100002154

Fifth Five-Year Review Report
for
Central City/Clear Creek Superfund Site
Gilpin and Clear Creek Counties

Colorado

November 2017

Prepared by:

Colorado Department of Public Health and Environment
Hazardous Materials and Waste Management Division
In collaboration with the
U.S. Environmental Protection Agency
Region 8

Approved by:

Betsy Smidinger

Betsy Smidinger
Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation.

Date:

11/3/17

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List of Acronyms

ACCLPP	Advisory Committee on Childhood Lead Poisoning Prevention
ARAR	Applicable or Relevant and Appropriate Requirements
ATWTF	Argo Tunnel Water Treatment Facility
CA	Cooperative Agreement
CCWF	Clear Creek Watershed Foundation
CDC	Center for Disease Control
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CIP	Community Involvement Plan
COPC	Contaminant of Potential Concern
DRMS	Colorado Division of Reclamation, Mining and Safety
EPA	United States Environmental Protection Agency
ESD	Explanation of Significant Difference
ft MSL	feet above mean sea level
HDS	High Density Sludge
HI	Hazard Index
HQ	Hazard Quotient
IC	Institutional Control
IEUBK	Integrated Exposure Uptake Biokinetic model
LTRA	Long Term Response Action
µg/dL	microgram per deciliter
µg/L	microgram per liter
mg/kg	milligram per kilogram
mg/L	milligram per liter
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NCCWTP	North Clear Creek Water Treatment Plant
NCP	National Contingency Plan
NPL	National Priorities List
O&F	operational and functional
O&M	operation and maintenance
OSWER	U.S. EPA Office of Solid Waste and Emergency Response
OU	Operable Unit
PHE	Public Health Evaluation
RBC	Risk Based Concentration
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RG	Remediation Goal
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SH119	State Highway 119
SHPO	State Historic Preservation Office
WQCC	Water Quality Control Commission

Executive Summary

The Central City/Clear Creek Superfund Site (Site) was added to the National Priorities List in 1983. The Site consists of mine waste piles, draining mine adits and impacted ground water resources within a 400-square-mile watershed. Historic mining and milling activities resulted in the watershed becoming contaminated with heavy (trace) metals, significantly impacting aquatic life and potentially threatening human health.

Several remedial actions have been performed to ensure protection of human health and the environment. Waste piles have been subjected to actions including stabilization, capping, off-site disposal and diversion of run-on water. Two point-source discharges from draining mine adits were addressed through conveyance to the Argo Tunnel Water Treatment Facility (ATWTF) to reduce the potential for human contact and to improve the water quality of the Clear Creek main stem. Metals-contaminated ground water that impacted Clear Creek's water quality also was addressed by collection and conveyance to the ATWTF. Water treatment at the Argo facility has successfully reduced metals loading to Clear Creek from these sources by 99.9 percent.

Since the last five-year review, the Quartz Hill waste rock pile was capped in Central City, and a flow-through bulkhead for the Argo tunnel was constructed to eliminate future surge events, which completed the recommended OU3 remedial improvements resulting from the 2007 Remedial System Evaluation.

In addition, remediation of mine waste rock piles and tailings identified for erosion control, capping or removal under the 2004 Record of Decision (ROD) for Operable Unit Number 4 (OU4) was completed, and a mine waste repository was constructed to consolidate and manage mine waste rock and tailings on-site. Instead of transporting the wastes off-Site to a landfill. habitat, sediment reduction and channel stability improvements were implemented along the North Fork of Clear Creek in conjunction with an adjacent highway widening project.

Remedial action is on-going. Along the North Fork of Clear Creek, three mine adit discharges will be conveyed to a new water treatment plant for treatment. Construction of the new water treatment plant took place during 2016 and 2017, and treatment activities will begin once the plant is fully operational.

In late 2014, the planned completion date for this five-year review, EPA and CDPHE discussed the need to collect additional data regarding potential human health exposures in selected areas of the Site. The need for additional assessment resulted from EPA's review of the risk analysis data derived from the Phase II studies conducted at the Site. The previous analysis used the 1988 Integrated Exposure Uptake Biokinetic (IEUBK) model and a non-standard cutoff blood lead concentration to determine the remedial action benchmark cleanup level (See Section 6.2.2 Soil Applicable or Relevant and Appropriate Requirements for more details). The primary objective of the additional investigation performed by EPA, which included arsenic speciation and lead bioavailability study of various waste piles at the Site, was to update the 1988 IEUBK model to better identify potential human health exposures to the surrounding population. These data and interpretation of their significance relative to the protectiveness of human health and the environment are included in relevant sections of this report.

Operable Unit 1 was superseded by Operable Unit 3, and therefore no protectiveness statement is required for OU1.

The remedy at OU2 is expected to be protective of human health and the environment upon completion. In the interim, remedial activities completed to date have adequately addressed all exposure pathways that could result in unacceptable risks in these areas.

A protectiveness determination of the remedy at OU3 cannot be made at this time until further information is obtained. Further information will be obtained by taking the following actions: Develop and implement a systematic, representative sampling program, including appropriate arsenic detection limits, to determine compliance with surface water quality criteria. Conduct additional water quality and aquatic life sampling to assess protectiveness. Propose re-segmentation or a site-specific stream standard to the Water Quality Control Commission. Address deficiencies of previous study including the collection and analysis of more robust location-specific data, and consider current guidance to determine if any changes are warranted to ensure protectiveness. It is expected that these actions will take approximately one year to complete, at which time a protectiveness determination will be made.

A protectiveness determination of the remedy at OU4 cannot be made at this time until further information is obtained. Further information will be obtained by taking the following actions: Establish long-term intergovernmental agreement with the City of Black Hawk to provide augmentation water to ensure the new OU4 water treatment plant can operate uncurtailed and continue to monitor water rights applications and participate in cases as a stakeholder when appropriate. It is expected that this action will take approximately one year to complete, at which time a protectiveness determination will be made.

Five-Year Review Summary Form

SITE IDENTIFICATION

Site Name: Central City / Clear Creek

EPA ID: COD980717557

Region: 8 | **State:** CO | **City/County:** Clear Creek and Gilpin Counties

SITE STATUS

NPL Status: Final

Multiple OUs?
Yes

Has the site achieved construction completion?
No

REVIEW STATUS

Lead agency: State
If "Other Federal Agency" was selected above, enter Agency name: Click here to enter text.

Author name (Federal or State Project Manager): Mary Boardman

Author affiliation: Colorado Department of Public Health and Environment

Review period: March 2014 – September 2014 (extended to 2015)

Date of site inspection: June 30 – July 3, 2014 (additional EPA sampling August 2015)

Type of review: Statutory

Review number: 5

Triggering action date: 9/30/2009

Due date *(five years after triggering action date)*: 9/30/2014

Five-Year Review Summary Form (continued)

Issues/Recommendations
OU(s) without Issues/Recommendations Identified in the Five-Year Review:
OU1, OU2

Issues and Recommendations Identified in the Five-Year Review:

OU(s): 3	**Issue Category: Monitoring**			
	Issue: Compliance with surface water ARARs cannot be assessed due to bias in the sampling program			
	Recommendation: Develop and implement a systematic, representative sampling program, including appropriate arsenic detection limits, to determine compliance with surface water quality criteria.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	EPA/State	EPA/State	9/30/2018

OU(s): 3	**Issue Category: Monitoring**			
	Issue: Remedial actions along Clear Creek Segment 2a may not be able to achieve attainment of the water quality standard for zinc			
	Recommendation: Conduct additional water quality and aquatic life sampling to assess protectiveness. Re-segmentation or a site-specific stream standard may be proposed to the Water Quality Control Commission at a future time.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	EPA/State	EPA/State	6/30/2019

OU(s): 3	**Issue Category: Site Access/Security**			
	Issue: Cattle encroachment is occurring at the Church Placer mine water repository and may impact the vegetated cover			
	Recommendation: Continue frequent site visits and fence repairs to avoid cattle encroachment.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	State	EPA/State	6/30/2018

Five-Year Review Summary Form (continued)

OU(s): 3	**Issue Category: Monitoring**			
	Issue: Seep water from the Church Placer mine waste repository is migrating onto an adjacent privately-owned property			
	Recommendation: Assess nature and extent of seep and mitigate as deemed necessary.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	State	EPA/State	6/30/2018

OU(s): 3 and 4	**Issue Category: Monitoring**			
	Issue: The current scientific literature on lead toxicology and epidemiology is evolving.			
	Recommendation: Run the IEUBK model using the current default values for input parameters and a range of target blood lead levels between 5-8 µg/dL. Consider collecting more robust site-specific data to improve the predictive nature of the model. Monitor results of blood lead sampling conducted by local health agencies.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	EPA/State	EPA/State	9/30/2018

OU(s): 3 and 4	**Issue Category: Monitoring**			
	Issue: Recent soil sampling indicates areas where lead concentrations exceed the site-specific screening level based on current land use.			
	Recommendation: Evaluate the need for further data collection and implement appropriate investigations.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	EPA/State	EPA/State	9/30/2018

Five-Year Review Summary Form (continued)

OU(s): 4	**Issue Category: Remedy Performance**			
	Issue: Exercising of new water rights acquired by local municipalities may substantially dewater portions of North Clear Creek, impacting the ability of the remedy to attain RAOs			
	Recommendation: The agencies were unable to obtain an agreement with water rights holders to maintain a minimum instream flow. However, the City of Black Hawk entered into an intergovernmental agreement with the State to provide augmentation water to ensure the new OU4 water treatment plant can operate uncurtailed. Continue to monitor water rights cases impacting Clear Creek.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	EPA/State	EPA/State	9/30/2018

Protectiveness Statement(s)

Include each individual OU protectiveness determination and statement. If you need to add more protectiveness determinations and statements for additional OUs, copy and paste the table below as many times as necessary to complete for each OU evaluated in the FYR report.

Operable Unit: 1	*Protectiveness Determination:* Choose an item.	*Addendum Due Date (if applicable):* Click here to enter date.

Protectiveness Statement:
Superseded by Operable Unit 3

Operable Unit: 2	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* Click here to enter date.

Protectiveness Statement:
The remedy at OU2 is expected to be protective of human health and the environment upon completion. In the interim, remedial activities completed to date have adequately addressed all exposure pathways that could result in unacceptable risks in these areas.

Five-Year Review Summary Form (continued)

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
3	Protectiveness Deferred	9/30/2018

Protectiveness Statement:
A protectiveness determination of the remedy at OU3 cannot be made at this time until further information is obtained. Further information will be obtained by taking the following actions: Develop and implement a systematic, representative sampling program, including appropriate arsenic detection limits, to determine compliance with surface water quality criteria. Conduct additional water quality and aquatic life sampling to assess protectiveness. Propose re-segmentation or a site-specific stream standard to the Water Quality Control Commission. Address deficiencies of previous study including the collection and analysis of more robust location-specific data, and consider current guidance to determine if any changes are warranted to ensure protectiveness. It is expected that these actions will take approximately one year to complete, at which time a protectiveness determination will be made.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
4	Protectiveness Deferred	9/30/2018

Protectiveness Statement:
A protectiveness determination of the remedy at OU4 cannot be made at this time until further information is obtained. Further information will be obtained by taking the following actions: Establish long term intergovernmental agreement with the City of Black Hawk to provide augmentation water to ensure the new OU4 water treatment plant can operate uncurtailed and continue to monitor water rights applications and participate in cases as a stakeholder when appropriate. It is expected that this action will take approximately one year to complete, at which time a protectiveness determination will be made.

