody>
</table>
1 INTRODUCTION

This Sampling and Analysis Plan (SAP) presents the purpose, objectives, and procedures for a sampling, laboratory analysis, and quality assurance/quality control (QA/QC) program for a Design Investigation that supports design and implementation of the “environmental components” of the barrier system associated with an open channel stormwater drainage structure planned to pass through and downstream of Operable Unit 2 (OU-2) of the Vasquez Boulevard/Interstate 70 (VB/I-70) Superfund Site. The “environmental components” of the barrier system are described in Section 1.1 of the Removal Action Work Plan (RAWP). Available Site Characterization information is presented in Section 2 of the RAWP. To avoid redundancy with the RAWP, reference is made to these two Sections of the RAWP for pertinent information. This SAP is Appendix C to the RAWP.

In accordance with EPA’s Guidance for Conducting Remedial Investigations/Feasibility Studies Under CERCLA (USEPA, 1988), and for consistency with EPA’s Quality Assurance requirements, this SAP consists of three parts. The first part is the Field Sampling Plan (FSP) that provides guidance for fieldwork by defining in detail the sampling and data-gathering methods to be used during the Design Investigation. The FSP is incorporated into this SAP as Appendix C-1. The second part is the Quality Assurance Project Plan (QAPP) that describes the policy, organization, functional activities, and quality assurance and quality control protocols that are necessary to achieve the objectives dictated by the intended use of the data collected during the Design Investigation. The QAPP is incorporated into this SAP as Appendix C-2. The third part is the Records Management Plan (RMP) that presents the approach, methods, and procedures for managing field data, design information, and project documents that are generated during design and implementation of the Removal Action. The RMP is incorporated into this SAP as Appendix C-3.

This SAP contains five sections, including this introduction. The purpose and objectives of the Design Investigation are discussed in Section 2. Data analysis, interpretation, and reporting are described in Section 3. A schedule for the investigation is provided in Section 4. Section 5 includes a list of references. As indicated above, The FSP, QAPP, and RMP are included as Appendices C-1, C-2, and C-3, respectively.
2 PURPOSE AND OBJECTIVES

As discussed in the RAWP, the purpose of the Design Investigation is to:

- Better characterize subsurface conditions through which the barrier system will be constructed;
- Provide information to better estimate the quantity and quality of waste material that will need to be removed;
- Better estimate the quality of groundwater that may be encountered during barrier system construction; and
- Assess the presence of and quality of soil gas that may need to be mitigated during construction.

Therefore, the specific objectives of the Design Investigation are to:

- Determine the areal extent and depth of waste material along the footprint of the proposed barrier system alignment;
- Sufficiently characterize the waste material for offsite disposal. Non-hazardous, solid waste disposal at the Denver Arapahoe Disposal Site (DADS) will require demonstration that the material will pass RCRA characteristic screens for ignitability, corrosivity, reactivity (cyanide and sulfide screen), oxidizers, and paint filter test, and TCLP toxicity for VOCs, PAHs, lead, and arsenic. In addition, samples that might visually appear to contain asbestos will be assessed for friable asbestos;
- Determine the potentiometric surface of groundwater beneath and adjacent to the barrier system;
- Characterize the quality of groundwater that may be encountered during construction to determine the need for and type of treatment required during construction; and
- Assess the methane and total VOC concentrations of soil gas that may be encountered during excavation and materials handling.

In general, the Design Investigation will consist of the following tasks:

- Surveying;
- Utility clearance;
• Advancement of soil borings while monitoring for soil gas;

• Collection of waste material from the soil borings for visual and chemical characterization;

• Off-site laboratory analyses of waste material;

• Installation of temporary piezometers in the boreholes;

• Measurement of groundwater levels and collection of groundwater samples;

• Off-site laboratory analyses of groundwater samples;

• Validation of laboratory analytical results;

• Data analysis and interpretation; and

• Report preparation.

Field sampling procedures and laboratory analytical methods are described in the FSP (Appendix C-1). Data validation procedures are described in the QAPP (Appendix C-2).
3 DATA ANALYSIS, INTERPRETATION, AND REPORTING

After the field activities are completed and laboratory analytical data received, a Data Summary Report will be prepared. The report will document the methodologies used and address results from the investigation. It is anticipated that the report will include:

- Boring logs;
- Field data sheets for each sample location;
- Photographs of waste material/soil cores and samples;
- Laboratory analytical results from solid and liquid samples, ACM testing results, and landfill gas field monitoring results. This will include laboratory data reports and an MSAccess database of the results;
- Data validation reports (DVRs) for the analytical results;
- Groundwater elevation data and potentiometric surface maps;
- Estimates of the quantity and quality of waste material that would need to be removed to construct and protect the barrier system;
- Estimates of the quality of groundwater that may be encountered during dewatering and a determination of the need for and type of treatment that would be required to satisfy discharge requirements; and
- An assessment as to whether soil gas may need to be mitigated during construction.

It is anticipated that the Data Summary Report will be organized as follows:

1. Introduction (purpose, Site background, report organization)
2. Design Investigation Activities (description of field activities and methodologies)
3. Design Investigation Results (results of investigation and evaluation and presentation of data)
4. Conclusions and Recommendations

Appendix A – Boring Logs, Field Data Sheets, and Photographs
Appendix B – Analytical Data and QA/QC Evaluation Results

All field and laboratory data, field records, technical evaluations, correspondence, and the Data Summary Report will be managed in accordance with the RMP (Appendix C).
4 SCHEDULE

A schedule for performance of the field work, offsite analytical and geotechnical testing, data validation, and preparation of the Data Summary Report is presented in Figure 7 of the RAWP.
REFERENCES

Appendix C-1

Field Sampling Plan
TABLE OF CONTENTS

1 INTRODUCTION ............................................................................................................ 1
2 SAMPLING OBJECTIVES................................................................................................ 2
3 SAMPLE LOCATIONS, FREQUENCY, AND DESCRIPTION ........................................... 3
   3.1 Sample Locations ........................................................................................................ 3
   3.2 Sample Frequency ....................................................................................................... 4
   3.3 Sample Description ..................................................................................................... 4
   3.4 Sample Importance .................................................................................................... 4
4 SAMPLING PROCEDURES AND EQUIPMENT .............................................................. 5
   4.1 Health and Safety ......................................................................................................... 5
   4.2 Surveying of Boring Locations and Utility Clearance ........................................... 5
   4.3 Borehole Drilling and Logging .................................................................................... 5
   4.4 Solids Sampling ........................................................................................................... 6
   4.5 Sampling of Suspected ACM ...................................................................................... 7
   4.6 Piezometer Construction ............................................................................................ 8
   4.7 Water Level Measurements ......................................................................................... 8
   4.8 Groundwater Sampling ................................................................................................ 9
   4.9 Soil Gas Monitoring .................................................................................................... 9
   4.10 Decontamination and Investigative Derived Waste (IDW) Management .............. 10
   4.11 Borehole/Piezometer Abandonment ...................................................................... 10
5 SAMPLE HANDLING AND ANALYSIS ....................................................................... 11
   5.1 Sample Handling ....................................................................................................... 11
   5.2 Sample Analysis ........................................................................................................ 12
6 QUALITY ASSURANCE/QUALITY CONTROL .............................................................. 13
   6.1 Field Quality Control ................................................................................................. 13
   6.2 Quality Control Samples ........................................................................................... 13
7 DOCUMENTATION ........................................................................................................ 15
   7.1 Field Notebook .......................................................................................................... 15
   7.2 Borehole Log ............................................................................................................. 15
   7.3 Groundwater Sampling Sheet .................................................................................... 15
   7.4 Direct Reading Instrument Form ............................................................................... 15
   7.5 Chain-of-Custody Form ............................................................................................. 15

LIST OF TABLES

Table C-1A: Anticipated Number and Type of Samples
Table C-1B: Sample Quantities, Preservation Requirements, and Holding Times
Table C-1C: Waste Characterization Field Screening Procedures

LIST OF FIGURES

Figure C-1A: Proposed Borehole Locations
Figure C-1B: Existing Groundwater Monitoring Well Locations
Figure C-1C: Borehole Log Form
Figure C-1D: Groundwater Sampling Field Data Sheet
Figure C-1E: Direct Reading Instrument Data Sheet
LIST OF ACRONYMS

ACM   Asbestos-Containing Material
AHERA  Asbestos Hazard Emergency Response Act
AIHA   American Industrial Hygiene Association
bgs   Below ground surface
COC   Compound of Concern
DOT   Department of Transportation
EMSI   Engineering Management Support, Inc.
EPA   Environmental Protection Agency
FSP   Field Sampling Plan
HASP  Health and Safety Plan
IDW   Investigative-Derived Waste
LEL   Lower Explosive Limit
MMP   Materials Management Plan
MS/MSD  Matrix Spike/Matrix Spike Duplicate
ORP   Oxidation Reduction Potential
PAHs  Polynuclear-aromatic Hydrocarbons
% v/v  percent by volume
PID   Photo-ionization Detector
PLV   Polarized Light Microscopy
PVC   Poly-vinyl chloride
OU-2   Operable Unit #2
QAPP  Quality Assurance Project Plan
RAWP  Response Action Work Plan
SAP   Sampling and Analysis Plan
SPT   Standard Penetration Test
SWDI  Stormwater Design Investigation
TCLP  Toxicity Characteristic Leaching Procedure
TSDF  Treatment, Storage, and Disposal Facility
TSP   Tri-sodium Phosphate
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNCC</td>
<td>Utility Notification Center of Colorado</td>
</tr>
<tr>
<td>VAE</td>
<td>Visual Area Estimation</td>
</tr>
<tr>
<td>VOCs</td>
<td>Volatile Organic Compounds</td>
</tr>
</tbody>
</table>
1 INTRODUCTION

This Field Sampling Plan (FSP) presents the technical approach, methods, and procedures for a Design Investigation that supports design and implementation of the “environmental components” of an open channel stormwater drainage structure planned for Operable Unit 2 (OU-2) of the Vasquez Boulevard/Interstate 70 (VB/I-70) Superfund Site. Quality assurance measures related to field and laboratory activities conducted during the Design Investigation are described in the companion document to this FSP, the Quality Assurance Project Plan (QAPP). Together, this FSP and QAPP present the details of the field sampling and laboratory analytical and testing programs generally discussed the Sampling and Analysis Plan (SAP).

This FSP is organized as follows.

• Section 2 – Sampling Objectives
• Section 3 – Sample Location, Frequency, and Description
• Section 4 – Sampling Procedures and Equipment
• Section 5 – Sample Handling and Analyses
• Section 6 – Quality Assurance/Quality Control (refer to QAPP)
• Section 7 – Documentation
2 SAMPLING OBJECTIVES

Sampling objectives listed in Section 2 of the SAP are reiterated below:

- Determine the areal extent and depth of waste material along the footprint of the proposed barrier system alignment;

- Sufficiently characterize the waste material for offsite disposal. Non-hazardous, solid waste disposal at the Denver Arapahoe Disposal Site (DADS) will require demonstration that the material will pass RCRA characteristic screens for ignitability, corrosivity, reactivity (cyanide and sulfide screen), oxidizers, and paint filter test, and TCLP toxicity for VOCs, PAHs, lead, and arsenic. In addition, samples that might visually appear to contain asbestos will be assessed for friable asbestos;

- Determine the potentiometric surface of groundwater beneath and adjacent to the barrier system;

- Characterize the quality of groundwater that may be encountered during construction to determine the need for and type of treatment required during construction; and

- Assess the methane and total VOC concentrations of soil gas that may be encountered during excavation and materials handling.
3 SAMPLE LOCATIONS, FREQUENCY, AND DESCRIPTION

3.1 Sample Locations

Samples of waste material will be collected from 14 new borehole locations shown in purple on Figure C-1A. These borings will be in addition to the 10 geotechnical borings shown in green on Figure C-1A that were recently drilled by others to define the depth and thickness of waste material, and to assess geotechnical properties of waste material and underlying soil and bedrock. In addition, the ten geotechnical borings drilled by others have been temporarily cased as piezometers to collect an initial round of groundwater levels. The piezometer casings will be removed in July, 2015 – the approximate timeframe the Respondent will be conducting this Design Investigation. Results from the drilling, sampling, and groundwater level monitoring by others will be shared with Respondent for use by the Respondent in the barrier system design.

Collectively, the 24 borings (14 by Respondent and 10 by others) are located in the study area of the proposed stormwater drainage system. The number and spacings of the 14 new borings is intended to tighten the density of data points in closer proximity to the proposed channel alignment. The new boring locations are general and may be moved if restricted by access or buried utilities, but locations are intended to be within 50 to 200 feet of the centerline of the proposed drainage channel. The new borings will enable collection of RCRA-characterization information for off-site disposal of waste material, for chemical characterization of the waste material for barrier material compatibility, and if necessary, for additional shear and compressive strength testing of in-place material.

Temporary piezometers will be completed in each of the Respondent’s new boreholes after soil samples have been collected. Groundwater levels will be gauged following piezometer construction. In addition, groundwater levels in existing wells MW-1, MW-2, MW-3, CTL MW-4, CTL MW-5, and CTL MW-6 (Figure C-1B) will be gauged. Groundwater samples will be collected from the Respondent’s 14 new piezometers, plus existing wells and CTL MW-4, CTL MW-5, and CTL MW-6.

Monitoring for soil gas will be conducted at each boring location during drilling and sampling of the boreholes as well as at each piezometer/monitoring well during water level measurements and sampling.
3.2 Sample Frequency

The estimated numbers of waste samples, water level measurements, and groundwater samples are provided on Table C-1A.

3.3 Sample Description

It is anticipated that each of the new borings will be numbered with a prefix of SWDI, designating that they were constructed as part of the Storm Water Design Investigation (SWDI). For example: SWDI-12.

Waste material samples will be identified and numbered using a two-part numbering system that consists of the borehole number and the sample depth interval. For example, SWDI-12-4-9 would indicate that the sample was collected from boring SWDI-12 in the 4 to 9-foot depth interval.

A field duplicate sample will be identified by adding a “D” to the end of the boring number. For example, SWDI-12-4-9D would be a duplicate sample of the above sample.

Waste samples that are suspected of containing ACM will be labeled with an ACM suffix. For example: SWDI-12-4-9-ACM

The temporary piezometers will be designated with the same number as the borehole in which they are completed. Therefore, a groundwater sample collected from temporary piezometer SWDI-12 would be labeled SWDI-12. If the sample is filtered, the letter “F” will be added to the end of the sample number (e.g., SWDI-16F). A field duplicate of the filtered groundwater sample will be identified by adding a “D” to the end of the sample number (e.g., SWDI-16FD).

3.4 Sample Importance

Collection of all of the samples proposed in this FSP is important to establish a technically sound basis of design for this Removal Action. Specifically, the study area is underlain by a heterogeneous mixture of waste material, so variability of material type, depth, width, stability, and constituents will impact the basis of design for excavation and barrier construction. Similarly, variability in groundwater quality will impact the type of water treatment and/or offsite disposal required. Consequently, a high level of effort should be devoted to collect all of the field and laboratory data proposed in this FSP.
4 SAMPLING PROCEDURES AND EQUIPMENT

Procedures and equipment for utility clearance, surveying, borehole drilling and waste sampling, construction of temporary piezometers, gauging water levels, groundwater sampling, soil gas monitoring, decontamination and management of investigative derived waste, and borehole/piezometer abandonment are discussed in this section.

4.1 Health and Safety

Prior to performance of any field activities, all project personnel shall have read, understood, and agreed to comply with provisions of the Health and Safety Plan (HASP) (RAWP, Appendix E) for the design investigation. All design investigation activities will be conducted in accordance with the HASP. Necessary safety equipment will be readily available at the Site at all times during on-Site activities and will meet the requirements of NIOSH/OSHA. Use, maintenance, care, and calibration (if applicable) will be documented in the field logbook on a daily basis. All work will cease whenever health and safety requirements are not followed or if environmental conditions deteriorate to work cessation levels indicated in the HASP.

4.2 Surveying of Boring Locations and Utility Clearance

Prior to borehole drilling and sampling, the proposed boreholes will be located by a licensed surveyor and representative of EMSI. Locations of proposed borings will be marked on the pavement with spray paint, and in vegetated areas, with painted stakes. After locating the boreholes, the Utility Notification Center of Colorado (UNCC) [call 811], the Denver Wastewater Management Division https://www.denvergov.org/wastewatermanagement/WastewaterManagement/EngineeringandPermits/UndergroundUtility/tabid/440517/Default.aspx and the Metro Wastewater Reclamation District http://www.metrowastewater.com/know/PublicOutreach/Pages/utilitylocate.aspx will be contacted to conduct a utility locates and to clear the borehole locations prior to the start of drilling. If the location of a borehole is found to be within 10 feet of a utility corridor, then the borehole location will be moved to avoid potential impacts to the utility line. Of particular concern is the location of two existing large diameter sanitary sewer lines that transverse beneath the proposed stormwater drainage structure alignment (Figure C-1A).

4.3 Borehole Drilling and Logging

All boreholes will be drilled using 6.25” out-side diameter and 3.25” inside diameter hollow-stem augers. The drill rig will be equipped with a 140-pound standard penetration test (SPT) pneumatic hammer and 1.5-ft long California split-barrel samplers.
Barrel samples will be collected at 5-foot intervals beginning at five feet below ground surface (bgs). SPT blow counts for each sample will be collected. Between sampling intervals, drill cuttings and rig penetration rates will be observed to assess borehole lithology between barrel samples. Boreholes will be drilled through waste material into a minimum of 5-feet of underlying soil, weathered bedrock, or until auger refusal is encountered, whichever occurs first. At that depth, a final barrel sample will be collected.

Core samples retrieved from the boreholes will be logged using the ASTM Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) [ASTM D2488-06]. In addition, the samples will be described using geologic interpretations and observations. For example, the presence and characteristics of waste material, the types of primary and secondary porosity, and other features not included in ASTM procedures will be noted. A photoionization detector (PID) scan and odor observation of the core will be made. All geologic, physical observations, and PID information will be recorded on the borehole log that will be constructed for each borehole. A sample borehole log form is provided as Figure C-1C. Geotechnical information during drilling will also be noted on the log, including blow counts, auger penetration rate, first encounter of water, and other items of interest.

During drilling, the auger-flight collars will be monitored for the presence of organic vapors and explosive gases using a PID and 4-gas meter. The values measured will be recorded on the geologic log.

### 4.4 Solids Sampling

Four types of solids samples will be collected; samples for geotechnical testing (if determined to be necessary following review of the recently-collected geotechnical samples), samples for total chemical constituents, samples for TCLP testing, and samples for ACM testing. Each type is discussed below:

**Geotechnical Testing:** Geotechnical properties required for design include, but are not limited to, material classification, shear strength, moisture content, and swell or consolidation potential. This information is pertinent to the material that will remain in place that will effectively support the barrier system and overlying weight of the stormwater channel and retained groundwater. Therefore, if additional geotechnical samples are determined to be necessary, they will be collected from material that best represents foundation material underlying the barrier system. The number, type, and testing requirements for the samples will be determined in the field with consultation from the Geotechnical Engineer.

**Total Chemical Constituents:** Chemical constituent analyses will be necessary for selection of the barrier material. Accordingly, the sample depth should be immediately below that to which the barrier will be placed, to extent such placement can be estimated. One sample per boring will be collected using the barrel sampler. The sample will be
screened for VOCs in the field, and analyzed for VOCs, PAHs, arsenic, and lead in the laboratory. A sample for each analysis will be placed in containers supplied by the analytical laboratory, the containers will be labeled and placed in a cooler filled with ice, and a chain-of-custody form (Section 7) will be completed. The samples will be delivered over-night to the analytical laboratory. Sample analytical methods, volumes, container types, preservation requirements, and holding times are listed on Table C-1B.

**TCLP Testing:** TCLP testing is necessary to pre-determine how and where excavated waste material will be disposed. Accordingly, the most representative sample type (except for VOCs) will be a vertical composite of the material estimated to be removed from the sample location. Compositing will involve collecting a uniform-size sample from each 5-foot interval sampled, placing each “sub-sample” into a one-time use plastic mixing bowl, and homogenizing them with a one-time use plastic spoon, knife or spatula. The composite sample will then be screened for hazardous characteristics consisting of ignitability, corrosivity, reactivity, oxidizers, and paint filter test in accordance with the procedures listed in Table C-1C. Composite samples for TCLP testing for PAHs and RCRA metals will be placed in jars supplied by the analytical laboratory. Because VOCs should not be composited, a single sample from a barrel interval that exhibits the highest PID reading will be collected and placed in a sample jar supplied by the laboratory and tested for TCLP VOCs.

All filled sample containers will be labeled, placed in a cooler filled with ice, and recorded on a chain-of-custody form (Section 7). The samples will be delivered over-night to the analytical laboratory. Sample quantities, types of container, sample preservation requirements, and holding times are listed on Table C-1B.

**ACM Testing:** Discussed below

### 4.5 Sampling of Suspected ACM

Any borehole cutting or barrel sample suspected of containing asbestos will be analyzed for asbestos content by Polarized Light Microscopy (PLM) visual area estimation (VAE) at an American Industrial Hygiene Association (AIHA) accredited laboratory. Friable materials containing asbestos estimated at less than ten percent by PLM-VAE may be reanalyzed by PLM point counting. Only one sample of each suspect material will be submitted per barrel sampler. If additional barrel samples have the same or similar material, those samples will be submitted for asbestos content by PLM analysis, only.

Sampling for ACM will be conducted by an EPA/Asbestos Hazard Emergency Response Act (AHERA) trained and accredited as a Colorado Certified Asbestos Building Inspector (CABI). Sampling will be conducted in general conformance with the method described in 40 CFR part 763.86 and the AHERA protocols. Sampling and analysis will comply with EPA’s *Asbestos/NESHAP Regulated Asbestos-Containing Materials Guidance* (EPA, 1990).
The sampler will use a sampling tool (e.g., knife, spatula, tweezers) appropriate for each kind of material, collect the sample, place it in a separate sealed plastic bag, and take a photograph of the sample. Each sample will be individually numbered, and sample information will be entered onto a Field Data Sheet or in a field logbook. Sample tools will be decontaminated with low lint wipes after each sample collection.

The suspect ACM sample will be submitted under chain-of-custody (Section 7) to Aerobiology Laboratories, located in Golden, CO or an equally-certified testing facility. Samples will be analyzed in accordance with AHERA requirements using the following reference methods:

- EPA Interim Method for the Detection of Asbestos in Bulk Insulation Samples (EPA 600/M4-82020, December 1982); and
- McCrone Research Institute's *The Asbestos Particle Atlas*.

### 4.6 Piezometer Construction

After soil sampling, temporary piezometers will be constructed in each new borehole. Each piezometer will be constructed of 1-inch diameter, threaded, flush-joint, polyvinyl chloride (PVC) well casing. The piezometer will be screened from the base of the borehole to 12-inches above the first encounter of water when the borehole was drilled, and as projected based on water level data from nearby wells and piezometers. A 10-30 sand will be installed in the boring outside of the well screen and extend a minimum of two feet above the slotted interval. A minimum three-foot thick bentonite seal will be installed above the sand pack. The remainder of the borehole will be filled with drill cuttings or bentonite chips to approximately 6 inches bgs. The top of casing will then be cut off approximately 2 inches bgs, and the vertical and horizontal coordinates of the top of casing will be surveyed. A PVC cap will be placed on top of the casing, then a flush-mounted surface casing will be cemented in place over the top of the casing. The piezometer number will be painted on the surface cover of the flush-mounted casing.

After a period of at least 48-hours following completion of a temporary piezometer, it will be developed using a 0.75-inch diameter disposable bailer until water turbidity has stabilized.

### 4.7 Water Level Measurements

Water level measurements will be made using a battery-powered portable water level sensor with a polyethylene coated stainless steel flat tape graduated to the nearest 1/100th of a foot. The depth to water will be measured from the north side of the top of the PVC casing, and recorded in the field logbook. For the first water level measurement event, the total depth of each piezometer and existing well will also be measured and recorded. On subsequent water level measurement events, the total depth of only the piezometers
will be measured. After water level and total depth measurements are collected, the sensor tape will be decontaminated using a solution of trisodium phosphate (TSP) or Alconox™ cleaning solution followed by rinsing with distilled water and air-drying.

4.8 Groundwater Sampling

Piezometers and monitoring wells will be purged and groundwater samples will be collected using disposable polyethylene bailers. Prior to purging and sampling, a water level measurement will be collected and the height of water column and standing volume of water in the well will be calculated. The well will be purged by removing a minimum of three (3) well casing volumes. After each one-half well volume is removed, a grab sample will be obtained and analyzed for pH, temperature, specific conductance, and oxidation/reduction potential (ORP) using a portable water quality meter. Field parameter results as well as the purge volume and time will be recorded on a Groundwater Sampling Field Data Sheet (Figure C-1D) or in the field logbook. The exact amount of purging will be determined in the field on the basis of recharge rate and/or water quality parameters. If a well or piezometer does not recover to within 50% of its static level within 15 minutes of a purge, or if its field parameters stabilize to within 90% of the previous reading, the well or piezometer may be sampled without purging all three well casing volumes.

After purging, the time of sampling will be recorded on the Groundwater Sampling Form or in the field logbook and on the sample labels, and the sample containers will be filled (including those for field duplicate samples). Samples for analysis of dissolved metals will be field-filtered using 0.45 micron disposable filters and a peristaltic pump. Filled sample bottles will be placed in their respective coolers on ice until prepared for shipment to the laboratory. Sample analytical methods, volumes, container type, preservation requirements, and holding times are listed on Table C-1B.

After sample collection, the chain-of-custody form(s) will be completed, ice and packing material (if necessary) will be added to the coolers, and the chain-of-custody form will be sealed in a plastic bag and taped to the underside of the lid of the cooler. Coolers will be custody-sealed and delivered to the laboratory.

4.9 Soil Gas Monitoring

Monitoring for soil gas using a calibrated PID and 4-gas meter will be performed during all borehole drilling and sampling activities, as well as during groundwater monitoring and sampling. Air monitoring conducted during this work will be documented on the Direct Reading Instrument Data Form (Figure C-1E) and subsequently filed with the project records in accordance with the Records Management Plan (SAP, Appendix C). The Data Form information may also be substituted for a meter data download if properly documented.
Air quality will be monitored in the breathing space adjacent to an open boring or completed well or piezometer, and at the top of the open boring, well, or piezometer during drilling and water quality sampling. Air will be monitored for 1) total VOCs using a calibrated hand-held PID, and 2) oxygen content, combustible gas levels, carbon monoxide (CO), and hydrogen sulfide (H₂S) using a calibrated hand-held 4-gas meter.

Air monitoring for total VOCs will be conducted continuously during all activities when there is potential exposure to oxygen deficiency, explosive vapors, methane, CO, H₂S, or VOCs. Levels will be logged hourly during continuous monitoring.

The 4-gas meter will have the ability to determine the level of explosive vapors, oxygen deficient environments, and CO and H₂S concentrations. The combustible gas indicator should have a range from 0 to 100 percent of the LEL. The oxygen sensor range should be from 0 to 40 percent, the CO sensor range 0 to 500 parts per million (ppm), and the H₂S range from 0 to 100 ppm.

4.10 Decontamination and Investigative Derived Waste (IDW) Management

The drill rig, auger flights, drill bits and soil sampling equipment will be pressure washed or steam cleaned prior to arrival on-Site. Following completion of each borehole, auger flights, drill bits, sampling rods, and soil coring equipment that have been used downhole, will be pressure washed over a portable wash basin. Management of the decontamination water will be performed in accordance with the MMP (RAWP, Appendix D).

All soil cuttings generated by drilling the boreholes will be containerized at the time of drilling. The containers will be labeled as to their contents with the borehole number and the date of drilling indicated on the label. The containers will then be transported to a central staging area designated by the EMSI Project Manager for screening and disposal in accordance with the MMP.

Management of liquids generated from well development, purging, and sampling will be performed in accordance with the MMP.

Used personal protective equipment (e.g., gloves, paper towels) will be placed in plastic garbage bags and disposed of as solid waste in accordance with the MMP.

4.11 Borehole/Piezometer Abandonment

All piezometers will be removed during construction of the barrier system. If the barrier excavation does not extend to the base of the piezometer casing, the remaining PVC casing will be removed and the open borehole will be backfilled with sand or bentonite.
5 SAMPLE HANDLING AND ANALYSIS

5.1 Sample Handling

Sample containers, volumes, preservation requirements, and holding times for specific analyses are shown on Table C-1B. Samples which must be stored at less than 6°C will be placed on ice in an insulated chest in the field. Designated containers or sample bottles received from the laboratory will already contain the requisite preservative and include a label indicating the preservative.

All sample containers will be labeled immediately after sealing. The label will identify the site name, sample number, sampler's initials, sampling date, time of day the sample was collected, analyses to be performed, and preservation used. This information along with any in-situ measurements or field observations will also be recorded in the field logbook or on the Borehole Log Form (Figure C-1B) or Groundwater Field Data Sheet (Figure C-1D).

Samples will be delivered to the designated laboratory for analysis. The EMSI On-site Representative (or Project Manager) will contact the laboratory to inform them of shipments before shipping samples. U.S. Department of Transportation (DOT) shipping requirements will be followed when applicable. Applicable procedures from ASTM D4220 – Practices for Preserving and Transporting Soil Samples will also be followed.

Samples will be packaged and shipped using the packing materials and insulated ice chests provided by the analytical laboratory. Sample containers should be placed in the plastic bubble wrap pouches and/or foam insulation materials provided by the laboratory and placed in the ice chest. Additional foam insulation material should be placed below, between, and above samples to prevent movement of the samples during transport. Enough room should be provided on top of the samples and underneath the lid of the ice chest for ice. Ice should be placed in several one-gallon zip-lock plastic bags and placed on top of the samples.

Chain-of-custody (COC) records describing the contents of the ice chest will be placed in a sealed plastic bag and taped to the inside of the ice chest lid. The lid will be closed, securely taped, and sealed with a custody seal. The custody seals will be signed and dated by the sampler.

In some cases, sealed ice chests may be picked up by a courier or dropped-off for shipment before the samples are chilled to the required temperature. In this case, samples need to be well-chilled during transport and the temperature of each sample should not be greater when received by the laboratory than when it was collected.
The samples will be shipped under chain-of-custody in ice chests by an EMSI representative, a courier, or by an overnight shipping service. If the samples are transported by a courier or overnight shipping service, a bill of lading will be used. Bills of lading will be retained as part of the permanent documentation in the project file.

5.2 Sample Analysis

As discussed in the text above, samples will be analyzed for the parameters using the methods indicated on Table C-1B. Chemical analysis of solids and groundwater samples will be performed by TestAmerica-Denver. Analysis of any asbestos analysis will be conducted by Aerobiology Laboratories or an equally-certified testing facility. Turnaround times of 10 business days will be requested. If additional geotechnical testing is determined to be necessary, it will be conducted by CTL Thompson in their Denver testing laboratory. All of the laboratories will be responsible for disposition of samples following completion of sample analyses or testing.
6 QUALITY ASSURANCE/QUALITY CONTROL

6.1 Field Quality Control

The drilling of the boreholes, geologic logging of the boreholes, soil sample collection, piezometer construction and development, water level measurements, groundwater sampling, sample handling, and piezometer abandonment will be conducted in accordance with the procedures discussed in Section 4 of this FSP.

6.2 Quality Control Samples

Waste Material/Visibly-Impacted Soil

One co-located field duplicate sample will be collected for each 20 investigative samples or analytical batch whichever is more frequent. A duplicate sample from the composited samples that will be analyzed for metals will be obtained by filling separate sample bottles from the homogenized composite soil sample. In the case of discreet samples for VOC analyses, a duplicate sample will be obtained by splitting the individual sample into two parts at the time of filling the sample bottles.

One sample for each batch of investigative samples will be designated as a matrix spike/matrix spike duplicate (MS/MSD) sample. In the case of metals analyses, MS/MSD samples from the composited samples will be obtained by filling two additional sample bottles from the homogenized composite solids sample. The MS/MSD samples of discrete samples for VOC analyses will be obtained by splitting the individual samples into three parts at the time of filling the sample bottles.

Groundwater/Liquid

Similar to solid samples, one co-located field duplicate sample will be collected for each 20 investigative samples or analytical batch whichever is more frequent. This includes samples for VOCs, PAHs, dissolved metals, and total metals analyses. Duplicate samples for all parameters will be obtained by pouring equal volumes of liquid from each sampling bailer into the sample bottles. For field-filtered samples, the same procedure will be followed when filling the filtration unit prior to filtration, and when filing samples bottles after filtration.

One sample for each batch of investigative samples will be designated as a matrix spike/matrix spike duplicate (MS/MSD) sample. Sample collection will be the same as for duplicate sampling.
With respect to VOC trip blanks, one trip blank sample will be submitted per 20 samples, or one per sample cooler.

The sample results will be subject to a Level III data validation consisting of the following elements:

- Methodology,
- Holding times,
- Blanks,
- Spikes,
- Duplicates, and
- Surrogates.
7 DOCUMENTATION

7.1 Field Notebook

Documentation of field activities will occur through the use of a field notebook that will be in the possession of the field geologist or engineer during all field activities. The following information will be contained in the field notebook.

- Name of person(s) making entries
- Date of field activities
- Summary of activities conducted on the particular day
- Summary of calibration information for instruments calibrated in the field
- Identification of any visitors on site and the times of when they arrived and departed
- Description of site conditions (e.g. weather, surface conditions)
- Deviations, if any, from planned activities or procedures set forth in the SAP.

7.2 Borehole Log

The geologic and subsurface conditions at the Site will be documented through the use of the borehole log. A sample of a borehole log form is provided as Figure C-1C.

7.3 Groundwater Sampling Sheet

The groundwater sampling sheet to be used is provided as Figure C-1D.

7.4 Direct Reading Instrument Form

The direct reading instrument data sheet to be used in provided as Figure C-1E.