1.0 INTRODUCTION

The Hazardous Materials and Waste Management Division of the Colorado Department of Public Health and Environment (CDPHE), in collaboration with the U.S. Environmental Protection Agency (EPA) under a cooperative agreement with the EPA, has conducted a five-year review of the Central City/Clear Creek Superfund Site (Site), located in Clear Creek and Gilpin counties, Colorado (Figure 1).

The purpose of five-year reviews is to determine whether the remedy at a site is, or is expected to be, protective of human health and the environment. The methods, findings and conclusions of reviews are documented in five-year review reports. In addition, five-year review reports identify issues found during the review, if any, and recommendations to address them. In accordance with the Comprehensive Five-Year Review Guidance, EPA 540-R-01-007, June 2001, this five-year review does not reconsider decisions made during the remedy-selection process, but rather evaluates the implementation and performance of the selected remedies.

This five-year review was performed under authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Contingency Plan for Oil and Hazardous Substances (NCP). CERCLA §121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

The EPA interpretation of this requirement is presented in the NCP, 40 CFR §300.430(f)(4)(ii).

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

CDPHE conducted this five-year review of the remedial actions implemented at the Site from March 2014 through September 2014. EPA Region VIII assisted in the review. In 2015, in an effort to update the 1988 IEUBK model used for risk analysis at the site, EPA performed an arsenic speciation and lead bioavailability study of various waste piles in Central City. This report includes the results of that study. The study, and lack of staff resources resulting from a Regional emergency response incident , contributed to the delay in completion of this five-year review.

This is the fifth five-year review for the Central City/Clear Creek Superfund Site. The fourth five-year review was completed in September 2009. In keeping with the requirements of CERCLA §121 (c) and the NCP, the subsequent five-year review is triggered by the signature date of the previous five-year review.

2.0 SITE CHRONOLOGY

The following table provides a summary of the Site chronology:

Table 1: Chronology of Events

Event	Date
NPL listing	9/8/1983
Time-Critical Removal Actions	3/1987 – 8/1991
Remedial Investigation/Feasibility Study complete	6/8/1987
OU1 ROD signature	9/30/1987
OU2 ROD signature	3/31/1988
Transfer of lead status to CDPHE	6/1988
OU2 Remedial Actions complete	9/1991 – 5/2003
Phase II Remedial Investigation/Feasibility Study complete	9/1991
OU3 ROD signature	9/30/1991
OU3 Administrative Orders on Consent	2/1993 – 9/1998
OU3 Potentially Responsible Party Removals complete	6/1993 – 11/1996
First Five-Year Review	**3/30/1994**
OU3 Unilateral Administrative Orders	7/1994 – 9/1997
OU3 Remedial Actions complete	1/1995 – 9/1999
OU3 Potentially Responsible Party Remedial Action complete	2/1995 – 8/2000
OU3 Non-Time Critical Removal Actions complete	11/1996 – 12/1998
Second Five-Year Review	**3/26/1999**
OU2 ROD Explanation of Significant Differences	9/1/1999
Argo Tunnel Water Treatment Plant operational and functional	9/28/1999
OU3 ROD Amendment (Burleigh Tunnel)	6/5/2003
OU4 Remedial Investigation/Feasibility Study complete	9/29/2004
OU4 ROD signature	9/29/2004
Third Five-Year Review	**9/29/2004**
Reorganize remaining OU2 and 3 projects under OU4	6/2006
Amendment to OU3 & OU4 ROD (On-Site Repository)	9/25/2006
Remediation System Evaluation for Argo Tunnel WTP	9/27/2007
Acquisition of repository property	10/30/2008
Fourth Five-Year Review	**9/30/2009**
OU3 Argo Tunnel Treatment Plant O&M transferred to state	10/1/2009
OU4 ROD Amendment (Active Treatment)	4/29/2010
Quartz Hill Waste Rock Pile	9/9/2014
OU3 ROD Explanation of Significant Differences (Argo Bulkhead)	9/12/2014
Argo Tunnel Flow-Through Bulkhead	8/19/2015

3.0 BACKGROUND and REGULATORY COMPLIANCE

3.1 Site Characteristics

The Site is located on the east slope of Colorado's Front Range, approximately 30 miles west of Denver. The Clear Creek drainage basin encompasses roughly 400 square miles and has elevations ranging from 5,700 feet above mean sea level (ft MSL) to more than 13,000 ft MSL. The cities of Central City, Black Hawk, Idaho Springs, Georgetown, Silver Plume and Empire are located within the watershed near the Clear Creek mainstem and/or its major tributaries. Designated uses of Clear Creek include recreation, agriculture and drinking-water supply. Downstream, Clear Creek empties into the South Platte River just north of Denver.

The Site is transected by the Colorado Mineral Belt; the location of numerous ore bodies developed in the late 1800s and through the 1900s by extensive underground mine workings. Precambrian gneisses and schists are the predominant host rock, and are cut by a network of faults. Tertiary Age veins and stocks within the host rock are the sources of sulfide ores that contain deposits of several minerals including gold, silver, iron, copper, lead, nickel, zinc, cadmium, manganese and others. The area has been heavily mined, beginning with the discovery of placer gold in Idaho Springs in 1859 and followed quickly by the first lode discovery in Gregory Gulch.

Historic mining resulted in modern-era environmental problems. Placer mining required the removal of stream substrate and relocation of stream channels. Mine tunnels continue to drain acidic metals-laden water. Mine waste and mill tailings piles were left unprotected throughout the watershed. Dissolved metals including iron, zinc, copper, cadmium, manganese, lead and arsenic, flow into Clear Creek and its tributaries and negatively impact the ecology and water quality of these streams. Ecological risk is the primary driver of cleanup actions at the Site and is mainly associated with direct exposure to metals-contaminated surface water. The Site was placed on the National Priorities List (NPL) in 1983 due to elevated concentrations of metals within the Clear Creek basin.

Modern urbanization also has impacted Clear Creek. The towns of Silver Plume, Georgetown and Idaho Springs have encroached on the stream. Major roadways including U.S. 6, U.S. 40 and I-70 have caused significant channelization of Clear Creek and created runoff of vehicle waste, traction sand and chemical de-icer from the roadway. The legalization of gaming in Black Hawk and Central City has increased traffic, impacted the North Fork of Clear Creek, and altered the landscape with the removal of steeply sloped hillsides to allow casino development.

3.2 Response Summary

The Site was added to the NPL in September 1983. Over the next several years, the EPA initiated Remedial Investigations and Feasibility Studies (RI/FS) at the Site. EPA's Emergency Response program conducted several removal actions at the Site.

The objectives of the planned remedial actions are to protect human health and the environment from the potentially harmful effects of metals present in waste materials associated with historic mining activities. Specific remedial action objectives and remediation goals are listed in the RODs for each Operable Unit (OU).

The initial focus of the Central City/Clear Creek Superfund Site was five discharging tunnels and their associated waste piles; the Argo and Big Five tunnels in Idaho Springs, Quartz Tunnel in Central City, and National Tunnel and Gregory Incline in Black Hawk. EPA initially contemplated three OUs for the Site, as listed below:

Operable Unit 1 – Acid Mine Drainage
Operable Unit 2 – Tailings and Waste Rock Remediation
Operable Unit 3 – Blowout Control for the Argo Tunnel

The Operable Unit 1 (OU1) ROD was signed September 30, 1987 and selected passive treatment of the five discharges, if passive treatment could be demonstrated to be effective. The remedy was designated an interim remedy, and treatment goals were identified as "upstream water quality." Implementation of the OU1 remedy was delayed pending the outcome of the Phase II investigations, as discussed below.

Operable Unit 2 (OU2) was designated to address remediation of mine tailings and waste rock in the immediate proximity of the five discharging tunnels specified in OU1. The OU2 ROD was signed March 31, 1988 and selected run-on control and slope stabilization as the preferred remedial alternative.

Operable Unit 3 (OU3) was designated to address control of surge events from the Argo Tunnel. In August 1988, EPA completed the Argo Tunnel Discharge Control Feasibility Study. The purpose of the study was to evaluate alternatives for reducing the sources of water into the Argo Tunnel such as alluvial ground water or snow buildup inside mine shafts and for controlling or reducing the likelihood of a sudden surge of acid water (a blowout) from the Argo Tunnel. The ROD for OU3 was suspended pending additional studies, as discussed below.

In June 1988, EPA transferred the lead role for the Site, excluding OU2 remedial design, to CDPHE via a cooperative agreement. OU2 remedial design was assigned to the U.S. Bureau of Reclamation, and remedial action was completed at two of the five tailings and waste rock piles before work on OU2 was temporarily suspended. On September 21, 1995, EPA gave the lead for remedial design for the remaining OU2 properties to CDPHE.

In 1988, CDPHE initiated a comprehensive evaluation of the Site via the Phase II RI/FS. The Phase II work expanded the original study area to include the approximately 400 square mile Clear Creek drainage basin. The Phase II RI was completed in September 1990, and the Phase II FS was finalized in September 1991.

The Record of Decision for the Phase II studies was signed September 30, 1991, and is referred to as the Operable Unit 3 (OU3) ROD. The OU3 ROD superseded the OU1 ROD and addressed several mine waste piles throughout the watershed. Major components of the OU3 ROD include:

- Capping or physical barriers and institutional controls for select mine waste piles;
- An alternate drinking water supply where required;
- Passive treatment of the Burleigh Tunnel discharge using constructed wetlands;
- Active treatment of the Argo Tunnel discharge;
- No action to control surge events from mine tunnels;

- A ground water pump and treat system in the Idaho Springs area to address non-point source metals loading to surface water;
- Reduction in the heavy metals loading from Woods Creek; and
- Collecting the discharges from the Gregory Incline, National and Quartz Hill tunnels, but delaying a treatment decision until treatability studies can be conducted under Operable Unit 4, described below.

A pilot scale wetland system was constructed at the Burleigh Tunnel. After three years of operation and data collection, it was concluded that a number of factors prevented the system from efficiently removing dissolved zinc. Annual high and low-flow surface water monitoring conducted for three years following the decommissioning of the pilot system indicated that the instream concentrations of dissolved zinc below the Burleigh Tunnel were significantly less than the aquatic stream standard for dissolved zinc. The OU3 ROD was amended June 5, 2003 to change the selected remedial action for the Burleigh Tunnel from passive treatment to no action.

In October 1991, soon after the OU3 ROD was signed, Colorado voters approved limited-stakes gambling in the municipalities of Black Hawk and Central City. Land values increased rapidly and significant construction activity ensued. Several private entities stepped forward to conduct remedial actions that once had been targeted for fund-lead tasks.

The OU3 ROD was initially intended to be the final response action for the Site; however, during alternative development, CDPHE and EPA recognized that an additional operable unit would be required. The OU3 ROD included interim measures for the Gregory Incline, National and Quartz Hill tunnels, but delayed the final decision on treatment until treatability studies could be conducted. This decision became the basis of Operable Unit 4 (OU4), which focused on the North Fork of Clear Creek.

The OU4 RI/FS was finalized, and the OU4 ROD was signed in September 2004. Components of the OU4 ROD included:

- Capping/removal of priority tailings/waste rock piles in the North Fork of the Clear Creek drainage;
- Treatment of discharges from the Quartz Hill, Gregory Incline and National tunnels;
- Collection and treatment of the Gregory Gulch drainage/ground water; and
- Sediment control in the North Fork of Clear Creek and its tributaries.

In June 2006, CDPHE submitted a cooperative agreement application to request federal funding assistance to implement the OU4 remedial actions. With the agreement, the remaining OU2 and OU3 projects, specifically the Quartz Hill mine waste pile and the Golden Gilpin mine waste site, were administratively reorganized under OU4.

An amendment to the Operable Unit 3 Record of Decision and the Operable Unit 4 Record of Decision for the addition of an On-Site Repository was signed on September 25, 2006. The OU4 ROD was amended again on April 29, 2010 to modify the type and location of treatment for the Gregory Gulch, Gregory Incline and National Tunnel discharges.

4.0 REMEDIAL ACTIONS

This section discusses each of the four Site operable units with respect to the description, background and remedial action objectives for each operable unit, with an emphasis on OU4, as projects related to this operable unit were initiated in 2007.

4.1 Operable Unit 1

4.1.1 Description

OU1 was designated to specifically address treatment of the acid mine drainage from five tunnels:

Table 2: Operable Unit 1 Sources

Operable Unit	Source Name	Location	Status
OU1	Argo Tunnel	Idaho Springs	Complete[1]
OU1	Big Five Tunnel	Idaho Springs	Complete[1]
OU1	National Tunnel	Black Hawk	Pending[2]
OU1	Gregory Incline Tunnel	Black Hawk	Pending[2]
OU1	Quartz Hill Tunnel	Central City	Pending[2]

[1] Addressed under OU3

[2] Addressed under OU4

4.1.2 Background

Surface water at the Site is impacted by the direct discharge from mine drainage tunnels. These discharges are characterized by low pH values and high concentrations of metals including aluminum, arsenic, cadmium, chromium, copper, lead, manganese, nickel, silver and zinc.

4.1.3 Selected Remedy

The OU1 ROD was signed in September 1987 (EPA/ROD/R08-87/016). Recognizing that the discharges from the tunnels covered under OU1 were one of several factors contributing to water-quality and aquatic-habitat degradation, EPA denoted that the selected remedy in the OU1 ROD was an interim remedy. This interim remedy was to comprise the construction of passive-treatment systems to treat acid mine drainage discharging from each of the five tunnels (Table 2), contingent on the successful completion of pilot studies. If the pilot studies did not show passive treatment to be effective, the OU1 ROD allowed the flexibility to implement active treatment.

4.1.4 Summary of Remedial Action

OU1 called for treatability studies of passive systems at the mine adits. Treatability studies performed by the Colorado School of Mines at the Big Five Mine Tunnel indicated that constructed wetlands would require a large areal extent in order for successful metals removal to occur, rendering this option infeasible. Concurrently with these studies, the Phase II investigation was initiated to evaluate the Site comprehensively. Full-scale application of passive treatment has not been implemented at any of the five tunnels. The OU1 ROD was superseded by the OU3 ROD; remedy implementation and operations and maintenance will be discussed with the summary of OU3

4.2 Operable Unit 2

4.2.1 Description

OU2 was designated specifically to address the remediation of waste rock in the immediate proximity of the five discharging tunnels designated under OU1, as summarized in the following table:

Table 3: Operable Unit 2 Sources

Operable Unit	Source Name at Time of ROD	Location	Status
OU2	National Waste Pile	Black Hawk	Complete
OU2	Gregory Incline Waste Pile	Black Hawk	Complete
OU2	Quartz Hill Waste Pile	Central City	Complete[1]
OU2	Argo Waste Pile	Idaho Springs	Complete
OU2	Big Five Waste Pile	Idaho Springs	Complete

[1] Addressed under OU4

4.2.2 Background

Waste rock piles contribute contaminants in a variety of ways, including runoff from the piles carrying dissolved and suspended metals, the potential for collapse of unstable piles into surface waters and human uptake of metals from inhalation of dust or ingestion of materials from the piles.

4.2.3 Selected Remedy

The OU2 ROD, dated March 31, 1988 (EPA/ROD/R08-88/019), selected remedial actions to include:

- Slope stabilization at the Big Five and Gregory Incline waste rock piles;
- Monitoring of the gabion wall at the Gregory Incline; and
- Run-on control at the Argo, Big Five, Gregory Incline, National and Quartz Hill waste rock piles.

Similar to the OU1 ROD, the OU2 ROD indicated the selected remedies were interim remedies, because the net beneficial impact to the Site would not be realized until completion of the other operable units.

CDPHE issued an explanation of significant differences (ESD) for OU2 in September 1999 to modify the remedy at the Big Five and Argo waste rock piles to include regrading, capping and construction of retaining walls.

4.2.4 Summary of Remedial Action

All of the OU2 response actions are complete. These response actions include slope stabilization, capping, run-on and runoff controls, and/or mine waste removal at the Argo and Big Five waste piles. Removal actions were conducted by private parties to remediate the Gregory Incline and National waste piles as development occurred on the properties. These actions are detailed in the Third Five-Year Review Report dated September 29, 2004.

Quartz Hill Mine Waste Pile – The OU2 ROD selected in-place capping for the Quartz Hill mine waste pile to stabilize the pile and improve Clear Creek surface water quality, by preventing run-on from contacting mine waste. In February 2006, CDPHE contracted with an engineering firm to design the Quartz Hill mine waste pile remediation. The key components of the design include: 1) re-grading of the side slopes to a 2:1 grade and capping with a rock cover, 2) placement of gravel road base on the parking area surface, 3) construction of run-on and run-off controls, and 4) installation of a new high-density polyethylene (HDPE) storm drainage system and abandonment of the existing storm culvert. The 90 percent complete construction documents for the remedial design were finished in September 2006.

CDPHE coordinated with EPA enforcement regarding ownership and access. Property owners were provided the design drawings in December 2006 and were presented the opportunity to comment or to propose their own development plans. No response was received, and in 2007 the EPA filed notices of intent to file liens on the properties on which the waste pile is located. The liens were finalized in early 2008. In July 2009, a new Colorado law went into effect that allows higher stakes gaming in the Central City area. The agencies anticipated this law could spur private development on the Quartz Hill properties given its proximity to the gaming district.

In June 2006, the Site was reorganized to address the Quartz Hill mine waste pile from OU2 under OU4 (see Section 4.4.4).

4.2.5 Operations and Maintenance

Operations and maintenance (O&M) is required at several of the OU2 waste piles. CDPHE performs annual O&M inspections and develops a report of its findings and corrective actions. All of the completed OU2 remedies were inspected during this five-year review. The city of Idaho Springs is performing O&M at the Big Five waste pile under a Prospective Purchaser Agreement and submits an annual report to EPA and CDPHE. O&M for the Gregory Incline and National waste piles was performed by their respective respondents during the first five years after completion of the response action but is no longer required since the waste piles were completely removed during private development of the properties. CDPHE currently conducts O&M of the Argo waste pile.

4.3 Operable Unit 3

4.3.1 Description

Operable Unit 3 encompasses the Clear Creek watershed, defined as the Site study area. The RI/FS screened multiple mine tunnels and waste piles to identify the major sources of contaminant loading to Clear Creek. Eight draining tunnels (five of which were discussed in OU1 and later moved to OU3) and 21 waste piles (five of which were included in OU2 and later moved to OU3) were selected for further evaluation and a remedial determination.

4.3.2 Background

OU3 was originally designated to address the control of surge events from the Argo Tunnel. In 1988, CDPHE assumed lead agency status and initiated a more comprehensive investigation of the watershed to ensure priority sources were addressed under CERCLA authority. The OU3 RI/FS investigations became known as the "Phase II" studies. The Phase II studies culminated in the issuance of the OU3 ROD.

4.3.3 Selected Remedy

The OU3 ROD, dated September 1991 (EPA/ROD/R08-91/055), updated decisions previously prescribed in the OU1 ROD and detailed the decisions resulting from the Phase II investigations. The surface-water remedial action objective developed during the Phase II studies is to "reduce metals loading to streams from point discharges in order to reduce in-stream metals concentrations to levels protective of aquatic life." More specifically, the remedial action objectives were defined in the OU3 ROD as:

Objectives of the Selected Alternative

1. Preventing incidental ingestion of mine waste posing an excess risk of 1 cancer incidence per 100,000 people or greater, and preventing incidental ingestion of mine waste containing more than 500 milligrams/kilogram of lead.
2. Reducing the excess cancer risk due to inhalation of dust containing heavy metals.
3. Preventing ingestion of ground water having contaminant concentrations in excess of Primary Drinking Water Standards, or exceed health-based levels for contaminants which have no Primary Drinking Water Standards for the contaminants of concern at the Site.
4. Preventing collapse of unstable mine waste piles through slope stabilization.
5. Reducing erosion from mine waste piles to the point where stream standards are not exceeded by storm water runoff from the mine waste pile.
6. Reducing contaminant loading from the mine drainage tunnels, for the contaminants of concern at the Site, to levels which allow state stream standards, and state table value standards (where they have been determined to be relevant and appropriate) to be met.

The OU3 ROD superseded the OU1 ROD by:

- Replacing constructed wetlands with chemical treatment for the Argo Tunnel discharge;
- Using an interim waiver of applicable or relevant and appropriate requirements (ARARs) for the discharge from the Big Five Tunnel;
- Collecting the discharges from the Gregory Incline, National, and Quartz Hill tunnels and piping the discharges to North Clear Creek to eliminate overland travel and to reduce the potential for direct human contact; and
- Invoking an interim remedy waiver of ARARs and delaying a decision on final treatment of the Gregory Incline, National, and Quartz Hill tunnels until further investigations were conducted under Operable Unit 4.

Other major components of the OU3 ROD included:

- An alternate drinking water supply for residences where required;
- Passive treatment of the Burleigh discharge;
- No action to control surge events from tunnels;
- Reduction in the heavy metals load from Woods Creek;

- A ground water collection system in the Idaho Springs area to address non-point source metals loading to surface water; and
- Capping or physical barriers, and institutional controls for select mine waste piles (Gregory Gulch piles #1 and #2, Clay County, Boodle Mill, McClelland, North Clear Creek, Chase Gulch #1 and #2, Quartz Hill, Golden Gilpin, Black Eagle, and Little Bear).

As discussed in Section 3.2, the OU3 ROD was amended June 5, 2003 to change the selected remedy for the Burleigh discharge from passive treatment to no action.

Table 4 summarizes tasks completed and pending under OU3.