7.5 Chain-of-Custody Form

All waste material/soil and groundwater samples collected at the Site will be collected under Chain-of-Custody procedures. As previously stated, with the exception of determination of asbestos content and geotechnical testing of soil samples, TestAmerica Denver will perform all analytical work on this project. A copy of the TestAmerica Chain-of-Custody form that is provided by the laboratory is included as Figure C-1F.
Chain-of-custody forms for the asbestos and geotechnical testing laboratories will be obtained prior to beginning fieldwork.
Tables
Table C-1A: Anticipated Number and Type of Samples

<table>
<thead>
<tr>
<th>Type of Sample</th>
<th>Estimated Number of Investigative Samples</th>
<th>Number of Field Duplicate and MS/MSD Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Material/Visually-Impacted Soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total VOCs</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Total PAHs</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Total Arsenic</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Total Lead</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>TCLP VOCs</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>TCLP PAHs</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>TCLP RCRA metals</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Asbestos Containing Material (ACM)</td>
<td>Unknown, collect if suspected</td>
<td></td>
</tr>
<tr>
<td>Soil for Geotechnical Properties Analysis</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Water Level Measurements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekly for one month, then</td>
<td>18 (per event)</td>
<td></td>
</tr>
<tr>
<td>Monthly for 5 months, weather permitting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater Samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOCs</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>PAHs</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Total Metals</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Dissolved Metals</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Monitoring for Soil Gas</td>
<td>Continuous monitoring during drilling and sampling</td>
<td></td>
</tr>
<tr>
<td>Media</td>
<td>Analysis</td>
<td>Method</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Soil</td>
<td>Percent Moisture</td>
<td>ASTM D-2216</td>
</tr>
<tr>
<td>Soil</td>
<td>VOCs</td>
<td>SW-846 8260B</td>
</tr>
<tr>
<td>Soil</td>
<td>PAHs</td>
<td>SW-846 8270C SIM</td>
</tr>
<tr>
<td>Soil</td>
<td>Arsenic and Lead</td>
<td>SW-846 6010C</td>
</tr>
<tr>
<td>Soil</td>
<td>TCLP VOCs</td>
<td>SW-846 1311 SW-846 8260B</td>
</tr>
<tr>
<td>Soil</td>
<td>TCLP PAHs</td>
<td>SW-846 1311 SW-846 8270C</td>
</tr>
<tr>
<td>Soil</td>
<td>TCLP 8 RCRA Metals</td>
<td>SW-846 6010C SW-846 1311 7470B (mercury)</td>
</tr>
<tr>
<td>Asbestos</td>
<td>Asbestos content</td>
<td>Polarized Light Microscopy EPA/M4-82020</td>
</tr>
<tr>
<td>Soil</td>
<td>Geotechnical properties</td>
<td>TBD</td>
</tr>
<tr>
<td>Media</td>
<td>Analysis</td>
<td>Method</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Groundwater</td>
<td>VOCs</td>
<td>SW-846 8260B</td>
</tr>
<tr>
<td>Groundwater</td>
<td>PAHs</td>
<td>SW-846 8270C SIM</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Metals (totals and dissolved $^1$)</td>
<td>SW-846 6010C 7470B (Hg) 7196A (Cr VI)</td>
</tr>
</tbody>
</table>

$^1$ Metals consist of arsenic, cadmium, chromium (III), chromium (VI), copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc
### Table C-1C: Waste Characterization Field Screening Procedures

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ignitability</strong></td>
<td>A waste is ignitable if it has a flash point below 140 degrees Fahrenheit. Each waste will be screened by exposing a sample to an open flame generated using a propane source. If the sample supports combustion, it will be classified as ignitable. Confirm result with SW1030.</td>
</tr>
<tr>
<td><strong>Corrosivity</strong></td>
<td>A waste is corrosive if it is aqueous and has a pH less than or equal to 2.0 or greater than or equal to 12.5. All waste will be screened using pH paper. For non-liquid wastes, a 10 percent non-liquid waste in water slurry will be used. Confirm with SW9040C (pH) and SW1120 (corrosivity).</td>
</tr>
<tr>
<td><strong>Reactivity</strong></td>
<td>A waste is reactive if, upon addition of water, it reacts violently; forms potentially explosive mixtures; or generates toxic fumes, vapors, or gases in quantities sufficient to present a danger to human health or the environment. This testing includes cyanide and sulfide screening. Confirmation testing for either screen should be performed in accordance with SW846, Chapter 7.</td>
</tr>
<tr>
<td><strong>Reactive Cyanides Screen</strong></td>
<td>To a beaker containing approximately 20 milliliters (ml) of sample, enough caustic is added to bring the pH to 12 or 13; then 5 to 10 ml of 10 percent ferrous sulfate solution is added and stirred; 5 to 10 ml of 5 percent ferric chloride solution is then added; and enough concentrated sulfuric acid is slowly added to bring the pH down to 1.0 or less. A bright blue or green color indicates the presence of cyanide. This test can detect free cyanide and many complexed cyanides in concentrations down to less than 100 parts per million (ppm).</td>
</tr>
<tr>
<td><strong>Reactive Sulfides Screen</strong></td>
<td>To a beaker containing approximately 20 ml of sample, enough concentrated sulfuric acid is slowly added to bring the pH down to 1.0 or less. Immediately after adding the acid, a wet strip of lead acetate paper is held over the beaker while agitating the contents. If the paper turns brown or silvery black, the presence of sulfides in the sample is indicated. If there is no color change, then total sulfides are reported as nondetectable (i.e., less than 100 ppm).</td>
</tr>
<tr>
<td><strong>Oxidizer Screen</strong></td>
<td>All wastes will be screened for oxidizer potential using potassium iodide test paper. A blue color on the test paper is a positive test for oxidizers. No confirmation test is available.</td>
</tr>
<tr>
<td><strong>Paint Filter Test</strong></td>
<td>To a fine-mesh paint filter (mesh number 60 ± 5%) add 100 ml or 100 g of representative sample. Test at ≤ 25°C (room temperature). If any portion of the material passes through and drops from the filter within a 5-minute test period the material contains free liquids. Confirm with SW9095.</td>
</tr>
</tbody>
</table>
Figures
Figure C-1A

PROPOSED BOREHOLE LOCATIONS
CONCEPTUAL STORMWATER DRAINAGE SYSTEM

OPERABLE UNIT #2, VB I70 SUPERFUND SITE

EMSI Engineering Management Support, Inc.
Figure C-1C
BOREHOLE LOG FORM
OPERABLE UNIT #2, VB I70 SUPERFUND SITE

EMSI  Engineering Management Support, Inc.
<table>
<thead>
<tr>
<th>Well ID no.</th>
<th>Well ID no.</th>
<th>Date</th>
<th>Time</th>
<th>Recorder</th>
<th>Sampler</th>
<th>Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casing Diameter (inches)</td>
<td>Casing Diameter (inches)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casing Backup (feet)</td>
<td>Casing Backup (feet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Well Depth (feet)</td>
<td>Total Well Depth (feet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static Water Level (feet)</td>
<td>Static Water Level (feet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated Thickness (feet)</td>
<td>Saturated Thickness (feet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casing Volume/Annular Volume (gallons)</td>
<td>Casing Volume/Annular Volume (gallons)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screened Interval (feet)</td>
<td>Screened Interval (feet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Sample depth (feet)</th>
<th>Casing Volume</th>
<th>Volume Recovered (gallons)</th>
<th>Tmp (°C)</th>
<th>Conductance (mS/cm)</th>
<th>DO (mg/L)</th>
<th>pH</th>
<th>ORP</th>
<th>Visual Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes

Sample Signature

Engineering Management Support, Inc.
7220 W. Jefferson Ave. Suite 420
Lakewood, CO 80225
303-460-3630

Figure C-1D
GROUNDWATER SAMPLING
FIELD DATA SHEET
OPERABLE UNIT #2, VB I70 SUPERFUND SITE

EMSI Engineering Management Support, Inc.
**DIRECT READING INSTRUMENT DATA FORM**

**DATE:**
**USER:**
**CALIBRATION DATE:**
**CALIBRATED BY:**

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>DATE/TIME</th>
<th>O₂</th>
<th>LEL</th>
<th>CO / H₂S</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Direct reading information may also be substituted onto downloaded report forms from the instrument.
## Chain of Custody Record

**Figure C-1F**

**CHAIN-OF CUSTODY FORM**

**OPERABLE UNIT #2, VB I70 SUPERFUND SITE**

**EMSI**  Engineering Management Support, Inc.

<table>
<thead>
<tr>
<th>Client Contact</th>
<th>Project Manager</th>
<th>Site Contact</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your Company Name</td>
<td>Test-Tax</td>
<td>Lab Contact</td>
<td>Career</td>
</tr>
<tr>
<td>Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City/State</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) xed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) xed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Name</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If Del.:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sample Identification

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>Sample Time</th>
<th>Sample Type</th>
<th>Matrix</th>
<th>No. of units</th>
</tr>
</thead>
</table>

### Preservation Used

1. HCl, 2. H2SO4, 3. HNO3, 4. HClO3, 5. NaOH, or Other

### Sample Disposal

- [ ] Return to Client
- [ ] Disposal by Lab
- [ ] Archive For __________ months

### Special Instructions

- [ ] Require check & Signature: __________

### Requested by

<table>
<thead>
<tr>
<th>Company</th>
<th>Date/Time</th>
<th>Received by</th>
<th>Company</th>
<th>Date/Time</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Requested by</th>
<th>Company</th>
<th>Date/Time</th>
<th>Received by</th>
<th>Company</th>
<th>Date/Time</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Requested by</th>
<th>Company</th>
<th>Date/Time</th>
<th>Received by</th>
<th>Company</th>
<th>Date/Time</th>
</tr>
</thead>
</table>
Appendix C-2

Quality Assurance Project Plan
TABLE OF CONTENTS

1 INTRODUCTION ............................................................................................................ 1
2 SAMPLE DOCUMENTATION, HANDLING AND CUSTODY REQUIREMENTS .. 2
  2.1 Field Documentation ................................................................. 2
  2.1.1 Sample Location Documentation ........................................ 2
  2.1.2 Field Documentation Forms ................................................. 2
  2.2 Sample Handling, Chain of Custody, and Sample Shipment .................... 2
  2.3 Record Keeping ................................................................. 3
3 LABORATORY ANALYTICAL METHOD REQUIREMENTS ......................................... 4
4 QUALITY CONTROL REQUIREMENTS ..................................................................... 6
  4.1 Field Quality Control Samples ................................................... 6
  4.1.1 Field Duplicates ................................................................. 6
  4.1.2 Trip Blanks ........................................................................ 6
  4.2 Laboratory Quality Control Samples ............................................... 7
  4.2.1 Internal Laboratory Quality Assurance .................................. 7
  4.2.2 Internal Laboratory Quality Control ....................................... 7
5 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE
   REQUIREMENTS .................................................................................................................. 11
  5.1 Field Equipment ........................................................................ 11
  5.2 Instrument Calibration and Frequency ............................................. 11
  5.2.1 Field Instruments .................................................................. 11
  5.2.2 Laboratory Instruments ........................................................ 11
6 DATA MANAGEMENT................................................................................................ 13
7 ASSESSMENT AND OVERSIGHT .............................................................................. 14
  7.1 Assessment and Response Actions ............................................... 14
  7.1.1 Field Sampling Activities Oversight ....................................... 14
  7.1.2 Laboratory Procedure Oversight .......................................... 14
  7.2 Corrective Action Procedures ....................................................... 14
  7.3 Reports to Management ............................................................. 15
8 DATA REVIEW, VERIFICATION, VALIDATION, AND QUALITY ASSESSMENT ..... 16
  8.1 Data Review and Verification ...................................................... 16
  8.2 Data Validation ........................................................................ 16
  8.2.1 Overview ........................................................................... 16
  8.2.2 Data Validation .................................................................. 17
  8.3 Data Quality Assessment .......................................................... 18
9 REFERENCES ............................................................................................................... 20

LIST OF TABLES

Table C-2A: Summary of Proposed Field and Laboratory Quality Control Samples
Table C-2B: Required Quality Control and Recommended Corrective Action
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACM</td>
<td>Asbestos-Containing Material</td>
</tr>
<tr>
<td>COC</td>
<td>Compound of Concern</td>
</tr>
<tr>
<td>DQA</td>
<td>Data Quality Assessment</td>
</tr>
<tr>
<td>DQO</td>
<td>Data Quality Objective</td>
</tr>
<tr>
<td>EDD</td>
<td>Electronic Data Deliverable</td>
</tr>
<tr>
<td>EMSI</td>
<td>Engineering Management Support, Inc.</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>FSP</td>
<td>Field Sampling Plan</td>
</tr>
<tr>
<td>HASP</td>
<td>Health and Safety Plan</td>
</tr>
<tr>
<td>LCS</td>
<td>Laboratory Control Sample</td>
</tr>
<tr>
<td>MMP</td>
<td>Materials Management Plan</td>
</tr>
<tr>
<td>MDL</td>
<td>Method Detection Limit</td>
</tr>
<tr>
<td>MS/MSD</td>
<td>Matrix Spike/Matrix Spike Duplicate</td>
</tr>
<tr>
<td>ORP</td>
<td>Oxidation Reduction Potential</td>
</tr>
<tr>
<td>PAHs</td>
<td>Polynuclear-aromatic Hydrocarbons</td>
</tr>
<tr>
<td>PARCC</td>
<td>Precision, Accuracy, Representativeness, Comparability, and Completeness</td>
</tr>
<tr>
<td>PID</td>
<td>Photo-ionization Detector</td>
</tr>
<tr>
<td>OU-2</td>
<td>Operable Unit #2</td>
</tr>
<tr>
<td>%R</td>
<td>Percent Recovery</td>
</tr>
<tr>
<td>RPD</td>
<td>Relative Percent Difference</td>
</tr>
<tr>
<td>QA/QC</td>
<td>Quality Assurance/Quality Control</td>
</tr>
<tr>
<td>QAPP</td>
<td>Quality Assurance Project Plan</td>
</tr>
<tr>
<td>RAWP</td>
<td>Response Action Work Plan</td>
</tr>
<tr>
<td>RCRA</td>
<td>Resource Conservation and Recovery Act</td>
</tr>
<tr>
<td>RMP</td>
<td>Records Management Plan</td>
</tr>
<tr>
<td>SAP</td>
<td>Sampling and Analysis Plan</td>
</tr>
<tr>
<td>SRM</td>
<td>Standard Reference Material</td>
</tr>
<tr>
<td>TCLP</td>
<td>Toxicity Characteristic Leaching Procedure</td>
</tr>
<tr>
<td>VOCs</td>
<td>Volatile Organic Compounds</td>
</tr>
</tbody>
</table>
1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) provides guidelines to assure high quality data and identify quality assurance and quality control (QA/QC) responsibilities for Engineering Management Support, Inc. (EMSI) and its subcontractors during performance of the Design Investigation that supports design and implementation of the “environmental components” of an open channel stormwater drainage structure planned for Operable Unit 2 (OU-2) of the Vasquez Boulevard/Interstate 70 (VB/I-70) Superfund Site. This QAPP is an appendix to the Sampling and Analysis Plan (SAP), which is Appendix C to the Removal Action Work Plan (RAWP). This QAPP is companion document to the Field Sampling Plan (FSP) and Records Management Plan (RMP), which are also appended to the SAP. This QAPP addresses the following activities:

- Sample documentation, handling and custody requirements;
- Laboratory analytical method requirements;
- Quality control requirements;
- Instrumentation/equipment testing, inspection and maintenance requirements;
- Data management;
- Assessment and oversight; and
- Data review, verification, validation and quality assessment.
2 SAMPLE DOCUMENTATION, HANDLING AND CUSTODY REQUIREMENTS

2.1 Field Documentation

2.1.1 Sample Location Documentation

The location and elevation of each boring location will be surveyed by a Colorado licensed surveyor before soil sampling activities are conducted at the location. After the temporary piezometers are constructed, the location and elevation of each piezometer will also be surveyed by a Colorado licensed surveyor. The soil, groundwater, and soil gas sampling locations will be documented on field sketches in the field logbook or on forms and recorded by photographs.

2.1.2 Field Documentation Forms

Sampling personnel will maintain a field logbook which will document the following information:

- Date;
- Signature and initials of project personnel completing entries in the log book;
- Project personnel, subcontractor personnel and visitors on-site;
- Weather conditions;
- Start and stop times of site activities;
- Field instrument calibration information;
- Sketches of sample locations;
- Photograph log;
- Identification number, description, and time of collection of samples obtained each day; and
- Any deviations or modifications to sampling protocols.

This logbook will be maintained daily during soil, groundwater, and landfill gas sampling activities. The logbook may be supplemented with forms that will be prepared for each sample location.

2.2 Sample Handling, Chain of Custody, and Sample Shipment

All samples collected will be handled in accordance with the methods specified in the FSP (RAWP Appendix C-1).

A chain-of-custody form shall accompany every shipment of samples to the analytical laboratory. The purpose of the chain-of-custody form is to establish the documentation necessary to trace possession from the time of collection to final disposal, and to identify the
type of analysis requested. All corrections to the chain-of-custody record will be marked out with a single line, initialed and dated using black indelible ink by the person making the corrections. Each chain-of-custody form will include signatures of the appropriate individuals indicated on the form. The originals will accompany the samples to the laboratory, and copies documenting each custody change will be recorded and kept on file.

All required paper work, including sample container labels, chain-of-custody forms, custody seals and shipping forms will be fully completed in black indelible ink (or printed from a computer) prior to shipping of the samples to the laboratory. Samples will be packaged for shipping by the sampler. Shipping to the respective analytical laboratory will be via common courier directly to the laboratory.

Upon receipt, the samples will be given to the laboratory sample custodian. The custody-sealed coolers containing the samples will be opened and the contents inspected. Chain-of custody forms will be reviewed for completeness, and samples will be logged and assigned a unique laboratory sample number. Any discrepancies or abnormalities in samples will be noted by the laboratory and the EMSI Project Manager will be promptly notified.

2.3 Record Keeping

Chain-of-custody forms will be maintained until final disposition of the samples by the laboratory and acceptance of analytical results by EMSI. One copy of the chain-of-custody will be kept by field personnel and will be included in the final field report. EMSI will maintain all original log books, field data sheets, analytical data packages and reports, and any other information required to document and support the findings of the investigation. Records management is discussed in the RMP (RAWP Appendix C-3).
3 LABORATORY ANALYTICAL METHOD REQUIREMENTS

Chemicals of concern (COCs) in the waste material and visibly-impacted soil beneath and in the vicinity of the alignment of the barrier system consist of volatile organic compounds (VOCs), polynuclear-aromatic hydrocarbons (PAHs), arsenic, and lead. Asbestos may also be randomly present in the waste material. COCs in groundwater consist of VOCs, arsenic, cadmium, copper, lead, manganese, and zinc. Soil gas monitoring will be conducted with field instruments; samples for laboratory analysis will not be collected.

Environmental media will be analyzed for the following parameters using the analytical methods listed below.

<table>
<thead>
<tr>
<th>Media</th>
<th>Parameters</th>
<th>Analytical Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Moisture Content</td>
<td>ASTM D-2216</td>
</tr>
<tr>
<td>Soil</td>
<td>VOCs</td>
<td>SW-846 8260B</td>
</tr>
<tr>
<td>Soil</td>
<td>PAHs</td>
<td>SW-846 8270C SIM</td>
</tr>
<tr>
<td>Soil</td>
<td>Metals (arsenic and lead)</td>
<td>SW-846 6010C</td>
</tr>
</tbody>
</table>
| Soil         | Toxicity Characteristic Leaching Procedure (TCLP) VOCs | Extraction: SW-846 1311  
Analysis: SW-846 8260B |
| Soil         | TCLP PAHs                           | Extraction: SW-846 1311  
Analysis: SW-846 8270C |
| Soil         | TCLP RCRA Metals                    | Extraction: SW-846 1311  
Analysis: SW-846 6010C  
Mercury (SW-846 7470B) |
| Groundwater  | VOCs                                | SW-846 8260B                       |
| Groundwater  | PAHs                                | SW-846 8270C SIM                   |
| Groundwater  | Metals (arsenic, cadmium, chromium (III), chromium (VI), copper, iron, lead, manganese, mercury, nickel, selenium, silver, zinc) | SW-846 6010C  
Mercury (SW-846 7470B)  
CrVI (SW-846 7196A) |
| Asbestos     | Friable Asbestos                    | Polarized Light Microscopy  
EPA/M4-82020 |
All of the analytical methods specified above are standard EPA or SW-846 methods. Their laboratory Reporting Limits are less than their respective action levels discussed in the Materials Management Plan (MMP). Laboratory turn-around times will be 10 business days from the date of receipt of the sample by the laboratory.

The required sample quantity, preservation, and holding times for the respective analytical methods are provided on Table C-1A in the FSP (RAWP Appendix C-1).

Samples to be analyzed for VOCs, PAHs, metals, and prepared by TCLP will be submitted to the TestAmerica - Denver laboratory located in Arvada, CO. The methods used by the laboratory for analysis of these parameters are available upon request to the laboratory.

Samples to be analyzed for asbestos content will be submitted to Aerobiology Laboratories located in Golden, CO. The method used by the laboratory for analysis of asbestos content is available upon request to the laboratory.
4 QUALITY CONTROL REQUIREMENTS

The principal objectives of any sampling and analysis program are to obtain accurate and representative environmental samples and to provide valid analytical data. The quality of data will be assessed through the use of Quality Control (QC) samples analyzed on a regular basis. Laboratory QC samples will be analyzed as per analytical method protocols to evaluate whether laboratory procedures and analyses have been completed properly. For this project, the types of QC samples to be analyzed are defined and their roles in the production of QC data are discussed in the following paragraphs. A summary of the number of field and laboratory QC samples to be collected and analyzed is provided as Table C-2A. The accuracy and measurement requirements for each QC sample are discussed in the following section. In addition to the particular QC requirements identified below, all analyses must be performed within holding times and must adhere to applicable laboratory protocols.

4.1 Field Quality Control Samples

Field QC samples are samples that have been either collected or prepared in the field that are submitted in a blind fashion to the laboratory for analysis. The field QC samples that will be collected for waste material/soil and groundwater during the design investigation and their associated requirements are summarized below:

4.1.1 Field Duplicates

Field duplicate samples will consist of two containers of the same sample. Collection of field duplicate samples for waste material/soil and groundwater will consist of filling two separate sample containers at the same time during sampling collection, as described in the FSP. The field duplicate samples will be submitted in a blind manner to the laboratory to allow for measurement of the precision of laboratory analysis and to evaluate field variability. Field duplicate samples will be collected at a frequency of 1 field duplicate sample per 10 investigative samples or one field duplicate sample per sampling event if less than 10 samples are collected.

Only disposable sampling equipment will be used for groundwater and any liquid IDW samples and therefore there should not be any potential for cross-contamination. Therefore, rinsate samples (equipment blanks) will not be collected.

4.1.2 Trip Blanks

Trip blank samples are used to assess the potential for introduction of VOCs during shipment of sample containers to and from the laboratory and during the field sample collection activities. Trip blanks for groundwater analyses consist of samples of deionized water prepared by the analytical laboratory and shipped with the sample containers to the project Site. Trip blank samples are maintained with the sample containers during the field sample
collection activities and are subsequently shipped back to the laboratory for analysis. One trip blank will be included in each cooler of samples.

4.2 Laboratory Quality Control Samples

Laboratory QC samples are samples that are prepared at the laboratory and are analyzed along with field samples to monitor the accuracy and precision of analysis. The types of Laboratory QC samples that will be collected during the site investigation and their associated requirements are summarized below:

4.2.1 Internal Laboratory Quality Assurance

Matrix Spike/Matrix Spike Duplicate (MS/MSD): A MS/MSD sample is an investigative sample having a matrix that is representative of investigative samples to which a known concentration of target analytes is added. This quality control sample measures the extent that the sample matrix affects the accuracy of reported target analytes and is proposed to be performed at a frequency of 5% of all investigative samples prepared for VOC analyses (one MS/MSD sample for every 20 investigative samples, for each media) or one per preparation batch, whichever is more frequent. The MS/MSD analyses provide an additional measure of precision. Specific precision, accuracy and method requirements are summarized in the analytical methods, which are available from the analytical laboratory upon request.

Laboratory Control Sample (LCS): An LCS originates in the laboratory or is provided as a standard reference material (SRM) by a manufacturer and contains target analytes of known concentration to serve as a second source standard. Because LCSs are independent of the calibration standards, they are analyzed to verify the accuracy of the standards used to calibrate the instrument. An LCS will be performed at a frequency of 5% of all investigative samples prepared for analysis (one LCS for every 20 investigative samples) or one per preparation batch, whichever is more frequent. Table C-2B lists the corrective actions required for out of control LCS recoveries by analytical method.

4.2.2 Internal Laboratory Quality Control

Method Blanks: A method blank is composed of the reagents, solvents or matrix of investigative sample following sample preparation and is used to discern if laboratory contamination is present. One method blank per analytical batch or every 20 samples is required. Concentrations of target analytes greater than the reporting limit may suggest that laboratory contamination may have occurred. Table C-2B lists the corrective actions required for all method blank contamination by analytical method.

Surrogate Spike Analyses: Surrogate spike analyses are used to determine the efficiency of target analyte recovery during sample preparation and analysis. A surrogate spike is prepared by adding a known amount of surrogate compound to an environmental sample before extraction. The surrogate compound is selected to exhibit an analytical response that is similar to the response displayed by a target compound during sample analysis. The
accuracy of the analytical method is measured using the calculated % recovery of the spiking compound. Poor reproducibility and % recovery during surrogate spike analyses may indicate sample matrix effects.

Both environmental and QC samples are spiked with surrogate compounds. Surrogate compounds are not added to inorganic analyses; however, surrogates are required for most organic analyses. Surrogate spike recoveries are acceptable if the results of a surrogate spike fall within the control limits established by laboratory QC protocol. Corrective action procedures for out-of-control surrogate spike results are listed in Table C-2B.

Holding Time: Holding times for sample extraction and/or analysis as required by the methods will be met for all samples. The holding time is calculated from the date and time of sample collection to the time of sample preparation and/or analysis. All sample analyses to include dilutions and second-column confirmation will meet the required holding times. Corrective action procedures for out-of-control holding times are listed in Table C-2A. Table C-1B of the FSP defines applicable method-specific analytical holding times.

Analytical Batches: Analytical batches will be designated in the laboratory at a minimum of one batch per sample delivery group (SDG). Each SDG will be comprised of a maximum of 20 project samples of similar matrix collected within a 7-day period. Included in each SDG of 20 (or fewer) samples per analytical method will be an analytical batch identification number. This identification number will clearly allow a reviewer to determine the association between field samples and QC samples. Analytical batches also will be inclusive of preparation lots and calibration periods. The Laboratory shall, as a minimum, analyze internal QC samples at the frequency specified by the methods. These QC samples for each analytical batch include calibration standards and checks, blanks, LCSs, and an MS/MSD pair per analytical batch.

Internal Standards: Internal Standards (ISs) are compounds of known concentrations used to quantitate the concentrations of target detections in field and QC samples. ISs are added to all samples before sample extraction or preparation. Because of this, ISs provide for the accurate quantitation of target detections by allowing for the effects of sample loss through extraction, purging, and/or matrix effects. ISs are used for any method requiring an IS calibration. Corrective action is required when ISs are out of control. Corrective action procedures for out-of-control internal standard spike results are listed in Table C-2B.

Calibration Requirements: Analytical instruments will be calibrated in accordance with the analytical methods. All analytes reported will be present in the initial and continuing calibrations, and these calibrations must meet the acceptance criteria specified in Table C-2B. Records of standard preparation and instrument calibration will be maintained by the contract laboratory. Records will unambiguously trace the preparation of standards and their use in calibration and quantitation of sample results. Calibration standards will be traceable to standard materials.

Analyte concentrations are determined with either calibration curves (linear regression) or response factors (RFs). Correlation coefficients for linear regression calibration curves will
be 0.995 or greater. Calibration curves evaluated using a coefficient of determination ($r^2$), require a squared correlation coefficient of greater than 0.990 acceptability. Calibration curves using the relative standard deviation (RSD) of RFs to determine linearity must meet the acceptability criteria specified within the method. For GC/MS methods, the average RF from the initial five-point calibration will be used to determine analyte concentrations. The continuing calibration (CCAL) will not be used to update the RFs from the initial five-point calibration. GC/MS methods also will meet all instrument performance and/or tuning criteria as specified by the methods.

**Initial Calibration Verification:** Initial calibration curves (ICALs) must be verified using a standard made from a source independent of the one used to make the initial calibration standards. All target compounds must be included within the initial calibration verification (ICV), typically at a concentration around the midpoint of the calibration curve. Control limits and corrective action procedures out-of-control ICAL results are listed in Table C-2B.

**Continuing Calibration and Verification:** Initial calibration curves must be verified daily prior to sample analysis using a CCAL. All target compounds must be included within the CCAL, typically at a concentration around the midpoint of the calibration curve. Continuing calibration verifications (CCVs) are required check samples at the beginning and end of each analytical sequence and after every ten samples analyzed (as specified in each analytical method). Control limits and corrective action procedures out-of-control CCAL/CCV results are listed in Table C-2B.

**Standard Materials:** Standard materials used in calibration and to prepare samples will be traceable to National Institute of Standards and Technology (NIST), USEPA, American Association of Laboratory Accreditation (A2LA), or other equivalent approved source, if available. The standard materials will be current, in accordance with the following expiration policy: The expiration dates for ampulated solutions will not exceed the manufacturer’s expiration date or one year from the date of receipt, whichever occurs first. Expiration dates for laboratory-prepared stock and diluted standards will be no later than the expiration date of the stock solution or material, or the date calculated from the holding time allowed by the applicable analytical method, whichever occurs first. The laboratory will label standard and QC materials with expiration dates.

**Method Blanks:** A method blank is composed of the reagents, solvents or matrix of investigative sample following sample preparation and is used to discern if laboratory-induced contamination is present. These samples are proposed to be inserted in the analysis stream at a frequency of 5% of investigative samples, at minimum. Concentrations of target analytes greater than 1 times the Method Detection Limit (MDL) for most analytes and 5 to 10 times the MDL for laboratory-induced contaminants may suggest that laboratory-induced contamination may have occurred. If laboratory-induced contamination is detected in a method blank sample, the investigative samples associated with that method blank may be qualified to reflect the potential for laboratory-induced contamination.
Laboratory Performance and System Audits

This QAPP requires that internal quality control samples, blanks, and matrix spikes be analyzed where applicable. All quality control results shall be reviewed by the analyst daily. In this way, trends in the quality control data are addressed. This continual examination and evaluation of quality control data ensures sample data of high quality.
5 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE REQUIREMENTS

5.1 Field and Laboratory Equipment and Supplies

Field equipment planned for use during the design investigation will be inspected daily to ensure it remains in good working condition. All information relating to the daily instrument/equipment inspection, calibration and maintenance will be documented in a field logbook. The primary field equipment is anticipated to be:

- A photoionization detector (PID) unit used for health and safety screening during drilling of borings, to field screen the borehole cuttings for the presence of VOCs, and for health and safety screening during soil and groundwater sampling activities;

- A 4-gas meter (monitors and displays combustibles, oxygen, carbon monoxide, and hydrogen sulfide) for health and safety screening during drilling of borings and sampling of soil and groundwater;

- A water level sensor; and

- A multi-parameter water quality meter that measures temperature, pH, conductivity, and oxidation reduction potential (ORP) in groundwater.

Field supplies will include, but not be limited to, groundwater bailers, rope, measuring tapes, expendable sampling supplies, decontamination solution and buckets, and personal protection equipment such as hard hats, safety glasses, hearing protection, and protective clothing, if required. Laboratory supplies will include, but not be limited to, calibration standards, replacement parts for analytical equipment parts, glassware, expendable testing equipment, sample bottles, and personal protection equipment. Acceptance of field and laboratory supplies and consumables will be inspected by the receiving entity for consistency with purchase orders and for usability.

5.2 Instrument Calibration and Frequency

5.2.1 Field Instruments

Calibration of field instruments will be performed in accordance with procedures provided in the user’s manual for the instrument as the start of each day or prior to initiation of field activities.

5.2.2 Laboratory Instruments

All laboratory instruments used in the analysis of samples generated during this project must be calibrated by the laboratory in accordance with the requirements of the instrument
manufacturer and the requirements specified in the relevant analytical method. Calibrations must be acceptable before any measurements on investigative samples may be made. Traceable calibration standards will be obtained by the analytical laboratories. All documentation relating to receipt, preparation and use of standards will be recorded in the appropriate laboratory logbooks. While data validation will be performed at Level III, the laboratory will provide a full Level IV report package that includes this information as part of the raw analytical data package.
6 DATA MANAGEMENT

All data will be entered into a project-specific database or spreadsheets. The data entered into the database/spreadsheets will include all relevant field information regarding each environmental sample collected, as well as the analytical results provided by the respective laboratories.

The analytical laboratories will provide electronic data deliverables (EDDs) of the analytical results. The EDDs will be used to incorporate the sample results into the project-specific database or spreadsheets. Use of the EDDs will eliminate the potential for transcription error associated with manual data entry.
7 ASSESSMENT AND OVERSIGHT

The following sections describe activities for assessing the effectiveness of the implementation of the project and associated QA/QC. The purpose of the assessment is to ensure that this QAPP is implemented as prescribed. The elements include assessments and response actions and reports to management as described in the following sections.

7.1 Assessment and Response Actions

Quality Assurance (QA) assessments performed during this project will include the following:

- Oversight of field sampling activities; and
- Review and oversight of laboratory procedures through QC sample verification.

7.1.1 Field Sampling Activities Oversight

Assessment of field sampling will be conducted by EMSI. Oversight of field activities will be conducted by the EMSI Project Manager during performance of the work to document that activities are proceeding in accordance with this QAPP; document any changes, additions or deletions that have occurred during field sampling; and to identify and immediately implement any corrective actions.

Any appropriate response action(s) that may be deemed necessary to resolve problems will be documented in the field notebook and later described in the Design Summary Report where the results from the soil, groundwater, and landfill gas sampling activities will be reported. A response action could range from a simple review of the approved sampling and analysis procedures described in the FSP with field staff to address minor concerns, to a temporary stop work order to provide time for the EMSI Project Manager to address more significant issues.

7.1.2 Laboratory Procedure Oversight

The quality of laboratory analyses will be assessed by evaluation of field and laboratory QC samples as discussed in Section 8.2. All analytical results will be assessed based on the analytical methods and requirements of this QAPP.

7.2 Corrective Action Procedures

Two types of corrective actions may result from assessments and oversight activities: immediate and long-term. Immediate corrective actions include correcting deficiencies or errors or correcting inadequate procedures. Long-term corrective actions are designed to eliminate the sources of deficiencies or errors. If either type of corrective action is deemed
necessary following assessment and oversight activities, each step in the following procedures must be documented:

- Identify the deviation;
- Request a corrective action;
- Report the problem to the regulatory agency Project Manager, if any;
- Review the corrective action response; and
- Perform a follow-up to ensure the deviation is not recurring.

Refer to Table C2-B for recommended corrective action for laboratory or field QC samples.

7.3 Reports to Management

EMSI will oversee implementation of the Design Investigation and RAWP and the EMSI Project Manager will provide the Respondent’s Project Manager with regular verbal reports on project status, as needed. If necessary, the EMSI Project Manager will also relay this information to the regulatory agency’s Project Manager. These reports will cover sampling and analysis progress and data quality assessment issues, and will identify any significant problems and recommended solutions.
8 DATA REVIEW, VERIFICATION, VALIDATION, AND QUALITY ASSESSMENT

The following sections describe the requirements and methods for data review, verification, validation, and quality assessment. The process of data review, verification, validation, and quality assessment is intended to provide consistent and defensible analytical results. Analytical data generated as part of this project will be reviewed and verified before they are incorporated into the project database. A Level III validation will be completed on all analytical data. Data validation will be performed in accordance with USEPA’s Guidance on Environmental Data Verification and Data Validation (USEPA, 2002b), USEPA Contract Laboratory Program National Functional Guidelines for Superfund Inorganic Data Review (USEPA, 2010) and USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Data Review (USEPA, 2008), the requirements of this QAPP, and the requirements in the analytical method. Note that this QAPP supersedes any discrepancies in accuracy and precision requirements among the three cited documents.

The following data review, verification, and validation procedures have been developed and will be followed before data is entered into the database.

8.1 Data Review and Verification

This procedure will include a review and verification of the findings of all QA assessment activities, including assessments of field collection procedures, sample labeling methods, chain-of-custody procedures, as well as assessments of analytical data collection, recording and reporting. If any deviations are identified, the potential impact of those deviations on the reliability of the data will be assessed, and that information will be provided to the Project Manager.

8.2 Data Validation

8.2.1 Overview

The data validation process consists of evaluation of the results of all individual samples collected and analyzed to determine if results are within acceptable limits. These quantitative or qualitative limits of acceptability are defined for Precision, Accuracy, Representativeness, Comparability, and Completeness (PARCC), as discussed below.

**Precision**: Precision is defined as the agreement between a set of replicate measurements without assumption or knowledge of the true value. Agreement is expressed as either the Relative Percent Difference (RPD) for duplicate measurements, or the range and standard deviation for larger numbers of replicates. Data regarding precision are obtained by analyzing duplicate or replicate samples (e.g., field duplicate samples and MS/MSD analyses).
Accuracy: Accuracy is a measure of the closeness of a sample analysis result to the "true" value. Accuracy of sample analyses is evaluated using laboratory control samples that are prepared and analyzed by the analytical laboratories as part of the analyses of the various batches (lots) of samples. As part of the soil and groundwater sample collection and analysis, matrix spike and matrix spike duplicate samples will be collected and analyzed to provide an additional check on the accuracy of the soil and groundwater sample analyses.

Representativeness: Representativeness is the degree to which data accurately and precisely represent characteristics of a population, parameter variations at a sampling point, or an environmental condition. For this QAPP, representativeness is ensured by the selection of sampling locations in accordance with the sampling design requirements presented above and in the FSP and RAWP.

Comparability: Data are comparable if collection techniques, measurement procedures, methods, and reporting units are equivalent for the samples within a sample set. These criteria allow comparison of data from different sources. Comparable data will be obtained by specifying standard units for physical measurements and standard procedures for sample collection, processing, and analysis.

Completeness: Completeness is defined as the percentage of measurements, either field or laboratory, which are judged to be valid measurements on a method-by-method, analyte-by-analyte basis. Valid data will be defined as all data and/or qualified data considered to meet the quality assurance objectives for this project. Data completeness is expressed as percent complete, and should not be less than 90 percent for each method and matrix. At the end of each sampling event, the completeness of the data will be assessed. If any data omissions are apparent, the parameter in question will be resampled and/or reanalyzed, if feasible. Laboratory results will be monitored as they become available to assess laboratory performance and its effect on data completeness requirements. In the event that percent complete goals are not met, additional samples will be collected to ensure that laboratory performance meets percent complete requirements.

8.2.2 Data Validation

Validation will be completed on 100% of the analytical results and will be performed to ensure that data were produced in accordance with procedures outlined in this QAPP. The following elements will be reviewed for compliance as part of the data validation:

- Methodology (including sample preservation);
- Holding Times;
- Surrogates;
- Blanks;
- Serial Dilutions (metals only);
Validation may be expanded if the results of the Level III validation identify a potential data quality issue with one or more of the data packages. Therefore, the laboratory will report a full Level IV report package. The following additional elements will be reviewed for compliance as part of the full data validation:

- Methodology;
- Calibrations;
- Initial Calibration Verification/Continuing Calibration Verification;
- Initial Calibration Blank/Continuing Calibration Blank;
- Internal standards;
- Practical Quantitation Limits;
- Analyte Identification; and
- Analyte Quantification.

8.3 Data Quality Assessment

Information obtained from the design investigation will be evaluated through the Data Quality Assessment (DQA) process to determine if the data obtained are of adequate quality and quantity to support their intended use. The DQA process consists of five steps (USEPA, 2002b), as summarized below:

Review the Data Quality Objectives (DQOs) and Sampling Design: DQO outputs will be reviewed to ensure that they are still applicable. The sampling, analysis, and data collection documentation will also be reviewed for completeness and consistency with DQOs.

Conduct a Preliminary Data Review: Data validation reports will be reviewed to identify any limitations associated with the analytical data. Basic statistics will be utilized where applicable and meaningful graphs of the data will be prepared. This information will be used to learn about the structure of the data and to identify patterns, relationships or potential anomalies/outliers.

Select the Statistical Test: The most appropriate statistical procedure for summarizing and analyzing the data will be selected based on the review of the DQOs, the sampling design, and on results of the preliminary data review. Key underlying assumptions will be identified that must hold true for the statistical procedures to be valid.

Verify the Assumptions of the Statistical Test: The statistical test will be evaluated to determine whether the underlying assumptions hold or whether departures from the
assumptions are acceptable given the actual data or other information about the investigation.

**Draw Conclusions from the Data:** Calculations required for the statistical test will be completed and any inferences drawn as a result of these calculations will be documented.
9 REFERENCES


USEPA, 2002b, Guidance on Environmental Data Verification and Data Validation, EPA QA/G-8, EPA/240/R-02/004, November.