Table 4: Operable Unit 3 Sources

Operable Unit	Source Name	Location	RA Status
Mine Adit Discharges			
OU1	National	Black Hawk	Pending[1]
OU1	Gregory Incline	Black Hawk	Pending[1]
OU1	Quartz Hill	Central City	Pending[1]
OU1	Argo	Idaho Springs	Complete
OU1	Big Five	Idaho Springs	Complete
OU3	Rockford	Idaho Springs	No Action
OU3	McClelland	Dumont	No Action
OU3	Burleigh	Silver Plume	No Action
OU3	Argo Bulkhead	Idaho Springs	Complete[1]
Waste Piles			
OU2	National	Black Hawk	Complete
OU2	Gregory Incline	Black Hawk	Complete
OU2	Quartz Hill	Central City	Complete[1]
OU2	Argo	Idaho Springs	Complete
OU2	Big Five	Idaho Springs	Complete
OU3	Urad	Woods Creek	Complete
OU3	Empire	Empire	No Action
OU3	Minnesota Mill Tailing	Empire	Complete
OU3	McClelland	Dumont	Complete
OU3	Black Eagle	Chicago Creek	Complete
OU3	Little Bear Creek	Idaho Springs	Complete
OU3	Boodle Mill	Central City	Complete
OU3	Gregory Gulch #1	Central City	Complete
OU3	Gregory Gulch #2	Central City	Complete
OU3	Gregory Gulch #3	Central City	Complete
OU3	Chase Gulch #1	Black Hawk	Complete
OU3	Chase Gulch #2	Black Hawk	Complete

Table 4 summarizes tasks completed and pending under OU3.

Table 4: Operable Unit 3 Sources

Operable Unit	Source Name	Location	RA Status
OU3	Golden Gilpin Mill	Black Hawk	Complete
OU3	North Clear Creek	Gilpin County	Complete
OU3	North Clear Creek Dredge	Gilpin County	Complete
OU3	Clay County	Gilpin County	Complete
OU3	Repository	Site wide	In Progress[1]
OU3	Golden Gilpin Mill	Gilpin County	Complete
Ground Water			
OU3	Drinking Water	Site wide	Complete
OU3	Virginia Canyon Project	Idaho Springs	Complete

[1]Remedial action was or will be conducted as part of OU4

4.3.4 Summary of Remedial Actions

Response actions completed prior to 2009 are detailed in the Fourth Five-Year Review Report dated September 30, 2009. The following narrative describes remedial actions completed since the fourth five-year review was conducted.

Argo Tunnel Water Treatment Plant (ATWTF), Implementation of Remedial System Evaluation Improvements – On April 7, 1998 the ATWTF began operating full time to address metals loading from the Argo Tunnel located in the eastern part of Idaho Springs. The plant was built on land acquired by EPA in a settlement with the landowner, pursuant to a consent decree lodged on June 3, 1997 (Civil Action No. 97-WY-286). The facility was deemed operational and functional on September 30, 1999. The plant uses active treatment to precipitate and remove heavy metals from the acid mine drainage. An average flow of 250 gallons per minute is treated, and approximately 900 pounds of metals are removed daily. The ATWTF's effluent is discharged directly to Clear Creek, and the solid metal sludge is disposed of at a municipal landfill. Certified operators run the plant under contract to CDPHE.

Following 10 years of Long Term Response Actions (LTRA), the remedy status of the ATWTF transitioned to O&M on October 1, 2009. CDPHE assumed title to the ATWTF, along with one hundred percent of the financial obligation for ongoing O&M. In preparation of the transition to CDPHE ownership in 2007, EPA contractors performed a Remediation System Evaluation (RSE).

The RSE report provided several recommendations to improve effectiveness, reduce costs and implement technical improvements. One of the recommendations provided was to improve metals treatment by solids recycling. This recommendation recognized that "after labor, solids transport and disposal and chemicals represent the next largest cost categories" and that "convincing small scale pilot tests conducted at the plant...suggest that solids recycling in a high density sludge (HDS) configuration can substantially reduce lime usage and increase sludge density." The RSE report suggested modifying the reactor tank to increase solids recycling in a quasi-HDS fashion, adding aeration to the process, and installing new filter presses.

Rather than implement the RSE recommendation of modifying the existing reactor tank with the intent of improving solids density and reducing chemical usage, CDPHE proposed implementing a "true" HDS system. While this approach was not specifically recommended in the RSE report, it was consistent with the intent. EPA concurred with CDPHE's proposal.

In 2009, CDPHE contracted with an engineer to perform pilot studies and issue an options evaluation report. CDPHE, in consultation with EPA, selected an option that allowed for the reuse of most of the existing process tanks, along with construction of a new thickener.

In 2011, a retrofit of the ATWTF to incorporate a HDS system was designed. Major components of the design included a new 50-foot diameter sludge thickener outside the southwest corner of the existing treatment building, new lime/slurry mix tanks, modifying the existing treatment systems into two HDS reactors, new mixers, new aeration blowers, new sludge pumping systems and piping, new electrical supply and controls for the new equipment, and removal of the rapid mix tanks, a sludge holding tank, and miscellaneous pumps and piping. The new thickener required a retaining wall, access stairway and a covered walkway to the center of the thickener. Following verification of the HDS process, a secondary filter press (added into the ATWTF during 2000) could be removed, and the solids handling system returned to its original design.

Construction of the HDS process occurred in 2012 and 2013. Since the ATWTF was constructed with two parallel treatment trains, each with a capacity of 350 gallons per minute, construction was timed with low discharge flows. This approach allowed for the HDS conversion to be constructed on one treatment train while the other treatment train continued to treat water discharging from Argo Tunnel, Big Five Tunnel and ground water conveyed from Virginia Canyon. No bypasses or exceedances of discharge standards occurred during implementation of the project.

The first treatment train began processing water in the HDS configuration on April 17, 2013. Following two weeks of successful operation of the HDS system on the first train, the second train was taken offline and converted to HDS. CDPHE issued the notice of final acceptance to the contractor on September 20, 2013. As anticipated, the sludge density has improved, and lime demand has been decreased. Detailed information can be found in the Argo Tunnel Water Treatment Facility High Density Sludge Treatment System Modifications Remedial Action Completion Report, signed July 9, 2014.

Argo Tunnel Bulkhead – The OU3 ROD contemplated the need for a flow-through bulkhead to be constructed within the Argo Tunnel to prevent future surge events similar to those that have occurred in the past, but deferred the final decision to the remedial design. A surge event would overwhelm the ATWTF, result in a fish kill on the mainstem, and compromise the city of Golden's drinking water supply. A flow-through bulkhead would help assure these events would not occur in the future and would provide controlled flow into the plant. The bulkhead would eliminate increased flows from the tunnel during run-off events that could result in the discharge bypassing the plant. Providing a constant flow into the ATWTF would also reduce treatment costs by eliminating the increased labor costs associated with treating high flows.

An Explanation of Significant Differences for the inclusion of a flow-through bulkhead was approved by EPA on September 12, 2014. Construction of the flow-through bulkhead was completed on October 1, 2015.

Virginia Canyon Mine Waste Rock Piles – Five mine waste rock piles located at the headwaters of Virginia Canyon in Clear Creek County (Williams, Rio Grande, Trio, Lower Clarissa and Diamond Joe) were identified as significant contributors of sediment transport to the Clear Creek mainstem during storm events.

The EPA Emergency Response Program (ER Program) completed a Removal Action under an Action Memorandum, dated June 15, 2010, at the Williams and Rio Grande waste piles in Virginia Canyon in September 2010. As part of this action, EPA removed portions of the waste rock piles in the immediate vicinity of the drainage, and transported the excavated material to the top of the Rio Grande pile. Although the Church Placer Repository was originally identified as the location for the deposition of the five Virginia Canyon piles, the Rio Grande pile was used for on-Site consolidation instead. This approach reduced hauling and placement costs considerably. The side of the Rio Grande waste rock pile and the run-on and run-off drainages were armored with grouted rip rap to stabilize and control erosion of the pile.

The Trio, Lower Clarissa and Diamond Joe waste piles were excavated and transported to the top of the Rio Grande pile. The drainage around the excavated Trio pile was reconstructed and armored with grouted rip rap to stabilize the area and control erosion.

Burleigh Tunnel Removal Action – A Removal Action was conducted at the Burleigh Tunnel by the ER Program under an Action Memorandum dated July 13, 2011. Following decommissioning of the pilot system in 1999, the drainage flowed from the tunnel to an influent control structure that was installed in 1993 to regulate flow to the passive treatment system, and then into the Clear Creek alluvium. The property was previously used by a wood pellet manufacturing company and lumber mill. Numerous cut and limbed trees were hauled to the property and stacked where the former passive treatment system influent control structure was located. This action appeared to have resulted in the plugging of the influent control structure, allowing the mine drainage to overflow onto the surface. The flows crossed the property onto Main Street at two locations. An increase in flow from the tunnel could have resulted in the drainage flowing eastward on Main Street into the residential area located six hundred feet east of the tunnel. During the winter, the flows froze and created a safety issue for drivers using Main Street.

The removal action consisted of construction of a pipeline to contain and manage the drainage. The drainage is conveyed to an overflow lagoon adjacent to Clear Creek where the drainage is allowed to assimilate into the base flow of Clear Creek.

4.3.5 Operation and Maintenance

The ATWTF is in an O&M status, treating flows from the Argo Tunnel, Big Five Tunnel and Virginia Canyon ground water. Between 2009 and 2013, the combined treatment flow rate averaged 222 gallons per minute, at an annual cost of approximately $1,000,000.

The most recent two years of discharge data for the ATWTF, January 2012 through December 2013, were reviewed. The long term average discharge concentrations were compared to the monthly average limit specified in the ARARs Compliance Document issued February 3, 1999 (COU-00100). The discharge concentrations are significantly below the allowable limits (Table 5). With EPA concurrence, CDPHE reduced the frequency of effluent analysis to two times per month.

CDPHE visually inspects the National and Gregory Incline pipeline inlets for the impoundment of water annually during the O&M inspections. Impounded water is a visual indicator of sediment buildup within the pipeline. When required, CDPHE performs periodic pipeline cleaning. The National and Gregory Incline pipelines were most recently jetted in August 2006.

O&M is required at several of the waste piles. The O&M for the OU3 waste piles is the responsibility of private parties, U.S. Forest Service, local cities, counties or CDPHE. As described previously, CDPHE performs O&M inspections and develops an annual report of its findings and corrective actions. The most recent report was completed in July 2014, documenting the September 2013 inspection. All of the completed OU3 remedies were inspected. Specific maintenance issues and follow-up activities are detailed in the July 28, 2014 report. No significant maintenance issues were observed that would compromise the protectiveness of the remedy.

For this five-year review, all OU3 Site remedies were inspected during the week of June 30, 2014. Observations were consistent with the annual O&M report.

4.4 Operable Unit 4

4.4.1 Description

Operable Unit 4 focuses on the North Fork of Clear Creek. Mine waste piles located in the tributaries of Russell, Gregory, Willis and Nevada gulches contribute heavy metals and sediment to the North Fork basin. Contaminated water discharging from the National tunnel, Gregory Incline and Quartz tunnel, and surface and groundwater flow from Gregory Gulch contribute significant dissolved metals loading.

4.4.2 Background

The need for OU4 was identified in the OU3 ROD and the OU was developed specifically for the North Fork of Clear Creek sub-watershed. The OU4 remedial actions address contaminated surface water, ground water and sediment. The cleanup strategies address threats through the capping or removal of waste piles and treatment of point and non-point sources of surface water contamination.

Table 5: Average Argo Tunnel Water Treatment Facility Discharge Concentrations, 2012 – 2013

	Parameter (mg/L)								
	Total Suspended Solids	Cadmium	Copper	Iron	Lead	Manganese	Nickel	Silver	Zinc
Long Term Average	4.1	0.0002	0.004	0.05	0.0003	0.199	0.005	ND	0.021
Monthly Average Limit	20	0.003	0.017	15.8	.00475	0.800	0.850	0.00002	0.225

4.4.3 Selected Remedy

OU4 efforts focus on the North Fork of Clear Creek. The September 29, 2004 OU4 ROD (EPA/ROD/R08-04/712) was prepared as a collaborative effort between EPA and CDPHE and was signed in September 2004. The OU4 ROD defined the remedial action objectives for the Site as follows:

Surface Water Remedial Action Objectives

1. Reduce in-stream metals concentrations and sediment transport to minimize water quality and habitat impacts and to maximize reasonably attainable water uses of the North Fork of Clear Creek. These actions will also support the survival of a brown trout population in the North Fork of Clear Creek.
2. Reduce in-stream metals concentrations and sediment transport in North Clear Creek with the purpose of reducing adverse water quality and habitat impacts on the main stem of Clear Creek, to protect aquatic life and to support a viable reproducing brown trout population in the main stem of Clear Creek.
3. Ensure that in-stream metals concentrations do not degrade drinking water supplies diverted from the main stem of Clear Creek.
4. Reduce the toxicity to benthic aquatic organisms living at the surface water/sediment interface or in sediment to levels that are protective of aquatic life.

Tailings/Waste Rock Remedial Action Objectives

1. Control and/or reduce run-on and runoff from tailings/waste rock piles to minimize generation of contaminated runoff and/or ground water, and to reduce sediment loading of streams.
2. Reduce exposure to arsenic and lead from incidental ingestion of surface tailings/waste rock and other mine wastes to minimize the potential threat to human health.

Ground Water Remedial Action Objectives

1. Control and/or reduce metals loading from ground water to reduce in-stream metals concentrations.
2. Ensure that contaminated ground water does not adversely impact human health.

Air Remedial Action Objective

1. Control airborne metals contaminants in residential areas.

To accomplish the remedial action objectives, the proposed remedial actions for OU4 outlined in the ROD included:

- Treatment of Gregory Incline discharge and Gregory Gulch ground water at the Bates Hunter Mine water treatment plant;
- Treatment of the National Tunnel discharge at a passive treatment system downstream of Black Hawk along State Highway 119;
- Tributary sediment control involving waste pile removal/capping, sediment detention structures on Russell and Nevada Gulches, and other sediment-reduction measures in Russell, Gregory and Nevada Gulches; and
- Improvements to the North Fork of Clear Creek.

With the June 2006 administrative restructuring of the Site, OU4 also includes the remaining OU2 and OU3 waste rock pile remedial actions.

A ROD amendment to add an on-Site repository was completed in September 2006. The OU4 ROD was amended again in 2010 to modify the water treatment component. The Gregory Incline discharge, Gregory Gulch base flows (which includes the Quartz Tunnel discharge), and National Tunnel discharge will all be treated at the North Clear Creek water treatment plant (NCCWTP). Construction of the NCCWTP was completed in March 2017 and is currently in the operational and functional shakedown phase of the remedial action.

4.4.4 Summary of Remedial Actions

Response actions completed prior to 2009 are detailed in the Fourth Five-Year Review Report. The following summarizes remedial actions conducted since the fourth five-year review. More detailed information on the projects can be found in the May 9, 2013 Remedial Action Completion Report for the Mine Drainage Pipeline Project, and in the Remedial Action Completion Report titled *Mine Waste Remediation and Sediment Control Project and North Fork Constructed Wetland and Stream Bank Restoration Project and Preliminary Interim Remedial Action Completion Report for the On-Site Repository and Church Placer Restoration* dated June 14, 2011. A Remedial Action Completion Report for the North Clear Creek Sediment Improvements and Water Treatment Plant Site Preparation project was completed September 23, 2014.

On-Site Repository – An amendment to the OU4 ROD was completed to include a Site-wide repository. After several years of negotiating with landowners, CDPHE was able to purchase 28.5 acres of the Church Placer claim located in Gilpin County and within the Site on October 30, 2008.

The Church Placer claim was the site of historic mining activities dating to 1908 and later was utilized by Solution Gold, LLC as a heap-leach facility for reprocessing mine waste rock and recovering gold. The company went into bankruptcy and abandoned operations by 1995. At that time the Colorado Division of Reclamation and Mine Safety (DRMS) attempted to close the heap-leach pads using an inadequate bond. Construction to reclaim the 28.5 acres and to establish a Site-wide repository began in 2008. The repository was used to consolidate mine waste under Phase III of the Sediment Control Measures and Mine Waste Remediation work. The repository also will be used for the storage of sediments from sediment-retention dams constructed as Phase I sediment-control measures and waste rock remediation.

The repository capacity was increased in 2010 with the addition of a new cell. Phase III capacity was 10,000 cubic yards, and the new cell added 37,000 cubic yard for total of 47,000 cubic yards. Prior to implementation, the increase in capacity was coordinated with potential future users of the repository and with EPA.

Due to concerns regarding the poor performance of revegetation over an area of approximately seven acres at the northern portion of the repository property, CDPHE developed engineering plans in consultation with a vegetation specialist to add additional soil cover and soil amendments and to revegetate the impacted area. The additional soil cover and amendments were installed in November 2013. To date, the revegetation effort is performing well and providing sufficient cover of the seven-acre repair area. CDPHE will continue to monitor this effort to ensure performance is being maintained.

<u>Mine Waste Remediation and Sediment Control Project</u> – The project objectives focused on reducing the erosion and transport of mine wastes from the high- and medium-ranked mine waste sources in Gregory, Russell, Willis and Nevada gulches. These objectives were achieved through mine waste removal and consolidation in an on-site repository, capping, construction of erosion controls such as run-on and run-off ditches, and construction of sedimentation dams.

Twenty waste rock piles were removed or remediated as part of the Mine Waste Remediation and Sediment Control Project. Two sediment retention basins were constructed: one in Nevada Gulch and one in Russell Gulch. Check dam structures were constructed in South Willis, Willis, Russell and Nevada gulches to stabilize these stream channels and to reduce sediment transport. An additional waste rock pile, the Kokomo, was removed from adjacent to the state-owned portion of the Church Placer repository property under an Interagency Agreement with DRMS. DRMS also closed hazardous mine openings associated with four waste rock piles.

The project was implemented in three phases, as shown in Table 6. Locations are shown on Figure 5. Phase I and Phase II actions are described in the fourth five-year review. The Phase III Sediment Control Measures and Mine Waste Remediation construction activities began July 6, 2009. This project, as shown in Table 6 and Figure 3, involved the excavation, transportation and consolidation of select waste rock piles from Nevada, Russell and South Willis gulches to the repository and reclamation where the piles have been removed. A soil cover was constructed over the filled portion of the repository. The project also included erosion-control measures at some additional piles in South Willis Gulch. The work included consolidation and regrading mine wastes and Site soils, placement of riprap, placement of rock and soil covers, run-on control ditches, revegetation and other elements intended to reduce the erosion of mine wastes. CDPHE relocated the Kokomo waste rock pile, located adjacent to the State's portion of the Church Placer property, to the repository with funding provided by DRMS. The field portion of the Phase III construction was completed on November 29, 2010.

As part of the CDOT State Highway 119 improvements project, CDOT's contractor screened and hauled rip-rap and interim soil cover to the CDPHE repository for future mine waste disposal at the repository.

Under an interagency agreement with CDPHE, DRMS closed four mine adits located at mine waste piles where CDPHE implemented erosion-protection measures (i.e., Hampton, Iroquois, Hazeltine and Anchor). The State Historical Preservation Office provided coordination and concurrence. These closures were completed in summer 2009.

North Clear Creek Sediment Improvements and Water Treatment Plant Site Preparation – CDPHE and EPA implemented certain components of the OU4 ROD (e.g., removal of mill tailings, preparation of future water treatment facility site) by funding the Colorado Department of Transportation (CDOT) to implement the remedy while constructing its State Highway 119 (SH119) Main Street South project. SH119 parallels North Clear Creek, and between 2011 and 2013, CDOT constructed significant road improvements just downstream of Black Hawk. CDPHE and EPA also planned on constructing the new NCCWTP downstream of Black Hawk (see below). The overlap of the two projects provided a unique opportunity for CDPHE and CDOT to work together to realize cost savings and to create a better end product. Recognizing the opportunity to collaborate on the projects occurring in the North Clear Creek watershed, CDPHE, CDOT and EPA entered into a memorandum of understanding, dated January 11, 2008, to coordinate efforts. This memorandum was followed by the *Interagency Agreement for the Construction, Operation and Maintenance of Central City/Clear Creek Superfund Site Facilities on CDOT Right of Way* between CDPHE and CDOT, effective August 6, 2009.

CDPHE funded CDOT via the interagency agreement to: a) screen and haul additional cover material and rip rap to the Church Placer for future use at the repository; b) prepare/grade the site of the new WTP; c) construct a retaining wall; d) run utilities to the new WTP; and e) conduct sediment-reduction measures along the North Fork Clear Creek.

The sediment-reduction measures along the North Fork of Clear Creek (North Clear Creek) included the removal of mine waste from the channel and riparian zone, reconstruction of disturbed portions of the channel, stabilization of the channel, and revegetation of the riparian zone.

Five locations along North Clear Creek were observed to have mill tailings present, as confirmed by EPA sampling in 2008. The mill tailings were relocated and placed per specifications at the CDPHE Church Placer Repository. Approximately 8,000 cubic yards of tailings and contaminated soil was removed from the riparian corridor of the North Fork. CDOT's contractor also hauled and stockpiled interim cover material and rip-rap for future use at the repository.

Historic mining practices in the Black Hawk/Central City area included placer mining and related activities. These activities, along with the deposition of mine waste along the creek (see above) have severely destabilized the North Clear Creek channel and floodplain. In order to reduce sediment generation and improve stream stability, the SH119 Main Street South plans included reconstruction of approximately 5,070 feet of North Clear Creek, extending south from the site of the proposed North Clear Creek water treatment plant. The stream stabilization construction included complete reconstruction of the stream channel based on plans developed by CDOT's design contractor, as well as replanting native vegetation throughout the stabilized area.