Tables
## Table C-2A  Anticipated Number and Type of Samples

<table>
<thead>
<tr>
<th>Type of Sample</th>
<th>Estimated Number of Investigative Samples</th>
<th>Number of Field Duplicate and MS/MSD Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Material/Visually-Impacted Soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total VOCs</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Total PAHs</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Total Arsenic</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Total Lead</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>TCLP VOCs</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>TCLP PAHs</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>TCLP RCRA metals</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Asbestos Containing Material (ACM)</td>
<td>Unknown, collect if suspected</td>
<td></td>
</tr>
<tr>
<td>Water Level Measurements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekly for one month, then Monthly for 5 months, weather permitting</td>
<td>18 (per event)</td>
<td></td>
</tr>
<tr>
<td>Groundwater Samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(both filtered and unfiltered)</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Monitoring for Soil Gas</td>
<td></td>
<td>Continuous monitoring during drilling and sampling</td>
</tr>
</tbody>
</table>

**Final**
### Table C-2B  Recommended Corrective Action for Laboratory and Field QC Samples

<table>
<thead>
<tr>
<th>Applicable Parameter</th>
<th>QC Check</th>
<th>Minimum Frequency</th>
<th>Acceptance Criteria</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile Organics SW8260B</td>
<td>Five-point initial calibration for all analytes</td>
<td>Initial calibration prior to sample analysis</td>
<td>SPCCs average RF $ \geq 0.30$ (&gt;0.10 for bromoform, chloromethane and 1,1-dichloroethane); and RSD for all target analytes $\leq 15%$</td>
<td>Correct problem then repeat initial calibration</td>
</tr>
<tr>
<td>Second-source calibration verification</td>
<td>Once per five-point initial calibration</td>
<td>All analytes within $\pm 25%$ of expected value</td>
<td></td>
<td>Correct problem then repeat initial calibration</td>
</tr>
<tr>
<td>Retention time window calculated for each analyte</td>
<td>Each initial calibration and calibration verifications</td>
<td>$\pm 3$ times standard deviation for each analyte retention time from 72-hour study</td>
<td></td>
<td>Correct problem then reanalyze all samples analyzed since the last retention time check</td>
</tr>
<tr>
<td>Calibration verification</td>
<td>Daily, before sample analysis, every 12 hours of analysis time, and at end of analysis sequence</td>
<td>SPCCs average RF $ \geq 0.30$ (&gt;0.10 for bromoform, chloromethane and 1,1-dichloroethane), and CCCs $&lt; 30%$ RSD; and all target analytes $&lt;15%$ RSD</td>
<td>Correct problem then repeat initial calibration</td>
<td></td>
</tr>
<tr>
<td>Demonstrate ability to generate acceptable accuracy and precision using four replicate analyses of a QC check sample</td>
<td>Once per analyst</td>
<td>Lab established</td>
<td>Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria</td>
<td></td>
</tr>
<tr>
<td>Check of mass spectral ion intensities using BFB</td>
<td>Prior to initial calibration and calibration verification</td>
<td>Refer to criteria listed in the method description</td>
<td>Retune instrument and verify</td>
<td></td>
</tr>
<tr>
<td>IS</td>
<td>Every sample, spiked sample, standard, and method blank</td>
<td>Retention time $\pm 30$ seconds: EICP area within -50% to +100% of last calibration verification (12 hours) for each</td>
<td>Inspect mass spectrometer or GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning</td>
<td></td>
</tr>
<tr>
<td>Applicable Parameter</td>
<td>QC Check</td>
<td>Minimum Frequency</td>
<td>Acceptance Criteria</td>
<td>Corrective Action</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------</td>
<td>-------------------</td>
<td>---------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Volatile Organics SW8260B (Cont'd)</td>
<td>Method blank</td>
<td>One per analytical batch</td>
<td>No analytes detected &gt; PRL</td>
<td>Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank</td>
</tr>
<tr>
<td></td>
<td>LCS for all analytes</td>
<td>One LCS per analytical batch</td>
<td>Lab established</td>
<td>Correct problem then reprep and analyze the LCS and all samples in the affected analytical batch</td>
</tr>
<tr>
<td></td>
<td>Surrogate spike</td>
<td>Every sample, spiked sample, standard, and method blank</td>
<td>Lab established</td>
<td>Correct problem then reextract and analyze sample</td>
</tr>
<tr>
<td></td>
<td>MS/MSD</td>
<td>One MS/MSD per every 20 project samples per matrix</td>
<td>Lab established</td>
<td>Re-extract and re-analyze the MS and MSD sample within holding time</td>
</tr>
<tr>
<td></td>
<td>MDL study</td>
<td>Once per year</td>
<td>Detection limits established shall meet QAPP-established criteria</td>
<td>Re-establish MDL</td>
</tr>
<tr>
<td></td>
<td>Results reported between MDL and PRL</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Semi-Volatile Organics SW8270</td>
<td>Five-point initial calibration for all analytes</td>
<td>Initial calibration prior to sample analysis</td>
<td>RF&gt;0.05; RSD for all target analytes ≤ 15%</td>
<td>Correct problem then repeat initial calibration</td>
</tr>
<tr>
<td></td>
<td>Second-source calibration verification</td>
<td>Once per five-point initial calibration</td>
<td>All analytes within ±25% of expected value</td>
<td>Correct problem then repeat initial calibration</td>
</tr>
<tr>
<td></td>
<td>Retention time window calculated for each analyte</td>
<td>Each initial calibration and calibration verifications</td>
<td>± 3 times standard deviation for each analyte retention time from 72-hour study</td>
<td>Correct problem then reanalyze all samples analyzed since the last retention time check</td>
</tr>
<tr>
<td></td>
<td>Calibration verification</td>
<td>Daily, before sample analysis, every 12 hours of analysis time, and at end of analysis sequence</td>
<td>All target analytes &lt;20%D</td>
<td>Correct problem then repeat initial calibration</td>
</tr>
<tr>
<td></td>
<td>Demonstrate ability to generate acceptable accuracy and precision using four replicate analyzes of a QC check sample</td>
<td>Once per analyst</td>
<td>Lab established</td>
<td>Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria</td>
</tr>
<tr>
<td></td>
<td>Check of mass spectral ion intensities using DFTPP</td>
<td>Prior to initial calibration and calibration verification</td>
<td>Refer to criteria listed in the method description</td>
<td>Retune instrument and verify</td>
</tr>
<tr>
<td>Applicable Parameter</td>
<td>QC Check</td>
<td>Minimum Frequency</td>
<td>Acceptance Criteria</td>
<td>Corrective Action</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------</td>
<td>-------------------</td>
<td>--------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Semi-Volatile Organics SW8270 (cont’d.)</td>
<td>IS</td>
<td>Every sample, spiked sample, standard, and method blank</td>
<td>Retention time &lt;±30 seconds; area within -50% to +100% of last calibration verification (12 hours) for each.</td>
<td>Inspect mass spectrometry or GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning</td>
</tr>
<tr>
<td>Method blank</td>
<td>One per analytical batch</td>
<td>No analytes detected &gt; PRL</td>
<td>Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank</td>
<td></td>
</tr>
<tr>
<td>LCS for all analytes</td>
<td>One LCS per analytical batch</td>
<td>Lab established</td>
<td>Correct problem then reprep and analyze the LCS and all samples in the affected analytical batch</td>
<td></td>
</tr>
<tr>
<td>Surrogate spike</td>
<td>Every sample, spiked sample, standard, and method blank</td>
<td>Lab established</td>
<td>Correct problem then re-extract and analyze sample</td>
<td></td>
</tr>
<tr>
<td>MS/MSD</td>
<td>One MS/MSD per every 20 project samples per matrix</td>
<td>Lab established</td>
<td>Re-extract and re-analyze the MS and MSD sample within holding time</td>
<td></td>
</tr>
<tr>
<td>MDL study</td>
<td>Once per year</td>
<td>Detection limits established shall meet QAPP-established criteria</td>
<td>Re-establish MDL</td>
<td></td>
</tr>
<tr>
<td>Results reported between MDL and PRL</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>ICP Metals SW6010B</td>
<td>Initial multipoint calibration (minimum 3 standards and a blank)</td>
<td>Daily initial calibration prior to sample analysis</td>
<td>Correlation coefficient ≥0.995 for linear regression</td>
<td>Correct problem then repeat initial calibration</td>
</tr>
<tr>
<td>Second-source calibration check standard</td>
<td>Once per initial daily multipoint calibration</td>
<td>Analyte within ±10% of expected value</td>
<td>Correct problem then repeat initial calibration</td>
<td></td>
</tr>
<tr>
<td>Highest calibration standard</td>
<td>Before beginning a sample run</td>
<td>All analytes within ±5% of expected value</td>
<td>Correct problem then repeat initial calibration</td>
<td></td>
</tr>
<tr>
<td>Calibration blank</td>
<td>After every 10 samples and at end of the analysis sequence</td>
<td>No analyte detected &gt;PRL.</td>
<td>Repeat twice, and average results; if average is not within ±3 standard deviations of background mean, terminate analysis; locate and correct problem; reanalyze previous 10 samples</td>
<td></td>
</tr>
<tr>
<td>Applicable Parameter</td>
<td>QC Check</td>
<td>Minimum Frequency</td>
<td>Acceptance Criteria</td>
<td>Corrective Action</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------</td>
<td>-------------------</td>
<td>---------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>ICP Metals SW6010B (Cont’d)</td>
<td>Continuing calibration verification standard</td>
<td>After every 10 samples and at the end of the analysis sequence</td>
<td>All analyte(s) within ±10% of expected value</td>
<td>Repeat calibration and reanalyze all samples since last successful calibration</td>
</tr>
<tr>
<td></td>
<td>Demonstrate ability to generate acceptable accuracy and precision using four replicate analyses of a QC check sample</td>
<td>Once per analyst</td>
<td>Lab established</td>
<td>Recalculate results; locate and fix problem with system and then rerun demonstration for those analytes that did not meet criteria</td>
</tr>
<tr>
<td></td>
<td>Method blank</td>
<td>One per analytical batch</td>
<td>No analytes detected &gt; PRL</td>
<td>Correct problem then reprep and analyze method blank and all samples processed with the contaminated blank</td>
</tr>
<tr>
<td></td>
<td>Interference check solution (ICS)</td>
<td>At the beginning and end of an analytical run or twice during an 8 hour period, whichever is more frequent</td>
<td>Within ±20% of expected value</td>
<td>Terminate analysis; correct problem; reanalyze ICS, reanalyze all affected samples</td>
</tr>
<tr>
<td></td>
<td>LCS for the analyte</td>
<td>One LCS per analytical batch</td>
<td>Lab established</td>
<td>Correct problem then reprep and analyze the LCS and all samples in the affected analytical batch</td>
</tr>
<tr>
<td></td>
<td>Dilution test</td>
<td>Each new sample matrix</td>
<td>1:4 dilution must agree within ±10% of the original determination</td>
<td>Perform post-digestion spike addition</td>
</tr>
<tr>
<td></td>
<td>Post-digestion spike addition</td>
<td>When dilution test fails</td>
<td>Recovery within 75-125% of expected results</td>
<td>Correct problem then reanalyze post-digestion spike addition</td>
</tr>
<tr>
<td></td>
<td>MS/MSD</td>
<td>One MS/MSD per every 20 project samples per matrix</td>
<td>Lab established</td>
<td>Re-extract and re-analyze the MS and MSD sample within holding time</td>
</tr>
<tr>
<td>Applicable Parameter</td>
<td>QC Check</td>
<td>Minimum Frequency</td>
<td>Acceptance Criteria</td>
<td>Corrective Action</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------</td>
<td>-------------------</td>
<td>---------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>MDL study</td>
<td>Once per year</td>
<td>Detection limits established shall meet QAPP-established criteria</td>
<td>Re-establish MDL</td>
<td></td>
</tr>
<tr>
<td>ICP Metals SW6010B (Cont’d)</td>
<td>Results reported between MDL and PRL</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Acronyms:

- %D - Percent difference.
- %R - Percent recovery.
- CCAL - Continuing calibration
- GC/MS - Gas chromatograph/mass spectroscopy
- ICAL - Initial Calibration
- LCL - Lower control limit
- LCS - Laboratory control sample
- LCSD - Laboratory control sample duplicate
- MS/MSD - Matrix spike/matrix spike duplicate
- NFG - National Functional Guidelines appendix
- RPD - Relative percent difference
- RRF - Relative response factor
- RT - Retention time
- RSD - Relative standard deviation
- UCL - Upper control limit
- VOCs - Volatile organic compounds
Appendix C-3

Records Management Plan
# TABLE OF CONTENTS

1 INTRODUCTION ........................................................................................................... 1

2 DOCUMENT CONTROL AND TRACKING ................................................................. 2
   2.1 Central File .............................................................................................................. 2
   2.2 Document Control ................................................................................................. 3
   2.3 Document Tracking ............................................................................................... 4

3 DATA GENERATION, TRANSFER, AND MANAGEMENT .............................................. 5
   3.1 Data Generation and Transfer .............................................................................. 6
   3.1.1 Field Analyses, Measurements and Logging ...................................................... 6
   3.1.1.1 Soil Borings and Piezometer Installation ......................................................... 6
   3.1.1.2 Sample Collection and Field Analyses ............................................................ 7
   3.1.1.3 Water Levels ................................................................................................. 8
   3.1.2 Laboratory Analyses ......................................................................................... 8
   3.1.3 Reports by Others ............................................................................................ 9
   3.2 Data Management ............................................................................................... 9
   3.2.1 Data Tracking .................................................................................................... 9
   3.2.2 Data Processing ............................................................................................... 10
   3.2.3 Data Entry and Transcription Checks ............................................................... 11
   3.2.4 Data Use ......................................................................................................... 11
   3.2.5 Data Transfer .................................................................................................. 12
   3.2.6 Database Storage, Maintenance and Security .................................................... 12
   3.2.6.1 Data Storage ................................................................................................. 12
   3.2.6.2 Data Maintenance ........................................................................................ 12
   3.2.6.3 Data Security ............................................................................................... 12

4 REPORT FORMATTING, DISTRIBUTION, and RECORDS RETENTION ................. 14
   4.1 Report Formatting and distribution ....................................................................... 14
   4.2 Records Retention ............................................................................................... 15

LIST OF TABLES

Table C-3A: Required Hardcopy Laboratory deliverables

LIST OF FIGURES

Figure C-3A: Data Processing Flowsheet
Figure C-3B: Conceptual Data Flow Diagram
Figure C-3C: VB/I-70 Databases

LIST OF APPENDICES

Appendix C-3A: Project File Structure
LIST OF ACRONYMS

ACM Asbestos-Containing Material
AOC Administrative Order on Consent
CABI Certified Asbestos Building Inspector
COC Compound of Concern
DBA Database Administrator
DBMS Database Management System
DCA Document Control Administrator
°C degrees Centigrade
DMT Data Management Team
EDD Electronic Data Deliverable
EMSI Engineering Management Support, Inc.
EPA Environmental Protection Agency
FSP Field Sampling Plan
ORP Oxidation Reduction Potential
OU-2 Operable Unit No. 2
PAHs Polynuclear-aromatic Hydrocarbons
PID Photo-ionization Detector
OU-2 Operable Unit #2
QAPP Quality Assurance Project Plan
QC Quality Control
RAWP Response Action Work Plan
RMP Records Management Plan
SAP Sampling and Analysis Plan
SDG Sample Delivery Group
TCLP Toxicity Characteristic Leaching Procedure
VOCs Volatile Organic Compounds
1 INTRODUCTION

This Records Management Plan (RMP) presents the approach, methods, and procedures for managing field data, design information, and project documents that are generated during design and implementation of the “environmental components” of an open channel stormwater drainage structure planned for Operable Unit 2 (OU-2) of the Vasquez Boulevard/Interstate 70 (VB/I-70) Superfund Site. The following information is presented in this Plan:

- Section 2 – Document control and tracking;
- Section 3 – Data generation and transfer from field activities and laboratory analyses to the electronic database. Management of the electronic database is also addressed in this section; and
- Section 4 – Report formatting, distribution, and records retention.
2 DOCUMENT CONTROL AND TRACKING

A system of labeling and storing hard copy and electronic data is being implemented to control and track documents generated during design and construction. The primary objectives are to:

- Establish and maintain a central file containing all project documents that have been generated to date, and those which will be generated during the VB/I-70 Removal Action;
- Establish procedures to verify that documents are routinely placed in the central file in a consistent and logical manner; and
- Facilitate efficient retrieval of information while maintaining accurate records of each document's location and custodian.

2.1 Central File

Documents generated as part of Site activities are being stored in a central file located at the EMSI office at 7220 West Jefferson Ave, Suite 406, Lakewood, CO. The point of contact responsible for the central file is the Project Manager, Tim Shangraw, at 303.940.3426. In addition, copies of all files are being retained by the City and County of Denver in their record repository located at 200 West 14th Avenue, Denver, CO. The point of contact for these files is Ms. Lisa Farrell, at 720.865.5439. The EMSI central file system is structured into a series of project files according to the following divisions:

1. Project Setup
2. Project Management File
3. Correspondence
4. Status Reports
5. Cost Control
6. Planning Documents
7. Design Investigation
8. Design Documents
9. Implementation
10. Health and Safety Monitoring
11. Miscellaneous
12. Reference Documents
13. Electronic Data Files
14. QA Files

Elements of each project file are further defined in Appendix C-3A.

The Project Manager serves as the Document Control Administrator (DCA). He is responsible for maintaining, updating and tracking files. Specific responsibilities include:
• Assign document control numbers;
• Routinely file records in a consistent and logical manner;
• Accurately record document locations in the Project File Index;
• Accurately update and maintain the Project File Index; and
• Supervise access to the file cabinets containing the documents.

These objectives are addressed through the document control and tracking procedures discussed below.

2.2 Document Control

Document control is accomplished using a document control number system. Each document is assigned a number and a file into which it is placed. The file number is unique to that document and is determined in accordance with following format:

\[
\begin{align*}
\text{VB} & = \text{VB/I-70 Superfund Site} \\
\text{pf} & = \text{Project file in which the document is stored (see Appendix C-3A for complete file structure)}
\end{align*}
\]

The format and content of the document control number provide sufficient information such that tracking and control of records and documents is facilitated. For example, the document control number VB-6-6.2.3 indicates that the document was generated for VB/I-70 Superfund Site, is stored in project file 6 (Planning Documents); subsection 6.2.3 (Final Sampling and Analysis Plan).

The DCA assigns each document a unique control number, files the document in the appropriate project file, and updates the File Index with the new document. The updating procedure involves the following:

• A project staff member submits a new file to the DCA along with a description of the file, where the file is to be located, and a proposed file number.
• The DCA then reviews the request and assigns the appropriate file number. The new file number is assigned in chronological order.
• The DCA then inserts the file into the Central File and adds the new file number to the File Index.
• The updated File Index is then dated, printed, and inserted into the File Index notebook in replacement of the previous index.

Electronic mail (e-mail) is managed in the same manner as hard-copy documents. First, e-mail is printed in hard copy. Next, the names of the sender and recipient are highlighted, along the date of transmission. The hard copy is then filed in accordance with the above procedure.
2.3 Document Tracking

Document tracking facilitates efficient retrieval of information while maintaining accurate records of each document's location and custodian. Document tracking is accomplished through an accurate and up-to-date tracking logbook. The logbook contains the following fields to aid in document tracking.

- Document control number;
- Individual borrowing the document and date of removal;
- Individual returning the document and date of return; and
- Confidential information business claims, if any.

In addition, whenever a document is removed from the central file, a sign-out card is inserted into the file holder from which the document was removed. In this manner, the DCA can quickly reference the status and location of the document that has been removed from the files. When the document is returned to the file, the card is removed.

Field or analytical data generated during Site activities requires a much greater level of control and tracking. The following Section discusses these procedures.
3 DATA GENERATION, TRANSFER, AND MANAGEMENT

A Database Management System (DBMS) is utilized to electronically process, store, track and manage relevant field and analytical data generated during Site activities. The DBMS is administered by the Data Management Team which consists of the Database Administrator (DBA) who manages the databases in Microsoft Access™, the validation chemist, a database manager specializing data use and graphics, and data checkers. DMT members report to the BDMS manager, who reports to the Project Manager.

The DMT coordinates with the field engineers, Certified Asbestos Building Inspector (CABI), and the Site Manager to collect and process the data. A flow diagram for processing data is presented in Figure C-3A. The primary objectives of the DBMS are to:

- Provide a mechanism to receive, process, store, track, and manage data from various field and monitoring sources including, but not limited to, geotechnical soil boring data, well installation data, field sampling data, water level data, analytical data, well abandonment data, and treatment process data; and
- Provide a tool to produce graphical outputs, tabular reports, and on-line queries that can be used to readily evaluate the geographic location of possible asbestos-containing material (ACM), hazardous material, performance of the water treatment facility, and to demonstrate regulatory compliance.

These objectives are accomplished by:

- Standardizing protocol to collect, transfer, process, track, and store technical data generated during investigative, design, and construction activities;
- Utilizing MS Access® to manage technical and environmental data generated during Site activities;
- Accessing data electronically to evaluate and map data; and
- Storing historical data.

Standardized protocol to collect, transfer, process, track, and store field and analytical data are presented in Subsection 3.1. Subsection 3.2 describes how Microsoft Access™ is used to store and manage the field and analytical data. Subsection 3.2 also contains protocol for preparing geologic and well construction logs, and the associated quality control procedures necessary to ensure the integrity of the information. Finally, end user needs and procedures to access electronic databases, as well as database security measures, are described in Subsection 3.2.
3.1 Data Generation and Transfer

As shown on Figure C-3A, the DBMS receives data from multiple sources. The field team directed by the Site Manager interfaces with the data management team (DMT) to transfer data generated from the field to the DBMS.

3.1.1 Field Analyses, Measurements and Logging

Field analyses and data logging include those activities that are associated with soil borings, piezometer installations, and field sampling events. Data generated during these activities are summarized in the following paragraphs. All laboratory analytical results are submitted by the laboratory’s project manager to the DBA, who then distributes the data to members of the DMT.

3.1.1.1 Soil Borings and Piezometer Installation

Soil borings and piezometers will be drilled/installed during the design investigation. Nomenclature for identifying borings, soil core, grab samples, and piezometers are presented in the Field Sampling Plan (FSP). Data documented during these activities include, but are not be limited to:

- Location name;
- Coordinates (northing, easting);
- Total depth;
- Operator (contractor);
- Completion date;
- Abandoned date;
- Status;
- Elevation of ground surface inner and outer casing;
- Stickup;
- Screened interval and length;
- Borehole or well diameter;
- Sump interval;
- Elevation of base of weathering;
- Water table elevation, if known;
- Formation (weathered Dawson, Lignite, etc.) of screened interval;
- Type and quality of core;
- Rig type;
- Boring type;
- Geologist;
- Installation date;
- Driller;
- Soil type and description;
- PID readings at interval; and
- Piezometer construction material.
These data are documented during installation activities by the field geologist or engineer on a hardcopy boring log diagram. A senior geologist or engineer reviews the log and makes edits as necessary. After any corrections, a hardcopy of the log is prepared, checked, and filed. Information from the logs and survey coordinates are forwarded to the DBA, who creates a new record in the Wellindex table of the Master-working.mdb.

3.1.1.2 Sample Collection and Field Analyses

Field analyses are performed and sample collection information is recorded as water samples, soil samples and waste characterization samples are collected. Samples will be collected from test borings, piezometers, and existing monitoring wells. Nomenclature for identifying samples are presented in the FSP. Data documented during field analyses and sample collection include, but are not limited to:

Sample Chain of Custody:

Sampling and transport from the Site to the analytical laboratory are documented on the chain-of-custody (COC) record by the sample collectors in the field. Data documented on this record include:

- Sample identification, boring location, or well name;
- Sample date and time;
- Chain-of-custody number;
- Signatures, dates, and times;
- Matrix type;
- Shipping tracking number;
- Container type, volume, and preservative.
- Laboratory to which the samples were sent;
- Special instructions or observations;
- Date and time at which the samples were sent;
- Requested analytical turnaround times; and
- Analytical test methods requested.

Original chain-of-custody forms accompany the associated samples throughout sample transport. Copies of the chain-of-custody record remain in the field with the field records for conducting the sampling activities. A copy of the chain of custody form is sent to the DMT for tracking purposes. In addition, the laboratory returns the original chain-of-custody record with the analytical report to the DMT.

Groundwater Sample Collection and Field Analyses:

Groundwater sampling field data are documented on a Groundwater Sampling Record in electronic format by the Site Manager. The Site Manager then forwards this information to the DMT. Information included on the Groundwater Sampling Record includes:
• Purge rate;
• Depth to water;
• Volume purged;
• Temperature (°C);
• Specific conductance;
• Dissolved oxygen;
• pH;
• Oxidation-Reduction Potential (ORP);
• Turbidity;
• Physical description;
• Date of purge;
• Sampling depth;
• Description of sampling equipment;
• Equipment calibration information;
• Weather conditions;
• Equipment blank associations;
• Filtering information; and
• Water level information (e.g., depth to water, measuring point reference).

Upon receipt of the Groundwater Sampling Record, the DMT processes the electronic file using queries and manual edits. After the data are checked for errors, the DBA appends the data to the Field Data table in Master-working.mdb.

**Soil Sample Collection:**

Soil sampling data are documented on a chain-of-custody form in the field, and are forwarded by the sampler to the DMT. The soil COC information also includes the depth interval from which the sample was collected.

3.1.1.3 Water Levels

As they are measured in the field, water levels are checked for outliers against the previous reading for that well. If the new measurement is greater or less than 0.25 feet from the previous reading at that well, the water level is re-measured. If the reading remains greater or less than 0.25 feet from the previous reading, the technician reviews the previous five water levels from that well and the Site Manager researches a possible explanation (nearby well being pumped, well hasn’t recharged after sampling, etc.). The Site Manager then annotates the water level result with pertinent information. The final data are then forwarded to the DBA who performs data checking and calculation routines before appending the new data set to the Water Levels table in Master-working.mdb.

3.1.2 Laboratory Analyses

Laboratory analyses are performed on water samples, soil samples, and waste characterization samples. Analytical procedures and internal quality control checks are
performed by the analytical laboratory in accordance with current EPA protocols for the analytical methods stipulated in the FSP.

When preliminary results are received from the analytical laboratory (usually in .pdf format) the DMT immediately forwards them to the appropriate user (see Subsection 3.2.1). When hardcopy or electronic data deliverable (EDD) results are received, they are logged in by the DMT and managed as described in Subsection 3.2.1.

3.1.3 Reports by Others

Sources of data from other investigative activities are identified in the RAWP. In addition, ongoing investigations at the VB/I70 site by others may be applied toward design of this Removal Action. If findings from reports by others are applied to this design project, the origin of such findings will be referenced and professional judgement will be applied regarding acceptance and usability of the information.

3.2 Data Management

This subsection describes the processes used to track, load, check, store, query, transfer, and maintain the analytical and field data (Figure C-3A). Here, the DMT’s responsibilities are to:

- Track analytical data from sample collection through validation;
- Process EDDs from the analytical laboratories, water level data, survey data, soil boring/piezometer construction data, and field sampling data and append to the appropriate database table;
- Perform transcription checks and validation qualifier entry;
- Assign data entry work and QC checking;
- Transfer data to appropriate end user;
- Query the data for end users; and
- Store and maintain the databases.

The following subsections describe these responsibilities in detail.

3.2.1 Data Tracking

After sample collection, a copy of the COC and a sample receipt notice (Confirmation Notice) from the laboratory are sent to the DMT, who logs each sample set into the Tracker table in Master-working.mdb. The following information is recorded:

- Classification/event (groundwater investigation, water treatment plant operation, etc.);
- Requirements for validation, transcription checking, and distribution;
- Laboratory name:
- Sample location identifiers;
At this point, the DMT compares the COC to the Confirmation Notice to confirm analyte lists and resolve any problems the laboratory may have with the sample shipment.

As indicated above, preliminary data are faxed or e-mailed to the DMT, who then forwards them to the appropriate user via e-mail. The receipt date of the preliminary data is then logged into the Tracker.

Hardcopy raw data packages (including the information specified in Table C-3A) are logged in using the Data Verification Checklist. A list of the data received is entered into the sample Tracker. The validation chemist then refers to the Tracker to determine which SDGs require validating, then performs the validation. The DBA also refers to the Tracker for a list of SDGs requiring transcription checks. Transcription checks are then performed.

Upon completion of data validation and transcription checks, the DBA updates the Tracker and enters any new data qualifiers or transcription information into the database. The EDD is e-mailed or sent by compact disk with the raw data package to the DBA. The DBA updates the Tracker after each SDG is processed.

The Tracker is also used periodically to check that all hardcopy and electronic data are received; that the data are processed into the appropriate data table; and that required validation and transcription checks were performed.

3.2.2 Data Processing

Data processing includes receipt, query checking, and appending new data; merging of validation qualifiers; corrections in the database as a result of transcription checks or other QC processes; and any other process by which the database is manipulated. Figure C-3B illustrates the conceptual flow of data.

As each set of data is received (laboratory, water level, field, logging, and process data), checking routines are performed and problems are resolved. These routines involve checking and resolving data consistency and integrity to verify that results have corresponding samples, samples have corresponding wells or locations, samples are uniquely identified, wells and locations are uniquely identified, units and compound names are consistent, and analytes are correct. For analytical data, the DBA refers to the Tracker to determine which table is appropriate to append the data. When QC and checking routines are complete the data are appended to the appropriate data table. Occasionally data from other sources are merged into the databases. The DBA processes these data by applying the appropriate formats and standardizing field content (such as compound names). When data originate from a source other than those directly managed
by the Respondent, a source identifier is added to identify its origin (i.e., EPA or Urban Drainage).

As indicated above, the validation chemist refers to the Tracker to determine which SDGs require validating. After validating an SDG, the chemist manually adds qualifiers to a queried set of data specific to that SDG in the Master-working.mdb. When the qualifiers have been added and QC’d, the DBA imports the information into Master-working.mdb and adds the qualifiers to the original data with an update query. The Tracker is then updated by the DBA.

Regarding transcription checks, the database manager provides a list of SDGs requiring transcription checks to a transcription checker. The checker prints out the electronic data and compares it to the summary data in the hardcopy or scanned raw data package. A yellow marker is used to indicate all data with which the checker agrees. A red pen is used to mark all proposed edits and to annotate corrections. Each printout is initialed and dated by the checker. The corrections are confirmed by a third party. The DBA then makes the changes to the electronic data, initials and dates the change, then files the printouts. The Tracker is again updated by the DBA after transcription checks are performed.

Occasionally, data users may find anomalous data and request a database change. Data verification is used to check data integrity prior to updating or modifying the databases. The verification process addresses the following issues relative to data entry:

- Identifying and resolving relatively simple data problems;
- Identifying and resolving missing information, as appropriate; and
- Identifying and resolving erroneous data (e.g., non-numeric results, incorrect sample numbers).

If adequate documentation or reasonable explanation is provided for the change, then the edits will be made. The verification process is supervised by the DBA. All changes are documented and maintained in the project files.

3.2.3 Data Entry and Transcription Checks

Manual entry data include field data (i.e., well location and construction information). Oversight of data entry is the responsibility of the DBA. Certain types of data are received as a hardcopy or a scanned (pdf) file. When this happens, the data must be entered manually. These data are entered into an Excel spreadsheet with the same fields as the data table to which it will be added. Following QC checking (same procedure as for transcription checks), the DBA appends the data to the appropriate table.

3.2.4 Data Use
The DBA provides technical support to DBMS users and provides data for design and waste disposal purposes, among others. The DMT accesses the databases to query data, evaluate and analyze data, and generate tabular data reports or graphics.

Data queries are used to collect groups of data specified by a set of parameters. The query parameters are selected by the user and the data can be queried by the DMT, by a predefined query screen, or directly by the user, whichever the user prefers.

Queried data are used for evaluating and analyzing data, generating data reports and generating graphical plots using different software. Evaluations and analyses can also be conducted visually by displaying output on the monitor or by printed hard copy.

3.2.5 Data Transfer

Data transfer from the field and laboratories is described in Subsection 3.1. Processed data can be transferred electronically from a host computer containing the DBMS database files to a remote computer. Files can also be transferred on disk. Such transfers might include a copy of a portion of the database, calculated results of requested queries or requested graphical files. Users are cautioned that such requests may include data that are current only up to the time that the transfer is made. If the same data are needed at a later time, a new request should be made to verify that the data are up-to-date.

Electronic databases are in Microsoft Access® formats. Databases and tables maintained and archived for the Site are listed in Figure C-3C.

3.2.6 Database Storage, Maintenance and Security

3.2.6.1 Data Storage

Multiple databases and data tables store data from the activities at the Site. Figure C-3C lists the data tables and databases.

3.2.6.2 Data Maintenance

Routine maintenance procedures performed on the databases include:

- Checking for database fragmentation and repair, as needed;
- Discovery and repair of basic software problems;
- Removal of obsolete data tables from the databases; and
- Performance of regular system backup.

3.2.6.3 Data Security

Data are secured from unauthorized access to minimize the potential for the loss or destruction of data. The DBA maintains a controlled, password-protected version of the database (Master-working.mdb). A password-protected copy of this database is available
for project personnel and is updated whenever the controlled copy is revised (Master.mdb).

The computer server that stores the data is secured in a locked room with limited access. Data are backed up daily and secured at an offsite location as part of regular network backup procedures. Measures are also taken to minimize the potential of database corruption by computer viruses. All system and local computers that manage the database are protected from computer viruses by an integrated virus scanner and firewall.
4 REPORT FORMATTING, DISTRIBUTION, and RECORDS RETENTION

4.1 Report Formatting and distribution

All draft report documents will be submitted in hard copy to the Agencies for their review and comment. Respondent may also submit electronic copies of draft documents to the agencies for their review and comment directly within the electronic document. Respondent will respond to comments (hard copy or electronic) in the manner in which they are received (hard copy or electronic). Informal comments, i.e., those discussed orally during work group meetings or via telephone, will be addressed and resolved in the same manner in which they are received. Comment resolutions will be incorporated into the final document, which will contain a signature page for EPA approval. An electronic copy of each draft document will be submitted to EPA.

Final report documents will be submitted in both hard copy and electronic format. Electronic format for text, tables, figures, and small appendices will be in “smart” Acrobat Adobe™ format where possible, that will retain active links within the document to the Table of Contents and referenced external internet sites/e-mail. This electronic format will also allow for word searches within the document. Large appendices that contain electronic databases or other structured electronic files (e.g. MS Excel™, MS Access™, AutoCad™) will be submitted in the format in which they were generated. All electronic format documents will be transmitted on compact disk in read-only format.

Distribution of documents will be as follows:

**Draft Documents:**
- EPA: 3 copies (2 hard copies and one in electronic format)
- CDPHE: 2 copies (1 hard copy and one in electronic format)

**Final Monitoring Plans and Work Plans:**
- EPA: 3 copies (2 hard copies and one in pdf format)
- CDPHE: 2 copies (1 hard copy and one in pdf format)

**Monthly Status Reports:**
- EPA: 3 copies (2 hard copies and one in pdf format)
- CDPHE: 2 copies (1 hard copy and one in pdf format)

Distribution of all other documents to other agencies or interested parties will be as directed by EPA.
4.2 Records Retention

In accordance with Section XI (Record Retention) of the AOC, project records that relate in any manner to the Respondent’s liability under CERCLA with respect to the Site will be retained for ten (10) years after Respondent’s receipt of EPA’s Notification of Completion of the Removal Action, pursuant to Paragraph 17 of the AOC. In addition, contractors or agents of the Respondent will preserve, for the same period of time, all non-identical copies of the last draft or final version of any documents or records (including documents or records in electronic format) that relate in any manner to the performance of the work.

At the conclusion of the retention period, Respondent will notify EPA at least ninety (90) days prior to the destruction of any such records or documents, and, upon request by the EPA, the Respondent will deliver any such records or documents to EPA. The Respondent may assert that certain documents, records, and other information are privileged under the attorney-client privilege, business confidential, or any other privilege recognized by federal law. In such a case, Respondent will provide EPA the general information about the documents required in Paragraph 37 of the AOC.
Tables
### Table C-3A

**REQUIRED HARCOPY LABORATORY DELIVERABLES**

**VB/I-70 SUPERFUND SITE**

<table>
<thead>
<tr>
<th>Method Requirements</th>
<th>Laboratory Deliverables (Definitive Data)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Requirements for all methods:</strong></td>
<td></td>
</tr>
<tr>
<td>Case narrative</td>
<td>Project identification</td>
</tr>
<tr>
<td></td>
<td>Analytical method description and reference citation</td>
</tr>
<tr>
<td></td>
<td>Discussion of unusual circumstances, problems, and nonconformances</td>
</tr>
<tr>
<td>Chain-of-custody (COC) form</td>
<td>Signed and dated when samples were received at laboratory</td>
</tr>
<tr>
<td>Dates of sample preparation and analysis (including first run and subsequent runs).</td>
<td>Any format</td>
</tr>
<tr>
<td>Quantitation limits achieved.</td>
<td>Any format</td>
</tr>
<tr>
<td>Dilution or concentration factors.</td>
<td>Any format</td>
</tr>
<tr>
<td>Summary analytical batch report including analytical batch samples, method of analysis, matrix description, date of sample collection and receipt, laboratory identification number of each environmental sample plus identification number of each batch quality control (QC) sample (including matrix spike/matrix spike duplicate (MS/MSD), calibration check, etc.).</td>
<td>Any format</td>
</tr>
<tr>
<td>Method reporting limits</td>
<td>QC summary report</td>
</tr>
<tr>
<td>QC limits</td>
<td>QC summary report</td>
</tr>
<tr>
<td>Practical quantitation limit (PQL) verification standard (weekly)</td>
<td>Any format</td>
</tr>
<tr>
<td>Corrective action reports.</td>
<td>Any format</td>
</tr>
<tr>
<td>Laboratory data validation/review checklists</td>
<td>Any format</td>
</tr>
<tr>
<td>A copy of all raw laboratory analytical data</td>
<td>Any format (chromatograms, mass spectra and data system printouts)</td>
</tr>
<tr>
<td>Example sample calculation</td>
<td>Any format</td>
</tr>
<tr>
<td>A copy of the sample preparation data form for each method indicating sample identification number, batch identification number, and date of preparation</td>
<td>Any format (preparation, extraction, or digestion data)</td>
</tr>
<tr>
<td>Percent moisture for all soil samples</td>
<td>Any format</td>
</tr>
</tbody>
</table>
Table C-3A (CONTINUED)
REQUIRED HARDCOPY LABORATORY DELIVERABLES
VB/I-70 SUPERFUND SITE

<table>
<thead>
<tr>
<th>Requirements for organic analytical methods:</th>
<th>Laboratory Deliverables (Definitive Data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample data sheets</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Surrogate recoveries</td>
<td>Summary information only</td>
</tr>
<tr>
<td>MS/MSD</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Method blank analysis</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Laboratory control spike (LCS)</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Instrument performance check (Tuning)</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Initial calibration data</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Continuing calibration data</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Calibration blank data</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Internal standard area and retention time summary data</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Retention time windows</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Analysis run log</td>
<td>No format</td>
</tr>
</tbody>
</table>

**Requirements for inorganic analytical methods**

<table>
<thead>
<tr>
<th>Metals:</th>
<th>Laboratory Deliverables (Definitive Data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample data sheets</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Initial and continuing calibration</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Method blank, taken through sample preparation</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Calibration blank data</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Interference check sample</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Laboratory control spike/laboratory control spike duplicate</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Matrix spike/matrix spike duplicate</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Post-digestion spike sample recovery</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Method of standard additions</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Serial dilutions</td>
<td>Summary information only</td>
</tr>
<tr>
<td>Analysis run logs</td>
<td>No format</td>
</tr>
</tbody>
</table>

a/ Summarized results can be in any format that provides the necessary data to completely validate that QC parameter. Example formats are the form equivalents to those defined for the EPA Contract Laboratory Program or SW 846 programs.
Appendix C-3A

Project File Structure
APPENDIX C-3A
PROJECT FILE STRUCTURE
VB/I-70 SUPERFUND SITE

1.0 PROJECT SETUP
1.1 File Inventory
1.2 Setup Sheet
1.3 Project Schedules

2.0 PROJECT MANAGEMENT FILE
2.1 Project Proposal
2.2 Admin Order (AO)/SOW
2.3 Services Agreement
   2.3.1 Insurance Certificates
   2.3.2 Change Orders
2.4 Subcontract Agreements

3.0 CORRESPONDENCE
3.1 Respondent or EMSI - EPA
   3.1.1 Incoming Correspondence
   3.1.2 Outgoing Correspondence
3.2 Respondent or EMSI - EPA/CDPHE
   3.2.1 Incoming Correspondence
   3.2.2 Respondent – Parsons Outgoing Correspondence
3.3 Design Team Correspondence
   3.3.1 EMSI – CTL Thompson
   3.3.2 EMSI – Frobel & Associates
   3.3.3 EMSI – Test America
   3.3.4 EMSI – Aquifer Technology
   3.3.5 EMSI – Site Services Drilling
   3.3.6 EMSI – Foresight West Surveying
   3.3.7 EMSI – Reserved
3.4 Interoffice Correspondence
   3.4.1 Telecons
3.4.2 Trip Reports

3.5 Construction Management
  3.5.1 Proposals
  3.5.2 Reserved

3.6 Memoranda

3.7 Meeting Notes/Minutes
  3.7.1 Respondent/Drainage Meetings
  3.7.2 EPA/CDPHE Meetings
  3.7.3 Public Meetings
  3.7.4 Subcontractor Meetings

4.0 STATUS REPORTS
  4.1 Monthly Status Reports
  4.4 Document Inventory

5.0 COST CONTROL
  5.1 Estimates
  5.2 Work Breakdown Structure
  5.3 Job Cost Summaries
  5.4 Cost Performance Reports
  5.5 Internal Review Documents

6.0 PLANNING DOCUMENTS
  6.1 RA Work Plan
    6.1.1 Draft
    6.1.2 Comments/Responses
    6.1.3 Final
  6.2 Sampling and Analysis Plan
    6.2.1 Draft
    6.2.2 Comments/Responses
    6.2.3 Final
  6.3 Field Sampling Plan
    6.3.1 Draft
    6.3.2 Comments/Responses
    6.3.3 Final
  6.4 Quality Assurance Project Plan
    6.4.1 Draft
6.4.2 Comments/Responses
6.4.3 Final
6.5 Materials Management Plan
6.5.1 Draft
6.5.2 Comments/Responses
6.5.3 Final
6.6 Health and Safety Plan
6.6.1 Draft
6.6.2 Comments/Responses
6.6.3 Final
6.7 Records Management Plan
6.7.1 Draft
6.7.2 Comments/Responses
6.7.3 Final

7.0 DESIGN INVESTIGATIONS

7.1 Mobilization
  7.1.1 Utility Clearances
  7.1.2 Water Supply
  7.1.3 On-site Facilities
  7.1.4 Well Permits

7.2 Survey Reports

7.3 Borehole and Piezometer Logs
  7.3.1 Field notes
  7.3.2 Hazardous Material Screen Results
  7.3.3 ACM Observations
  7.3.4 Boring and Piezometer Construction logs
  7.3.5 Photographs
  7.3.6 Chain of Custody