Table 6: Operable Unit 4 Sediment Control Measures and Mine Waste Remediation

Phase	Project	Location	Remedy	Status
I	Gregory Gulch #3	Gregory Gulch	Erosion Control	Complete
I	Nevada Gulch Sediment Retention Basin	Nevada Gulch Drainage	Sediment retention	Complete
I	Russell Gulch Sediment Retention Basin	Russell Gulch Drainage	Sediment retention	Complete
I	Hampton Waste Rock Pile	Russell Gulch	Erosion control	Complete
I	Russell Gulch Check Dam	Russell Gulch	Water management	Complete
I	Anchor Waste Rock Pile	Willis Gulch	Erosion control	Complete
I	Powers Waste Rock Pile	Willis Gulch	Erosion control	Complete
I	Silver Dollar Waste Rock Pile	Willis Gulch	Erosion control	Complete
I	Willis Gulch Check Dam	Willis Gulch	Water management	Complete
II	Keystone Waste Rock Pile	Nevada Gulch	Erosion control	Complete
II	Nevada Gulch Check Dams	Nevada Gulch	Water management	Complete
II	Alva Adams Waste Rock Pile	Russell Gulch	Erosion control	Complete
II	Baltimore Waste Rock Pile	Russell Gulch	Erosion control	Complete
II	Mattie May Waste Rock Pile	Russell Gulch	Erosion control	Complete
II	Russell Gulch Drop Structures	Russell Gulch	Water management	Complete
II	Pittsburgh Waste Rock and Tailings Piles	Russell Gulch	Erosion control	Complete
II	South Willis Gulch Check Dams	South Willis Gulch	Water management	Complete
III	Kokomo Waste Rock Pile	South Willis Gulch	DRMS Removal	Complete
III	Old Jordan Waste Rock Pile	South Willis Gulch	Removal	Complete
III	Hazeltine Waste Rock Pile	South Willis Gulch	Erosion control	Complete
III	Iroquois Waste Rock Pile	Russell Gulch	Removal	Complete
III	Section 19 Waste Rock Pile	Russell Gulch	Removal	Complete
III	Argo Waste Rock Pile	Russell Gulch	Removal	Complete
III	Aurora Waste Rock Pile	Russell Gulch	Removal	Complete
III	Centennial East Waste Rock Pile	Russell Gulch	Erosion control	Complete
III	Centennial Waste Rock Pile	Russell Gulch	Erosion control	Complete
III	Niagara Waste Rock Pile	Russell Gulch	Removal	Complete
III	Nevada Gulch Tailings Piles	Nevada Gulch	Removal	Complete
I - III	Church Placer	South Willis Gulch	Site-wide Repository	In Progress

Due to highway realignment, the SH119 Main Street South project resulted in a site with a buildable area of approximately 1.1 acres on the south side of the highway approximately 500 feet south of the intersection of SH119 and Main Street. Per the 2009 interagency agreement, CDPHE and EPA were provided the opportunity to construct the NCCWTP at this location and within CDOT right of way. The SH119 Main Street South project included filling the site and constructing retaining walls, stormwater drainage, and related utilities at this location to allow future construction of the NCCWTP.

The State Highway 119 project reached substantial completion in May 2013, including all components of the project for which CDPHE contributed funding.

Gregory Incline, Gregory Gulch and National Tunnel conveyance projects – The OU4 ROD called for passive treatment of the National Tunnel discharge and active treatment of the Gregory Incline and Gulch at the Bates Hunter Mine Water Treatment Plant. CDPHE contracted with an engineering firm to design the collection and conveyance systems for mine discharge drainages associated with the Gregory Gulch, the Gregory Incline and the National Tunnel.

The engineering services also included evaluation of the Bates Hunter Mine water treatment plant, identified in the OU4 ROD as the treatment location for the Gregory Gulch and Gregory Incline mine waters. The assessments of the Bates Hunter facility indicated it did not have adequate capacity, and substantial upgrades would be required. As a result, an amendment to the OU4 ROD was issued April 29, 2010 modifying the water treatment component of the remedy. The National Tunnel, Gregory Incline and Gregory Gulch flows will be treated at the new water treatment plant downstream of the National Tunnel discharge, the NCCWTP.

A conveyance pipeline was constructed in 2011 and 2012. The mainline pipe consists of approximately 5,400 feet of 12-inch-diameter corrugated polyethylene pipe located under the southbound lanes of State Highway 119. There are three laterals that will collect the sources of mining-impacted water; the Gregory Incline lateral, Gregory Gulch lateral and National Tunnel lateral. Eighteen manholes provide access for maintenance. Four communications conduits were installed along the length of the pipeline. These conduits are intended for use by CDPHE to monitor and control future components of the collection system, as well as to provide conduit for communications to be used by CDOT and the city of Black Hawk.

Along with the conveyance pipeline, the work also included extension of a water main to the site of the NCCWTP and a partial extension of a natural gas main.

Gregory Incline, Gregory Gulch and National Tunnel Treatment – Following the issuance of the OU4 ROD amendment on April 29, 2010, CDPHE contracted with an architect/engineer to design the NCCWTP, to be located in CDOT right of way, as described above. Pre-design studies focused on quantifying the flow and contaminant load that the NCCWTP would be required to handle, and conducting bench and pilot studies to define the treatment process. The resulting design is a high-density sludge treatment system with a 600-gallon-per-minute capacity.

In late January 2011, CDPHE and EPA discovered that the city of Black Hawk had filed water rights applications with the Colorado district water court on December 29, 2010. Given the large amount of water requested in the applications, the agencies became concerned that these new water rights would reduce the flow of water in North Clear Creek to the extent that a fishery would no longer be possible. As detailed in Section 4.3.3, one of the main surface water remedial action objectives is to "[r]educe in-stream metals concentrations and sediment transport to minimize water quality and habitat impacts and to maximize reasonably attainable water uses of the North Fork of Clear Creek. These actions will also support the survival of a brown trout population in the North Fork of Clear Creek." Gilpin County also filed a new water rights application on December 28, 2011 (11CW271). This right would allow Gilpin County to divert water from any of several locations located along North Clear Creek or its tributaries, further decreasing the flow available in North Clear Creek. CDPHE filed statements of opposition on case numbers 10CW308, 10CW309 and 11CW271.

Concurrent with the design development for the water treatment plant, CDPHE began negotiations with the city of Black Hawk, Gilpin County and Central City in early 2011 with the goal of reaching an agreement to leave enough water in the stream to allow brown trout to survive. These entities each have water rights on or impacting North Clear Creek. Central City withdrew from the negotiations in May 2013. Negotiations for a bypass flow agreement were unsuccessful. CDPHE will continue to monitor water rights applications and participate in cases as a stakeholder when appropriate.

CDPHE and Colorado Department of Personnel and Administration filed water rights application 11CW282 to protect CDPHE's ability to divert and treat the mine drainages. In addition, the city of Black Hawk will provide fully consumable water to the NCCWTP to offset any depletions through the treatment process. This augmentation is defined in Case Number 12CW303.

CDPHE submitted a cooperative agreement application dated September 12, 2013 for funding for the construction of the new WTP. An award of $17,730,000 was received (Award V - 96804301 - 0, dated September 27, 2013). CDPHE received an assurance letter from EPA on December 16, 2013 that OU4 WTP is subject to LTRA.

CDPHE and Black Hawk executed an intergovernmental agreement on December 15, 2015 wherein Black Hawk will provide augmentation water. CDPHE will pay for the engineering costs associated with Black Hawk's consultant modifying their augmentation plan. CDPHE will procure potable water from Black Hawk for use in the water treatment process.

Quartz Hill Removal Action – The Quartz Hill Pile is a large tailings pile located in Central City. The pile comprises approximately 500,000 cubic yards of tailings derived from milling operations that took place in the 1930s and 1940s, and covers an area of approximately five acres

Storm events in Central City resulted in the erosion of the tailings and subsequent transport of the tailings onto nearby residential and business properties. The tailings impoundment had steep sides subject to erosion, and the tailings contain residual metals from the milling process. EPA and CDPHE met with the Central City planner in May 2011 at his request to discuss the problem and possible solutions to address the tailings transport. As an interim measure, the EPA Emergency Response Program conducted a removal action. A sediment retention basin was constructed to prevent the release of tailings until the remedial action could be implemented.

Quartz Hill Remedial Action – The 2006 draft design (see Section 4.2.4) was updated based on consultation with Central City and fully completed in October 2013.

Because the Quartz Hill project is located within the core area of Central City, and because a number of project components required coordination with the city, a memorandum of understanding (MOU) between CDPHE and Central City was negotiated prior to construction and was finalized on September 13, 2013. This MOU addresses several key components of the project and coordination between CDPHE and the city, including use of city-owned material at the Central City Parkway for cover material at Quartz Hill, air monitoring during construction, incorporation of the new Quartz Hill storm sewer into the city's operations and maintenance responsibilities, and execution of environmental covenants for the remedy on portions of the property owned by the city.

The Quartz Hill Remediation Project commenced construction on March 31, 2014 and was deemed substantially complete in August 2014. The project included re-grading the steep tailings slopes to a more stable configuration and placement of an inert rock cover underlain by a separation geotextile. The rock cover material was derived from rock excavated during the 2003-2004 construction of the Central City Parkway.

A major component of the project addressed storm water drainage through the Site. A pre-existing concrete storm sewer carried flows from Nevada Gulch under the tailings pile. This concrete storm sewer showed significant degradation after many years in service. A new storm sewer system, consisting of approximately 1,000 feet of 60-inch-diameter polyethylene pipe was installed to replace the degraded concrete pipe system.

Because of the potential that excavation of tailings might uncover historic resources, a memorandum of agreement (MOA) was executed with the State Historic Preservation Office (SHPO) prior to construction. Under the MOA, CDPHE agreed to hire a cultural resources consultant to provide documentation of the pre-construction conditions of the site and provide an archeologist to monitor critical parts of the work. The MOA also required that the cultural resources consultant provide a summary report after construction completion detailing construction monitoring and any cultural resources discovered during construction. No cultural resources were discovered during the work.

4.4.5 Operations and Maintenance

CDPHE performs O&M inspections and develops an annual report of its findings and corrective actions. The most recent report was completed in July 2014, documenting the September 2013 inspection. All of the completed OU3 remedies were inspected. Specific maintenance issues and follow-up activities are detailed in the July 28, 2014 report. No significant maintenance issues were observed that would compromise the protectiveness of the remedy. In 2017, an AOC was finalized between Central City regarding the Quartz Hill site. The City enacted an ordinance and assumed responsibility for conducting O&M at the Quartz Hill site.

4.5 Institutional Controls

Institutional controls (ICs) are actions, such as legal controls, that help minimize the potential of human exposure to contamination by ensuring appropriate land or resource use. ICs are typically used when residual contamination remains onsite at a level that does not allow for unrestricted use and unlimited exposure after remediation is complete or for remediation that installs an engineered feature that must be maintained or otherwise operated in order for the remediation to remain protective of human health and the environment.

Response actions completed within the Site include water treatment, waste pile capping, waste pile removal, and construction of storm water and erosion controls. Because most of the response actions have left waste in place and do not allow for future unrestricted use, ICs are required to ensure long-term protectiveness of the response actions.

OU2 and OU3 Institutional Controls

For Operable Units 2 and 3, the most commonly utilized institutional controls are requirements embodied in enforcement tools, such as administrative orders on consent, unilateral administrative orders, consent decrees, and prospective purchaser agreements. Other ICs, such as contractual agreements and zoning requirements also have been used. Table 7 identifies the different OU2/OU3 parcels within the Superfund Study area where response actions have been completed, and the institutional control associated with those parcels.