7.4 Groundwater Monitoring and Sampling
  7.4.1 Groundwater Levels
  7.4.2 Groundwater Sampling Logs
  7.4.3 Chain of Custody Records

7.5 Geotechnical Testing Reports

7.6 Analytical Testing Reports
7.7 Data Reduction/Interpretation
    7.7.1 Cross-Sections
    7.7.2 Volume Estimates
    7.7.3 Data Validation Assessment
    7.7.4 Extent of Non-Haz and ACM Material
    7.7.5 Extent of Haz Material
    7.7.6 Groundwater Quality vs Discharge Limits
    7.7.7 Reserved

7.8 Data Summary Report
    7.8.1 Draft
    7.8.2 Comments/Responses
    7.8.3 Final

8.0 DESIGN DOCUMENTS

8.1 Preliminary Design (barrier system and water treatment)
    8.1.1 Basis of Design
    8.1.2 Plans and Specifications
    8.1.3 Comments/Responses

8.2 Pre-Final Design (barrier system and water treatment)
    8.2.1 Basis of Design
    8.2.2 Cost Estimate
    8.2.3 Plans and Specifications
    8.2.4 Comments/Responses

8.3 Final Design (barrier system and water treatment)
    8.3.1 Basis of Design
    8.3.2 Cost Estimate
    8.3.3 Plans and Specifications
    8.3.4 Comments/Responses

9.0 IMPLEMENTATION

9.1 Procurement
    9.1.1 Prequalified Contractors
    9.1.2 Construction Bid Documents
    9.1.3 Reserved
    9.1.4 Reserved

9.2 Preconstruction Conferences
9.3 Inspection Diaries
9.4 Shop Drawing Submittal Log
9.5 Waste Profiles
  9.5.1 Waste Tracking
  9.5.2 Manifests
  9.5.3 Handling notes
9.6 Water Treatment
  9.6.1 Operating Records
  9.6.2 Analytical Results
  9.6.3 Secondary Wastes
9.7 Change Orders
9.8 Claim Documentation
9.9 Photographs
9.10 Test Reports
9.11 Survey Reports
9.12 Pre-Certification Inspection
9.13 Construction Completion Report
  9.13.1 Draft Report
  9.13.2 Comments/Responses
  9.13.3 Final Report

10.0 HEALTH AND SAFETY MONITORING
  10.1 Personnel Certificates
  10.2 Incidence Reports

11.0 MISCELLANEOUS
  11.1 Articles/Publications
  11.2 News releases
  11.3 Other

12.0 REFERENCE DOCUMENTS
  12.1 Reserved
  12.2 Reserved

13.0 ELECTRICAL DATA FILES
  13.1 Reserved
  13.2 Reserved
  13.3 Reserved
14.0 QA FILES

14.1 QA Audits
14.2 QA Memoarandum
Figures
**Figure C-3A**

**DATA PROCESSING FLOWCHART**

**Laboratory Analytical Data:**
- Groundwater, Waste (TCLP), Treatability

**Borehole Logging: Well Construction Data**
- Field Geologist creates initial borehole log
- Senior Geologist reviews electronic log
- Site Mgr sends survey data to DMT

**Groundwater Sampling Log sent to DMT**
- Preliminary data forwarded to users
- Samples sent to Lab, Logged In & Analyzed
- Lab sends confirmation notices and log-in problems to DMT
- DMT confirms analytic lists, resolves problems, and updates tracker

**Electronic Data File (EDD)**
- Queries for data checking
- Resolve problems
- Qualifiers added to SDG table in Master.mdb
- Copy validation tables to Master-working.mdb
- Query to update main data tables with qualifiers
- Copy data to master.mdb (for general users)
- Copy data to master.mdb (password protected for DMT only)
- Upload data to FTP site weekly
- Site manager downloads data and annotated file with pertinent information

**Data Checking and Calculations**
- TRACER
- Update Tracker
- Tracker used to categorize data and assign data table
- Query to update main data tables with qualifiers
- Transcriptions checks
- Update Tracker

**Update Table Tracker in Master.mdb**

**Water Level Data**
- Checks for outliers
- Resource Water Level
- Site Mgr sends survey data to DMT
- Field geologist creates initial hardcopy borehole log
- Senior geologist reviews electronic log
- Print hardcopy of boring log and cross section
- Lab sends confirmation notices and log-in problems to DMT
- Hardcopy data and pdf file
- Upload data to FTP site weekly
- Site manager downloads data and annotated file with pertinent information
- Sends file to DMT
- Data is checked, edited, and revised
- Site manager downloads data and annotated file with pertinent information
- Sends file to DMT
- Data checking and calculations
- TRACER
- Update Tracker
- Tracker used to check that all analytical data is received, checked, validated, and appended (Hardcopy and EDD)
Figure C-3B
CONCEPTUAL DATA FLOW DIAGRAM

- Monitoring Well Analytical Samples
- On-Site Water Treatment Analytical Samples
- Waste Analytical and ACM Samples

- Off-Site Analytical Laboratory

- Consultants: Validation and
- Database Management System

- Field Analytical Data

- Consultants: Interpretation and processing

- Consultants: Processing

- Waste Profiling

- Reports and data to Respondent
Figure C-3C
VB/I-70 DATABASES

Master-Working.mdb
Data tables listed below

**Groundwater:**
Groundwater Analytical Data
Water Levels
WellIndex
Field Data

**Waste:**
RCRA Field Screen
Totals (VOCs, PAHs, metals)
TCLP (VOCs, PAHs, metals)
Asbestos
Other

**Water Treatment Plant:**
WTP New Analytical Data
WTP Analytical Data
WTP New Bio
WTP New Bio Field

Tracker
Appendix D
Materials Management Plan

For the

Removal Action
High Street Outfall and 40th Avenue Storm Sewer System

Vasquez Boulevard/Interstate 70 Site, Operable Unit #2

Prepared for:
City and County of Denver
Environmental Quality Division
200 West 14th Ave, Suite 310
Denver, Colorado 80204

Prepared by:
Engineering Management Support, Inc.
7220 W. Jefferson Ave., Suite 406
Lakewood, Colorado 80235

June 19, 2015
# TABLE OF CONTENTS

1 INTRODUCTION .............................................................................................................. 1

1.1 OBJECTIVES AND GOALS .............................................................................................. 1 
1.2 PLAN ORGANIZATION ................................................................................................... 1 

2 WASTE MATERIAL AND COMPOUNDS OF CONCERN .......................................... 2 

2.1 WASTE MATERIAL ........................................................................................................ 2 
2.2 GROUNDWATER ............................................................................................................ 2 

3 REGULATORY CRITERIA ............................................................................................. 3 

3.1 WASTE MATERIAL ........................................................................................................ 3 
3.1.1 Solid Waste ........................................................................................................... 3 
3.1.2 Hazardous Waste .................................................................................................. 4 
3.1.3 Asbestos-Containing Material .............................................................................. 5 
3.2 GROUNDWATER ............................................................................................................ 8 
3.2.1 Release to the South Platte River or Sand Creek .................................................. 8 
3.2.2 Off-Site Disposal .................................................................................................. 9 
3.3 OFF-SITE RULE ............................................................................................................. 9 

4 MATERIALS MANAGEMENT ..................................................................................... 11 

4.1 WASTE MATERIAL ...................................................................................................... 11 
4.2 GROUNDWATER .......................................................................................................... 12 
4.3 INVESTIGATIVE-DERIVED AND DECONTAMINATION WASTE .............................. 12 

5 REFERENCES ................................................................................................................. 14 

## LIST OF TABLES

Table D-1 Preliminary Waste Material Screen Against TCLP Toxicity and CDPHE Contained-Out Criteria for Restricted Use 
Table D-2 Preliminary Discharge Limits for South Platte River, Segment 14 
Table D-3 Preliminary Discharge Limits for South Platte River, Segment 16c (Sand Creek) 

## LIST OF FIGURES

Figure D-1 Conceptual Plan View of Stormwater Drainage System 
Figure D-2 Conceptual Stormwater Channel Cross-section 
Figure D-3 Waste/Soil Material Compounds of Concern 
Figure D-4 Groundwater Compounds of Concern 

## LIST OF APPENDICES

Appendix D-1 Summary of Environmental Conditions 
Appendix D-2 Regulatory Criteria 
Appendix D-3 Mobile Water Treatment Equipment
# LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACM</td>
<td>Asbestos-Containing Material</td>
</tr>
<tr>
<td>bgs</td>
<td>Below ground surface</td>
</tr>
<tr>
<td>BMPs</td>
<td>Best Management Practices</td>
</tr>
<tr>
<td>CCoD</td>
<td>City and County of Denver</td>
</tr>
<tr>
<td>CCR</td>
<td>Construction Completion Report</td>
</tr>
<tr>
<td>CDOT</td>
<td>Colorado Department of Transportation</td>
</tr>
<tr>
<td>CDW</td>
<td>Construction Dewatering</td>
</tr>
<tr>
<td>CERCLA</td>
<td>Comprehensive Environmental Response, Compensation, and Liability Act</td>
</tr>
<tr>
<td>COC</td>
<td>Compound of Concern</td>
</tr>
<tr>
<td>EMSI</td>
<td>Engineering Management Support, Inc.</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>ESD</td>
<td>Explanation of Significant Difference</td>
</tr>
<tr>
<td>FSP</td>
<td>Field Sampling Plan</td>
</tr>
<tr>
<td>HASP</td>
<td>Health and Safety Plan</td>
</tr>
<tr>
<td>LEL</td>
<td>Lower Explosive Limit</td>
</tr>
<tr>
<td>mg/kg</td>
<td>milligram per kilogram</td>
</tr>
<tr>
<td>MMP</td>
<td>Materials Management Plan</td>
</tr>
<tr>
<td>PAHs</td>
<td>Polynuclear-aromatic Hydrocarbons</td>
</tr>
<tr>
<td>% v/v</td>
<td>percent by volume</td>
</tr>
<tr>
<td>OU-2</td>
<td>Operable Unit #2</td>
</tr>
<tr>
<td>QAPP</td>
<td>Quality Assurance Project Plan</td>
</tr>
<tr>
<td>RACS</td>
<td>Regulated Asbestos-Contaminated Soil</td>
</tr>
<tr>
<td>RAWP</td>
<td>Response Action Work Plan</td>
</tr>
<tr>
<td>RD/RA/O&amp;M</td>
<td>Remedial Design/Remedial Action /Operations and Maintenance</td>
</tr>
<tr>
<td>ROD</td>
<td>Record of Decision</td>
</tr>
<tr>
<td>RPM</td>
<td>Remedial Project Manager</td>
</tr>
<tr>
<td>RTD</td>
<td>Regional Transportation District</td>
</tr>
<tr>
<td>SAP</td>
<td>Sampling and Analysis Plan</td>
</tr>
</tbody>
</table>
SOW  Statement of Work
SVOCs  Semi-volatile Organic Compounds
TSDF  Treatment, Storage, and Disposal Facility
VOCs  Volatile Organic Compounds
1 INTRODUCTION

Work under this Removal Action entails design and implementation of the “environmental components” of an open channel stormwater drainage feature to be constructed through a portion of Operable Unit 2 of the VB/170 Superfund site. A conceptual plan and cross-section of the segment of the stormwater channel of interest, which lies on property owned by the Respondent, are illustrated on Figures D-1 and D-2, respectively.

1.1 Objectives and Goals

Objectives of this MMP consist of providing for safe handling and disposal of waste material and management of groundwater and perched liquids that are encountered during construction of the Removal Action. These solids and liquids are to be managed in a manner that complies with applicable environmental regulations, EPA guidelines, and applicable or relevant and appropriate requirements (ARARs). Accordingly, this plan describes the handling, treatment, and disposal procedures that pertain to these media.

Specific goals consist of:

- Removal and disposal of waste material as soon as possible following excavation to minimize health risk involved in onsite storage;
- Minimize the volume of liquids that need to be managed by routing non-contact stormwater around the construction area and expediting excavation and backfilling of material below the groundwater table; and
- Maximize use of onsite water treatment with discharge to the South Platte River or Sand Creek to reduce risks associated with off-site disposal.

1.2 Plan Organization

This MMP contains five sections, including this introduction. Compounds of concern associated with waste material and groundwater are described in Section 2. Applicable regulatory criteria are presented in Section 3. Management of waste material, groundwater, and investigative-derived wastes is presented in Section 4, and references are presented in Section 5.

The text is followed by three appendices that contain:

Appendix D-1: Summaries of known environmental conditions
Appendix D-2: Regulatory criteria
Appendix D-3: Mobile water treatment equipment

Materials Management Plan
VB/170 Operable Unit 2 Removal Action
06/19/15
2 WASTE MATERIAL AND COMPOUNDS OF CONCERN

2.1 Waste Material

Waste material beneath and west of the Denver Coliseum parking lot have been characterized by EMSI, 2009; Brown and Caldwell, 2010; and CTL Thompson, 2011. Summary results from their investigations are presented in Appendix D-1.

Within the limits of the study area illustrated on Figure D-1, waste material is present from approximately two feet below the ground surface (bgs) to as much as 20 feet bgs. Inferred thicknesses of the waste material within the study area range from zero to approximately 15 feet (Figure D-1). Note: Additional waste material may be present in the Globeville Landing Park area located west of the Coliseum parking lot, but the areal extent, thickness, and depth are not known at this time.

Compounds of potential concern consist of volatile organic compounds (VOCs), polynuclear-aromatic hydrocarbons (PAHs), arsenic, lead, and asbestos. Reported concentrations of VOCs, PAHs and metals in waste material within and adjacent to the study area are shown on Figure D-3.

Asbestos was detected in waste material collected from HS-2 (Figure D-3) at a concentration of 0.5 percent of the total sample analyzed (CTL Thompson, 2011). This may be considered a trace amount, but its presence raises concern that asbestos may be randomly present in the waste material.

2.2 Groundwater

Groundwater quality was also been characterized by EMSI, 2009; Brown and Caldwell, 2010; and CTL Thompson, 2011. Summary results from their investigations are also presented in Appendix D-1.

Within and adjacent to the study area, groundwater depths below the ground surface were measured in 2010 (Brown and Caldwell, 2010) and 2011 (CTL-Thompson, 2011). Their single-point readings indicate depths below ground surface of approximately 11.5 feet at CTL MW-4; 10.7 feet at HS-02; 12.0 feet at CTL MW-5; 13.7 feet at HS-08; 23.5 at MW-1; and 23.8 feet at HS-01. These depths will vary over time, but the single-point data provide a general indication of the depth to groundwater for construction planning purposes.

As shown on Figure D-4, compounds of potential concern in groundwater consist of volatile organic compounds (VOCs), arsenic, cadmium, copper, lead, manganese, and zinc.
3 REGULATORY CRITERIA

3.1 Waste Material

Based on the samples of waste material collected to date, these media do not appear to be characteristically hazardous, nor TCLP toxic. However, there is a potential for encountering hazardous and/or asbestos-containing material (ACM) within the buried waste. If encountered, this material will need to be handled separately. Regulations governing the handing non-hazardous solid waste, hazardous waste, and ACM are discussed below:

3.1.1 Solid Waste

A preliminary screen of the compounds of concern in waste material that is anticipated to be excavated was conducted to assess whether 1) the material may be characteristically hazardous, and 2) to assess the whether the material can be disposed of at the Denver Arapahoe Disposal Site (DADS) as a “Contained-Out, Restricted” media under CDPHE’s Contained-Out policy for environmental media (https://www.colorado.gov/pacific/sites/default/files/HM_corrective-action-app2-contained-out-determination.pdf, as updated in Appendix D-2). To the latter screen, media are non-hazardous for restricted use (disposal into a RCRA Subtitle D landfill) if the media concentrations are: A) less than or equal to USEPA Regional Screening Levels for Residential Soils times 100 (Criteria A); and B) are equal to or less than TCLP limits (Criteria B-1) or Colorado Basic Standards for Groundwater x 100 (Criteria B-2). In the case where no B-1 criteria are available, B-2 criteria do not apply. In addition, the material must not fail Land Disposal Restriction (LDR) criteria, which equate to EPA’s Universal Treatment Standards times a multiplier.

Results of the screen using an average concentration of the analytical results from the borings shown on Figure D-3 are presented in Table D-1. They indicate that 1) none of the compounds of concern exceed Contained-Out Criteria A; 2) only lead might exceed Contained-Out Criteria B-1 or B-2, and 3) none of the values exceed LDR criteria. It should be noted that the possible B-1 exceedance for lead is based on a synthetic TCLP value, which was derived by dividing the Total lead value by 20. This is likely to be overly conservative in that the actual Total lead-to-TCLP lead ratio may be closer to 187, as evidenced by results from HS-02, shown on Figure D-3. So for planning purposes, lead is not expected to exceed its TCLP value. Nonetheless, additional samples of waste material will be characterized during the Design Investigation and results will be screened against TCLP and Contained-Out criteria in the manner discussed above, as a basis for acceptance of the material for disposal at DADS.

Procedures for planning and implementing offsite response actions under CERCLA are specified in 40 CFR Part 300.44, known as the Offsite Rule. This regulation may apply to offsite treatment and disposal of non-hazardous solid waste material from a CERCLA site that cannot be managed onsite. Further discussion of the Offsite Rule is presented in Section 3.3, below.
3.1.2 Hazardous Waste

To the extent that hazardous waste may be encountered, regulations concerning the identification and listing of hazardous waste are specified under 40 CFR Parts 260 through 261, and 6 CCR 1007-3 Parts 260 through 261. Applicable portions of these regulations include the definition of hazardous waste (Part 261.3); hazardous waste exclusions (Part 261.4); and the characteristics of hazardous waste, including ignitability (Part 261.21), corrosivity (Part 261.22), reactivity (Part 261.23), and toxicity (Part 261.24). Based on the age of the landfill material present within OU-2, and on the characterization data available to date, buried material will probably not be listed hazardous waste.

Regulations concerning standards applicable to generators of hazardous waste are specified under 40 CFR Part 262, and 6 CCR 1007-3 Part 262. Applicable portions of these regulations include the hazardous waste determination requirements in accordance with Part 262.11.

Should hazardous wastes be present at the site, a hazardous waste generator identification number will need to be obtained from CDPHE. This number will be applied to all offsite shipments of hazardous waste in accordance with Part 262.12. Similarly, use of manifest documents as described in Part 262.20; packaging, labeling, marking, and placarding requirements described in Parts 262.30 through 262.33; and recordkeeping and reporting requirements described in Parts 262.40 through 262.42 will be applicable in the event that hazardous wastes are sent offsite for disposal.

Regulations pertaining to the operating and performance standards for container storage of hazardous waste are specified in 40 CFR Part 264, Subpart I; and 6 CCR 1007-3 Part 264, Subpart I. Containers holding hazardous waste, such as drums, will be in good condition or will be overpacked if discovered to not be in good condition (Part 264.171). Drums specified for use in Subsection 4.6 of this plan are constructed with materials that are compatible with the wastes being stored (Part 264.172). Containers will be kept closed during storage, and will not be handled in a manner that may rupture the container or cause it to leak (Part 264.173). Weekly inspections of containers stored onsite will need to be performed (Part 264.174). Containers with ignitable or reactive waste (if encountered) will be stored more than 50 feet from the site property line (Part 264.176), and incompatible waste will not be placed in the same container, in an unwashed container that previously held an incompatible waste or material, or stored near other containers of incompatible wastes or materials (Part 264.177).

Regulations concerning the handling of potentially incompatible wastes are specified in 40 CFR Part 265.17, and 6 CCR 1007-3 Part 265.17. Precautions should be taken to prevent accidental ignition or reaction of wastes, and incompatible wastes (if encountered) will be separated and protected from sources of ignition or reaction (Part 265.17). Regulations concerning LDRs are specified in 40 CFR Part 268, and 6 CCR 1007-3 Part 268. These regulations will apply to offsite treatment and disposal of hazardous wastes.
As discussed above, procedures for planning and implementing offsite response actions under CERCLA are specified in 40 CFR Part 300.44, known as the Offsite Rule. This regulation applies to offsite treatment and disposal of hazardous wastes that cannot be managed onsite. Further discussion of the Offsite Rule is presented in Section 3.3, below.

### 3.1.3 Asbestos-Containing Material

The substantive requirements of CDPHE’s Asbestos Contaminated Soil regulations and guidance are relevant to this site. The regulations are incorporated into Section 5.5 (Management of Regulated Asbestos-Contaminated Soil) of the State’s Solid Waste Regulations and can be downloaded from: [https://www.colorado.gov/pacific/sites/default/files/Part%201%20eff%2001-14-15.pdf](https://www.colorado.gov/pacific/sites/default/files/Part%201%20eff%2001-14-15.pdf).

Guidance documents can be found at: [https://www.colorado.gov/pacific/sites/default/files/HM_sw-asbestos-waste-disposal_0.pdf](https://www.colorado.gov/pacific/sites/default/files/HM_sw-asbestos-waste-disposal_0.pdf) and [https://www.colorado.gov/pacific/sites/default/files/HM_sw-regs-sect-5-asbestos.pdf](https://www.colorado.gov/pacific/sites/default/files/HM_sw-regs-sect-5-asbestos.pdf)

Two types of ACM may be encountered consisting of Regulated Asbestos-Contaminated Soil (RACS), and non-RACS. Descriptions of each, as well as protocol for a RACS-Determination, are discussed below:

**RACS is defined as:**

Soil, ash or debris (plus six (6) inches in all directions of surrounding soil or other matrix material) containing:

1. Friable asbestos-containing materials (ACM) as determined in the field by a Certified Asbestos Building Inspector (CABI) through a RACS determination (defined below);
2. Previously non-friable ACM(s) that have been rendered friable as determined in the field by a CABI(s) through a RACS determination;
3. Non-friable ACM(s) that have a high probability of releasing fibers based on the forces expected to act upon the material during soil disturbance as determined in the field by a CABI(s) through a RACS determination;
4. Deteriorated non-friable ACM(s) that are in poor condition resulting in a high probability to release fibers due to weathering, historical mechanical impact, fire damage (by evidence of ACM within an ash layer) or other factors as determined in the field by a CABI(s) through a RACS determination; and
5. If determined by the CABI to potentially-contain ACM, the following broken, resized, or damaged material are also RACS:
   a. Asbestos cement materials;
   b. Plaster;
   c. Brittle caulking, glazing and sealants;
   d. Powdery Concrete Masonry Unit (CMU) sealant;
e. Powdery floor leveling compound;

f. Drywall/wallboard and associated joint compound material;

g. Firebrick; and

h. Other material as determined by CDPHE Solid Waste Division, at the request of the owner or person disturbing debris, to have a high probability to release fibers.

**Non-RACS is defined as:**

Soil or debris that contains only:

1) Intact non-damaged, non-friable ACM; or,

2) Damaged non-friable ACM(s) that do not have a high probability to release fibers based on the forces expected to act upon the material during disturbance as determined in the field by a CABI(s) through a “RACS Determination”. The following ACM(s) are predetermined to be Non-RACS:

   a. Resin based materials including but not limited to phenolic-plastic (Bakelite), used in electrical and mechanical parts;

   b. Resilient flooring (vinyl, asphalt, rubber) excluding non-tar impregnated friable felt backing on sheet vinyl flooring (linoleum);

   c. Tar impregnated or asphaltic materials in good condition that have not become brittle;

   d. Elastic, pliable, or rubberized materials, including but not limited to:

      i. Pliable duct sealant;

      ii. Pliable fiberglass insulation sealant;

      iii. Pliable fire-stop caulking/sealants; and

      iv. Pliable window and door caulking.

   v. Extremely hard materials, coatings and sealants including but not limited to:

      • Laboratory countertops and sinks;

      • Epoxy type Concrete Masonry Unit (CMU) coatings;

      • Epoxy type panel adhesive;

      • Duct sealant;

      • Ceiling tile adhesive; and

      • Other ACM(s) as approved by CDPHE Solid Waste Division at the request of the owner or person disturbing debris, to not have a high probability to release fibers.
A “RACS Determination” is defined as:

A determination, conducted in the field by a CABI, of the friability of ACM and the probability of non-friable ACM to release fibers based on the condition of the material and the forces that are expected to act on it during disturbance. Determinations of friability shall be based on the requirements for such determinations set forth in Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B). Determinations of the probability for nonfriable ACM to release fibers during disturbance shall be based on the following:

1) The condition of the material prior to disturbance, based on observations of weathering, the integrity of the material, historical mechanical impact, or fire damage;

2) The potential for the material to be broken, resized or damaged during planned disturbance;

3) The material shall be considered RACS if the planned disturbance includes any of the following:
   a. Augers;
   b. Rotary style trenchers;
   c. Driving on ACM lying on the surface (vehicles or equipment);
   d. Blasting or other detonation;
   e. Intentional burning;
   f. Other types of direct mechanical impact which are:
      i. In direct contact with ACM or result in observation of ACM after disturbance; and
      ii. Causing damage to the ACM.

Section 5 of the Solid Waste Regulations (6 CCR 1007-2) includes regulations on packaging of asbestos for disposal and disposal criteria for landfills. Non-friable asbestos may be disposed at DADS in compliance with Sections 5.1 and 5.2 of the regulations. Friable asbestos, and non-friable asbestos damaged to the point of being friable, may be disposed at DADS in compliance with Sections 5.1 and 5.3 of the regulations. In either case, the landfill operator must be contacted for approval prior to disposal.

Friable asbestos waste and non-friable asbestos waste damaged to the point of being friable must be properly packaged before being sent to the landfill. It must be tightly sealed, while wet, in at least two 6-mil, leak-tight polyethylene bags or in a wrapping or other container deemed equivalent by the CABI. The outermost layer of the packaging must be labeled with a waste shipment manifest label that gives the name and address of the generator of the waste, and either of the following statements in letters at least 0.5 inches tall. Additional requirements for: Establishment and Control of a Regulated Work Area; Personal Protective Equipment; Wetting; Wind Speed Monitoring; Air Monitoring; Work Practices; Loading and Placement of RACS; Onsite Staging, Stockpiling, and Storage of RACS; Decontamination;
RACS Spill Response; Requirements for Exposed RACS Remaining in Place; and Documentation, are described in Section 5.5.7 of the Solid Waste Regulations.

As discussed above, procedures for planning and implementing offsite response actions under CERCLA are specified in 40 CFR Part 300.44, known as the Offsite Rule. This regulation applies to offsite treatment and disposal of RACS and non-RACs waste material that cannot be managed onsite. Further discussion of the Offsite Rule is presented in Subsection 3.3, below.

3.2 Groundwater

If groundwater, which includes perched water, is encountered the excavation will require dewatering. Two management scenarios are considered. The first is release of the water to the South Platte River or Sand Creek under Colorado’s General Permit for Construction Dewatering or Remediation. The second is disposal of the water offsite as an industrial or hazardous waste in a licensed RCRA treatment, storage, or disposal facility (TSDF). Both options are discussed below.

3.2.1 Release to the South Platte River or Sand Creek

Under this option, coverage under Colorado’s General Permit for Construction Dewatering or Remediation is required from the Water Quality Control Division (WQCD) of the Colorado Department of Public Health and Environment (CDPHE). Such coverage is required any time groundwater, including groundwater that is commingled with stormwater or surface water, is encountered during construction activities where the water needs to be discharged to surface water or back to the ground (Construction Dewatering), or any time groundwater, including groundwater that is commingled with stormwater or surface water, is encountered during construction activities and the water quality is known or suspected to contain constituents in excess of one-half the allowable discharge limit, where the water needs to be discharged to surface water or back to the ground (Remediation). It should be noted that if surface water is diverted around a construction area and no pollutants are introduced during the diversion, neither type of permit coverage is required. This applies to pumped diversions. However, if the diverted water enters the construction area and contacts pollutant sources (e.g., disturbed soil, concrete washout, etc.), permit coverage is required.

A copy of the General Permit and an application for coverage under the General Permit are available at [http://www.cdphe.state.co.us/wq/PermitsUnit/Industrial/Index.html](http://www.cdphe.state.co.us/wq/PermitsUnit/Industrial/Index.html). Additional information regarding application submittals, durations, fees, and conditions is available at [https://www.colorado.gov/pacific/sites/default/files/cog070000faq.pdf](https://www.colorado.gov/pacific/sites/default/files/cog070000faq.pdf).

Preliminary assessments of water quality limits that would be applicable to discharge to the South Platte River from an outfall at Globeville Park, or to Sand Creek are presented in Tables D-2 and D-3, respectively. Supporting information is provided in Appendix D-2.

The metals limits are based on CDPHE Regulation 38. For the South Platte River, the metals
limits are based on an average water quality hardness of 250 mg/L in Segment 14 of the South Platte River. For Sand Creek, which is a component of Segment 16c of the Upper South Platte River basin, a water quality hardness of 400 mg/L is applied, which is the maximum hardness value allowed for the calculations, even though the actual hardness in this creek is much higher. Water quality limits for the VOCs of concern are based on Regulation 31 surface water quality standards.

3.2.2 Off-Site Disposal

If the construction waters cannot be cost-effectively treated and released to the South Platte River or Sand Creek, off-site disposal will be considered. The off-site disposal option involves an initial assessment of RCRA-hazardous or non-hazardous status. Based on historic and process knowledge, the dewatering waters are not listed wastes. Therefore, the hazardous determination will be based on RCRA characteristics and TCLP toxicity. Based on the characterization data collected to date (Appendix D-1 and Figure D-4), the TCLP toxicity parameters will be limited to VOCs, SVOCs, and eight RCRA metals. Note: additional characterization data collected during the Design Investigation may impact this determination.

If dewatering water is determined to be RCRA non-hazardous and cannot be cost-effectively treated to the limits required for release to the South Platte River or Sand Creek, it will be manifested as a non-hazardous waste, transported offsite to a Clean Harbors facility where it will be stabilized (solidified) for disposal in a RCRA Subtitle D landfill, or transported offsite to a RCRA Subtitle D landfill where it will be land-applied in accordance with the landfill’s prescreening land-application criteria.

If construction water is determined to be RCRA hazardous it will be transported to Clean Harbor’s Deer Trail facility for stabilization (solidification) and buried as a hazardous waste. If LDRs preclude such burial, the water may be treated in a Subtitle C facility, or incinerated at Clean Harbor’s Kimball, Nebraska facility.

As discussed above, procedures for planning and implementing offsite response actions under CERCLA are specified in 40 CFR Part 300.44, known as the Offsite Rule. This regulation applies to offsite treatment and disposal of contaminated water that cannot be managed onsite. Further discussion of the Offsite Rule is presented in Subsection 3.3, below.

3.3 Off-Site Rule

The Offsite Rule indicates that EPA will determine the acceptability of any offsite facility that has been selected for treatment, storage or disposal of CERCLA wastes. The proposed receiving facility must be operating in compliance with all applicable federal, state, and local regulations, and there must be no relevant violations affecting the receiving unit. In addition, there must be no releases from the receiving unit, and contamination from prior releases at the receiving unit must be addressed as appropriate. Releases from other units located within
the receiving facility boundaries must also be addressed as appropriate.

Respondent will, prior to any offsite shipment of waste material from the site to an out-of-state waste management facility, provide written notification to the appropriate state environmental official in the receiving facility’s state and to the EPA Project Coordinator of such shipment of waste material. However, this notification requirement does not apply to any offsite shipments when the total volume of all such shipments does not exceed ten (10) cubic yards.

Respondent will include in the written notification the following information, where available: (1) the name and location of the facility to which the waste material is to be shipped; (2) the type and quantity of the waste material to be shipped; (3) the expected schedule for the shipment of the waste material; (4) the method of transportation; and (5) the route to be traveled. The Respondent will notify the state in which the planned receiving facility is located of major changes in the shipment plan, such as a decision to ship the waste material to another facility within the same state, or to a facility in another state.

The identity of the receiving facility and state will be determined by the Respondent following the award of a services agreement for offsite transportation, treatment, storage, and disposal services. The Respondent will provide the name and location of the receiving facility(ies) to the appropriate state environmental official in the receiving facility’s state and to the EPA Project Coordinator as soon as practicable after the award of the contract and no less than sixty (60) days before the waste material is actually shipped.

Before shipping any hazardous substances, pollutants, or contaminants from the Site to an off-site location, Respondent will obtain EPA’s certification that the proposed receiving facility is operating in compliance with the requirements of CERCLA Section 121(d)(3), 42 U.S.C. § 9621(d)(3), and 40 C.F.R. § 300.440. Respondent will only send hazardous substances, pollutants, or contaminants from the Site to an off-site facility that complies with the requirements of the statutory provision and regulations cited in the preceding sentence.
4 MATERIALS MANAGEMENT

4.1 Waste Material

The contractor removing the waste material from OU-2 is responsible for placement of a competent person, whose qualifications include a CABI, on site to oversee all excavation activities to witness any variation in the exhumed waste that would require additional characterization prior to acceptance at DADS. The competent person performing the oversight should be equipped with instrumentation that can monitor changes in the waste stream for organic compounds and ACM, and maintain visual contact with the excavation to identify potentially hazardous wastes if they were encountered. Specific examples of materials that would require additional characterization include, but are not limited to:

- Potential ACM
- Battery casings
- Drums or barrels
- Materials with excessive odor or discoloration
- Tanks
- Transformers, including carcasses
- Materials with free liquids (can include waste materials with intrusive water)
- Containers greater than 5 gallons in size containing chemicals or unidentifiable waste material
- Previously uncharacterized petroleum contaminated materials or what appears to be industrial-type wastes
- Ash

Many of the wastes identified above may be acceptable at DADS. However, a specific profile with the necessary lab testing to demonstrate the material is non-hazardous, RACS, or non-RACs will be required.

As discussed in the previous sections, the bulk of the waste material to be exhumed is likely to be non-hazardous and absent ACM. The Design Investigation, which will be performed prior to excavation, is anticipated to confirm this, and to adequately profile the waste for acceptance at DADS, without the need for additional characterization during excavation. A waste profile acceptance certification by DADS will include a provision for visually monitoring and screening the waste stream during excavation, as discussed above.

Should potential hazardous waste be identified during the Design Investigation or by the competent person monitoring waste removal, the material will be temporarily staged on-site and characterized for hazardous waste. If determined to be hazardous, it will be profiled, packaged, manifested, and transported offsite to a RCRA-licensed TSDF in accordance with the regulations discussed in Section 3.1.2 of this MMP.
Should RACS or Non-RACS be identified during the Design Investigation or by the CABI during excavation the material will be temporarily staged onsite, sampled, and profiled. If the RACS Determination (discussed in Section 3.1.3) identifies the material as either RACS or Non-RACS and the material contains putrescible material, the material will be packaged, manifested, and transported to DADS for disposal within their municipal solid waste landfill in a special cell designated for asbestos disposal. RACS that does not contain putrescible material will be manifested as such, transported to DADS and disposed in their asbestos monofil. Non-RACS that does not contain putrescible material will be manifested as such, transported to DADS, and disposed in a designated area within the active solid waste landfill such that the material can be buried with minimal disturbance from heavy equipment. Alternatively, if the volume of the Non-RACS without putrescible material is relatively small, the landfill manager may elect to place the material in the asbestos monofil.

4.2 Groundwater

As shown in the Tables D-2 and D-3, treatment of construction water may be required to reduce VOCs and metals to meet surface water discharge limits. Treatment would consist of aeration, gravity settling to precipitate suspended solids, and filtration. If dissolved metals concentrations exceed discharge limits, additional treatment requiring micro- or ultra-filtration may be necessary. All of these processes can be performed onsite using mobile treatment equipment. Examples of some of the equipment are presented in Appendix D-3. Secondary waste streams would be characterized for hazardous characteristics (ignitability, corrosivity, reactivity, reactive cyanides and sulfides, oxidizer, and paint-filter test), and TCLP toxicity, then manifested and disposed offsite in an appropriate RCRA-licensed TSDF.

Note: Additional groundwater characterization data consisting of potentiometric surface and groundwater quality will be obtained during the Design Investigation and applied to assess the potential presence and quality of groundwater that will need to be pumped and/or treated during construction. A final analysis of discharge limits should then be performed by a CDPHE WGCD permit writer. The collective characterization data and final permit limits will be compared to assess the type and amount and treatment required.

4.3 Investigative-Derived and Decontamination Waste

Solid investigative-derived waste (IDW) and residual solids from decontamination activities will be collected and screened for hazardous characteristics (including TCLP toxicity) as discussed in Section 3.1.1 of this MMP, and for ACM as discussed in Section 3.1.3 of this MMP. Should screening results indicate the material is non-hazardous and does not contain ACM, the material will be manifested as a solid waste and disposed at DADS. Should hazardous characteristics be present, or ACM be suspected, the material will be managed as described in Section 4.1, above.

Liquid IDW and decontamination waters will be poured into a shallow, open-top stock tank where they will be allowed to evaporate. If the volume of liquids generated exceeds the rate
of natural evaporation, the water will be characterized for hazardous constituents, then managed in accordance with the options discussed in Section 3.2 of this MMP.
5 REFERENCES


CTL Thompson, Inc., 2011. Limited Phase II Environmental Site Assessment, 40th Street Outfall, South Platte River to Blake Street, Denver, CO, prepared for WHPacific, Inc. May 10, 2011.