Where enforcement tools implement the institutional control, various restrictions are typically applied to the property via the enforcement mechanism. A number of land use and other restrictions have been used at the Site. Typical land use restrictions include requirements to notify successors in title, requirements to notify EPA prior to any transfer of property, developmental restrictions, and requirements to perform response action operation and maintenance. Using an enforcement tool to implement an IC can be of limited use, because it generally only applies to and is enforceable against the respondent/property owner identified in the enforcement document. CDPHE and EPA need to continue to monitor property ownership at these Sites to ensure that existing ICs remain applicable and enforceable. Should property ownership change, new or additional ICs may be necessary.

OU 4 Institutional Controls

In 2001, Colorado Senate Bill 01-145 modified sections of the state hazardous waste statutes to create the authority for CDPHE to approve requests by any party to restrict the future use of a property using an enforceable agreement called an environmental real covenant. These covenants are recorded with the deed and run with the land. They provide a mechanism to ensure that institutional controls that are a part of environmental remediation projects are properly implemented, and that engineered structures are protected and maintained so that remedies remain effective as long as residual contamination remains. Since the passage of Colorado's environmental covenant law, covenants are required for all clean-up decisions made on or after July 1, 2001 unless the cleanup removes all waste material and results in unrestricted use of the property affected.

As shown in Table 8, CDPHE has secured environmental covenants for all of the OU4 Phase I properties and most of the Phase II and Phase III properties as required per C.R.S. 25-15-318 through 327. The environmental covenant is intended to alert future landowners that an environmental remediation action was completed at the property and to memorialize the associated land use restrictions. Copies of these covenants were provided to EPA for its Superfund institutional control tracking system. CDPHE continues to work with the remaining landowners to have them grant their respective covenants. CDPHE performs annual inspections of all Site properties with environmental covenants to ensure land use is consistent with environmental covenant restrictions.

In addition to institutional controls, engineering controls, such as fences, may be used to ensure remedy protectiveness. For the OU4 Site-wide mine waste repository, significant resources were directed towards establishing vegetation to prevent erosion of the soil cover and potential release of mine waste. A three-strand barbed wire fence was constructed around the boundary of the property to protect the vegetation from off-highway vehicles and cattle. In July 2014, CDPHE inspectors observed that several areas of the fence were damaged, including one area that had been cut, and numerous cattle were present. CDPHE herded the cattle off the property, repaired the fence and notified the Gilpin County sheriff's office. Cattle were observed on several occasions in August and more fence repairs made. The Church Placer Operations and Maintenance Plan (June 2011) includes the inspection of fences and gates. More frequent monitoring of the integrity of the fence needs to be conducted in the future.

Table 7: Operable Units 2 and 3 Institutional Controls and Inspection Summary

Project (OUs 2 & 3)	In-place Closure Engineered Structure Removal	Institutional Control Settlement Document	Document Date Docket Number	Settlement Restrictions Identified	Inspection Required
Argo Mill	In-place closure	Consent decree	CERCLA VIII-97-WY-286	None	Yes
Black Eagle	In-place closure	Unilateral order	CERCLA VIII-94-23	Deed notifications, notify EPA of property transfer and development restrictions.	Yes
Big 5 Waste Rock Pile	In-place closure	Prospective purchaser agreement	-	Deed notifications and successor in title requirements	Yes
Big Five Tunnel	Engineered structure	None	-	None	Yes
Boodle Mill	In-place closure	Prospective purchaser agreement	-	O&M responsibilities, deed notifications and notify EPA of property transfer	Yes
Chase Gulch 1	Removal	Prospective purchaser agreement	CERCLA VIII-98-20	None	No
Chase Gulch 2	In-place closure	None	-	-	Yes
Clay County Mill	In-place closure	Administrative order on consent	CERCLA VIII-95-18	Deed notifications, notify EPA of property transfer and development restrictions.	Yes
Gregory Gulch 1	In-place closure	Administrative order on consent	CERCLA VIII-95-16	Deed notifications, notify EPA of property transfer and development restrictions.	Yes
Gregory Gulch 2	In-place closure	Unilateral administrative order	CERCLA VIII-95-74,75, 97	Deed notifications, notify EPA of property transfer.	Yes
Gregory Incline	In-place closure	Administrative order on consent	CERCLA VIII-95-12	Deed notifications, notify EPA of property transfer.	Yes
Little Bear	Removal	Participating agreement	CERCLA VIII-95-04	None	No
Millsite 11 & 12	Removal	Administrative order on consent	-	None	No
McClelland Tailings Pile	In-place closure	Three-party agreement	18-November-1997	O&M requirements & zoning restrictions	Yes
Minnesota Mine	In-place closure	Administrative order on consent	CERCLA VIII-95-04	Deed notifications, notify EPA of property transfer. Development restrictions.	Yes
National Tunnel Waste Rock Pile	Removal	Administrative order on consent	CERCLA VIII-95-14, 21, 22	Deed notifications, notify EPA of property transfer. Development restrictions	No
North Clear Creek Tailings	In-place closure	Administrative order on consent	CERCLA VIII-96	Deed notifications, notify EPA of property transfer. Development restrictions.	Yes

Table 8: OU4 Environmental Covenants

Waste Rock Pile	Owner	Covenant Date	Covenant Number	Property Description
Anchor	William H. Hearne III	25-Aug-08	HMCOV00054	Helmer Lode Claim MS# 148, Gilpin County
Anchor	Shugar Living Trust	25-Aug-08	HMCOV00058	Church Placer MS# 416, Gilpin County
Anchor	Shuger Living Trust	25-Aug-08	HMCOV00056	Martin Lode Claim MS# 147, Gilpin County
Anchor	Shuger Living Trust	25-Aug-08	HMCOV00055	Helmer Lode Claim MS# 148, Gilpin County
Anchor	Glory Hole Mining Co.	25-Aug-08	HMCOV00059	Helmer Lode Claim MS# 148, Gilpin County
Church Placer	State of Colorado	30-Oct-08	n/a[1]	Tract B, Parcel C, Church Placer Claim, Gilpin
Gregory Gulch #3	William C Russell Jr.	25-Aug-08	HMCOV00060	Bates Lode Claim MS# 13391, Gilpin County
Hampton	City of Black Hawk	25-Aug-08	HMCOV00057	Hampton Lode claim MS# 581, Gilpin County
Hampton	Sanford S. Herrick	19-Oct-09	HMCOV00067	Rainbow Lode Claim MS# 770, Gilpin County
Powers	City of Black Hawk	25-Aug-08	HMCOV00062	Hope Lode Claim MS# 19873, Gilpin County
Powers	City of Black Hawk	25-Aug-08	HMCOV00053	Powers Lode Claim MS# 550, Gilpin County
Russell Gulch Sediment Dam	Robert/Anna Young	6-Oct-10	HMCOV00071	NW Qtr. Section 19, T 3 SOUTH, R 72 WEST
Silver Dollar	City of Black Hawk	25-Aug-08	HMCOV00052	Silver Dollar Lode Claim MS# 591Gilpin County
Silver Dollar	Jefferson A. Fassler	19-Mar-09	HMCOV00063	Silver Dollar Lode Claim MS# 591Gilpin County
Iroquois Check Dam	City of Black Hawk	25-Aug-08	HMCOV00061	Iroquois Lode Claim MS# 4969, Gilpin County
Keystone	Bonanza Land, LLC	29-Aug-2013	HMCOV00096	Helos Lode Claim MS # 127, Gilpin County
Keystone	Bonanza Land, LLC	29-Aug-2013	HMCOV00098	Moon Lode Claim MS # 818, Gilpin County
Keystone	Bonanza Land, LLC	29-Aug-2013	HMCOV00095	Express Lode Claim MS # 555, Gilpin County
Keystone	Bonanza Land, LLC	29-Aug-2013	HMCOV00097	Keystone Lode Claim MS # 163, Gilpin County
Pittsburg	Bonanza Land, LLC			La Place Lode Claim MS # 6003, Gilpin County
Pittsburg	Superior Gold, LLC	18-Nov-2013	HMCOV00103	Dorchester Lode Claim MS # 408, Gilpin County
Pittsburg	Superior Gold, LLC	18-Nov-2013	HMCOV00100	Annie Mary Lode Claim MS # 11571, Gilpin County
Pittsburg	Superior Gold, LLC	18-Nov-2013	HMCOV00102	Eighty Niner Lode Claim MS# 16779, Gilpin County
Pittsburg	Philip R. Inglee	15-Nov-2013	HMCOV00101	Mineral Lode Claim MS# 162, Gilpin County
Alva Adams	Scott Hobbs			Alva Adams Lode Claim MS # 6323, Gilpin County
Centennial East	Allen G. Provost			Togo Lode Claim MS # 17945, Gilpin County
Church Placer	Young Ranch	16-Nov-2013	HMCOV00099	Church Placer MS # 416, Gilpin County
Church Placer/Hazeltine	His Followers Limited, LP			Parcel 183524200009, Gilpin County
Church Placer /Hazeltine	His Followers Limited, LP			Parcel 183524200008, Gilpin County (Acct R114740)
Church Placer/Hazeltine	His Followers Limited, LP			Parcel 18352420007, Gilpin County
Church Placer/Hazeltine	His Followers Limited, LP			Parcel 183524200008, Gilpin County (Acct R114738)

Unless otherwise noted, covenant prohibits disturbance of engineered structure unless approved by CDPHE.

[1] Deed restriction prohibits any future residential development of the property.

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The 2009 Five-Year Review for the Clear Creek/Central City Superfund Site provided the following protectiveness statement:

> *A full determination of the protectiveness of the remedies cannot be made because Site actions are not complete. A determination of protectiveness will be obtained by completing a comprehensive sampling of Clear Creek once the remedy is complete and operational. In the interim, exposure pathways that could result in unacceptable risks to human health are being controlled. The remedies that have been completed at the Site remain protective.*

Eight recommendations were provided in the 2009 Five-Year Review. Items 1, 2, 3, 4 and 6 affect protectiveness, whereas items 5, 7 and 8 do not. The recommendations and a summary of the follow-up actions are listed in Table 9.

In addition, on August 11, 2015, in an effort to update the IEUBK model used for risk analysis at the site, EPA collected and analyzed soil samples from various waste piles in Central City. See discussion in Section 6.2.2.