Appendix D-1

Summary of Environmental Conditions

- Waste Material
- Groundwater
- Soil Gas
WASTE MATERIAL
Arterial Soil Samples with Addresses

Arsenic Soil Sample Concentrations

Depth (ft) - Concentration (ppm)

As concentrations exceeding 15 ppm background limit (red)

Figure 10
VB/I-70 Remedial Investigation

EMSI Engineering Support Management, Inc.
Figure 12
Arsenic Soil Sample Concentrations
5 to 10 feet
VB/I-70 Remedial Investigation

As concentrations exceeding 15 ppm background limit (red)
Depth (ft) - Concentration (ppm)

Legend
- 2008 Drilling
- Barn Samples
- Pepsi Area 3 Soil Samples
- QUAD Samples
- Pepsi Area 5 Soil Samples
- Pepsi Area 6 Soil Samples
- CDOT Holes
- BB-BB-xx Holes
- Pepsi UT (Utility Trench) Soil Locations

1 inch = 250 feet

EMSI Engineering Support Management, Inc.
Figure 11
Lead Soil Sample Concentrations
0 to 5 feet

VB/I-70 Remedial Investigation

Engineering Support Management, Inc.
Figure 14
Lead Soil Sample Concentrations
5 to 10 feet
VB/I-70 Remedial Investigation

Pb concentrations exceeding 400 ppm background limit (red)
Depth (ft) - Concentration (ppm)

Legend
- 2008 Drilling
- Barn Samples
- Pepsi Area 3 Soil Samples
- QAR Samples
- Pepsi Area 5 Soil Samples
- BM Soil Samples
- CDOT Holes
- 55-BB-xx Holes
- Pepsi UT (Utility Trenches) Soil Locations

EMSI Engineering Support Management, Inc.
FIGURE 2 - SOIL SAMPLE EXCEEDANCES
CITY AND COUNTY OF DENVER

LEGEND
SOIL AND GROUNDWATER
SAMPLE LOCATION
EXISTING MONITORING WELL
LOCATION
CSEV COLORADO SOIL EVALUATION
VALUES
mg/kg MILLIGRAMS PER KILOGRAM

REFERENCE STANDARD
TABLE

<table>
<thead>
<tr>
<th>CONSTITUENT</th>
<th>CSEV EXCEEDANCE (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzo(a)anthracene</td>
<td>3.9</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>0.39</td>
</tr>
<tr>
<td>Benzo(b)fluoranthene</td>
<td>3.9</td>
</tr>
<tr>
<td>Dibenzo(a,h)anthracene</td>
<td>0.39</td>
</tr>
<tr>
<td>Indeno(1,2,3-cd)pyrene</td>
<td>3.9</td>
</tr>
<tr>
<td>Arsenic</td>
<td>1.6</td>
</tr>
</tbody>
</table>

BOLD RED TEXT INDICATES EXCEEDANCE

**TABLE**

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzo(a)anthracene</td>
<td>&lt;0.0076</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>0.0054</td>
</tr>
<tr>
<td>Benzo(b)fluoranthene</td>
<td>0.0064</td>
</tr>
<tr>
<td>Dibenzo(a,h)anthracene</td>
<td>&lt;0.0076</td>
</tr>
<tr>
<td>Indeno(1,2,3-cd)pyrene</td>
<td>&lt;0.0076</td>
</tr>
<tr>
<td>Arsenic</td>
<td>3.5</td>
</tr>
</tbody>
</table>

**HS-01**
- Benzo(a)anthracene: <0.0076
- Benzo(a)pyrene: 0.0054
- Benzo(b)fluoranthene: 0.0064
- Dibenzo(a,h)anthracene: <0.0076
- Indeno(1,2,3-cd)pyrene: <0.0076
- Arsenic: 3.5

**HS-02**
- Benzo(a)anthracene: 0.698
- Benzo(a)pyrene: 0.625
- Benzo(b)fluoranthene: 0.599
- Dibenzo(a,h)anthracene: 0.155
- Indeno(1,2,3-cd)pyrene: 0.358
- Arsenic: 3.7

**HS-03**
- Benzo(a)anthracene: <0.0069
- Benzo(a)pyrene: <0.0069
- Benzo(b)fluoranthene: <0.0069
- Dibenzo(a,h)anthracene: <0.0069
- Indeno(1,2,3-cd)pyrene: <0.0069
- Arsenic: <2.1

**HS-04**
- Benzo(a)anthracene: <0.0074
- Benzo(a)pyrene: <0.0074
- Benzo(b)fluoranthene: <0.0074
- Dibenzo(a,h)anthracene: <0.0074
- Indeno(1,2,3-cd)pyrene: <0.0074
- Arsenic: <2.5

**HS-05**
- Benzo(a)anthracene: <0.008
- Benzo(a)pyrene: <0.008
- Benzo(b)fluoranthene: <0.008
- Dibenzo(a,h)anthracene: <0.008
- Indeno(1,2,3-cd)pyrene: <0.008
- Arsenic: <2.4

**HS-06**
- Benzo(a)anthracene: 0.0441
- Benzo(a)pyrene: 0.0431
- Benzo(b)fluoranthene: 0.0054
- Dibenzo(a,h)anthracene: 0.023
- Indeno(1,2,3-cd)pyrene: 4.3
- Arsenic: 4.3

**HS-07**
- Benzo(a)anthracene: <0.0068
- Benzo(a)pyrene: <0.0068
- Benzo(b)fluoranthene: <0.0068
- Dibenzo(a,h)anthracene: <0.0068
- Indeno(1,2,3-cd)pyrene: <0.0068
- Arsenic: <1.9

**HS-08**
- Benzo(a)anthracene: 1.45
- Benzo(a)pyrene: 1.65
- Benzo(b)fluoranthene: 1.55
- Dibenzo(a,h)anthracene: 0.267
- Indeno(1,2,3-cd)pyrene: 0.936
- Arsenic: 7.4

**HS-09**
- Benzo(a)anthracene: 0.0441
- Benzo(a)pyrene: 0.0431
- Benzo(b)fluoranthene: 0.0054
- Dibenzo(a,h)anthracene: 0.023
- Indeno(1,2,3-cd)pyrene: 4.3
- Arsenic: 4.3

**HS-10**
- Benzo(a)anthracene: <0.0074
- Benzo(a)pyrene: <0.0074
- Benzo(b)fluoranthene: <0.0074
- Dibenzo(a,h)anthracene: <0.0074
- Indeno(1,2,3-cd)pyrene: <0.0074
- Arsenic: <2.5

**HS-11**
- Benzo(a)anthracene: <0.0074
- Benzo(a)pyrene: <0.0074
- Benzo(b)fluoranthene: <0.0074
- Dibenzo(a,h)anthracene: <0.0074
- Indeno(1,2,3-cd)pyrene: <0.0074
- Arsenic: <2.5
LEGEND:

**HS-01** SOIL AND GROUNDWATER SAMPLE LOCATION INSTALLED BY BROWN AND CALDWELL 2010

**MW-1** SOIL AND GROUNDWATER SAMPLE LOCATION INSTALLED AS PART OF VB-V70 OU2 ASSESSMENTS

**MW-1** CTL MONITORING WELL LOCATION

5170 EXISTING GROUND SURFACE ELEVATION (FEET)

NOTES:

ND = NONE DETECTED
GROUNDWATER
Legend

- Groundwater Sample Locations

Figure 24

Cadmium Groundwater Concentrations

VB/I-70 Remedial Investigation

EMSI  Engineering Support Management, Inc.
## Table of Groundwater Sample Exceedances

<table>
<thead>
<tr>
<th>Reference</th>
<th>Chloroform</th>
<th>Tetrachloroethylene</th>
<th>Trichloroethylene</th>
<th>Cadmium</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW-1</td>
<td>&lt;2.0</td>
<td>12.7</td>
<td>4.6</td>
<td>&lt;10</td>
</tr>
<tr>
<td>HS-01</td>
<td>&lt;2.0</td>
<td>24.8</td>
<td>5.8</td>
<td>&lt;10</td>
</tr>
<tr>
<td>HS-02</td>
<td>1.1</td>
<td>1.0</td>
<td>&lt;2.0</td>
<td>&lt;10</td>
</tr>
<tr>
<td>HS-03</td>
<td>3.1</td>
<td>2.6</td>
<td>&lt;2.0</td>
<td>18.2</td>
</tr>
<tr>
<td>HS-04</td>
<td>6.0</td>
<td>&lt;2.0</td>
<td>&lt;2.0</td>
<td>109</td>
</tr>
<tr>
<td>HS-05</td>
<td>2.9</td>
<td>&lt;2.0</td>
<td>&lt;2.0</td>
<td>&lt;10</td>
</tr>
<tr>
<td>HS-06</td>
<td>2.1</td>
<td>&lt;2.0</td>
<td>&lt;2.0</td>
<td>&lt;10</td>
</tr>
<tr>
<td>MW-6</td>
<td>0.73</td>
<td>&lt;2.0</td>
<td>&lt;2.0</td>
<td>&lt;10</td>
</tr>
<tr>
<td>HS-07</td>
<td>3.5</td>
<td>5</td>
<td>5</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

### Sample Locations
- **MW-1**: Chloroform <2.0, Tetrachloroethylene 12.7, Trichloroethylene 4.6, Cadmium <10
- **HS-01**: Chloroform <2.0, Tetrachloroethylene 24.8, Trichloroethylene 5.8, Cadmium <10
- **HS-02**: Chloroform 1.1, Tetrachloroethylene 1.0, Trichloroethylene <2.0, Cadmium <10
- **HS-03**: Chloroform 3.1, Tetrachloroethylene 2.6, Trichloroethylene <2.0, Cadmium 18.2
- **HS-04**: Chloroform 6.0, Tetrachloroethylene <2.0, Trichloroethylene <2.0, Cadmium 109
- **HS-05**: Chloroform 2.9, Tetrachloroethylene <2.0, Trichloroethylene <2.0, Cadmium <10
- **HS-06**: Chloroform 2.1, Tetrachloroethylene <2.0, Trichloroethylene <2.0, Cadmium <10
- **HS-07**: Chloroform 0.73, Tetrachloroethylene <2.0, Trichloroethylene <2.0, Cadmium <10

**Legend**
- **Soil and Groundwater Sample Location**
- **Existing Monitoring Well Location**
- **CDPHE Colorado Department of Public Health and Environment, Regulation 41, Basic Standards for Groundwater**
- **Micrograms per Liter**
- **Reference Standard Table**
- **Bold Blue Text Indicates Exceedance**

**Figure 3** - Groundwater Sample Exceedances

City and County of Denver
High Street Storm Drainage Project
**Legend:**

- **SOIL AND GROUNDWATER**
  - Sample location installed by Brown and Caldwell 2010

- **MW-1**
  - Soil and groundwater sample location installed as part of VB-70 OUI assessments

- **MW-1**
  - C1L monitoring well location

- **5170 existing ground surface elevation (feet)**

**Notes:**

- Results provided in micrograms/liters (µg/L)
- PCE - Tetrachloroethylene
- TCE - Trichloroethylene
- CB2-1,2-DCE - CB2-1,2-Dichloroethene
- Total metal results provided by 200.8 analysis
- Dissolved metal results provided by 200.7 analysis
  - (Samples lab filtered prior to analysis)
SOIL GAS
FIGURE 4 - METHANE SOIL GAS CONCENTRATION

CITY AND COUNTY OF DENVER

LEGEND

SOIL AND GROUNDWATER SAMPLE LOCATION
EXISTING MONITORING WELL LOCATION
CH₄ METHANE SOIL GAS CONCENTRATION (PERCENT OF TOTAL)

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>CH₄ Concentration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS-01</td>
<td>0.5</td>
</tr>
<tr>
<td>HS-02</td>
<td>43.4</td>
</tr>
<tr>
<td>HS-03</td>
<td>56.7</td>
</tr>
<tr>
<td>HS-04</td>
<td>0.0</td>
</tr>
<tr>
<td>HS-05</td>
<td>0.5</td>
</tr>
<tr>
<td>HS-06</td>
<td>4.8</td>
</tr>
<tr>
<td>HS-07</td>
<td>0.0</td>
</tr>
<tr>
<td>HS-08</td>
<td>0.5</td>
</tr>
<tr>
<td>HS-09</td>
<td>9.8</td>
</tr>
</tbody>
</table>

APPROXIMATE SCALE IN FEET
0 - 300' 600'
Figure D-1

CONCEPTUAL PLAN VIEW OF STORMWATER DRAINAGE SYSTEM
OPERABLE UNIT #2, VB 170 SUPERFUND SITE

EMSI Engineering Management Support, Inc.
EXISTING PARKING LOT

ANCHOR TRENCH (2'X2')

PROPOSED CHANNEL

LINEAR:
A) 30 MIL PVC (UNREINFORCED), OR
B) 40 MIL HDPE

LANDFILL MATERIAL

BALLAST:
A) 8 OZ. GEOTEXTILE, OR
B) 24" LOAM, SAND, GRAVEL <3/8"

SUBGRADE:
A) 8 OZ. NONWOVEN GEOCOMPOSITE, OR
B) 12" GRAVEL/SAND <3/8" SIEVE

APPROXIMATE
BEDROCK LEVEL

3:1 UPPER SLOPE IN CONFORMANCE WITH COLORADO SOLID WASTE REGULATIONS

10:1 TO 15:1 LOWER SLOPE

NOTE:
IF SUBGRADE ENTERS REGIONAL GWT, USE WASHED GRAVEL/SAND <3/8" SIEVE

CONCEPTUAL STORMWATER CHANNEL CROSS-SECTION

OPERABLE UNIT #2, VB I70 SUPERFUND SITE

EMSI Engineering Management Support, Inc.
WASTE MATERIAL COMPOUNDS OF CONCERN
OPERABLE UNIT #2, VB I70 SUPERFUND SITE

Figure D-3

LEGEND

- Monitoring Wall
- Soil Boring
- Limits of Fill Material Within the Coliseum Parking Area as Defined During the OU2 Remedial Investigation (EMSI, 2009)
- Thickness of Fill Material Based on EMSI 2009 Remedial Investigation
- Option 2 - High Street Outfall Alignment
- Sanitary Sewer
- Drainage Channel Sampling Area

Note: Results presented in milligrams per kilogram (mg/kg).
TCLP results presented in milligrams per liter (mg/L)
a/ CTL Thompson, 2011
b/ EMSI, 2009

<table>
<thead>
<tr>
<th>Monitoring Well</th>
<th>Soil Boring</th>
<th>Limits of Fill Material Within the Coliseum Parking Area as Defined During the OU2 Remedial Investigation (EMSI, 2009)</th>
<th>Thickness of Fill Material Based on EMSI 2009 Remedial Investigation</th>
<th>Option 2 - High Street Outfall Alignment</th>
<th>Sanitary Sewer</th>
<th>Drainage Channel Sampling Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTL MW-5</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SB4-4 b/ ARSENIC</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SB4-5 b/ ARSENIC</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTL MW-6</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTL MW-5</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTL MW-6</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTL MW-5</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTL MW-6</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTL MW-5</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTL MW-6</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTL MW-5</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTL MW-6</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTL MW-5</td>
<td>SB4-3</td>
<td>ARSENIC 1.5 - 22</td>
<td>LEAD 12 - 750</td>
<td>SB4-4 b/ ARSENIC 0.06</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2 140 2 170 SCALE IN FEET

170 170
**LEGEND**

- Monitoring Wall
- Soil Boring
- Limits of Fill Material Within the Coliseum Parking Area as Defined During the OU2 Remedial Investigation (EMSI, 2009)
- Thickness of Fill Material Based on EMSI 2009 Remedial Investigation
- Option 2 - High Street Outfall Alignment
- Drainage Channel Sampling Area
- Sanitary Sewer

**Note:** Results presented in micrograms per liter (µg/L).

**EMSI, 2009**

**b/ CTL Thompson, 2011**

**Figure D-4**

**GROUNDWATER COMPOUNDS OF CONCERN**

**OPERABLE UNIT #2, VB I70 SUPERFUND SITE**

**EMSI** Engineering Management Support, Inc.
# Table D-1 - Preliminary Waste Material Screen Against TCLP Toxicity and CDPHE Contained-Out Criteria for Restricted Use

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Detected Concentration</th>
<th>Contained - Out Criteria for Restricted Use</th>
<th>Land Disposal Restrictions per 268.48</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average of Total Soil Values</td>
<td>Total value divided by 20, or TCLP&lt;sup&gt;a/&lt;/sup&gt;</td>
<td>Criteria A: Residential Soil RSL&lt;sup&gt;b/&lt;/sup&gt; \times 100</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>0.16 (mg/kg)</td>
<td>n/a (mg/kg)</td>
<td>580 (mg/kg)</td>
</tr>
<tr>
<td>p-Dichlorobenzene</td>
<td>0.18 (mg/kg)</td>
<td>n/a (mg/kg)</td>
<td>260 (mg/kg)</td>
</tr>
<tr>
<td>Toluene</td>
<td>0.87 (mg/kg)</td>
<td>n/a (mg/kg)</td>
<td>490,000 (mg/kg)</td>
</tr>
<tr>
<td>Xylene</td>
<td>0.48 (mg/kg)</td>
<td>n/a (mg/kg)</td>
<td>58,000 (mg/kg)</td>
</tr>
<tr>
<td>Benzo(a)anthracene</td>
<td>0.72 (mg/kg)</td>
<td>n/a (mg/kg)</td>
<td>15 (mg/kg)</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>0.76 (mg/kg)</td>
<td>n/a (mg/kg)</td>
<td>1.5 (mg/kg)</td>
</tr>
<tr>
<td>Benzo(b)fluoranthene</td>
<td>0.72 (mg/kg)</td>
<td>n/a (mg/kg)</td>
<td>15 (mg/kg)</td>
</tr>
<tr>
<td>Di-Benz(a,h)anthracene</td>
<td>0.14 (mg/kg)</td>
<td>n/a (mg/kg)</td>
<td>1.5 (mg/kg)</td>
</tr>
<tr>
<td>Indeno(1,2,3-cd)pyrene</td>
<td>0.43 (mg/kg)</td>
<td>n/a (mg/kg)</td>
<td>15 (mg/kg)</td>
</tr>
<tr>
<td>Arsenic</td>
<td>5.79 (mg/kg)</td>
<td>0.29 (mg/kg)</td>
<td>67 (mg/kg)</td>
</tr>
<tr>
<td>Lead</td>
<td>138 (mg/kg)</td>
<td>6.91 (mg/kg)</td>
<td>40,000 (mg/kg)</td>
</tr>
</tbody>
</table>

<sup>a/</sup> USEPA Toxicity Characteristic Leaching Procedure (TCLP) limit  
<sup>b/</sup> USEPA Regional Screening Level, TR=1E-06 and THQ=1.0  
<sup>c/</sup> Colorado Basic Standard for Groundwater  
n/a = not available.

Color indicates passing criteria  
Color indicates possible failing criteria. Note - This comparison is based on total lead divided by 20, not TCLP. Actual TCLP value is likely less than 5.
# Table D-2 - Preliminary Discharge Limits for South Platte River, Segment 14

<table>
<thead>
<tr>
<th>Parameter</th>
<th>South Platte River Segment 14 Hardness (mg/L)</th>
<th>Stream Segment Standard (ug/L)</th>
<th>Max daily (acute) (ug/L)</th>
<th>Max daily (acute trout) (ug/L)</th>
<th>Monthly Average (chronic) (ug/L)</th>
<th>Monthly Average (chronic trout)(ug/L)</th>
<th>GW Quality - Open Channel Alignment (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>250</td>
<td>6.5-9 s.u.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CN</td>
<td>250</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As</td>
<td>250</td>
<td></td>
<td>340 (potentially dissolved)</td>
<td></td>
<td>3 (Trec)³/</td>
<td>2.0 - 2.3 (diss)²/; 2.0 - 15.4 (total)c/</td>
<td>0.2 - 0.25 (diss); 0.24 - 15.4 (total)</td>
</tr>
<tr>
<td>Cd</td>
<td>250</td>
<td></td>
<td>6.1</td>
<td>3.8</td>
<td>0.8</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Cr(III)</td>
<td>250</td>
<td></td>
<td>1207</td>
<td>157</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr(VI)</td>
<td>250</td>
<td></td>
<td>16</td>
<td></td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>250</td>
<td></td>
<td>1036</td>
<td></td>
<td>640</td>
<td>2.7 - 3.7 (diss); 2.8 - 3.2 (total)</td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>250</td>
<td></td>
<td>1000 (Trec)</td>
<td></td>
<td></td>
<td>23300</td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>250</td>
<td></td>
<td>172</td>
<td></td>
<td>7</td>
<td>0.0 - 0.14 (diss); 0.25 - 0.55 (total)</td>
<td>775 - 2140 (diss)</td>
</tr>
<tr>
<td>Mn</td>
<td>250</td>
<td></td>
<td>4051</td>
<td></td>
<td>2238</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hg</td>
<td>250</td>
<td></td>
<td></td>
<td></td>
<td>0.01 (total)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ni</td>
<td>250</td>
<td></td>
<td>1017</td>
<td></td>
<td>113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Se</td>
<td>250</td>
<td></td>
<td>18.4</td>
<td></td>
<td>4.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ag</td>
<td>250</td>
<td></td>
<td>10</td>
<td></td>
<td>1.5</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>250</td>
<td></td>
<td>313</td>
<td></td>
<td>271</td>
<td>12 - 14 (diss); 14 - 19 (total)</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>0.69</td>
<td>0.69</td>
<td>1 - 24.8</td>
<td>1 - 24.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>2.5</td>
<td>2.5</td>
<td>1 - 24.8</td>
<td>1 - 24.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>3.4</td>
<td>3.4</td>
<td>1 - 24.8</td>
<td>1 - 24.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a/ Trec = Total recoverable  
b/ Diss = Dissolved (filtered)  
c/ Total = Total dissolved and suspended (unfiltered)  

<table>
<thead>
<tr>
<th>Treatment Required</th>
<th>No Treatment Required</th>
<th>Filtration Required to Remove Suspended Metal</th>
<th>Treatment Required to Remove Dissolved Metal</th>
<th>Aeration Required to Remove VOCs</th>
</tr>
</thead>
</table>

G:\Environmental Quality\Env Quality Support\Special Projects\Removal Action Work Plan\MMP Tables D-1 to D-3
<table>
<thead>
<tr>
<th>Parameter</th>
<th>South Platte River Segment 16c (Sand Creek) Hardness (mg/L)</th>
<th>Segment Standard (ug/L)</th>
<th>Max daily (acute) (ug/L)</th>
<th>Max daily (acute trout) (ug/L)</th>
<th>Monthly Average (chronic) (ug/L)</th>
<th>Monthly Average (chronic trout)(ug/L)</th>
<th>GW Quality - Open Channel Alignment (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>400</td>
<td>6.5 - 9 s.u.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CN</td>
<td>400</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As</td>
<td>400</td>
<td>340 (potentially dissolved)</td>
<td>100 (Trec)(^a)</td>
<td></td>
<td>2.0 - 2.3 (diss)(^b);</td>
<td>2.0 - 15.4 (total)(^c)</td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>400</td>
<td>9.1</td>
<td>5.7</td>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr(III)</td>
<td>400</td>
<td>1773</td>
<td>231</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr(VI)</td>
<td>400</td>
<td>16</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>400</td>
<td>1613</td>
<td>956</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>400</td>
<td>1613</td>
<td>956</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>400</td>
<td>281</td>
<td>11</td>
<td></td>
<td></td>
<td>0.2 - 0.25 (diss);</td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>400</td>
<td>4738</td>
<td>2618</td>
<td></td>
<td></td>
<td></td>
<td>775 - 2140 (diss)</td>
</tr>
<tr>
<td>Hg</td>
<td>400</td>
<td>0.01</td>
<td>168</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ni</td>
<td>400</td>
<td>1513</td>
<td>168</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Se</td>
<td>400</td>
<td>18.4</td>
<td>4.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ag</td>
<td>400</td>
<td>22</td>
<td>3.5</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>400</td>
<td>467</td>
<td>405</td>
<td></td>
<td></td>
<td>12 - 14 (diss);</td>
<td>14 - 19 (total)</td>
</tr>
<tr>
<td>TCE</td>
<td>0.69</td>
<td>0.69</td>
<td>1 - 24.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCE</td>
<td>2.5</td>
<td>2.5</td>
<td>1 - 24.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Trec = Total recoverable  
\(^b\) Diss = Dissolved (filtered)  
\(^c\) Total = Total dissolved and suspended (unfiltered)
Appendix D-2

Regulatory Criteria
Colorado Soil Evaluation Values (CSEV) and EPA Regional Screening Levels (RSL)

Update on the Division's New Approach to Soil Screening Numbers

For the last few years, the Division has published health-based screening numbers in its Colorado Soil Evaluation Values (CSEV) table, the most recent version dated July 2011. Historically, numbers in the CSEV table were calculated using a mix of both EPA and Colorado specific methods and assumptions used for assessing risk and calculating soil screening numbers. However, in light of the fact that a) with each passing year, Colorado adopted more of the EPA approach, and b) in recognition of EPA's decision to harmonize the Region 3, 6 and 9 numbers into a single table, the Division was faced with the question of whether it was worthwhile maintaining the CSEV table considering that the differences between it and the national table were relatively small. After considering the benefits of adopting the EPA Regional Screening Levels (RSL) table versus the cost in time and money having to maintain Colorado's version of that table, a decision was made to be consistent with the nation and use the EPA RSLs to determine whether levels of contamination found at a site may warrant further investigation or cleanup, or whether no further investigation or action may be required.

Rather than delay this change, after November 28, 2012 the Division will use the RSL and CSEV tables in the following fashion:

Screening Levels for Residential and Industrial Worker Exposure Scenarios

From this point forward, the Division will be using the direct exposure levels for residential and industrial exposure scenarios listed in the EPA RSLs. This table, which EPA updates on a regular basis, can be found at:


Please use one of the links to the Summary Table in the top row of links.

Another benefit of adopting the national approach to calculating screening levels is that EPA also has a Calculator that can be used to adjust the input parameters for the purpose of coming up with site-specific RSLs. A link to this feature is provided on the web page referenced above. A useful background document and User's Guide identifying the toxicity values, equations and exposure assumptions used to calculate RSLs is also provided on this web page.

Screening values presented in the RSL table are based on human health risk from the combined exposure of direct soil ingestion, dermal contact with soil, and inhalation of vapors or particulates associated with soil. Other pathways, such as indoor air or food chain effects, may need to be considered on a site-specific basis. Users should also be aware that some sites in sensitive ecological settings may need to be evaluated for potential ecological risk. In addition, please continue to take into consideration the following:
Colorado Department of Public Health and Environment-specific toxicity values such as an inhalation Reference Concentration (RfC) of 7.0 ug/m³ for 1,1-dichloroethylene (1,1-DCE) and an oral Reference Dose (RfD) of 0.0011 mg/kg/day for diisopropyl methylphosphonate (DIMP).

For facilities where multiple non-carcinogenic chemicals are present, HQ values should be divided by a factor of 10 to account for additivity. If adjusted tables values are exceeded, consultation with a toxicologist is recommended to assess likely impact on specific target organs.

For lead, consideration of site-specific inputs to the IEUBK or ALM lead models and consultation with a toxicologist is strongly recommended for facilities with lead levels in soil that exceed the residential or worker table values. Contact the Division for additional information about details of the lead models and site-specific considerations.

For workers at facilities where soil-intensive use is anticipated, additional analysis and consultation with a toxicologist will be required to determine appropriate site-specific inputs to the risk equations.

**Screening Levels Protective of Groundwater Quality**

The Division will continue using the Groundwater Protection Level and Leachate Reference Concentration columns in the CSEV table, the last column in that table identifying the water standard used in the calculations which are based on standards and methods established and employed by the Water Quality Control Commission.

**Colorado Soil Evaluation Values (CSEV) Table**

These two columns should be consulted when reviewing site data because in some cases, decisions on whether or not further evaluation or remediation are needed may be based on the mobility of constituents and their potential to reach and degrade groundwater quality.

**Air Screening Concentrations**

Although the method by which the Division calculates air exposure screening numbers is identical to the method used by EPA, there are a few differences between our Air Screening Concentration Table and air columns listed in the RSLs. You are therefore advised to continue using the Division's air table.

**Air Screening Concentrations Table**

Target indoor air concentrations for those chemicals not included on the Division's list may be found in the EPA RSL table.

**Next Steps**

When time permits, the Division will modify the CSEV table to only show the Groundwater Protection Level, Leachate Reference Concentration and the Water Standard columns, relying entirely on the EPA RSLs for the direct exposure soil concentrations. The groundwater
protection numbers for certain constituents will need be modified in light of the recent changes approved by the Water Quality Control Commission that went into effect on January 31, 2013.

If you have questions about the derivation or application of these table values, please contact the Division by email sent to comments.hmwwd@state.co.us. Please be sure to put "Avramenko" in the subject line.
<table>
<thead>
<tr>
<th>REGION: 3 AND 4</th>
<th>BASIN: UPPER SOUTH PLATTE RIVER</th>
<th>PHYSICAL and BIOLOGICAL</th>
<th>INORGANIC STANDARDS</th>
<th>METALS</th>
<th>TEMPORARY MODIFICATIONS AND QUALIFIERS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stream Segment Description</strong></td>
<td><strong>DESIG</strong></td>
<td><strong>CLASSIFICATIONS</strong></td>
<td><strong>NUMERIC STANDARDS</strong></td>
<td><strong>METALS</strong></td>
<td><strong>TEMPORARY MODIFICATIONS AND QUALIFIERS</strong></td>
</tr>
<tr>
<td><strong>UPPER SOUTH PLATTE RIVER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Mainstem of the South Platte River from the outlet of Chatfield Reservoir to the Burlington Ditch diversion in Denver, Colorado.</td>
<td>As Life Warm 1</td>
<td>Recreation E Water Supply Agriculture</td>
<td>T=TVS+(WS-I) °C summer=14 Feb-Nov D.O.=5.0 mg/l pH=6.5-9.0 E. Colm 126/100ml</td>
<td>NH₄(ac)=0.019 CN=0.005 S=0.002 NO=0.75 NO=0.10 Cl=250 SO₃=WS</td>
<td>As(ac)=100(Trec) Cu(ac/ch)=TVS Cr(ac/ch)=TVS Fe(ac/ch)=WS(dis)</td>
</tr>
<tr>
<td>15. Mainstem of the South Platte River from the Burlington Ditch diversion in Denver, Colorado, to a point immediately below the confluence with Big Dry Creek.</td>
<td>As Life Warm 2</td>
<td>Recreation E Water Supply Agriculture</td>
<td>T=TVS+(WS-I) °C D.O. = 6.5-9.0 ** pH = 6.5-9.0 E. Colm 126/100ml</td>
<td>NH₄(ac)=0.019 CN=0.005 S=0.002 NO=0.75 NO=0.10 Cl=250 SO₃=WS</td>
<td>As(ac)=100(Trec) As(ch)=0.02-10(Trec) Cr(ac/ch)=TVS Cr(ac/ch)=TVS Cu(ac/ch)=TVS Fe(ac/ch)=WS(dis)</td>
</tr>
<tr>
<td>16a. Mainstem of Sand Creek from the confluence of Murphy and Coal Creek in Arapahoe County to the confluence with the Toll Gate Creek.</td>
<td>As Life Warm 2</td>
<td>Recreation E Agriculture</td>
<td>T=TVS+(WS-II) °C D.O. = 5.0 mg/l pH=6.5-9.0 E. Colm 126/100ml</td>
<td>NH₄(ac)=0.019 CN=0.005 S=0.002 NO=0.75 NO=0.10 Cl=250 SO₃=WS</td>
<td>As(ac)=100(Trec) As(ch)=0.02-10(Trec) Cr(ac/ch)=TVS Cr(ac/ch)=TVS Cu(ac/ch)=TVS Fe(ac/ch)=WS(dis)</td>
</tr>
<tr>
<td>16b. Aurora Reservoir.</td>
<td>As Life Warm 1</td>
<td>Recreation E Water Supply Agriculture</td>
<td>T=TVS+(WL) °C D.O. = 5.0 mg/l pH=6.5-9.0 E. Colm 126/100ml</td>
<td>NH₄(ac)=0.019 CN=0.005 S=0.002 NO=0.75 NO=0.10 Cl=250 SO₃=WS</td>
<td>As(ac)=100(Trec) As(ch)=0.02-10(Trec) Cr(ac/ch)=TVS Cr(ac/ch)=TVS Cu(ac/ch)=TVS Fe(ac/ch)=WS(dis)</td>
</tr>
<tr>
<td>16c. All tributaries to the South Platte River, including all wetlands, from the outlet of Chatfield Reservoir, to a point immediately below the confluence with Big Dry Creek, except for specific listings in the subbasins of the South Platte River, and in Segments 16a, 16d, 16e, 16f, 16g, 16h, 16i, 16j, 16k, 16l, 16m, 16n, 16o, 16p and 16q.</td>
<td>As Life Warm 2</td>
<td>Recreation E Agriculture</td>
<td>T=TVS+(WS-II) °C D.O. = 5.0 mg/l pH=6.5-9.0 E. Colm 126/100ml</td>
<td>NH₄(ac)=0.019 CN=0.005 S=0.002 NO=0.75 NO=0.10 Cl=250 SO₃=WS</td>
<td>As(ac)=100(Trec) As(ch)=0.02-10(Trec) Cr(ac/ch)=TVS Cr(ac/ch)=TVS Cu(ac/ch)=TVS Fe(ac/ch)=WS(dis)</td>
</tr>
<tr>
<td>16d. Second Creek from the source to the O’Brien Canal.</td>
<td>As Life Warm 2</td>
<td>Recreation E Agriculture</td>
<td>T=TVS+(WS-I) °C D.O. (ch)=3.3 mg/l pH=6.5-9.0 E. Colm 126/100ml</td>
<td>NH₄(ac)=0.019 CN=0.005 S=0.002 NO=0.75 NO=0.10 Cl=250 SO₃=WS</td>
<td>As(ac)=100(Trec) As(ch)=0.02-10(Trec) Cr(ac/ch)=TVS Cr(ac/ch)=TVS Cu(ac/ch)=TVS Fe(ac/ch)=WS(dis)</td>
</tr>
<tr>
<td>16e. Third Creek from the source to the O’Brien Canal.</td>
<td>As Life Warm 2</td>
<td>Recreation E Agriculture</td>
<td>T=TVS+(WS-I) °C D.O. (ch)=4.0 mg/l pH=6.5-9.0 E. Colm 126/100ml</td>
<td>NH₄(ac)=0.019 CN=0.005 S=0.002 NO=0.75 NO=0.10 Cl=250 SO₃=WS</td>
<td>As(ac)=100(Trec) As(ch)=0.02-10(Trec) Cr(ac/ch)=TVS Cr(ac/ch)=TVS Cu(ac/ch)=TVS Fe(ac/ch)=WS(dis)</td>
</tr>
</tbody>
</table>

**Note:** Temporary modification: Cu(ac/ch)=TVSx2.7 (Type iii). Applies below the confluence with Marcy-Gulch. Expiration date of 12/31/2015. Current conditions (Type iii). Expiration date of 12/31/2015. *Temporary modification: As(ac) undefined. Expiration date of 12/31/21.*
COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT  
WATER QUALITY CONTROL COMMISSION  
5 CCR 1002-38  
REGULATION NO. 38  
CLASSIFICATIONS AND NUMERIC STANDARDS  
FOR  
SOUTH PLATTE RIVER BASIN, LARAMIE RIVER BASIN  
REPUBLICAN RIVER BASIN, SMOKY HILL RIVER BASIN  

<table>
<thead>
<tr>
<th>ADOPTED:</th>
<th>EFFECTIVE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 6, 1981</td>
<td>May 16, 1981</td>
</tr>
<tr>
<td>April 12, 1982</td>
<td>May 16, 1982 through May 30, 1982</td>
</tr>
<tr>
<td>December 6, 1982</td>
<td>January 30, 1983</td>
</tr>
<tr>
<td>December 6, 1982</td>
<td>January 30, 1983</td>
</tr>
<tr>
<td>May 9, 1983</td>
<td>July 16, 1983</td>
</tr>
<tr>
<td>December 12, 1983</td>
<td>January 30, 1984</td>
</tr>
<tr>
<td>May 15, 1984</td>
<td>June 30, 1984</td>
</tr>
<tr>
<td>August 14, 1984</td>
<td>September 30, 1984</td>
</tr>
<tr>
<td>April 1, 1985</td>
<td>May 30, 1985</td>
</tr>
<tr>
<td>March 7, 1986</td>
<td>April 30, 1986</td>
</tr>
<tr>
<td>April 8, 1986</td>
<td>May 30, 1986</td>
</tr>
<tr>
<td>May 9, 1986</td>
<td>June 30, 1986</td>
</tr>
<tr>
<td>September 18, 1986</td>
<td>October 30, 1986</td>
</tr>
<tr>
<td>August 4, 1987</td>
<td>September 30, 1987</td>
</tr>
<tr>
<td>November 3, 1987</td>
<td>December 30, 1987</td>
</tr>
<tr>
<td>May 2, 1988</td>
<td>June 30, 1988</td>
</tr>
<tr>
<td>February 6, 1989</td>
<td>March 30, 1989</td>
</tr>
<tr>
<td>February 6, 1989 through August 30, 1989</td>
<td></td>
</tr>
<tr>
<td>March 6, 1989</td>
<td>April 30, 1989</td>
</tr>
<tr>
<td>June 5, 1989</td>
<td>July 30, 1989</td>
</tr>
<tr>
<td>July 11, 1989 through March 30, 1990</td>
<td></td>
</tr>
<tr>
<td>February 5, 1990</td>
<td>March 30, 1990</td>
</tr>
<tr>
<td>January 6, 1992</td>
<td>March 1, 1992</td>
</tr>
<tr>
<td>June 2, 1992</td>
<td>July 30, 1992</td>
</tr>
<tr>
<td>July 6, 1992</td>
<td>August 30, 1992</td>
</tr>
<tr>
<td>December 7, 1992</td>
<td>January 30, 1993</td>
</tr>
<tr>
<td>March 1, 1993</td>
<td>April 30, 1993</td>
</tr>
<tr>
<td>August 2, 1993</td>
<td>September 30, 1993</td>
</tr>
<tr>
<td>September 7, 1993</td>
<td>October 30, 1993</td>
</tr>
<tr>
<td>March 7, 1994</td>
<td>April 30, 1994</td>
</tr>
<tr>
<td>May 2, 1994</td>
<td>June 30, 1994</td>
</tr>
<tr>
<td>February 13, 1995</td>
<td>March 30, 1995</td>
</tr>
<tr>
<td>June 12, 1995</td>
<td>July 30, 1995</td>
</tr>
<tr>
<td>July 10, 1995</td>
<td>August 30, 1995</td>
</tr>
<tr>
<td>December 11, 1995</td>
<td>January 30, 1996</td>
</tr>
<tr>
<td>Amended Date</td>
<td>Effective Date</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>May 13, 1996</td>
<td>June 30, 1996</td>
</tr>
<tr>
<td>August 12, 1996</td>
<td>September 30, 1996</td>
</tr>
<tr>
<td>April 14, 1997</td>
<td>May 30, 1997</td>
</tr>
<tr>
<td>May 12, 1997</td>
<td>June 30, 1997</td>
</tr>
<tr>
<td>November 9, 1998</td>
<td>December 30, 1998</td>
</tr>
<tr>
<td>May 11, 1999</td>
<td>June 30, 1999</td>
</tr>
<tr>
<td>October 10, 2000</td>
<td>February 20, 2001</td>
</tr>
<tr>
<td>February 13, 2001</td>
<td>June 20, 2001</td>
</tr>
<tr>
<td>May 14, 2001</td>
<td>May 14, 2001</td>
</tr>
<tr>
<td>September 10, 2001</td>
<td>October 30, 2001</td>
</tr>
<tr>
<td>December 10, 2001</td>
<td>January 30, 2002</td>
</tr>
<tr>
<td>September 13, 2004</td>
<td>November 1, 2004</td>
</tr>
<tr>
<td>Clear Creek seg. 5 and Middle South Platte segs. 1a &amp; 1b</td>
<td></td>
</tr>
<tr>
<td>September 13, 2004</td>
<td>January 20, 2005</td>
</tr>
<tr>
<td>December 12, 2005</td>
<td>March 2, 2006</td>
</tr>
<tr>
<td>August 14, 2006</td>
<td>September 30, 2006</td>
</tr>
<tr>
<td>February 12, 2007</td>
<td>July 1, 2007</td>
</tr>
<tr>
<td>April 9, 2007</td>
<td>September 1, 2007</td>
</tr>
<tr>
<td>August 13, 2007</td>
<td>September 30, 2007</td>
</tr>
<tr>
<td>January 14, 2008</td>
<td>March 1, 2008</td>
</tr>
<tr>
<td>February 9, 2009</td>
<td>March 30, 2009</td>
</tr>
<tr>
<td>August 10, 2009</td>
<td>January 1, 2010</td>
</tr>
<tr>
<td>February 8, 2010</td>
<td>June 30, 2010</td>
</tr>
<tr>
<td>April 12, 2010</td>
<td>June 30, 2010</td>
</tr>
<tr>
<td>July 12, 2010</td>
<td>November 30, 2010</td>
</tr>
<tr>
<td>January 10, 2011</td>
<td>June 30, 2011</td>
</tr>
<tr>
<td>December 13, 2011</td>
<td>December 13, 2011</td>
</tr>
<tr>
<td>June 13, 2011</td>
<td>January 1, 2012</td>
</tr>
<tr>
<td>August 13, 2012</td>
<td>December 31, 2012</td>
</tr>
<tr>
<td>October 9, 2012</td>
<td>March 1, 2013</td>
</tr>
<tr>
<td>January 14, 2013</td>
<td>June 30, 2013</td>
</tr>
<tr>
<td>May 13, 2013</td>
<td>May 13, 2013</td>
</tr>
<tr>
<td>May 1, 2013</td>
<td>September 30, 2013</td>
</tr>
<tr>
<td>March 11, 2014</td>
<td>April 30, 2014</td>
</tr>
<tr>
<td>March 11, 2014</td>
<td>June 30, 2014</td>
</tr>
</tbody>
</table>
38.1 AUTHORITY

These regulations are promulgated pursuant to section 25-8-101 et seq C.R.S., as amended, and in particular, 25-8-203 and 25-8-204.

38.2 PURPOSE

These regulations establish classification and numeric standards for the South Platte River, the Laramie River, the Republican River and the Smoky Hill River, including all tributaries and standing bodies of water as indicated in section 38.6. The classifications identify the actual beneficial uses of the water. The numeric standards are assigned to determine the allowable concentrations of various parameters. Discharge permits will be issued by the Water Quality Control Division to comply with basic, narrative, and numeric standards and control regulations so that all discharges to waters of the state protect the classified uses. (See section 31.14). It is intended that these and all other stream classifications and numeric standards be used in conjunction with and be an integral part of Regulation 31.0 - BASIC STANDARDS AND METHODOLOGIES FOR SURFACE WATER.

38.3 INTRODUCTION

These regulations and Tables present the classifications and numeric standards assigned to stream segments listed in the attached Tables (See section 38.6). As additional stream segments are classified and numeric standards for this drainage system, they will be added to or replace the numeric standards in the Tables in section 38.6). Any additions or revisions of classifications or numeric standards can be accomplished only after public hearing by the Commission and proper consideration of evidence and testimony as specified by the statute and the “basic regulations”.

38.4 DEFINITIONS

See the Colorado Water Quality Control Act and the codified water quality regulations for definitions.

38.5 BASIC STANDARDS

(1) TEMPERATURE

All waters of the South Platte, Laramie, Republican and Smoky Hill River Basins are subject to the following standard for temperature. (Discharges regulated by permits, which are within the permit limitations, shall not be subject to enforcement proceedings under this standard). Temperature shall maintain a normal pattern of diurnal and seasonal fluctuations with no abrupt changes and shall have no increase in temperature of a magnitude, rate, and duration deemed deleterious to the resident aquatic life. This standard shall not be interpreted or applied in a manner inconsistent with section 25-8-104, C.R.S.
QUALIFIERS

See Basic Standards and Methodologies for Surface Water for a listing of organic standards at 31.11 and metal standards found at 31.16 Table III. The column in the tables headed “Water Fish” are presumptively applied to all aquatic life class 1 streams which also have a water supply classification, and are applied to aquatic life class 2 streams which also have a water supply classification, on a case-by-case basis as shown in the Tables 38.6. The column in the tables at 31.11 headed “Fish Ingestion” is presumptively applied to all aquatic life class 1 streams which do not have a water supply classification, and are applied to aquatic life class 2 streams which do not have a water supply classification, on a case-by-case basis as shown in the Tables in Tables 38.6.

URANIUM

(a) All waters of the South Platte River Basin are subject to the following basic standard for uranium, unless otherwise specified by a water quality standard applicable to a particular segment. However, discharges of uranium regulated by permits which are within these permit limitations shall not be a basis for enforcement proceedings under this basic standard.

(b) Uranium level in surface waters shall be maintained at the lowest practicable level.

(c) In no case shall uranium levels in waters assigned a water supply classification be increased by any cause attributable to municipal, industrial, or agricultural discharges so as to exceed 30 µg/l or naturally-occurring concentrations (as determined by the State of Colorado), whichever is greater.

(d) In no case shall uranium levels in waters assigned a water supply classification be increased by a cause attributable to municipal, industrial, or agricultural discharges so as to exceed 30 µg/l where naturally-occurring concentration are less than 30 µg/l.

38.6 TABLES

(1) Introduction

The numeric standards for various parameters in the attached tables were assigned by the Commission after a careful analysis of the data presented on actual stream conditions and on actual and potential water uses.

Numeric standards are not assigned for all parameters listed in the Tables attached to 31.0. If additional numeric standards are found to be needed during future periodic reviews, they can be assigned by following the proper hearing procedures.

(2) Abbreviations:

(a) The following abbreviations are used in the attached tables:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ac</td>
<td>acute (1-day)</td>
</tr>
<tr>
<td>Ag</td>
<td>Silver</td>
</tr>
<tr>
<td>Al</td>
<td>Aluminum</td>
</tr>
<tr>
<td>As</td>
<td>Arsenic</td>
</tr>
<tr>
<td>B</td>
<td>Boron</td>
</tr>
<tr>
<td>Ba</td>
<td>Barium</td>
</tr>
<tr>
<td>Be</td>
<td>Beryllium</td>
</tr>
<tr>
<td>°C</td>
<td>degrees celsius</td>
</tr>
<tr>
<td>Cd</td>
<td>Cadmium</td>
</tr>
</tbody>
</table>
(b) In addition, the following abbreviations are used:

- Fe(ch) = WS(dis)
- Mn(ch) = WS(dis)
- SO₄ = WS
These abbreviations mean: For all surface waters with an actual water supply use, the less restrictive of the following two options shall apply as numerical standards, as specified in the Basic Standards and Methodologies at 31.11(6);

(i) existing quality as of January 1, 2000; or

(ii) Iron = 300 µg/l (dissolved)  
     Manganese = 50 µg/l (dissolved)  
     SO₄ = 250 mg/l

For all surface waters with a "water supply" classification that are not in actual use as a water supply, no water supply standards are applied for iron, manganese or sulfate, unless the Commission determines as the result of a site-specific rulemaking hearing that such standards are appropriate.

(c) As used in the “Temporary Modifications and Qualifiers” column of the tables, the term “type i” refers to a temporary modification adopted pursuant to subsection 31.7(3)(a)(i) of the Basic Standards and Methodologies for Surface Water (i.e., “where the standard is not being met because of human-induced conditions deemed correctable within a twenty (20) year period”). The term “type iii” refers to a temporary modification adopted pursuant to subsection 31.7(3)(a)(iii) of the Basic Standards and Methodologies for Surface Water (i.e., “where there is significant uncertainty regarding the appropriate long-term underlying standard”).

(d) Temporary Modification for Water + Fish Chronic Arsenic Standard

(i) The temporary modification for chronic arsenic standards applied to segments with an arsenic standard of 0.02 µg/l that has been set to protect the Water+Fish qualifier is listed in the temporary modification and qualifiers column as As(ch)=hybrid.

(ii) For discharges existing on or before 6/1/2013, the temporary modification is: As(ch)=current condition, expiring on 12/31/2021.

(iii) For new or increased discharges commencing on or after 6/1/2013, the temporary modification is: As(ch)=0.02-3.0 µg/l (Trec), expiring on 12/31/2021.

(a) The first number in the range is the health-based water quality standard previously adopted by the Commission for the segment.

(b) The second number in the range is a technology based value established by the Commission for the purpose of this temporary modification.

(c) Control requirements, such as discharge permit effluent limitations, shall be established using the first number in the range as the ambient water quality target, provided that no effluent limitation shall require an “end-of-pipe” discharge level more restrictive than the second number in the range.

(3) Table Value Standards

In certain instances in the attached tables, the designation “TVS” is used to indicate that for a particular parameter a "table value standard" has been adopted. This designation refers to
numerical criteria set forth in the Basic Standards and Methodologies for Surface Water. The criteria for which the TVS are applicable are on the following table.

**TABLE VALUE STANDARDS**

(Concentrations in µg/l unless noted)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TABLE VALUE STANDARDS</th>
</tr>
</thead>
</table>
| Ammonia \( (4) \) | Cold Water = (mg/l as N)Total  
  \[ \text{acute} = \frac{0.275}{1 + 10^{7.204-pH}} + \frac{39.0}{1 + 10^{pH-7.204}} \] 
  \[ \text{chronic} = \frac{0.0577}{1 + 10^{7.688-pH}} + \frac{2.487}{1 + 10^{pH-7.688}} \] * MIN \( 2.85, 1.45 \times 10^{0.028(25-T)} \) |
| Warm Water = (mg/l as N)Total  
  \[ \text{acute} = \frac{0.411}{1 + 10^{7.204-pH}} + \frac{58.4}{1 + 10^{pH-7.204}} \] 
  \[ \text{chronic (Apr 1 – Aug 31)} = \left( \frac{0.0577}{1 + 10^{7.688-pH}} + \frac{2.487}{1 + 10^{pH-7.688}} \right) \right) \) * MIN \( 2.85, 1.45 \times 10^{0.028(25-T)} \) 
  \[ \text{chronic (Sep 1 – Mar 31)} = \left( \frac{0.0577}{1 + 10^{7.688-pH}} + \frac{2.487}{1 + 10^{pH-7.688}} \right) \right) \) * 1.45 \times 10^{0.028(25-MAX(7, 7))} |
| NH\(_3\) = old TVS | Cold Water Acute = 0.43/FT/FPH/2\(^{0.069}\) in mg/l (N) 
  Warm Water Acute = 0.62/FT/FPH/2\(^{0.069}\) in mg/l (N) |
| Cadmium | Acute = \( (1.136672-[\ln(\text{hardness}) \times x (0.041838)]) \times e^{(0.9151[\ln(\text{hardness})]-3.1485)^{0.069}} \) 
  Acute(TROUT) = \( (1.136672-[\ln(\text{hardness}) \times x (0.041838)]) \times e^{(0.9151[\ln(\text{hardness})]-3.6236)^{0.069}} \) 
  Chronic = \( (1.101672-[\ln(\text{hardness}) \times x (0.041838)]) \times e^{(0.7998[\ln(\text{hardness})]-4.4451)^{0.069}} \) |
| Chromium III\(^{(5)}\) | Acute = \( e^{(0.819[\ln(\text{hardness})]+2.5736)^{0.069}} \) 
  Chronic = \( e^{(0.819[\ln(\text{hardness})]+0.5340)^{0.069}} \) |
| Chromium VI\(^{(5)}\) | Acute = 16 
  Chronic = 11 |
| Copper | Acute = \( e^{(0.9422[\ln(\text{hardness})]-1.7408)^{0.069}} \) 
  Chronic = \( e^{(0.8545[\ln(\text{hardness})]-1.7428)^{0.069}} \) |
| Lead | Acute = \( (1.46203-\ln(\text{hardness}) \times (0.145712)) \times e^{(1.273[\ln(\text{hardness})]-1.46)^{0.069}} \) 
  Chronic = \( (1.46203-\ln(\text{hardness}) \times (0.145712)) \times e^{(1.273[\ln(\text{hardness})]-4.705)^{0.069}} \) |
| Manganese | Acute = \( e^{(0.333[\ln(\text{hardness})]+6.4676)^{0.069}} \) 
  Chronic = \( e^{(0.333[\ln(\text{hardness})]+5.8743)^{0.069}} \) |
### Nickel

<table>
<thead>
<tr>
<th>Type</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute</td>
<td>$e^{(0.846\ln(\text{hardness})+2.253)}$</td>
</tr>
<tr>
<td>Chronic</td>
<td>$e^{(0.846\ln(\text{hardness})+0.0554)}$</td>
</tr>
</tbody>
</table>

### Selenium

#### (6)

<table>
<thead>
<tr>
<th>Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute</td>
<td>18.4</td>
</tr>
<tr>
<td>Chronic</td>
<td>4.6</td>
</tr>
</tbody>
</table>

### Silver

<table>
<thead>
<tr>
<th>Type</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute</td>
<td>$\frac{1}{4}e^{(1.72\ln(\text{hardness})-6.52)}$</td>
</tr>
<tr>
<td>Chronic</td>
<td>$e^{(1.72\ln(\text{hardness})-9.06)}$</td>
</tr>
<tr>
<td>Chronic (Trout)</td>
<td>$e^{(1.72\ln(\text{hardness})-10.51)}$</td>
</tr>
</tbody>
</table>

### Temperature

<table>
<thead>
<tr>
<th>Temperature</th>
<th>TIER TIER CODE</th>
<th>SPECIES EXPECTED TO BE PRESENT</th>
<th>APPLICABLE MONTHS</th>
<th>TEMPERATURE STANDARD (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Stream</td>
<td>Tier I</td>
<td>CS-I</td>
<td>Brook trout, cutthroat trout</td>
<td>June – Sept.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Oct. – May</td>
</tr>
<tr>
<td>Cold Stream</td>
<td>Tier II</td>
<td>CS-II</td>
<td>Brown trout, rainbow trout, mottled sculpin, mountain whitefish, longnose sucker, Arctic grayling</td>
<td>April – Oct.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nov. – March</td>
</tr>
<tr>
<td>Cold Lake</td>
<td></td>
<td>CL</td>
<td>Brook trout, brown trout, cutthroat trout, lake trout, rainbow trout, Arctic grayling, sockeye salmon</td>
<td>April – Dec.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jan. - March</td>
</tr>
<tr>
<td>Cold Large</td>
<td>Lake (&gt;100 acres surface area)</td>
<td>CLL</td>
<td>Rainbow trout</td>
<td>April – Dec.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jan. - March</td>
</tr>
<tr>
<td>Warm Stream</td>
<td>Tier I</td>
<td>WS-I</td>
<td>Common shiner, Johnny darter, orangemouth darter</td>
<td>March – Nov.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dec. – Feb.</td>
</tr>
<tr>
<td>Warm Stream</td>
<td>Tier II</td>
<td>WS-II</td>
<td>Brook stickleback, central stoneroller, creek chub, longnose dace, Northern redbelly dace, finescale dace, white sucker</td>
<td>March – Nov.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dec. – Feb.</td>
</tr>
<tr>
<td>Warm Stream</td>
<td>Tier III</td>
<td>WS-III</td>
<td>Razorback sucker</td>
<td>March – Nov.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dec. – Feb.</td>
</tr>
<tr>
<td>Warm Stream</td>
<td>Tier IV</td>
<td>WS-IV</td>
<td>Other Warmwater Species</td>
<td>March – Nov.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dec. – Feb.</td>
</tr>
<tr>
<td>Warm Lakes</td>
<td></td>
<td>WL</td>
<td>Yellow perch, walleye, pumpkinseed, smallmouth bass, striped bass, white bass, largemouth bass, bluegill, spottail shiner, Northern pike, tiger muskellunge, black crappie, common carp, gizzard shad, sauger, white crappie, wiper</td>
<td>April – Dec.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jan. - March</td>
</tr>
</tbody>
</table>

### Uranium

<table>
<thead>
<tr>
<th>Type</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute</td>
<td>$e^{(1.1021\ln(\text{hardness})+2.7088)}$</td>
</tr>
<tr>
<td>Chronic</td>
<td>$e^{(1.1021\ln(\text{hardness})+2.2382)}$</td>
</tr>
</tbody>
</table>
Zinc

<table>
<thead>
<tr>
<th></th>
<th>Acute = 0.978 e^{(0.8525[ln(hardness)]+1.0617)}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chronic = 0.986 e^{(0.8525[ln(hardness)]+0.9109)}</td>
</tr>
</tbody>
</table>

**TABLE VALUE STANDARDS - FOOTNOTES**

1. Metals are stated as dissolved unless otherwise specified.

2. Hardness values to be used in equations are in mg/l as calcium carbonate and shall be no greater than 400 mg/L. The hardness values used in calculating the appropriate metal standard should be based on the lower 95 per cent confidence limit of the mean hardness value at the periodic low flow criteria as determined from a regression analysis of site-specific data. Where insufficient site-specific data exists to define the mean hardness value at the periodic low flow criteria, representative regional data shall be used to perform the regression analysis. Where a regression analysis is not appropriate, a site-specific method should be used. In calculating a hardness value, regression analyses should not be extrapolated past the point that data exist.

3. Both acute and chronic numbers adopted as stream standards are levels not to be exceeded more than once every three years on the average.

4. \[ FT = 10^{0.03(20-TCAP)}; \]
   \[ FT = 10^{0.03(20-T)}; \]
   Where \( TCAP \) is \( T \leq 30 \)
   \[ FT = 10^{0.03(20-T)}; \]
   Where \( 0 \leq T \leq TCAP \)

   \( TCAP = 20^\circ C \) cold water aquatic life species present
   \( TCAP = 25^\circ C \) cold water aquatic life species absent

   \[ FPH = 1; \text{ Where } 8 \leq pH \leq 9 \]
   \[ FPH = 1 + 10(7.4-pH); \]
   \[ 1.25; \text{ Where } 6.5 \leq pH \leq 8 \]

   \( FPH \) means the acute pH adjustment factor, defined by the above formulas.
   \( FT \) Means the acute temperature adjustment factor, defined by the above formulas.
   \( T \) means temperature measured in degrees celsius.
   \( TCAP \) means temperature CAP; the maximum temperature which affects the toxicity of ammonia to salmonid and non-salmonid fish groups.

   NOTE: If the calculated acute value is less than the calculated chronic value, then the calculated chronic value shall be used as the acute standard.

5. Unless the stability of the chromium valence state in receiving waters can be clearly demonstrated, the standard for chromium should be in terms of chromium VI. In no case can the sum of the instream levels of Hexavalent and Trivalent Chromium exceed the water supply standard of 50 µg/l total chromium in those waters classified for domestic water use.

6. Selenium is a bioaccumulative metal and subject to a range of toxicity values depending upon numerous site-specific variables.
(4) Assessment Criteria

The following criteria shall be used when assessing whether a specified waterbody is in attainment of the specified standard.

(a) Upper South Platte Segment 6b, Chatfield Reservoir: Assessment Thresholds

chlorophyll = 11.2 µg/l, summer average, 1 in 5 year allowable exceedance frequency
phosphorus(Tot) = 0.035 mg/l, summer average, 1 in 5 year allowable exceedance frequency.

(b) Upper South Platte Segment 16h: Selenium Assessment Locations

- Toll Gate Creek (TG6): Downstream of the confluence of East and West Toll Gate Creeks, at 6th Avenue near the gage station.
- East Toll Gate Creek (ET1): Upstream of the confluence with West Toll Gate Creek, at Chambers Road and 1st Avenue.
- West Toll Gate Creek (WT1): Upstream of the confluence with East Toll Gate Creek, at 2nd Avenue.

(c) Upper South Platte Segment 15 and Middle South Platte Segment 1a: Dissolved Oxygen Assessment Locations

For the purpose of determining attainment of the standard, dissolved oxygen measurements shall only be taken in the flowing portion of the stream and at mid depth, and at least six inches above the bottom of the channel. Dissolved oxygen measurements in man-made pools are not to be used for determination of attainment of the standards.

(d) Big Dry Creek Segment 1: Selenium Assessment Locations

- bdc 1.5: upstream of Broomfield Wastewater Treatment Plant
- bcd 2.0: upstream of Westminster Big Dry Creek Wastewater Treatment Facility
- bcd 4.0: upstream of Northglenn Wastewater Treatment Plant

(e) Big Dry Creek Segment 2 (Standley Lake): Assessment Thresholds

Chlorophyll = 4.4 ug/L, Mar-Nov average, 1 in 5 yr allowable exceedance frequency

(f) Upper South Platte Segment 16i, Sand Creek from Toll Gate Creek to the confluence with the South Platte River: assessment locations for selenium.

- Upper – (SWA) Downstream of the confluence of Sand Creek and Toll Gate Creek approximately 250 meters upstream of the Sand Creek Water Reuse Facility (SCWRF) discharge near the Peoria Street Bridge.
- Lower – (SW1) Above Suncor, approximately 60 meters upstream of the Union Pacific Railroad crossing and upstream of Brighton Boulevard.
(g) Upper South Platte Segment 16g (Marcy Gulch): Selenium assessment.

Determination of attainment of the chronic and acute selenium standards will be based on the 85th and 95th percentile, respectively, of paired samples taken the same day from from the two following locations:

- L29: Marcy Gulch upstream of Santa Fe Drive, immediately upstream of the Centennial Water & Sanitation District WWTF
- L36: Marcy Gulch upstream of the confluence with the South Platte River.

(h) Upper South Platte Segment 16j: Selenium assessment.

Determination of attainment of the chronic and acute selenium standards will be based on the 85th and 95th percentile, respectively. The selenium assessment locations are:

- Lee Gulch: Upstream of the confluence with the South Platte River
- Little’s Creek: Upstream of the confluence with the South Platte River
- Big Dry Creek: Upstream of the confluence with the South Platte River
- Little Dry Creek: Upstream of the confluence with the South Platte River
Appendix D-3

Mobile Water Treatment Equipment
4" FILL LINE CENTERED ON BACK OF TANK

UNDER WEIR

OVER WEIR

(22" MANWAY 3 PLACES)
BF 400
Up to 400 GPM

Features

• Manifold connections are 6" 150 lb flanges
• Quadruple bag filter
• Bag filter for high solids holding capacity
• Replaceable bag filters from 100 to 1 micron nominal rating
• No moving parts
• Skid mounted

Technical

• Bag filter chambers connect in parallel
• Units are fitted with bleed valves and pressure gauges
• System can stand alone for sediment removal or be used in combination with filter equipment
• Footprint: 62" long x 36" wide x 61" high
• Dry weight: 1,150 lbs.

Material Specifications

• Chambers constructed of 304 Stainless Steel
• Piping constructed of 304 stainless steel
• Each bag filter chamber holds one (1) 7" x 30" double- stitched filter bag
• Maximum operating pressure: 125psi
• Stainless Steel inlet and outlet manifolds

Available Accessories

• Power Prime Pumps
• Spill Guard Containment berms
• Stainless Steel 304 and Carbon Steel storage tanks in Bi-Level, Mixer, Weir and Manifold configurations
• Polyethylene storage tanks
• Cartridge and bag filters
• HDPE pipe and fittings
• Roll off boxes, dewatering bins and vacuum boxes
• Flow meters and pressure reducing/ sustaining valves
• Aluminum Victaulic pipe and fittings
• Suction and discharge hose
DV-80
SIZE 3” x 3”
- 500 GPM MAX
- 138 FT HEAD MAX

FEATURES
- Solids handling capabilities to 1-¼” diameter maximum
- Continuous self priming
- Runs dry unattended
- Suction lift to 28’
- Skid or trailer mounted
- Stainless Steel Pump Options

TECHNICAL
- The DV-80 is flex coupled to a Deutz F3M1008 3-cylinder diesel engine producing 15.75 HP @ 2800 rpm.
- The engine is 12 volt electric start with control panel.
- The pump and engine are skid or trailer mounted with lifting bracket and integral 24-hour minimum capacity fuel tank.
- Belt-driven compressor is fitted to operate the air-ejector priming system.
- Other makes of diesel engines and electric power options are available.

MATERIAL SPECIFICATIONS
- Standard build: cast iron wet end, with open impellers and replaceable wear plates.
- The mechanical seal, with solid silicon carbide mating faces, is lubricated in an oil bath.
- Suction and discharge flanges are 3” ANSI 150# FF.

Flows given in American Gallons Per Minute

Fuel consumption: 0.96 GPH @ 2,800 RPM
PPP-DV080-250-01/00
Spillguard™
Portable Containment Berms

FEATURES

• Lightweight
• Compact
• Portable
• Durable
• No Inflation Necessary, Sets Up in Minutes
• Heavy Duty, Chemical Resistant Materials

TECHNICAL

The SPILLGUARD™ berm is a compact, portable system ideal for use with temporary liquid storage tanks, pumps, or other equipment used in handling hazardous materials. The SPILLGUARD™ berm can be set up in minutes. The patented, collapsible walls and light-weight materials allow for quick deployment. Tough, one piece construction, reinforced seams, and chemically resistant materials give extra protection under field conditions.

MATERIAL SPECIFICATIONS

The SPILLGUARD™ berm is manufactured of heavy duty 35 mil polyurethane coated fabric that offers excellent chemical resistance characteristics and durability. The unique design, patented collapsible walls, and compact size allow for convenient storage. SPILLGUARD™ units are available in a variety of sizes and can be made to fit specific applications. The heavy duty ground tarp and traffic belting supplied with the unit gives the drive-on capabilities and operator safety. Chemical and environmental resistance data available upon request.

Rain for Rent
P.O Box 2248 • Bakersfield, CA 93303
800-742-7246 • rainforrent.com
NOTES:
1. MATERIAL OF CONSTRUCTION: TYPE 316L STAINLESS STEEL.
2. MATERIAL SPECIFICATIONS ARE PROVIDED AND SHALL MEET APPLICABLE MATERIAL SPECIFICATIONS.
3. FLANGE BOLT HOLES TO STRADDLE COMMON CENTERLINES UNLESS OTHERWISE NOTED.
4. INLET/OUTLET CONNECTION: 4" RD. ANSI B16.5, CLASS 150, SCH 40, RAISED FACE - WELD NECK FLANGE.
5. SUCTION PORT CONNECTION: 3" NPT ANSI B16.5, CLASS 150, SCH 40, RAISED FACE - WELD NECK FLANGE.
6. WELDING JOINTS TO BE COMPLETE JOINT PENETRATION WHERE POSSIBLE.
7. DYE PENETRANT TESTING IN ACCORDANCE WITH ASME B31.3 NORMAL SERVICE RECOMMENDATIONS WILL BE PERFORMED ON A MINIMUM OF 20% OF LINEAR LENGTH OF WELDS OR HYDROSTATIC TESTING WILL BE PERFORMED AS PART OF MAIZEI NON-Destructive Testing Procedure.
8. CLEANED FOR PASSivation PER ASMA A380 GUIDELINES.
9. PASSivated PER ASMA A947 SPECIFICATION.
10. WELD MAP, NONdestructive TESTING (NDT), CLEANING AND INSPECTION REPORTS TO BE PROVIDED BY MAIZEI.
11. MAIZEI RECOMMENDS INSTALLING THE INJECTOR IN A HORIZONTAL POSITION. INJECTORS MAY BE INSTALLED IN A VERTICAL POSITION WITH THE LIQUID FLOW UPWARDS, HOWEVER, IN CERTAIN APPLICATIONS THIS MAY AFFECT PERFORMANCE, PLEASE REFER TO MAIZEI TECHNICAL BULLETIN No. 11: "MAIZEI INJECTOR INSTALLATION RECOMMENDATIONS FOR GAS TO LIQUID MIXING APPLICATIONS."

REVISED DRAWING
<table>
<thead>
<tr>
<th>Operating Pressure kg/cm²</th>
<th>WATER SUCTION</th>
<th>Operating Pressure kg/cm²</th>
<th>WATER SUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injector Inlet</td>
<td>Injector Outlet</td>
<td>Water Suction in m³/h</td>
<td>Injector Inlet</td>
</tr>
<tr>
<td>0.35</td>
<td>643</td>
<td>0.00</td>
<td>4.22</td>
</tr>
<tr>
<td>0.07</td>
<td>94.3</td>
<td>0.35</td>
<td>177</td>
</tr>
<tr>
<td>0.14</td>
<td>75.7</td>
<td>0.70</td>
<td>177</td>
</tr>
<tr>
<td>0.21</td>
<td>53.0</td>
<td>1.05</td>
<td>177</td>
</tr>
<tr>
<td>0.28</td>
<td>22.7</td>
<td>1.41</td>
<td>177</td>
</tr>
<tr>
<td>0.35</td>
<td>177</td>
<td>2.11</td>
<td>177</td>
</tr>
<tr>
<td>0.49</td>
<td>48.2</td>
<td>2.46</td>
<td>177</td>
</tr>
<tr>
<td>0.56</td>
<td>15.1</td>
<td>3.16</td>
<td>177</td>
</tr>
<tr>
<td>0.62</td>
<td>*(0.62)</td>
<td>*(3.59)</td>
<td>108</td>
</tr>
<tr>
<td>0.70</td>
<td>810</td>
<td>0.00</td>
<td>174</td>
</tr>
<tr>
<td>0.00</td>
<td>177</td>
<td>0.35</td>
<td>174</td>
</tr>
<tr>
<td>0.35</td>
<td>177</td>
<td>0.70</td>
<td>174</td>
</tr>
<tr>
<td>0.49</td>
<td>143</td>
<td>1.05</td>
<td>174</td>
</tr>
<tr>
<td>0.64</td>
<td>45.4</td>
<td>1.41</td>
<td>174</td>
</tr>
<tr>
<td>0.84</td>
<td>22.7</td>
<td>2.11</td>
<td>174</td>
</tr>
<tr>
<td>1.05</td>
<td>*(1.23)</td>
<td>2.46</td>
<td>174</td>
</tr>
<tr>
<td>1.27</td>
<td>950</td>
<td>3.16</td>
<td>174</td>
</tr>
<tr>
<td>1.76</td>
<td>1,162</td>
<td>3.52</td>
<td>174</td>
</tr>
<tr>
<td>2.11</td>
<td>1,257</td>
<td>*(4.23)</td>
<td>60.8</td>
</tr>
<tr>
<td>2.46</td>
<td>1,522</td>
<td>*(4.93)</td>
<td>53.0</td>
</tr>
<tr>
<td>2.81</td>
<td>1,446</td>
<td>*(5.56)</td>
<td>159</td>
</tr>
<tr>
<td>3.52</td>
<td>60.6</td>
<td>*(6.23)</td>
<td>56.8</td>
</tr>
</tbody>
</table>

*NUMBERS IN PARENTHESES indicate the injector outlet pressure when suction stops (Zero Suction Point).
<table>
<thead>
<tr>
<th>Operating Pressure PSIG</th>
<th>AIR SUCTION SCFM</th>
<th>Operating Pressure PSIG</th>
<th>AIR SUCTION SCFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>131</td>
<td>60</td>
<td>455</td>
</tr>
<tr>
<td>0</td>
<td>20.0</td>
<td>1</td>
<td>65.4</td>
</tr>
<tr>
<td>1</td>
<td>19.1</td>
<td>5</td>
<td>63.0</td>
</tr>
<tr>
<td>2</td>
<td>17.4</td>
<td>10</td>
<td>57.2</td>
</tr>
<tr>
<td>3</td>
<td>15.5</td>
<td>20</td>
<td>38.3</td>
</tr>
<tr>
<td>4</td>
<td>*(4.5)</td>
<td>25</td>
<td>27.4</td>
</tr>
<tr>
<td>5</td>
<td>10.3</td>
<td>30</td>
<td>23.5</td>
</tr>
<tr>
<td>7</td>
<td>*(8.8)</td>
<td>35</td>
<td>17.7</td>
</tr>
<tr>
<td>8</td>
<td>12.0</td>
<td>40</td>
<td>12.0</td>
</tr>
<tr>
<td>15</td>
<td>227</td>
<td>45</td>
<td>*(51.0)</td>
</tr>
<tr>
<td>0</td>
<td>*(13.1)</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>10</td>
<td>10.6</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>12</td>
<td>6.4</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>20</td>
<td>263</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>0</td>
<td>37.8</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>5</td>
<td>26.2</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>10</td>
<td>13.4</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>12</td>
<td>11.6</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>15</td>
<td>*(17.5)</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>25</td>
<td>294</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>0</td>
<td>19.4</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>5</td>
<td>19.4</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>10</td>
<td>10.5</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>15</td>
<td>7.6</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>30</td>
<td>322</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>0</td>
<td>42.7</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>5</td>
<td>29.7</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>10</td>
<td>21.1</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>15</td>
<td>15.5</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>20</td>
<td>10.4</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>25</td>
<td>7.2</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>35</td>
<td>347</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>0</td>
<td>45.7</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>5</td>
<td>37.5</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>10</td>
<td>29.9</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>15</td>
<td>22.0</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>20</td>
<td>13.1</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>25</td>
<td>10.9</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>30</td>
<td>7.9</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>40</td>
<td>371</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>0</td>
<td>47.9</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>5</td>
<td>40.1</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>10</td>
<td>31.5</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>15</td>
<td>21.8</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>20</td>
<td>15.3</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>25</td>
<td>11.2</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>30</td>
<td>9.0</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>45</td>
<td>394</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>0</td>
<td>51.9</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>5</td>
<td>43.6</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>10</td>
<td>37.1</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>15</td>
<td>31.8</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>20</td>
<td>26.8</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>25</td>
<td>21.9</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>30</td>
<td>14.2</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>35</td>
<td>11.6</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>40</td>
<td>*(38.9)</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>50</td>
<td>415</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>0</td>
<td>22.3</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>5</td>
<td>49.0</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>10</td>
<td>43.5</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>15</td>
<td>30.8</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>20</td>
<td>22.2</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>25</td>
<td>17.0</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>30</td>
<td>13.7</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>35</td>
<td>10.0</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>40</td>
<td>*(43.1)</td>
<td></td>
<td>8.8</td>
</tr>
</tbody>
</table>

*NUMBERS IN PARENTHESES INDICATE the injector outlet pressure when suction stops (Zero Suction Point).*
<table>
<thead>
<tr>
<th>Operating Pressure (kg/cm²)</th>
<th>AIR SUCTION</th>
<th>Operating Pressure (kg/cm²)</th>
<th>AIR SUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.35</td>
<td>497</td>
<td>0.35</td>
<td>1,722</td>
</tr>
<tr>
<td>0.70</td>
<td>703</td>
<td>2.11</td>
<td>658</td>
</tr>
<tr>
<td>1.05</td>
<td>861</td>
<td>2.81</td>
<td>366</td>
</tr>
<tr>
<td>1.41</td>
<td>994</td>
<td>1.05</td>
<td>469</td>
</tr>
<tr>
<td>1.76</td>
<td>1,111</td>
<td>2.11</td>
<td>852</td>
</tr>
<tr>
<td>2.11</td>
<td>1,217</td>
<td>1.05</td>
<td>492</td>
</tr>
<tr>
<td>2.46</td>
<td>1,315</td>
<td>1.05</td>
<td>582</td>
</tr>
<tr>
<td>2.81</td>
<td>1,406</td>
<td>1.05</td>
<td>655</td>
</tr>
<tr>
<td>3.16</td>
<td>1,491</td>
<td>1.05</td>
<td>718</td>
</tr>
<tr>
<td>3.52</td>
<td>1,572</td>
<td>1.05</td>
<td>760</td>
</tr>
</tbody>
</table>

*NUMBERS IN PARENTHESIS INDICATE THE INJECTOR OUTLET PRESSURE WHEN SUCTION STOPS (ZERO SUCTION POINT).*
Appendix E
Health and Safety Plan

For the

Removal Action
High Street Outfall and 40th Avenue
Storm Sewer System

Vasquez Boulevard/Interstate 70 Site,
Operable Unit #2

Prepared for:

City and County of Denver
Environmental Quality Division
200 West 14th Ave, Suite 310
Denver, Colorado 80204

Prepared by:

Engineering Management Support, Inc.
7220 W. Jefferson Ave., Suite 406
Lakewood, Colorado 80235

June 19, 2015
HEALTH AND SAFETY PLAN

PROJECT NAME: Design Investigation and Removal Action High Street Outfall and 40th Avenue Storm Sewer System

PROJECT SITE LOCATION: Vasquez Boulevard/Interstate 70 Site Operable Unit 2 Western Portion of Denver Coliseum Parking Lot and Globeville Landing Park adjacent to the South Platte River Intersection of Arkins Ct and McFarland Dr Denver, CO 80216

PROJECT MANAGER: Timothy Shangraw

SITE SAFETY AND HEALTH OFFICER: Robert Jelinek

PREPARATION DATE: June 19, 2015

APPROVED BY: EMSI Project Manager

Timothy Shangraw (Date)

APPROVED BY: EMSI On-Site Health and Safety Officer (HSO)

Robert Jelinek (Date)

This document was prepared for the sole use of Engineering Management Support, Inc., the City and County of Denver, and the regulatory agencies involved with the project, the only intended beneficiary of our work. No other parties should rely on the information contained herein without the prior written consent of EMSI.
TABLE OF CONTENTS

1 PURPOSE AND INTRODUCTION .................................................................................................................. 1

2 APPLICABILITY ............................................................................................................................................... 1

3 HISTORICAL SITE CHARACTERIZATION RESULTS ............................................................................. 2

4 SCOPE OF WORK ............................................................................................................................................. 3

5 BIOLOGICAL, PHYSICAL, AND CHEMICAL HAZARD EVALUATION ..................................................... 3

   5.1 BIOLOGICAL HAZARDS ........................................................................................................................... 3
   5.2 PHYSICAL HAZARDS ............................................................................................................................... 3
   5.3 CHEMICAL HAZARDS ...................................................................................................................................... 4

6 GENERAL HEALTH AND SAFETY PROCEDURES .............................................................................. 4

   6.1 ORGANIZATIONAL STRUCTURE ............................................................................................................. 4
   6.2 ON-SITE CONTROL .................................................................................................................................. 5
   6.3 PERSONAL PROTECTIVE EQUIPMENT (PPE) ......................................................................................... 6
   6.4 COMMUNICATION ...................................................................................................................................... 6
   6.5 SAFE WORK PRACTICES AND LIMITATIONS ....................................................................................... 7
   6.6 FIRE PREVENTION .................................................................................................................................... 7
   6.7 HEALTH AND SAFETY PRACTICES DURING DRILLING INTO AND EXCAVATION OF WASTE MATERIAL AND VISUALLY-IMPACTED SOILS ........................................................................................................................... 8
   6.8 AUTHORIZED PROJECT FIELD PERSONNEL ..................................................................................... 10
   6.9 MEDICAL MONITORING ......................................................................................................................... 10
   6.10 RECORD KEEPING AND REPORTING ................................................................................................. 10

7 CONSTRUCTION-RELATED HEALTH AND SAFETY PROCEDURES ................................................. 10

   7.1 HAZARD COMMUNICATION .................................................................................................................. 11
   7.2 BACK SAFETY/LIFTING .......................................................................................................................... 11
   7.3 ELECTRICAL SAFETY GENERAL .......................................................................................................... 11
   7.4 FALL PROTECTION .................................................................................................................................. 11
   7.5 OPERATION OF MECHANIZED EQUIPMENT AND MOTOR VEHICLES ................................................... 12
   7.6 STRUCK-BY AND CAUGHT-IN/CAUGHT-BETWEEN HAZARDS .......................................................... 12
   7.7 MATERIAL HANDLING - GENERAL ..................................................................................................... 12

8 EMERGENCY CONTACTS AND PROCEDURES ............................................................................ 13

   8.1 EMERGENCY CONTACTS ....................................................................................................................... 13
   8.2 EMERGENCY PROCEDURES ................................................................................................................... 13
   8.3 LOCATION OF SITE RESOURCES ......................................................................................................... 14

9 REFERENCES .................................................................................................................................................. 15

10 HEALTH AND SAFETY COMPLIANCE AGREEMENT ...................................................................... 16

LIST OF TABLES

Table E-1: Emergency Contacts
LIST OF FIGURES

Figure E-1: Site Location Map
Figure E-2: Site Plan
Figure E-3: Organization Chart
Figure E-4: Hospital Route Map

APPENDICES

Appendix E-1: First Aid and Emergency Care
Appendix E-2: Toxicological Properties and Hazard Assessments
1 PURPOSE AND INTRODUCTION

The purpose of this Health and Safety Plan (HASP), prepared by Engineering Management Support, Inc. (EMSI), is to provide background information, assign responsibilities, and establish personal protection standards and safety procedures for tasks associated with a design investigation and the “environmental components” of constructing a barrier system associated with the open channel stormwater drainage structure planned to pass through and downstream of Operable Unit 2 (OU-2) of the Vasquez Boulevard/Interstate 70 (VB/I-70) Superfund Site. The stormwater drainage structure to be constructed in OU-2 is part of the High Street Outfall and 40th Avenue Storm Sewer System that is intended to convey stormwater from Regional Transportation District (RTD), Colorado Department of Transportation (CDOT), and City and County of Denver (CCD) projects that are being developed in the VB/I-70 watershed area.

The planned barrier system is located in the parking lot west of the Denver Coliseum and in a portion of Globeville Landing Park between the parking lot and the South Platte River, as shown on Figures E-1 and E-2. Activities identified in this HASP will be completed in accordance with the Removal Action Work Plan (RAWP). This HASP is Appendix E to the RAWP. Companion documents to this HASP include the Sampling and Analysis Plan (SAP) and Materials Management Plan (MMP). The SAP and MMP are Appendices C and D, respectively, to the RAWP.

The activities for which this HASP applies include conducting a design investigation (drilling of soil borings, collection of waste material and visually-impacted soil samples, completing the borings as piezometers and sampling groundwater, and monitoring for soil gas) and the “environmental components” (i.e., removal of waste material and visually-impacted soils, and groundwater [dewatering water]) associated with construction of the barrier system.

Included in this HASP are an applicability statement, historical Site characterization results, a brief description of work to be conducted, Site-specific health and safety procedures, emergency contacts and procedures, and a compliance agreement. Prior to any work being conducted at the Site, a copy of this HASP will be distributed to all EMSI employees and subcontractors. Prior to anyone entering the Site, they will be required to read this HASP and sign the Compliance Agreement.

2 APPLICABILITY

EMSI personnel, subcontractors and visitors who have the potential to be exposed to chemical or physical hazards are held responsible for operating in accordance with the applicable Occupational Safety and Health Administration (OSHA) rules and regulations, especially provisions of 29 CFR 1910.120, 1910.134, 1910.1001-1101, 1910.1200, and 29 CFR 1926; these provisions are incorporated into this document by reference. Those Site personnel who will perform work at the Site shall produce written documentation at least three (3) days prior to the
commencement of field activities verifying completion of appropriate health and safety training, in accordance with 29 CFR 1910.120, the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard. Many of the training requirements included in these regulations have been summarized by OSHA in a publication entitled, Training Requirements in OSHA Standards and Training Guidelines (OSHA, 1998). Personnel are also responsible for adherence to applicable state or local regulations that relate to their respective Site activities.

EMSI requires that subcontractors shall abide by a HASP for their employees covering, among other things, exposure to hazardous materials, and shall complete all work in accordance with the HASP. The subcontractor may choose to use EMSI's HASP as a guide in developing its own HASP or may choose to adopt in full EMSI's HASP. In either case, EMSI's HASP will be considered the primary HASP for all project-related activities; if a HASP is provided by a subcontractor, it will be considered an attachment to this HASP. EMSI reserves the right to review the subcontractor's HASP at any time. All subcontractors shall, at a minimum, follow all provisions of EMSI’s HASP and/or applicable OSHA guidelines; whichever is more stringent or appropriate. Although EMSI has prepared the HASP, the City and County of Denver, each subcontractor, and any organizations performing oversight shall be responsible for the health and safety of their employees at the job Site and for providing and verifying that each and every person present at the job Site has the appropriate health and safety training.

Inadequate health and safety precautions on the part of a subcontractor, or EMSI's opinion that subcontractors personnel are or may be exposed to health hazards, can be cause for EMSI to suspend the subcontractor's Site work and ask the subcontractor's personnel to evacuate the hazard area.

3  HISTORICAL SITE CHARACTERIZATION RESULTS

Visibly-impacted soil and material beneath and in the vicinity of the alignment of the proposed barrier system have been characterized, as discussed in Section 2.1 of the RAWP. Compounds of potential concern in the waste material and soil consist of volatile organic compounds (VOCs), polynuclear-aromatic hydrocarbons (PAHs), arsenic, and lead. A trace amount of asbestos was detected at one location, raising the concern that asbestos containing material (ACM) may be present in the subsurface material.

As discussed in Section 2.2 of the RAWP, groundwater quality along the alignment of the barrier system has also been characterized. Compounds of potential concern in groundwater consist of VOCs, arsenic, cadmium, copper, lead, manganese, and zinc. Groundwater depths below the ground surface within and adjacent to the limits of the alignment were measured in 2010 and 2011. Groundwater level depths ranged from 10.7 to 23.8 feet below ground surface.

Soil gas monitoring was conducted in 2010 during the advancement of borings for Site characterization within the limits of the channel alignment. Methane concentrations ranged from 0.5 to 43.4 percent by volume in air (% v/v). Additional measurements to the southeast of the alignment detected methane concentrations up to 56.7 % v/v. During advancement of borings in
2011, well-head gas at the ground surface was measured and Lower Explosive Limits (LELs) of 100% were recorded at many of the well-heads. Soil gas monitoring results are detailed in Section 2.3 of the RAWP.

4 SCOPE OF WORK

A detailed description of the work to be conducted is provided in Section 3 of the RAWP.

EMSI will manage the design investigation, prepare a results report, participate in and oversee field activities, coordinate with the analytical laboratory, and interact with the City and County of Denver and any regulatory agency personnel. EMSI will be supported by Foresight West Surveying for field surveying and utility clearances; Site Services Drilling for soil boring and piezometer construction, CTL Thompson for geotechnical testing of subsurface samples; and TestAmerica for laboratory analysis of solid and liquid samples.

During implementation of the “environmental components” (i.e., removal of waste material and visually-impacted soils and groundwater [dewatering water]) associated with construction of the barrier system, EMSI will manage and oversee one or more contractors who will remove asphalt pavement and subsurface materials and transport these materials off site for disposal. The excavation contractor(s) will also be responsible for dewatering the area around the excavation, treatment of the dewatering water (if necessary), and discharge of the water either to the South Platte River or Sand Creek. EMSI will also manage and oversee a barrier system installation contractor.

5 BIOLOGICAL, PHYSICAL, AND CHEMICAL HAZARD EVALUATION

A potential for biological, physical, and chemical hazards will exist at the Site during design investigation activities and implementation of the “environmental components” associated with construction of the drainage structure. A conceptual Site layout plan showing potential facilities and truck traffic routes that might be employed during the “environmental components” is provided as Figure 6 in the RAWP. Potential hazards are described below.

5.1 Biological Hazards

Possible biological hazards include venomous insects (e.g., bees, wasps, spiders) and to a lesser extent poisonous snakes (e.g., rattlesnakes). Exposure to these hazards will be minimized with appropriate protective clothing.

5.2 Physical Hazards

The only personnel who will be allowed access to the Site will be EMSI and subcontractor personnel and City and County of Denver and/or regulatory agency visitors accompanied by an EMSI employee.
Physical hazards which may be encountered include the presence of support vehicles (driller’s support truck, forklift for water treatment tanks and equipment) and semi-trucks on the Site, drilling activities (i.e., drill rig), exposure to electrical and other utility hazards, potential for improperly grounded electrical equipment, and noise. In addition, there is a possibility of slip/trip/fall hazards during soil and groundwater sampling, traversing wet/slippery surfaces (e.g., solids storage area shown on Figure 6 of the RAWP), and strains/sprains from carrying of sampling equipment, samples, sample coolers, and heavy tools or equipment. These hazards are discussed in greater detail in Sections 6 and 7.

The potential for extreme weather conditions may exist depending upon the implementation schedule. Extreme weather conditions may include excessive heat or cold, thunderstorms, high wind conditions, heavy rains, and snow/ice. Special precautions will be taken during periods of extreme weather, and work may be halted by the respective Site Safety Officer (SSO) until the severe weather has subsided. In addition, subcontractors may elect to independently halt their activities in the event of extreme weather conditions, especially thunderstorms. Additional information regarding heat and cold stress and other physical hazards is provided in Appendix E-1.

5.3 Chemical Hazards

Based on available information as summarized in Section 3, the primary chemical of concern at the Site are expected to be VOCs, PAHs, metals, soil gas, and ACM in waste material. Exposure could occur from inhalation of dust, vapors, soil gas, or ACM and/or direct skin contact with subsurface materials and groundwater containing these chemicals of concern. Contact with the eyes is also a route of exposure for asbestos.

Toxicological properties and hazard assessments of chemicals of concern are provided in Appendix E-2.

6 GENERAL HEALTH AND SAFETY PROCEDURES

This section presents general safety procedures to be followed during the planned activities at the Site. The measures contained herein will be supplemented as necessary with standard safe work practices.

6.1 Organizational Structure

An organizational chart for Site health and safety is included as Figure E-3. This chart presents the identification of Site safety personnel, as follows:

Project Manager
The EMSI Project Manager, Timothy Shangraw, will be responsible for overall design, implementation, safety, and cost/schedule control of the activities described in the RAWP. He will be responsible for making the proper personal protection equipment (PPE) available to EMSI personnel, ensuring that adequate time and budget is available for health and safety activities for EMSI personnel, and making available qualified personnel to perform Site work in a safe manner. He will also be responsible for monitoring compliance of subcontractors and field personnel with this HASP and will have the authority to stop Site work in the event of safety violations or safety concerns.

EMSI On-Site Representative/Health and Safety Officer (HSO)

The EMSI On-Site Representative, Robert Jelinek, will have responsibility for coordinating and overseeing all field-related aspects of the Site investigation and will also serve as the Health and Safety Officer (HSO). In conjunction with the Project Manager, the On-Site Representative/HSO will have day-to-day responsibilities for acquainting field personnel with potential hazards, implementing the health and safety program described in this HASP, and ensuring that work is being performed in a safe manner in accordance with the HASP. In many cases, the EMSI On-Site Representative will be the Project Manager.

Site Safety Officer (SSO)

While conducting activities at the Site, each of the program subcontractors will designate one of their on-Site personnel as the Site Safety Officer (SSO) for the work being performed by the respective subcontractor (Figure E-3). The SSO should be familiar with local emergency services and will be responsible for ensuring that work by the subcontractor is being performed in a safe manner in accordance with the subcontractor’s HASP. The SSO will also monitor on-Site hazards and physical condition of their respective personnel. Each SSO has the authority to shutdown operations if the operation poses a potential threat to field personnel.

Field Personnel

All field personnel shall be familiar with the contents of this HASP and sign the Compliance Agreement. Field personnel are also responsible for following the directions of the SSO, performing all work in a safe manner, and maintaining/inspecting PPE.

6.2 On-Site Control

There will be no on-Site control at the Site during the design investigation activities. On-Site control during implementation of the “environmental components” associated with construction of the barrier system will be provided by temporary barricades erected around the drainage channel excavation and the water treatment equipment, if any. All personnel performing work defined in this HASP and any visitors must sign in and out using a field Log Book maintained by the EMSI On-Site Representative.
6.3 Personal Protective Equipment (PPE)

Due to the anticipated level of risk and hazards involved in performing the design investigation tasks and construction activities, Level D PPE, the lowest level, is anticipated to be appropriate for most activities. The specific protective equipment for Level D will consist of the following:

- Steel-toed boots,
- Hard hat,
- Work gloves, or Nitrile gloves, as necessary based on the specific activity,
- Safety glasses, as necessary based on the specific activity (e.g., when collecting samples of landfill materials where ACM may be present),
- Hearing protection (e.g., earplugs or earmuffs), as necessary based on the specific activity, and
- A safety vest or shirt of bright yellow/lime or orange color.

If the action levels for oxygen, carbon monoxide, combustibles, and hydrogen sulfide are not exceeded (see Section 6.7 below), but the action level of volatile organics is exceeded, consideration may be given to continue working by upgrading PPE to a modified Level C. Modified Level C PPE would include Level D protective equipment with the addition of a National Institute for Occupational Safety and Health (NIOSH)-approved full-face or half-mask air purifying respirator. The decision to continue working under these conditions will be made by the On-Site Representative/Health and Safety Officer.

6.4 Communication

This section discusses the equipment and procedures for normal field communications and communications in the event of an emergency.

A cellular telephone shall be carried by the HSO and each SSO. An air horn will be located in each field vehicle for announcing emergency evacuation procedures and backup for other forms of communication. Three long air horn blasts is the emergency signal to indicate that all personnel should leave the work area.

The following standard hand signals will be used in the event that verbal communication becomes impossible:

<table>
<thead>
<tr>
<th>Hand Signal</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand gripping throat</td>
<td>Out of air, can't breathe</td>
</tr>
<tr>
<td>Grip partner's wrist or both hands around waist</td>
<td>Leave area immediately</td>
</tr>
<tr>
<td>Hands on top of head</td>
<td>Need assistance</td>
</tr>
<tr>
<td>Thumbs up</td>
<td>OK, I am all right, I understand</td>
</tr>
</tbody>
</table>
6.5 Safe Work Practices and Limitations

Site activities will be conducted during daylight hours only. Daylight hours are defined as 7:00 AM to 7:00 PM from May 1 to October 31 and as 8:00 AM to 5:00 PM from November 1 to April 30. The HSO must provide permission for fieldwork conducted by EMSI staff or subcontractors beyond daylight hours or on weekends and holidays. The HSO will review pertinent health and safety matters with on-Site personnel in daily health and safety meetings. Additional work practices and limitations are listed as follows:

- All Site personnel shall acknowledge in the Compliance Agreement (Section 10) that they have read, understood, and agree to comply with this HASP.
- In addition to an initial health and safety meeting, daily project health and safety meetings will be conducted by the HSO (or designated representative) at the start of each workday to discuss the upcoming activities for the day and to address the health and safety procedures to be followed.
- Applicable OSHA guidelines will be followed for all Site activities.
- Dress in accordance with the activity-specific level of protection.
- Eating, drinking, gum or tobacco chewing, and smoking are not permitted in work areas.
- Any person under a physician’s care, taking medication, or those who experience allergic reactions must inform the HSO.
- The buddy system must be employed at all times. At least two people from EMSI or their subcontractors should be present during all active field tasks unless specifically permitted by the HSO or designated representative.
- The wearing of contact lenses for on-Site personnel is prohibited by best management practice and OSHA.
- Be aware of symptoms of heat or cold stress, exposure to hazardous chemicals or dangerous atmospheres, and work-related injuries.
- All potential underground utilities (gas, electric, sanitary and storm sewer, water, telephone, cable, fiber optic) at the Site must be identified and marked prior to the commencement of any drilling or excavation activity.
- Good personal hygiene practices are especially important when working in the proximity of potentially hazardous compounds. Of particular importance is the need to keep fingers away from the face unless they have been carefully washed. Cuts and abrasions should be covered by an appropriate dressing.
- Proper lifting techniques should be followed at all times to minimize the risk of back injury.
- All accidents and hazardous material exposure incidents will be reported on the appropriate forms, discussed in Section 6.10.

6.6 Fire Prevention

All flammable and/or combustible liquids (i.e., gasoline, diesel fuel) shall be stored in approved safety containers that meet the specifications of National Fire Protection Association (NFPA)

All personnel performing work at the Site must be trained in the proper use of fire extinguishers. OSHA-approved portable fire extinguishers will be located in every field vehicle. These extinguishers shall be rated for Class A (wood, paper), B (flammable liquid), and C (electrical) fires, and their locations shall be clearly identified with signs and/or labels. As required by 29CFR1910.157(d), at least one fire extinguisher with the appropriate rating must be located within 75 feet of a Class A fire hazard and 50 feet of a Class B or C fire hazard.

6.7 Health and Safety Practices during Drilling into and Excavation of Waste Material and Visually-Impacted Soils

Hazards associated with drilling into and/or excavation of waste material and visually-impacted soils include oxygen depletion/enrichment and the presence of toxic and flammable and/or explosive gases. The U.S. Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PEL’s) for some of the more common atmospheric conditions/contaminants that are encountered during drilling and excavation activities are as follows:

<table>
<thead>
<tr>
<th>Test</th>
<th>Permissible Exposure Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>19.5% to 23.5%</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>Under 35 parts per million (ppm)</td>
</tr>
<tr>
<td>Lower Flammable (Explosive) Limit</td>
<td>Under 10% of LFL/LEL</td>
</tr>
<tr>
<td>(LFL/LEL)</td>
<td></td>
</tr>
<tr>
<td>Hydrogen Sulfide (H₂S)</td>
<td>Under 10 ppm</td>
</tr>
<tr>
<td>Aromatic hydrocarbons</td>
<td>Under 5 ppm</td>
</tr>
</tbody>
</table>

If site activities include drilling into and/or excavation of waste material and visually-impacted soils, the following action levels and actions shall apply:

<table>
<thead>
<tr>
<th>Constituent (Instrument)</th>
<th>Action Level</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen (4 Gas Meter)</td>
<td>Below 19.8% in breathing zone</td>
<td>Clear area by 10 feet minimum. Retest site after 2 minutes.</td>
</tr>
<tr>
<td>Carbon Monoxide (4 Gas Meter)</td>
<td>35 ppm in breathing zone</td>
<td>Clear area by 10 feet minimum. Retest site after 2 minutes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constituent (Instrument)</th>
<th>Action Level</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustibles (4 Gas Meter)</td>
<td>10% of Lower Explosive Limit (LEL)</td>
<td>Clear area by 10 feet and turn off motor. Retest site after 2 minutes.</td>
</tr>
<tr>
<td>Hydrogen Sulfide (4 Gas Meter)</td>
<td>10 ppm</td>
<td>Clear area by 10 feet minimum. Retest site after 2 minutes.</td>
</tr>
</tbody>
</table>
Volatile Organics (PID)  5 ppm  Clear area by 10 feet minimum. Retest site after 2 minutes.

If flammable gas is suspected to be present, the following health and safety practices shall be followed:

- A flammable gas indicator shall be utilized at all times during trenching, excavation, drilling, or when working within ten (10) feet of an open excavation.

- Before personnel are permitted to enter an open trench or excavation, the trench or excavation shall be monitored to ensure that flammable gas is not present in concentrations exceeding 1% and that oxygen is present at a minimum concentration of 19.8%. When in an excavation or trench, each work party shall work no more than five (5) feet from a continuous flammable gas and oxygen monitor.

- When trenching, excavating, or drilling deeper than two (2) feet into the fill, or in the presence of detectable concentrations of flammable gas, the soils shall be wetted and the operating equipment shall be provided with spark proof exhausts.

- A dry chemical fire extinguisher, ABC rated, shall be provided on all equipment used in areas containing waste material.

- Personnel within or near an open trench or drill hole shall be fully clothed, and wear shoes with non-metallic soles, gloves, hard hat and safety goggles or glasses.

- Smoking shall not be permitted in any area within one hundred (100) feet of the excavation.

- Personnel shall be kept upwind of any open trench unless the trench is continuously monitored.

- All other applicable Safety and Health Regulations for Construction, as promulgated in 29 CFR by OSHA, shall be met. Applicable regulations include, but may not be limited to, the confined space standard (Part 1926.21(b)(6)( i ) and ( ii ) in Subpart C ); gases, vapors, fumes, dusts and mists (Part 1926.55 in Part 1926 Subpart E); fire protection and prevention (Part 1926 Subpart F); and trenching and excavation (Part 1926 Subpart P).

- Compliance with OSHA’s confined space requirements for general industry, as promulgated in 29 CFR 1910.146 and Appendices A- F.
6.8 Authorized Project Field Personnel

Only authorized project personnel will be granted access to active work areas during field activities. A Log Book will be maintained by the EMSI On-Site Representative or his designee to record the personnel performing work at or visiting the Site.

6.9 Medical Monitoring

Medical monitoring will be performed in a manner prescribed by and consistent with each contractor’s corporate policies.

6.10 Record Keeping and Reporting

The following records and/or logs will be maintained in the EMSI field vehicle at the Site:

- Daily Sign-in Log that documents all personnel entering and exiting the Site;
- Daily Health and Safety Meeting Log that documents personnel attending daily health and safety meetings and a brief summary of the meeting;
- Accident Report Forms that document any accidents and/or injuries at the Site, including corrective actions;
- HAZWOPER Training, Medical Monitoring, and Fit Testing Certification that document compliance with applicable requirements of 29 CFR 1910.120 for all personnel performing work at the Site; and
- Material Safety Data Sheets (MSDSs, also referred to as SDSs) that provide health and safety and emergency response information on chemicals, if any, and materials used at the Site.

All accidents (including vehicular accidents while traveling to/from the Site), injuries, illnesses, chemical exposures, fires, and/or deviations from the HASP shall be reported to the HSO. The HSO must complete an Accident Report Form for all accidents or injuries occurring at the Site. The accident or injury must be reported to the Project Manager and appropriate actions taken.

7 CONSTRUCTION-RELATED HEALTH AND SAFETY PROCEDURES

This section presents selected safety procedures to be followed during the design investigation and construction activities; this section is not intended to be all-inclusive. Applicable OSHA and Department of Transportation (DOT) requirements will be followed at all times. The measures contained herein will be supplemented as necessary with standard safe work practices. Each subcontractor will be responsible for ensuring that each of its employees complies with the appropriate OSHA construction standards and providing appropriate warnings to their Site personnel.
7.1 Hazard Communication

In accordance with 29 CFR 1910.1200, MSDSs will be retained in the EMSI field vehicle. It is the responsibility of all subcontractors to furnish EMSI with current (less than one year old) MSDSs for chemicals used by the subcontractor; before work starts.

7.2 Back Safety/Lifting

Proper lifting techniques must be followed at all times to minimize the risk of back injury. These techniques include:

1. Size up load before lifting. Test by lifting one of the corners or pushing. If object is too heavy, get a mechanical aid or help from another person.
2. When performing the lift:
   • Place your feet close to the object and center yourself over the load.
   • Bend the knees.
   • Lift straight up, smoothly and let your legs do the work, not your back.
   • Avoid overreaching or stretching to pick up or set down a load.
3. Make sure you have a clear path to carry the load.
4. Do not twist or turn your body once you have made the lift.
5. Always push, not pull, the object when possible.

Alternate techniques for carrying or moving loads are to be used whenever possible to minimize lifting and bending requirements. These alternatives include hoists, forklifts, dollies, and carts.

7.3 Electrical Safety General

All applicable regulations contained in Subpart S (Electrical) of 29 CFR 1910, Subpart K (Electrical) of 29 CFR 1926, Subpart V (Power Transmission and Distribution) of 29 CFR 1926, and any other applicable requirements must be followed during the performance of all construction-related tasks at the Site. In particular, the requirements outlined in 29 CFR 1910.331 through .335 (Electrical Safety-Related Work Practices) will be followed at all times.

While any employee is exposed to contact with the parts of fixed electric equipment or circuits which have been de-energized, the circuits energizing the parts shall be locked out or tagged or both in accordance with 29 CFR 1910.333(b) and 29 CFR 1926.417. It is the responsibility of all Site personnel to understand and follow these requirements.

7.4 Fall Protection

Appropriate measures will be taken to reduce the risk of falls during the performance of tasks requiring the use of ladders and/or scaffolding, including:

1. All ladders and scaffolding must meet OSHA specifications for design and safety.
2. All ladders and scaffolding must be properly secured before use per OSHA requirements.
3. Appropriate fall protection equipment must be worn at all times while working on ladders and scaffolding.

Additional requirements for the use of ladders and scaffolding, as outlined in 29 CFR 1926.450 through 543 (Subpart L, Ladders and Scaffolding), must also be followed at all times.

7.5 Operation of Mechanized Equipment and Motor Vehicles

All mechanized equipment (e.g., drilling equipment) and other motor vehicles (e.g., support trucks, excavators, backhoes, loaders, semi-trucks) shall only be operated by qualified personnel who have been trained by their employer in the proper use of the equipment. The equipment will be operated according to all applicable OSHA and Department of Transportation (DOT) regulations. Specifically, the requirements of 29 CFR 1926.600 through .606 (Subpart O. "Motor Vehicles, Mechanized Equipment, and Marine Operations") will be observed, including, but not limited to the following:

1. Seat belts must be worn at all times.
2. All heavy equipment must be equipped with a reverse signal alarm.
3. All earth moving equipment must be equipped with rollover protective structures.

7.6 Struck-By and Caught-In/Caught-Between Hazards

The potential for being struck by falling or swinging objects, or situations where an employee is caught in or caught between heavy equipment and/or other items, are to be minimized by following any and all appropriate OSHA precautions. In particular, the drilling subcontractor should incorporate provisions of 29 CFR 1926.600 (a)(3)(i), which refers to suspension of equipment or parts, 29 CFR 1926.651(e), which refers to falling loads, and 29 CFR 1926, Subpart O. which refers to machinery and heavy equipment. Precautions should include, but not be limited to, Site personnel listening for back up alarms and watching for spotters and backing equipment.

The use of towing and lifting equipment should be in accordance with OSHA and other applicable requirements.

7.7 Material Handling - General

The potential for injury due to improper material handling is to be minimized by following the material handling and storage requirements found in Subpart N of 29 CFR 1910 (Materials Handling and Storage). The following general procedures, as listed in 29 CFR 1910.176, will be followed at all times:

1. When mechanical handling equipment is used, sufficient safe clearance shall be allowed.
2. Storage of material shall not create a hazard. Materials stored in tiers must be stacked, blocked, interlocked, and limited in height so that they are stable and secure against sliding or collapse.

3. Storage areas shall be kept relatively free from accumulation of materials that constitute hazards from tripping, fire or explosion.

Covers and/or guardrails shall be provided as necessary to protect personnel from hazards of open pits, tanks, and excavations.

8  EMERGENCY CONTACTS AND PROCEDURES

8.1 Emergency Contacts

In the event of an emergency related to the field activities, notification of the appropriate contacts from Table E-1 should be made. A hospital route map is included as Figure E-4.

When calling for assistance in an emergency situation, the following information should be provided:

1. Name of person making the call.
2. Telephone number at location of person making the call.
3. Name of person(s) exposed or injured.
5. Actions already taken.

Recipient of call should hang up first – NOT the caller.

8.2 Emergency Procedures

The following standard emergency procedures will be used by on-Site personnel. The EMSI HSO and/or a designated substitute shall be notified of any on-Site emergencies and be responsible for ensuring that the appropriate procedures are followed.

Pre-Emergency Planning: The provisions of this section will be discussed with on-Site field personnel during the health and safety orientation meeting. A copy of Table E-1 and Figure E-4 shall be clearly displayed in the support vehicle.

Lines of Authority: Figure E-3 presents the line of authority for Site operations with respect to safety. The subcontractor SSO representatives shall assume responsibility for the health and safety of their workers.

Personnel Injury in the Work Zone: Upon noticing any apparently serious injury in the work zone, the designated emergency signal (three horn blasts) will be sounded by the closest EMSI or subcontractor observer. All work must be halted, and all personnel must report to the location
designated by the HSO at the initial safety meeting and wait until clearance is given to resume work. The HSO and/or Project Manager (see Figure E-3) should evaluate the nature of the injury. If the accident is deemed serious (i.e., bodily harm has occurred) by the Site HSO or respective SSO, an ambulance should be requested.

After any serious injury, the HSO will be responsible for evaluating Site and work zone conditions and determining the appropriate response measures, if any, that need to be implemented prior to work continuing after the injury.

**Fire/Explosion:** Proper storage of gasoline and other flammable liquids should be maintained to prevent or avoid spreading of a fire. Upon notification of a fire or explosion on-Site, the designated emergency signal, three horn blasts, will be sounded and all Site personnel must report to the location designated by the HSO at the initial safety meeting. The fire department will be alerted and all personnel moved to a safe distance from the involved area. Workers must know the location, use, and limitations of available on-Site fire extinguishers. The escape route from the Site will be determined by the HSO prior to start of the design investigation and construction activities and will be shared with field personnel at the initial safety meeting prior to the start of work.

**PPE Failure:** If any Site worker experiences a failure or alteration of PPE that affects the protection factor, that person and his/her "buddy" will immediately stop work. Commencement of work will not be permitted until the equipment has been repaired or replaced.

**Other Equipment Failure:** If any other equipment fails to operate properly, the EMSI on-Site representative and the HSO will be notified to evaluate the effect of this failure on continuing operations on-Site. If the failure affects the safety of personnel or prevents completion work tasks, all personnel will leave the work zone until the situation is evaluated and appropriate actions taken.

In all situations when an on-Site emergency results in evacuation of the work zone, personnel will not re-enter until any of the following conditions have been met, as appropriate:

- The conditions resulting in the emergency have been corrected.
- The hazards have been reassessed by the HSO and the Project Manager.
- The HASP has been reviewed and revised, if necessary.
- Site personnel have been briefed on any changes in the HASP.

8.3 Location of Site Resources

A support vehicle will be established at the Site that contains a cell phone, air horn, this HASP, the daily log book, monitoring instrument manuals, multiple sets of maps and directions to the nearest hospital, first aid kit, portable eye wash, fire extinguisher, other safety supplies (e.g., extra gloves, ear plugs, hard hats, safety glasses, and other PPE) and any other important items.
9 REFERENCES


U.S. Department of Labor, Occupational Safety and Health Administration, 1998 (revised), Training Requirements in OSHA Standards and Training Guidelines, OSHA 2254.
I have read, understand, and agree to comply with the health and safety procedures in this Health and Safety Plan (HASP). In addition, I have attended, understand, and agree to comply with the information presented in the health and safety pre-activity meeting. I hereby agree that (1) compliance with the HASP is a condition of entry to the Site, and (2) non-compliance with the HASP may result in work stoppage and/or dismissal from the Site.

<table>
<thead>
<tr>
<th>Printed Name</th>
<th>Organization</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Personnel health and safety pre-activity meeting conducted by:

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Tables
### Table E-1 List of Emergency Telephone Contacts

<table>
<thead>
<tr>
<th>Agency/Facility</th>
<th>Telephone No.</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Emergencies</td>
<td>911</td>
<td>Sheriff, Fire, Ambulance</td>
</tr>
<tr>
<td>St. Joseph Hospital</td>
<td>303-801-2000</td>
<td>See attached Hospital Route Map (Figure E-4)</td>
</tr>
<tr>
<td>1375 E. 19th Ave.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denver, CO  80218</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering Management Support, Inc.</td>
<td>303-940-3426</td>
<td>Tim Shangraw (Project Manager)</td>
</tr>
<tr>
<td>(office)</td>
<td>x. 9</td>
<td></td>
</tr>
<tr>
<td>EMSI on-Site cellular</td>
<td>303-619-5179</td>
<td>Tim Shangraw</td>
</tr>
<tr>
<td>telephones</td>
<td>303-808-7227</td>
<td>Paul Rosasco</td>
</tr>
<tr>
<td></td>
<td>303-807-9601</td>
<td>Bob Jelinek</td>
</tr>
</tbody>
</table>


Figures
Figure E-1

SITE LOCATION MAP

OPERABLE UNIT #2, VB I70 SUPERFUND SITE

EMSI  Engineering Management Support, Inc.
Figure E-3
Organization Chart
OPERABLE UNIT #2, VB I70 SUPERFUND SITE
EMSI Engineering Management Support, Inc.
Hospital Route
Directions:
Head SW on Arkins Ct to 38th
Left on 38th
Right on Walnut
Left on Downing
Left on E. 21st Ave
Right on Franklin
Right on E. 18th Ave.
Right on Lafayette

St Joseph Hospital
1375 E. 19th Ave
Denver, CO 80218

Project Site for High Street Outfall and 40th Avenue Storm Sewer System

Figure E-4
HOSPITAL ROUTE MAP
OPERABLE UNIT #2, VB I70 SUPERFUND SITE

EMSI Engineering Management Support, Inc.
Appendix E-1

First Aid and Emergency Care
UNDERSTANDING AND PREVENTING
HEAT STRESS
HEAT STRESS: IT'S A MATTER OF DEGREE

Under certain conditions, your body may have trouble regulating its temperature. As a result, your body overheats and suffers from some degree of heat stress. Whether mild, moderate, or severe, heat stress can come on suddenly and be dangerous to your health. But if you’re prepared, you can “keep your cool” and prevent heat-related problems.

When It’s Too Hot for You to Handle

Hard work or play can overload your body with extra heat—especially if you’re active in a hot, humid, or poorly ventilated environment. These conditions make it harder for your body to handle heat—the sweat pours out, you don’t feel well or work well, and you may feel dizzy or faint. If these signs of heat stress go unrecognized and untreated, serious—and sometimes permanent—health problems can occur.

Keep Your Cool

Our bodies vary in their ability to handle heat, but everyone can learn to avoid the adverse health and safety effects of heat stress. Keep your cool by knowing your body and its limitations, by understanding heat stress, and by preventing heat stress in the first place.

Know Your Body

Your body has a “heat regulator” that controls body temperature. But activity, heat, humidity, or lack of air movement can overload this mechanism.

Understand Heat Stress

Protect yourself from heat stress. Learn to recognize warning signs—such as heavy sweating, fatigue, and dizziness—and know how heat stress is treated.

Prevent Heat Stress

Take an active role to prevent heat problems. Know the factors that increase your risk and take steps to reduce them, such as drinking water and acclimatizing to the heat.

HOW YOUR BODY HANDLES HEAT

You have a natural mechanism that regulates the core temperature deep inside your body. You maintain a normal core temperature of 98.6°F by releasing excess heat into the air. The heat leaves your body through the blood vessels near the skin's surface and through the evaporation of sweat. Your level of activity and certain environmental conditions make the regulator work harder to increase your body’s blood flow and heat production.

Blood Flow

Your regulator tells the blood vessels near the surface of your skin to expand. The extra blood brings more body heat to the surface and releases it into the air. To keep your cool, your body needs enough water and minerals, such as salt, to keep its blood vessels supplied with blood.

Sweat Production

If increased blood flow alone isn’t enough, your regulator also speeds up production of sweat. This allows more heat to be carried away through evaporation. You can lose up to one quart of water, plus important minerals such as salt, each hour you sweat—water which must be replaced to keep you feeling well and healthy.

Activity

When you are active, the more heat your muscles generate. Heavy physical activity also sets up competition between your muscles and skin for the blood supply.

Air Movement

Air moving across your skin carries away heat from your body, which helps cool you down. But if there’s little air movement, these processes don’t work as well.

Humidity

The higher the humidity, the less sweat evaporates. That’s because the moisture content of the air is already high, making it difficult for the air to absorb more moisture.
**UNDERSTAND HEAT STRESS**

When your body's heat regulator is pushed too far and your body overheats, some form of heat stress occurs. It may be mild, moderate, or severe, and symptoms may range from excessive sweating to dizziness to unconsciousness. Since even severe heat stress can appear suddenly, learn the warning signs and how they're treated, so you can be more comfortable and productive, and prevent heat problems from occurring.

---

**Mild: Minor Heat Problems**

This is usually the earliest and least serious form of heat stress. Mild heat stress is always reversible and usually isn't dangerous unless the symptoms persist. Although you usually can continue work soon after treatment, always inform your supervisor if you have symptoms of mild heat stress.

**Signs and Symptoms**
- Excessive sweating
- Thirst
- Fatigue
- Headache
- Nausea

**What's Going On**
- Sweating causes your body to lose too much water and minerals. This imbalance may cause muscles to cramp. Your heart works harder to maintain the blood supply, straining your cardiovascular system. Some organs, such as the brain, may not get enough blood.

**Treatment**
- Drink water or other fluids.
- Use cold compresses on forehead, around the neck, and under armpits.
- Take additional salt only if advised.
- Rest in a cool, shady area.
- Remove excess clothing.
- Lower body temperature with cool compresses, sweating, air movement, or fans.

---

**Moderate: Heat Exhaustion**

This is a more serious form of heat stress than mild. Symptoms of moderate heat exhaustion include dizziness, disorientation, disorientation, or convulsions. Your body begins to lose its ability to cool itself.

**Signs and Symptoms**
- Lack of sweating
- Hot, dry, flushed skin
- Deep, rapid breathing
- A rapid, weak, and possibly irregular pulse
- Headache, nausea
- Dizziness, confusion, or delirium
- Loss of consciousness
- Convulsions

**What's Going On**
- Your regulator becomes so overheated that the temperature cannot cool your body enough. Your body becomes so overheated that sweat glands and other organs don't function normally. This can affect vital organs, including your heart and brain, and may cause permanent damage.

**Treatment**
- Call for medical help right away. While waiting for medical treatment, begin first aid:
  - Rest in a cool, shady area.
  - Remove excess clothing.
  - Lower body temperature with cool compresses, sweating, air movement, or fans.
  - Drink water or other fluids (if conscious, of course).
There are several steps you and your employer can take to prevent heat stress. Both supervisors and employees can recognize risks and follow safety procedures to reduce them. Be sure to inform your employer about any medical conditions you have and discuss whether you might be at increased risk.

- **Know Your Environment**
  Your company controls the work environment so it's safe. You can help by knowing which factors increase your risk of heat stress. Talk with your supervisor about ways to reduce them, so you can take special precautions to protect yourself when the risk is especially high, such as in hot, humid days.

- **Drink Plenty of Water**
  Increase the water you drink to replenish the water you lose from sweating. Drink more than you need to satisfy your thirst. It's best to replenish regularly by drinking small amounts frequently throughout the day. You may need to drink a glass of water or more every hour.

- **Take Appropriate Breaks**
  Whether you need rest breaks depends on conditions such as air temperature, sun exposure, and how hard you're working. Your company monitors these conditions and establishes a safe work/rest regimen for you and your coworkers.

- **Wear Proper Clothing**
  Your employer supplies you with heat-protective clothing and equipment, such as heat shields, if needed. When possible, wear loose, lightweight clothing, which encourages heat to be released.

- **Acclimatize Yourself**
  Your employer may give you guidelines to help you adapt to the heat. This natural process, called acclimatization, takes about 7 to 10 days. It usually consists of short periods of working in the heat, which gradually increase in time and intensity. If you spend time out of the heat due to vacation or reassessment, you may need to acclimatize yourself again.

- **Stay in Good Shape**
  Conditioned muscles work more efficiently and generate less body heat, while extra body weight makes you work harder. People in good condition tend to acclimate better because their cardiovascular systems respond better.

- **Eat Wisely**
  Hot, heavy meals add heat to your body and divert blood to your digestive system, so eat lightly during your workday. Remember, too, a normal diet usually supplies all the salt you need to replace the salt lost through sweating.

- **Know Special Risks**
  Alcohol (including beer), caffeine, medications such as those used to control high blood pressure or allergies, medical conditions including diabetes, recent illnesses such as flu, and increasing age all increase your risk of heat stress.
"TEAMWORK HELPS YOU BEAT THE HEAT"

In many jobs, heat is a fact of life. Since too much heat can be harmful to your health and be a safety problem, your company wants to help you reduce the risk of heat stress by monitoring and controlling the work environment. Be sure to follow company procedures, such as adjusting gradually to working in the heat and drinking plenty of water. You'll feel better on and off the job knowing what heat stress is and how to prevent it.

Consultants:
Robert Harrison, MD, MPH, Occupational Medicine
Lawrence D. McLouth, CH, Occupational Health and Safety

With contributions by:
Dale M. Shapero, CIM, Industrial Hygiene Manager
Mary E. Willis, RN, Occupational Health
Terrance G. Yonash, Corporate Safety Director

KRAMES COMMUNICATIONS
MORE THAN INFORMATION

Lithographed in Canada 1285 9107
Appendix E-2

Toxicological Properties and Hazard Assessments
**Landfill Gas**

Typical components of landfill gas are as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percent by Volume</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>methane</td>
<td>45–60</td>
<td>Methane is a naturally occurring gas. It is colorless and odorless. Landfills are the single largest source of U.S. man-made methane emissions.</td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>40–60</td>
<td>Carbon dioxide is naturally found at small concentrations in the atmosphere (0.03%). It is colorless, odorless, and slightly acidic.</td>
</tr>
<tr>
<td>nitrogen</td>
<td>2–5</td>
<td>Nitrogen comprises approximately 79% of the atmosphere. It is odorless, tasteless, and colorless.</td>
</tr>
<tr>
<td>oxygen</td>
<td>0.1–1</td>
<td>Oxygen comprises approximately 21% of the atmosphere. It is odorless, tasteless, and colorless.</td>
</tr>
<tr>
<td>ammonia</td>
<td>0.1–1</td>
<td>Ammonia is a colorless gas with a pungent odor.</td>
</tr>
<tr>
<td>NMOCs (non-methane organic compounds)</td>
<td>0.01–0.6</td>
<td>NMOCs are organic compounds (i.e., compounds that contain carbon). (Methane is an organic compound but is not considered an NMOC.) NMOCs may occur naturally or be formed by synthetic chemical processes. NMOCs most commonly found in landfills include acrylonitrile, benzene, 1,1-dichloroethane, 1,2-cis dichloroethylene, dichloromethane, carbonyl sulfide, ethyl-benzene, hexane, methyl ethyl ketone, tetrachloroethylene, toluene, trichloroethylene, vinyl chloride, and xylenes.</td>
</tr>
<tr>
<td>sulfides</td>
<td>0–1</td>
<td>Sulfides (e.g., hydrogen sulfide, dimethyl sulfide, mercaptans) are naturally occurring gases that give the landfill gas mixture its rotten-egg smell. Sulfides can cause unpleasant odors even at very low concentrations.</td>
</tr>
<tr>
<td>hydrogen</td>
<td>0–0.2</td>
<td>Hydrogen is an odorless, colorless gas.</td>
</tr>
<tr>
<td>carbon monoxide</td>
<td>0–0.2</td>
<td>Carbon monoxide is an odorless, colorless gas.</td>
</tr>
</tbody>
</table>

Source: Tchobanoglous, Theisen, and Vigil 1993; EPA 1995

The routes of exposure from these contaminants are primarily through inhalation of organic vapors and dusts, and by direct contact with contaminated media. Hazard information regarding the major components of landfill gas that are of concern is included below.
Methane (CH₄)

Methane is usually a component of landfill gas. Pure methane is a colorless and odorless gas. It has practically no toxic effects below the flammable limits. While methane has no noticeable toxic effects, high concentrations can displace oxygen and serve as a simple asphyxiate. Methane has a lower explosive limit (LEL) of 5 percent and an upper explosive limit (UEL) of 15 percent by volume in air.

OSHA does not regulate exposure to methane by a specific standard. However, methane is a flammable gas and must be controlled at least 20 percent below its LEL; below 10 percent of the LEL in excavations and confined spaces.

Carbon Monoxide (CO)

Carbon monoxide is a colorless, odorless, non-irritating gas generally produced as a by-product of incomplete combustion of carbonaceous materials. The toxicity of carbon monoxide results from the way it interferes with the body’s ability to transport oxygen. Therefore, in carbon monoxide poisoning, red blood cells are less able to pick up oxygen for transport from the lungs to the rest of the body, and are also less able to release whatever oxygen they do pick up. The first symptoms include headache, fatigue, and lightheadedness. At higher levels, skin flushing, rapid heart rate, and lowered blood pressure occur. Carbon monoxide poisoning is treated by administering oxygen to the patient.

The OSHA recommended exposure limit (REL) for carbon monoxide is 35 parts per million (ppm) as an 8-hour time weighted average (TWA), with a ceiling limit of 200 ppm, which should not be exceeded at any time during the workday. Specific information from the National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards is included in this Appendix.

Hydrogen Sulfide (H₂S)

Hydrogen sulfide is a colorless, toxic gas that is identified by the offensive odor of rotten eggs. It is heavier than air, flammable, and is generally a component of landfill gas. Hydrogen sulfide can cause irritation of eyes, nose and throat, beginning at approximately 10 ppm. Long-term exposure (30 minutes or longer) to high concentrations can cause drowsiness, staggering and nausea, which can lead to death due to respiratory system failure.

The odor of hydrogen sulfide can be detected at approximately 0.03 ppm, becomes offensive at 3 ppm, and causes irritation at 10 ppm. An especially dangerous situation is brief exposure to concentrations of 50 ppm, which can cause a person to lose the sense of smell. This has been described in accident reports as “I first smelled hydrogen sulfide,
then it went away.” This is called olfactory fatigue. The toxic effect of hydrogen sulfide paralyzes the respiratory control center, which leads to suffocation and then death.

Hydrogen sulfide has a wide flammable range (LEL 4.0%, UEL 44.0%). This property, coupled with its heavier-than-air density, makes it a hazard in trenches and low-lying areas.

Hydrogen sulfide is regulated by OSHA on a 20 ppm ceiling Permissible Exposure Limit (PEL) concentration. A ceiling concentration means that this level cannot be exceeded during any part of the work period. OSHA has also established a Recommended Exposure Limit (REL) concentration at 10 ppm, and an Immediately Dangerous to Life or Health (IDLH) concentration of 100 ppm. Specific information from the NIOSH Pocket Guide to Chemical Hazards is included in this Appendix.

**Ammonia**

Ammonia is a compound of nitrogen and hydrogen with the formula NH₃ in the gas form. It is a colorless gas with a characteristic pungent smell. Ammonia can be a potential skin, eye, and throat irritant. OSHA has also established a PEL concentration at 50 ppm, and an IDLH concentration of 300 ppm. Ammonia is flammable. Its LEL is 15 percent and its UEL is 28 percent. However, ammonia is unlikely to collect at a concentration high enough to pose an explosion hazard. Specific information from the NIOSH Pocket Guide to Chemical Hazards is included in this Appendix.

**Benzene**

Benzene is a colorless and highly flammable liquid with a sweet smell. Benzene is commonly used in industrial processing and can be present at waste facilities. The primary route of exposure to benzene is through inhalation. Benzene over-exposure can cause damage to the liver, kidneys, lungs, heart and the brain, and can cause DNA strand breaks and chromosomal damage. Benzene causes cancer in both animals and humans. OSHA has established a PEL concentration at 1 ppm and an IDLH concentration of 500 ppm. Its LEL is 1.2 percent and it has a UEL of 7.8 percent. It is not anticipated that benzene alone is likely to collect at concentrations high enough to pose explosion or ignition hazards. Specific information from the NIOSH Pocket Guide to Chemical Hazards is included in this Appendix.
Carbon monoxide

**Synonyms & Trade Names**
Carbon oxide, Flue gas, Monoxide

**CAS No.**
630-08-0

**RTECS No.**
FC1567E0

**DOT ID & Guide**
1016

**RTECS No.**
FG3500000

**CAS No.**
630-08-0

**RTECS No.**
FG3567E0

**DOT ID & Guide**
1016

**RTECS No.**
FG3500000

**DOT ID & Guide**
1016

**Synonyms & Trade Names**

**CAS No.**
630-08-0

**RTECS No.**
FC1567E0

**DOT ID & Guide**
1016

**RTECS No.**
FG3500000

**CAS No.**
630-08-0

**RTECS No.**
FG3567E0

**DOT ID & Guide**
1016

**RTECS No.**
FG3500000

**DOT ID & Guide**
1016

**Physical Description**
Colorless, odorless gas. [Note: Shipped as a nonliquefied or liquefied compressed gas.]

**MW:** 28.0

**BP:** -313°F

**MLT:** -337°F

**Sol:** 2%

**VP:** >35 atm

**IP:** 14.01 eV

**FLP:** NA (Gas)

**UEL:** 74%

**LEL:** 12.5%

**RGasD:** 0.97

**Incompatibilities & Reactivities**
Strong oxidizers, bromine trifluoride, chlorine trifluoride, lithium

**Exposure Routes**
inhalation, skin and/or eye contact (liquid)

**Symptoms**
headache, tachypnea, nausea, lassitude (weakness, exhaustion), dizziness, confusion, hallucinations; cyanosis; depressed S-T segment of electrocardiogram, angina, syncope

**Target Organs**
cardiovascular system, lungs, blood, central nervous system

**Exposure Limits**

**NIOSH REL:**
- TWA 35 ppm (40 mg/m³)
- 200 ppm (229 mg/m³)

**OSHA PEL:**
†
- TWA 50 ppm (55 mg/m³)

**Measurement Methods**

- NIOSH 6604
- OSHA ID209
- OSHA ID210

**Flammable Gas**

**Personal Protection/Sanitation**
(See protection codes)

**Skin:** Frostbite

**Eyes:** Frostbite

**Wash skin:** No recommendation

**Remove:** When wet (flammable)

**Change:** No recommendation

**Provide:** Frostbite wash

**First Aid**
(See procedures)

**Eye:** Frostbite

**Skin:** Frostbite

**Breathing:** Respiratory support

**Respirator Recommendations**

**NIOSH**

- Up to 350 ppm: (APF = 10) Any supplied-air respirator
- Up to 875 ppm: (APF = 25) Any supplied-air respirator operated in a continuous-flow mode
- Up to 1200 ppm: (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern
- (APF = 50) Any self-contained breathing apparatus with a full facepiece
- (APF = 50) Any supplied-air respirator with a full facepiece

**Emergency or planned entry into unknown concentrations or IDLH conditions:**

- (APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
- (APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

**Escape:**

- (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern
- Any appropriate escape-type, self-contained breathing apparatus

**Important additional information about respirator selection**
(protect.html#mustread)

See also:
INTRODUCTION (/niosh/npg/pgintrod.html)
See ICSC CARD: 0023 (/niosh/ipcsneng/neng0023.html)
See MEDICAL TESTS: 0040 (/niosh/docs/2005-110/nmed0040.html)
Carbon dioxide

**Carbonic acid gas, Dry ice [Note: Normal constituent of air (about 300 ppm)].**

**CAS No.** 124-38-9  **RTECS No.** FF61A800 (http://www.cdc.gov/niosh/rtecs/FF61A800.html)

**Formula** CO₂

**Conversion** 1 ppm = 1.80 mg/m³

**IDLH** 40,000 ppm

**Measurement Methods**

NIOSH: 6603 (http://www.cdc.gov/niosh/docs/2003-154/pdfs/6603.pdf)


**Exposure Limits**

NIOSH REL: TWA 5000 ppm (9000 mg/m³) ST 30,000 ppm (54,000 mg/m³)

OSHA PEL (http://www.cdc.gov/Other/disclaimer.html): TWA 5000 ppm (9000 mg/m³)

**Physical Description** Colorless, odorless gas. [Note: Shipped as a liquefied compressed gas. Solid form is utilized as dry ice.]

**MW:** 44.0  **BP:** Sublimes MLT: -109°F (Sublimes) Sol(77°F): 0.2%

**VP:** 56.5 atm  **IP:** 13.77 eV

**Nonflammable Gas**

**Incompatibilities & Reactivities** Dusts of various metals, such as magnesium, zirconium, titanium, aluminum, chromium & manganese are ignitable and explosive when suspended in carbon dioxide. Forms carbonic acid in water.

**Exposure Routes** Inhalation, skin and/or eye contact (liquid/solid)

**Symptoms** Headache, dizziness, restlessness, paresthesia; dyspnea (breathing difficulty); sweating, malaise (vague feeling of discomfort); increased heart rate, cardiac output, blood pressure; coma; asphyxia; convulsions; frostbite (liquid, dry ice)

**Target Organs** Respiratory system, cardiovascular system

**Personal Protection/Sanitation** Skin: Frostbite (See protection codes (protect.html))

Eye: Frostbite

Wash skin: No recommendation

Remove: No recommendation

Change: No recommendation

Provide: Frostbite wash

**First Aid** (See procedures (firstaid.html))

Eye: Frostbite

Skin: Frostbite

Breathing: Respiratory support

**Respirator Recommendations**

NIOSH/OSHA

Up to 4000 ppm:

(APF = 10) Any supplied-air respirator

(APF = 50) Any self-contained breathing apparatus with a full facepiece

Emergency or planned entry into unknown concentrations or IDLH conditions:

(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:

Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (pgintrod.html#mustread)

See also: INTRODUCTION (/niosh/npg/pgintrod.html) See ICSC CARD: 0021 (/niosh/ipcsneng/neng0021.html)
Hydrogen sulfide

**Synonyms & Trade Names**
Hydrosulfuric acid, Sewer gas, Sulfuretted hydrogen

**CAS No.** 7783-06-4

**RTECS No.** MX1225000


**Formula** H₂S

**Conversion** 1 ppm = 1.40 mg/m³

**IDLH** 100 ppm

See: 7783064 (http://niosh/idlh/7783064.html)

**Exposure Limits**

<table>
<thead>
<tr>
<th>NIOSH REL</th>
<th>CAS 10 ppm (15 mg/m³) [10-minute]</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSHA PEL†</td>
<td>C 20 ppm 50 ppm [10-minute maximum peak]</td>
</tr>
</tbody>
</table>

**Measurement Methods**

NIOSH 6013 (http://niosh/docs/2003-154/pdfs/6013.pdf) ;
OSHA ID141 (http://www.osha.gov/dts/sltc/methods/inorganic/id141/id141.html)


**Physical Description**
Colorless gas with a strong odor of rotten eggs. [Note: Sense of smell becomes rapidly fatigued & can NOT be relied upon to warn of the continuous presence of H₂S. Shipped as a liquefied compressed gas.]

**MW:** 34.1

**BP:** -77°F

**FRZ:** -122°F

**Sol:** 0.4%

**VP:** 17.6 atm

**IP:** 10.46 eV

**Fl.P:** NA

**UEL:** 44.0%

**LEL:** 4.0%

**RGasD:** 1.19

**Flammable Gas**

**Inc. & Reactivities**
Strong oxidizers, strong nitric acid, metals

**Exposure Routes**
inhalation, skin and/or eye contact

**Symptoms**
irritation eyes, respiratory system; apnea, coma, convulsions; conjunctivitis, eye pain, lacrimation (discharge of tears), photophobia (abnormal visual intolerance to light), corneal vesciculation; dizziness, headache, lassitude (weakness, exhaustion), irritability, insomnia; gastrointestinal disturbance; liquid: frostbite

**Target Organs**
Eyes, respiratory system, central nervous system

**Personal Protection/Sanitation**
(See protection codes (protect.html))

<table>
<thead>
<tr>
<th>Skin</th>
<th>Frostbite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyes</td>
<td>Frostbite</td>
</tr>
</tbody>
</table>

**Wash skin:** No recommendation

**Remove:** When wet (flammable)

**Change:** No recommendation

**Provide:** Frostbite wash

**First Aid** (See procedures (firstaid.html))

<table>
<thead>
<tr>
<th>Eye</th>
<th>Frostbite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin</td>
<td>Frostbite</td>
</tr>
</tbody>
</table>

**Breathing:** Respiratory support

**Respirator Recommendations**

**NIOSH**

Up to 100 ppm:
(APF = 25) Any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern
(APF = 10) Any supplied-air respirator
(APF = 50) Any self-contained breathing apparatus with a full facepiece

**Emergency or planned entry into unknown concentrations or IDLH conditions:**

(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

**Escape:**
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern
Any appropriate escape-type, self-contained breathing apparatus

**Important additional information about respirator selection (pgintro.html#mustread)**

See also: INTRODUCTION (http://niosh/npg/pgintro.html), See ICSC CARD: 0165 (http://niosh/ipcsneng/neng0165.html)

**Page last reviewed:** April 4, 2011
**Page last updated:** February 13, 2015
**Content source:** National Institute for Occupational Safety and Health (NIOSH) Education and Information Division

Centers for Disease Control and Prevention
1600 Clifton Road Atlanta, GA 30329-4027, USA
800-CDC-INFO (800-232-4636) TTY: (888) 232-4648 - Contact CDC–INFO

http://www.cdc.gov/niosh/npg/npgd0337.html

1 of 1 5/18/2015 4:04 PM
Ammonia

### Synonyms & Trade Names
- Anhydrous ammonia, Aqua ammonia, Aqueous ammonia [Note: Often used in an aqueous solution.]

### Exposure Limits
- **NIOSH REL**: TWA 25 ppm (18 mg/m³)
- **OSHA PEL**: ST 35 ppm (27 mg/m³)
- **IDLH**: 300 ppm

### Physical Description
- Colorless gas with a pungent, suffocating odor. [Note: Shipped as a liquefied compressed gas. Easily liquefied under pressure.]
- **MW**: 17.0
- **BP**: -28°F
- **FLP**: NA (Gas)
- **UEL**: 28%
- **LEL**: 15%
- **VP**: 8.5 atm
- **IP**: 10.18 eV

### Incompatibilities & Reactivities
- Strong oxidizers, acids, halogens, salts of silver & zinc [Note: Corrosive to copper & galvanized surfaces.]

### Symptoms
- Irritation eyes, nose, throat; dyspnea (breathing difficulty), wheezing, chest pain; pulmonary edema; pink frothy sputum; skin burns, vesiculation; liquid: frostbite

### Target Organs
- Eyes, skin, respiratory system

### Personal Protection/Sanitation
- **Skin**: Prevent skin contact
- **Eyes**: Prevent eye contact
- **Wash skin**: When contaminated (solution)
- **Remove**: When wet or contaminated (solution)
- **Change**: No recommendation
- **Provide**: Eyewash (>10%), Quick drench (>10%)

### Respirator Recommendations

#### NIOSH

**Up to 250 ppm**
- (APF = 10) Any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern
- (APF = 10) Any supplied-air respirator

**Up to 300 ppm**
- (APF = 25) Any supplied-air respirator operated in a continuous-flow mode
- (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern
- (APF = 50) Any self-contained breathing apparatus with a full facepiece

**Emergency or planned entry into unknown concentrations or IDLH conditions**:
- (APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
- (APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

### Escape
- (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern
- Any appropriate escape-type, self-contained breathing apparatus

---

**DOT ID & Guide**
- 1005 125 (anhydrous) [http://www.cdc.gov/NIOSH/Other/disclaimer.html](http://www.cdc.gov/NIOSH/Other/disclaimer.html)
- 2672 154 (anhydrous) [http://www.cdc.gov/NIOSH/Other/disclaimer.html](http://www.cdc.gov/NIOSH/Other/disclaimer.html)
- 2073 125 (anhydrous) [http://www.cdc.gov/NIOSH/Other/disclaimer.html](http://www.cdc.gov/NIOSH/Other/disclaimer.html)
- 1005 125 (anhydrous) [http://www.cdc.gov/NIOSH/Other/disclaimer.html](http://www.cdc.gov/NIOSH/Other/disclaimer.html)

**Formula** NH₃

**Conversion** 1 ppm = 0.70 mg/m³

**IDLH** 300 ppm

Benzene

Synonyms & Trade Names
Benzol, Phenyl hydride

CAS No. 71-43-2
RTECS No. CY1400000
DOT ID & Guide 111 530
CAS No. 71-43-2
RTECS No. CY1400000
DOT ID & Guide 111 530

Formula C₆H₆
Conversion 1 ppm = 3.19 mg/m³
IDLH Ca [500 ppm]
Sec: 71432

Exposure Limits
NIOSH REL: Ca TWA 0.1 ppm ST 1 ppm See Appendix A
OSHA PEL: [1910.1028] TWA 1 ppm ST 5 ppm See Appendix F

Physical Description
Colorless to light-yellow liquid with an aromatic odor. [Note: A solid below 42°F.]

MW: 78.1
BP: 176°F
FRZ: 42°F
Sol: 0.07%
VP: 75 mmHg
IP: 9.24 eV
Sp.Gr: 0.88
Fl.P: 12°F
UEL: 7.8%
LEL: 1.2%

Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F.

Incompatibilities & Reactivities
Strong oxidizers, many fluorides & perchlorates, nitric acid

Exposure Routes
inhalation, skin absorption, ingestion, skin and/or eye contact

Symptoms
irritation eyes, skin, nose, respiratory system; dizziness; headache, nausea, staggered gait; anorexia, lassitude (weakness, exhaustion); dermatitis; bone marrow depression; [potential occupational carcinogen]

Target Organs
Eyes, skin, respiratory system, blood, central nervous system, bone marrow

Cancer Sites
[leukemia]

Personal Protection/Sanitation
(See protection codes protect.html)
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: When contaminated
Remove: When wet (flammable)
Change: No recommendation
Provide: Eyewash, Quick drench

First Aid
(See procedures firstaid.html)
Eye: Irrigate immediately
Skin: Soap wash immediately
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations
(See Appendix E nengasdhv.html)

NIOSH
At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister
Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection qintrod.html#mustread

See also: INTRODUCTION /niosh/npd/npintrod.html See ICSC CARD: 0015 /niosh/ipcsneng/neng0015.html See MEDICAL TESTS: 0022 /niosh/docs/2005-110/nmed0022.html
Polycyclic Aromatic Hydrocarbons (PAHs)/Semi-Volatile Organics (SVOCs)

**ROUTES OF ENTRY**

Ingestion, inhalation of vapor or dust, skin absorption, skin or eye contact.

**HARMFUL EFFECTS**

PAHs are mixtures of semi-volatile organic compounds such as acenapthene, benzo(a)pyrene, chrysene, and naphthalene. Specific information for individual PAH compounds can be found under the name of the individual PAH.

*Local Effects:*
Contact with some PAH compounds can cause irritation to skin, eyes, and mucous membranes. Chapping or burning of the skin and/or photosensitivity may occur after repeated contact. Exposure to large quantities of some PAH compounds can cause headaches, nausea, and vomiting. When heated to decomposition, some PAH compounds can emit irritating fumes and acrid smoke.

*Systemic Effects:*
Some individual compounds present in TPH act as central nervous system depressants. Some individual PAH compounds are known mutagens and/or carcinogens.


**POINTS OF ATTACK**

Liver, kidney, respiratory system, central nervous system, eyes, and skin.

**PERMISSIBLE EXPOSURE LIMIT (PEL)**

0.1 milligrams per cubic meter (mg/m³) for a 10-hour workday, 40-hour workweek, for Coal Tar Pitch PAHs (NIOSH).

0.2 mg/m³ for all PAHs (OSHA).
Arsenic (inorganic compounds, as As)

Synonyms & Trade Names
Arsenic metal: Arsenia
Other synonyms vary depending upon the specific As compound. [Note: OSHA considers "Inorganic Arsenic" to mean copper acetoarsenite and all inorganic compounds containing arsenic except ARSINE.]

CAS No. 7440-38-2
RTEC No. (metal) CG0525000 (metal) (/niosh-rtec/CG0525000.html)
 Formula As (metal)
Sp.Gr: 5.73
BP: NA
Fl.P: Sublimes
VP: 0 mmHg (approx)
MLT: 1135°F (Sublimes)
Sol: Insoluble
UEL: NA
LEL: NA

Exposure Limits
NIOSH REL: Ca C 0.002 mg/m³
[15-minute] See Appendix A (nengapda.html)
OSHA PEL: [1910.1018] TWA 0.010 mg/m³

Measurement Methods
9102 ([niosh/dosy/2001-154/els/9102.pdf])

NIOSH
At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted acid gas canister having an N100, R100, or P100 filter.
Click here (pgintrod.html#mustread) for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (pgintrod.html#mustread)

For more information:
See also: INTRODUCTION (/niosh/npg/pgintrod.html)
See ICSC CARD: 0017 (/niosh/icscEng/neng0017.html)
See MEDICAL TESTS: 0017/niosh/dosy/2005-110/medtest017.html

Source: National Institute for Occupational Safety and Health (NIOSH) Education and Information Division

Page last reviewed: April 4, 2011
Page last updated: February 13, 2015
Content source: National Institute for Occupational Safety and Health (NIOSH) Education and Information Division

Centers for Disease Control and Prevention
 Atlanta, GA 30329-4027, USA
800-CDC-INFO (800-232-4636) TTY: (888) 232-6348 - Contact CDC-INFO

http://www.cdc.gov/niosh/npg/npgd0038.html
Cadmium dust (as Cd)

Synonyms & Trade Names
Cadmium metal: Cadmium
Other synonyms vary depending upon the specific cadmium compound.

CAS No. 7440-43-9
DOT ID & Code 2570154

Formula Cd (metal)

Conversion

Exposure Limits
NIOSH REL *: Ca See Appendix A
OSHA REL: [1910.1027] TWA 0.005 mg/m³

Respirator Recommendations
Change:

Wash skin:

Eyes:

Skin: No recommendation

Eyes: No recommendation

Wash skin: Daily

Remove: No recommendation

Change: Daily

NIOSH

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:

(AFP = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

(AFP = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:

(AFP = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.

Click here (pgintrod.html#mustread) for information on selection of N, R, or P filters.

Important additional information about respirator selection (pgintrod.html#nrp)

See also:

 See NIOSH methods (/niosh/docs/2003-154/pdfs/niosh-rtecs/EU958940.html) for information on selection of N, R, or P filters.

See procedures (firstaid.html)

First aid (See procedures (firstaid.html))

Eye: Irrigate immediately

Skin: Soap wash

Breathing: Respiratory support

Swallow: Medical attention immediately

Incompatibilities & Reactivities
Strong oxidizers; elemental sulfur, selenium & tellurium

Environmental Chambers

Physical Description
Metal: Silver-white, blue-tinged lustrous, odorless solid.

Metal: Noncombustible Solids in bulk form, but will burn in powder form.

Inhalation, ingestion

pulmonary edema, dyspnea (breathing difficulty), cough, chest tightness, substernal (occurring beneath the sternum) pain; headache; chills, muscle aches;

Symptoms
nausea, vomiting, diarrhea; anosmia (loss of the sense of smell), emphysema, proteinuria, mild anemia; [potential occupational carcinogen]

Exposure Routes
inhalation, ingestion

Exposure Limits NIOSH REL

Metal: Noncombustible Solid in bulk form, but will burn in powder form.

NIOSH

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:

(AFP = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

(AFP = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:

(AFP = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.

Click here (pgintrod.html#mustread) for information on selection of N, R, or P filters.

Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (pgintrod.html#nrp)

See also:

See NIOSH methods (/niosh/docs/2003-154/pdfs/niosh-rtecs/EU958940.html) for information on selection of N, R, or P filters.

See procedures (firstaid.html)

First aid (See procedures (firstaid.html))

Eye: Irrigate immediately

Skin: Soap wash

Breathing: Respiratory support

Swallow: Medical attention immediately
Copper (dusts and mists, as Cu)

### Synonyms & Trade Names
- Copper metal dusts, Copper metal fumes

### Exposure Limits

<table>
<thead>
<tr>
<th>REL</th>
<th>PEL</th>
<th>TWA</th>
<th>ACGIH REL</th>
<th>IDLH</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWA 1 mg/m³</td>
<td>1 mg/m³</td>
<td>1 mg/m³</td>
<td>1 mg/m³</td>
<td>1 mg/m³</td>
</tr>
<tr>
<td>TWA 5 mg/m³</td>
<td>5 mg/m³</td>
<td>5 mg/m³</td>
<td>5 mg/m³</td>
<td>5 mg/m³</td>
</tr>
<tr>
<td>TWA 10 mg/m³</td>
<td>10 mg/m³</td>
<td>10 mg/m³</td>
<td>10 mg/m³</td>
<td>10 mg/m³</td>
</tr>
</tbody>
</table>

### Physical Description
- Reddish, lustrous, malleable, odorless solid.

### Noncompatibilities & Reactivities
- Oxidizers, alkalis, sodium azide, acetylene

### Exposure Routes
- Inhalation, ingestion, skin and/or eye contact

### Target Organ(s)
- Eyes, skin, respiratory system, liver, kidneys (increased risk with Wilson's disease)

#### Personal Protection/Utilization

<table>
<thead>
<tr>
<th>Skin: Prevent skin contact</th>
<th>Eyes: Prevent eye contact</th>
<th>Wash skin: When contaminated</th>
<th>Remove: When wet or contaminated</th>
<th>Change: Daily</th>
</tr>
</thead>
</table>

#### Respirator Recommendations

**NIOSH/OSHA**

**Up to 5 mg/m³:** Any quarter-mask respirator.

**Up to 10 mg/m³:** Any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100, P100.

**Up to 25 mg/m³:** Any supplied-air respirator.*

**Up to 50 mg/m³:** Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter.*

**Up to 100 mg/m³:** Any supplied-air respirator with a full facepiece

**Up to 300 mg/m³:** Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand mode.

**Emergency or planned entry into unknown concentrations or IDLH conditions:** Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

### Emergency or planned entry into unknown concentrations or IDLH conditions:

- Any air-purifying, full-facepiece respirator with an N91, R91, or P91 filter.
- Any self-contained breathing apparatus with a full facepiece

### Important additional information about respirator selection

- See also: [NIOSH Pocket Guide to Chemical Hazards](http://www.cdc.gov/niosh/npg/npgd0150.html)
Search the NIOSH Pocket Guide

Enter search terms separated by spaces.

Lead metal, Plumbum

CAS No. 7439-92-1

RTCS No. OF72D288.html

Formula Pb

DOT ID & Guide

H101 100 mg/m³ (as Pb)

See: ID121 / (niosh/dlib/740099.html)

Exposure Limits

NIOSH REL: * TWA (8-hour) 0.005 mg/m³

See Appendix C (nongapc.html) [*Note: The REL also applies to other lead compounds (as Pb) -- see Appendix C.]

OSHA PEL: * TWA (8-hour) 0.005 mg/m³

See Appendix C (nongapc.html) [*Note: The PEL also applies to other lead compounds (as Pb) -- see Appendix C.]

Measurement Methods:

NIOSH 7082a (http://www.osha.gov/dts/sltc/methods/inorganic/id125g/id125g.html)

OSHA (http://www.osha.gov/Other/disclaimer.html)

Exposure Routes

Inhalation, ingestion, skin and/or eye contact

Incompatibilities & Reactivities

Strong oxidizers, hydrogen peroxide, acids

Symptoms

Lassitude (weakness, exhaustion), insomnia; facial pallor; anorexia, weight loss, malnutrition; constipation, abdominal pain, colic; anemia; gingival lead line; tremor; paralysis wrist, ankles; encephalopathy; kidney disease; irritation eyes; hypertension

Target Organs

Eyes, gastrointestinal tract, central nervous system, kidneys, blood, gingival tissue

Personal Protection/Isolation

First Aid

Respirator Recommendations

NIOSH/OSHA

Up to 0.5 mg/m³:

(AFP = 100) Any supplied-air respirator with an N100, R100, or P100 filter (including N100, R100, and P100 filtering facepieces) except quarter-mask respirators.

Up to 1.25 mg/m³:

(AFP = 25) Any supplied-air respirator operated in a continuous-flow mode

Up to 2.0 mg/m³:

(AFP = 50) Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode

Up to 5.0 mg/m³:

(AFP = 50) Any supplied-air respirator with a tight-fitting facepiece and a high-efficiency particulate filter

Emergency or planned entry into unknown concentrations or IDLH conditions:

(AFP = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (niosh/dlib.html)

See also: INTRODUCTION (niosh/npg/pd0368.html), See ICSC CARD: 9102 (niosh/icsc entrega/9102g.html), See MEDICAL TESTS: 9127 (niosh/docs/2005-110/named137.html)
Manganese compounds and fume (as Mn)

Synonyms & Trade Names:
Manganese metal; Colloidal manganese, Manganese-55

DOT ID & Guide:
MHS: 500 mg/m³ (as Mn)

Exposure Limits:
NIOSH REL: *: TWA 1 mg/m³ ST 3 mg/m³ [*Note: Also see specific listings for Manganese cyclopentadienyl tricarbonyl, Methyl cyclopentadienyl manganese tricarbonyl, and Manganese tetroxide.]
OSHA REL: *: C 3 mg/m³ [*Note: Also see specific listings for Manganese cyclopentadienyl tricarbonyl and Methyl cyclopentadienyl manganese tricarbonyl.]

Physical Description:
A lustrous, brittle, silvery solid.

Metal: Combustible Solid

Incompatibilities & Reactivities:
Oxidizers [Note: Will react with water or steam to produce hydrogen.]

Exposure Routes:
inhalation, ingestion

Symptoms:
Manganism; asthenia, insomnia, mental confusion; metal fume fever: dry throat, cough, chest tightness, dyspnea (breathing difficulty), rales, flu-like fever; low-back pain; vomiting; malaise (vague feeling of discomfort); lassitude (weakness, exhaustion); kidney damage

Target Organs: respiratory system, central nervous system, blood, kidneys

Personal Protection/Sanitation:

First Aid:

Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations:

NIOSH

Up to 10 mg/m³:
(APF = 10) Any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100, P100.

Click here (niosh.html#mustread) for information on selection of N, R, or P filters.

Up to 25 mg/m³:

(APF = 25) Any supplied-air respirator operated in a continuous-flow mode

(APF = 25) Any powered, air-purifying respirator with a high-efficiency particulate filter.

Up to 50 mg/m³:

(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.

Click here (niosh.html#mustread) for information on selection of N, R, or P filters.

(APF = 50) Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode

(APF = 50) Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter

(APF = 50) Any self-contained breathing apparatus with a full facepiece

Up to 500 mg/m³:

(APF = 100) Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

Emergency or planned entry into unknown concentrations or IDLH conditions:

(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:

(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.

Click here (niosh.html#mustread) for information on selection of N, R, or P filters.

Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (niosh.html#mustread)
Search the NIOSH Pocket Guide

Enter search terms separated by spaces.

Zinc oxide

**Synonyms & Trade Names**

Zinc peroxide

**CAS No.:** 1314-13-2

**RTECS No.:** ZH4810000

**DOT ID & Guide:** 1516 143

**Formula:** ZnO

**Recommended Limit (IDLH):** 500 mg/m³

**Exposure Limits**

<table>
<thead>
<tr>
<th>Expiration</th>
<th>NIOSH REL</th>
<th>Measurement Methods</th>
<th>NIOSH (800) 232-4636</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust: TWA</td>
<td>5 mg/m³</td>
<td>150</td>
<td>500 mg/m³</td>
</tr>
</tbody>
</table>

**Fume:**

<table>
<thead>
<tr>
<th>Expiration</th>
<th>NIOSH REL</th>
<th>Measurement Methods</th>
<th>NIOSH (800) 232-4636</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWA</td>
<td>15 mg/m³</td>
<td>500</td>
<td>500 mg/m³</td>
</tr>
</tbody>
</table>

**Soluble Gas:**

<table>
<thead>
<tr>
<th>Expiration</th>
<th>NIOSH REL</th>
<th>Measurement Methods</th>
<th>NIOSH (800) 232-4636</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWA</td>
<td>5 mg/m³</td>
<td>150</td>
<td>500 mg/m³</td>
</tr>
</tbody>
</table>

**Physical Description:**

White, odorless solid.

**Noncombustible Solid:**

Chlorinated rubber (at 419°F), water [Note: Slowly decomposed by water.]

**Incompatibilities & Reactivities:**

Chlorinated rubber (at 419°F), water [Note: Slowly decomposed by water.]

**Exposure Routes:**

Metal fume fever: chills, muscle ache, nausea, fever, dry throat, cough; lassitude (weakness, exhaustion); metallic taste; headache; blurred vision; low back pain; vomiting; malaise (vague feeling of discomfort); chest tightness; dyspnea (breathing difficulty), rules, decreased pulmonary function

**Target Organs:** respiratory system

### Personal Protection/Sanitation

<table>
<thead>
<tr>
<th>Skin: No recommendation</th>
<th>Eyes: No recommendation</th>
<th>Wash skin: No recommendation</th>
<th>Remove: No recommendation</th>
<th>Change: No recommendation</th>
</tr>
</thead>
</table>

### First Aid

**Breathing:** Respiratory support

**See also:** NIOSH/OSHA

**NIOSH/OSHA**

**Up to 50 mg/m³:**

- (APF = 10) Any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100, P100.

- Click here [http://www.cdc.gov/NIOSH/PDF/OSHAID143.html](http://www.cdc.gov/NIOSH/PDF/OSHAID143.html)

**Up to 125 mg/m³:**

- (APF = 25) Any supplied-air respirator operated in a continuous-flow mode

- APF = 25 Any powered, air-purifying respirator with a high-efficiency particulate filter.

**Up to 250 mg/m³:**

- (APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.

- Click here [http://www.cdc.gov/NIOSH/PDF/OSHAID143.html](http://www.cdc.gov/NIOSH/PDF/OSHAID143.html)

**Up to 500 mg/m³:**

- (APF = 100) Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

**Emergency or planned entry into unknown concentrations or IDLH conditions:**

- (APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

**Escape:**

- (APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.

- Click here [http://www.cdc.gov/NIOSH/PDF/OSHAID143.html](http://www.cdc.gov/NIOSH/PDF/OSHAID143.html)

### See also:


Appendix F

Monthly Report Template
I.онHEADING

Date:  (File each report by the tenth day of each month until demobilization completed)
Site Name: Vasquez Boulevard / Interstate-70 Operable Unit-2
From: XYZ Consultants
To: Dania Zinner, USEPA Region 8, Oversight Manager
Progress Report No.: (sequential numbered series of reports for ease in retrieval)

II. BACKGROUND

Site No.: ###
Response Authority: CERCLA
CERCLA No: CO###
NPL Status: Listed
Action Memo: TBD (use date of final action memo authorizing this removal to be provided by USEPA)
Start Date: TBD (use effective date of Agreement governing this removal action/to be provided by USEPA)
Demobe Date: TBD (use forecast date until demobe occurs then use that effective date)
Completion Date: TBD (use forecast date for delivery of final closeout report)

III. SITE INFORMATION

A. Incident Category

Time Critical, Private-funded removal action.

B. Site Description

1. Site Location [below is an example of a typical description]

The Vasquez Boulevard and Interstate 70 (VB/I-70) Superfund Site is an approximately four square mile area located in the north-central portion of Denver, Colorado near the intersections of Interstate 70 and Interstate 25. OU2 consists primarily of the southern portion of the Denver Coliseum property (that portion of the Coliseum property located south of Interstate 70, which is owned by the Respondent), the Forney Transportation Museum property along Brighton Boulevard, the Pepsi Bottling Company property along Brighton Boulevard, and various other commercial properties located along Brighton Boulevard. The Removal Action involves primarily of the southern portion of Denver Coliseum parking lot and Globeville Landing Park, both of which are
owned by the City and County of Denver (CCoD).

2. Description of Threat

Arsenic and lead (but particularly lead) have been identified at the Site as the contaminants of concern (COCs). Arsenic and lead are hazardous substances, as defined by Section 101 (14) of CERCLA. The threats posed by this Site include dermal absorption; inhalation of contaminated dust; and the inadvertent ingestion of contaminated soil and surface water.

C. Remedial Investigation Results

Arsenic and lead were detected at levels greater than background and in some locations at concentrations greater than those consider acceptable for commercial/industrial land uses.

IV. PHYSICAL PROGRESS INFORMATION FOR THE REMOVAL ACTION

USEPA Region 8 has authorized contaminated soil and waste removal and installation of containment measures in those portions of the site where stormwater diversion structures are anticipated to be installed under a "time-critical" Removal Action memorandum.

A. Contamination:

Soil contaminated with lead and arsenic is present in both surface and subsurface soil. Solid waste is present in the subsurface beneath portions of the Denver Coliseum parking lot.

B. Cleanup Levels:

The action levels established for the Site are 800 milligrams/kilograms (mg/kg) for lead and 70 mg/kg for arsenic based on commercial land use as the reasonably anticipated land use for the site.

C. Removal Actions to Date:

(Here describe what has been accomplished since commencing the environmental remediation activities or since the last report)

D. Planned Removal Actions for Next Month:

(Here describe what you plan to accomplish by the next report)
E. **Key Issues and Proposed Resolutions**

(Describe any technical or regulatory compliance issues impacting your plans)

V. **DISPOSITION OF WASTES**

As of this date, a total of "reported quantity" tons/cubic yards of soil/waste has been disposed at the Denver Arapahoe Disposal Site.