Table 9: Status of Recommendations from the 2009 Five-Year Review

Issue	Implementation Status Description	Status	Completion Date
The Gregory Incline, National Tunnel and Quartz Hill discharges remain the major sources of metals loading to the North Fork of Clear Creek. These three discharges have been identified for treatment per the OU4 ROD.	A 2010 Amendment to the OU4 ROD selected active treatment of the National Tunnel, Gregory Incline and Gregory Gulch surface water (which includes the Quartz Tunnel discharge) at a new water treatment plant. A conveyance pipeline has been constructed to convey the sources to the location of the future water treatment plant. Construction of the new water treatment plant is complete, however the plant is in the Operational and Functional phase of the remedial action.	Pending	September 2018
The Quartz Hill tailings pile has been identified for capping or other response action under OU4. This task will need to be completed to finalize OU4 tasks at the Site.	Implementation of the remedy for the Quartz Hill waste pile occurred, as described in Section 4.4.4	Complete	September 2014
The OU4 ROD called for North Clear Creek improvements. CDPHE will continue to work with CDOT to implement the North Clear Creek improvements in coordination with CDOT's SH 119 widening project.	Mine waste removal and sediment improvement measures were installed in conjunction with the SH 119 widening project, as described in Section 4.4.4.	Complete	September 2012
Construction of a flow-through bulkhead in the Argo Tunnel is needed to prevent a future surge event that could overwhelm the ATWTF and result in a system by-pass. A surge event from the tunnel could cause a fish kill and compromise the city of Golden's drinking water supply.	An Explanation of Significant Differences for the inclusion of a flow-through bulkhead was approved by EPA on September 12, 2014. Construction of the flow-through bulkhead is completed.	Complete	October 2015
An evaluation of Clear Creek aquatic conditions and zinc-loading reductions in the area of Silver Plume should be conducted in coordination with	CDPHE and EPA continue to collect water quality data, and sampling frequency of the Clear Creek reach along Silver Plume was increased to eight times during 2013. Recent data suggests that	Complete	September 2017

Table 9: Status of Recommendations from the 2009 Five-Year Review

Issue	Implementation Status Description	Status	Completion Date
the Water Quality Control Division and Colorado Division of Wildlife prior to the 2013 Water Quality Control Commission triennial issues scoping hearing. This data collection effort should be timed to support that hearing.	while the Burleigh Tunnel is a source of zinc loading, the majority of the zinc load originates along the east end of Silver Plume. Macroinvertebrate sampling occurred in October 2014. CDPHE and EPA was unable to reach agreement on an approach for attainment before the 2015 rulemaking hearing. EPA and CDPHE continues to collaborate on this matter with the goal of reaching consensus before the next rulemaking hearing (scheduled for 2018)		
Removal of five waste rock piles in the headwaters of Virginia Canyon would eliminate any further transport of metals-contaminated sediment to Clear Creek and the residents of Idaho Springs during storm events.	The EPA Emergency Response Program conducted a removal action to address the five Virginia Canyon waste piles, as described in Section 4.3.4. The action included excavation, consolidation, regrading and erosion control.	Complete	August 2010
Repair damage to the sediment control and mine waste remediation project that occurred as a result of the July 2009 severe storm event.	Damage incurred during the July 2009 storm event was repaired during 2010. Additional damage was noted at the Pittsburgh Waste Rock and Tailings Pile as a result of the extreme rainfall event of mid-September 2013. Repair work was again conducted at the Pittsburg during this period and completed the following month.	Complete	October 2013
Implement the ATWTF improvements identified during the Remedial System Evaluation.	The ATWTF was reconfigured to function as a high-density sludge treatment process in 2013, as described in Section 4.3.4.	Complete	July 2014

6.0 FIVE-YEAR REVIEW PROCESS

This five-year review was largely completed between March and September 2014, but was extended to include the results of the soil sampling effort described in Section 6.2.2. Components of the five-year review included:

- Community involvement
- Document review
- Soil sampling and analysis
- Data review
- Site inspection
- Local interviews
- Five-year review report development and review

6.1 Community Involvement

Members of the community were informally notified that the fifth five-year review was occurring via a public notice published in the *Clear Creek Courant* newspaper on April 23, 2014. Notification also occurred as an announcement at the May 8, 2014 meeting of the Upper Clear Creek Watershed Association. The Clear Creek/Central City Community Involvement Plan was updated in conjunction with this five-year review, and is included as Attachment E of this report. Once finalized, the community will be notified that the five-year review has been completed, and the results of the review will be provided to all Site document repositories.

A summary of the interviews is included in the updated Community Involvement Plan. One of the comments is discussed below, as it pertains to the remedial action objectives and remediation goals previously established for the Site.

One commenter expressed concern over the ability of the OU4 remedy to meet the new table value standard for cadmium in surface water. In 2005, the Water Quality Control Commission adopted new hardness based equations for cadmium in North Clear Creek. These equations applied to the Regulation 38 - *Classifications and Numeric Standards for South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin* tables in 2010 and result in more stringent standards. Since these new standards postdate the ROD, they will be reviewed to determine if they have an impact on the determination of protectiveness of the remedy.

While it is anticipated that the NCCWTP will attain a discharge quality that meets the new, more stringent cadmium requirements, the extent to which other sources may contribute cadmium loading is uncertain. Following implementation of the NCCWTP, water quality and aquatic sampling of North Clear Creek will be conducted throughout the year. The results of this effort will help determine if existing standards might be attained, or if less stringent Site-specific water quality criteria would be protective and necessary for this segment.

6.2 Document Review

Several relevant documents were examined in support of this five-year review. A list of documents referenced is presented in Section 12. A thorough evaluation of remediation goals and associated Applicable or Relevant and Appropriate Requirements was conducted.

6.2.1 Water Quality Applicable or Relevant and Appropriate Requirements

As part of the five-year review, ARARs developed during previous Site evaluations were reviewed. The primary purpose of this review was to determine if any newly promulgated or modified requirements of federal or state environmental laws have significantly changed the protectiveness of the remedies implemented at the Site. The ARARs reviewed were those included in the OU2, OU3 and OU4 RODs. The OU1 ARARs were not reviewed because OU1 was superseded by OU3.

The surface-water remedial action objective developed during the Phase II studies is to "reduce metals loading to streams from point discharges in order to reduce in-stream metals concentrations to levels protective of aquatic life." The OU3 ROD stated:

> *"The Selected Alternative may not achieve Colorado state table value standards on Clear Creek below the confluence with the West Fork of Clear Creek. EPA and [CDPHE] will monitor the effectiveness of the remedy after it is implemented to determine if state table value standards are achieved. If they are not achieved, an evaluation will be made to determine if additional cleanup is required, or it may be determined that a site-specific state stream standard can be established which is protective of the uses of Clear Creek."*

Remedial actions have occurred with the general objective of protecting brown trout in Clear Creek's mainstem as well as major tributaries. While no numeric criteria were established in the OU3 ROD, the agencies have continually evaluated the goal of compliance with ARARs by comparing ambient water quality to the water quality criteria outlined in regulations promulgated under the Colorado Water Quality Control Act. Water quality standards for Clear Creek are promulgated by the Water Quality Control Commission (WQCC) under Regulation 31 – *The Basic Standards and Methodologies for Surface Water*; and Regulation 38 - *Classifications and Numeric Standards for South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin.*

Table 10: Water Quality Standards for Clear Creek Basin in effect at OU3 ROD, 1991

Total Recoverable unless otherwise noted (μg/L)

	Arsenic	Cadmium	Chromium		Copper	Iron		Lead	Manganese		Nickel	Silver	Zinc
Segment			III	VI		Diss.	Total		Diss.	Total			
01	50	0.4	50	25	11	300	-	8.0	50	1,000	50	0.1	80
02	50	8.0	100	25	10	-	1,000	5.0	-	1,000	50	0.1	280
03a	50	0.4	50	25	5.0	300	1,000	4.0	50	1,000	50	0.1	90
03b	50	0.4	50	40	50	300	1,000	4.0	50	1,000	50	0.1	450
04	50	3.0	50	25	17	300	1,000	25	50	1,225	100	0.1	60
05	50	3.0	100	25	23	-	1,000	25	-	1,100	100	0.1	100
06	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS
07	50	14	100	25	23	-	1,000	25	-	9,400	100	0.1	740
08	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 10: Water Quality Standards for Clear Creek Basin in effect at OU3 ROD, 1991

Total Recoverable unless otherwise noted (µg/L)

	Arsenic	Cadmium	Chromium		Copper	Iron		Lead	Manganese		Nickel	Silver	Zinc
Segment			III	VI		Diss.	Total		Diss.	Total			
09	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS	TVS
10	50	0.4	50	25	6.0	300	1,000	4.0	50	1,000	50	0.1	110
11	TVS	3.0	TVS	TVS	17	TVS	TVS	TVS	TVS	TVS	TVS	TVS	300
12	50	10	50	50	1,000	300	-	50	50	-	-	50	5,000
13	50	0.4	100	25	64	-	5,400	45	-	1,000	50	0.1	500

TVS – Table Value Standards

In order to achieve the OU4 remedial action objectives, numeric remediation goals were established in the OU4 ROD. Due to the significant variation in hardness during high and low flow regimens, the numeric goals were established on a seasonal basis of May 1 through August 31 (high flow) and September 1 through April 30 (low flow).

Table 11: Site Remediation Goals and Stream Standards in effect at OU4 ROD, 2004

Metal	Flow Regime	Remediation Goals (µg/L)		Stream Standard (µg/L)	
		North Fork (Segment 13b)	Clear Creek below Idaho Springs (Segment 11)	North Fork (Segment 13b)	Clear Creek below Idaho Springs (Segment 11)
Zinc (dissolved)	High-Flow	381	200	1,864 (740)[1]	339 (300)[1]
	Low-Flow	675	300	1,864 (740)[1]	339 (300)[1]
Copper (dissolved)	High-Flow	7.4	5.2	64	17
	Low-Flow	15.1	9.2	64	17
Cadmium (dissolved)	High-Flow	1.9	1.4	6.0 (1.9)[1]	1.4
	Low-Flow	3.5	2.3	6.0 (3.5)[1]	2.9
Manganese (dissolved)	High-Flow	1,531	600	5,293 (1,431)[1]	861 (600)[1]
	Low-Flow	2,021	600	5,293 (2,021)[1]	861 (600)[1]

[1] Value presented is a temporary modification. The underlying standard is in parenthesis.

In the years that have elapsed since the signing of the OU2 (March 1988), OU3 (September 1991) and OU4 (September 2004) RODs, the WQCC has adopted several changes in Regulation 38, including changes to the water quality standards of the Clear Creek mainstem and tributaries. The historical chronology of development and changes of the stream standards of interest (trace metals) through September 2009 is outlined in the 2009 Five-Year Review.

Since the 2009 review, the WQCC has further amended Regulation 38. Effective January 1 2010, segment 2 was divided into three segments. Clear Creek segments 2a, 2b and 2c were created to better represent differences in water quality between the segments. Temporary modifications were revised based on the re-segmentation and/or to be protective of the aquatic community expected to be present in the riverine portions. The new temporary modifications were listed as:

Segment 2a: Zn(ac) = 586 µg/L; Zn(ch) = 353 µg/L; Cd(ch) = 1.54 µg/L
Segment 2c: Cu(ch) = 11.4 µg/L
Segment 11: Cd(ch) = 1.42 µg/L

Recalculated underlying zinc standards were also adopted for segments 2a, 2c, 3a, 3b and 11.

$$\mathrm{Zn(ac)} = 0.978e^{0.8537[\ln(\mathrm{hardness})]+1.9467)}$$

$$\mathrm{Zn(ch)} = 0.986e^{0.8537[\ln(\mathrm{hardness})]+1.8032)}$$

In addition, a review of trivalent chromium standards showed that the existing standard was not protective of aquatic life when the average hardness was less than 61 mg/L. Therefore, the chronic chromium III standard for segments with aquatic life use classifications and an average hardness less than 61 mg/L, was revised to table value standards. This applies to Clear Creek segments 1, 3a, 3b, 6, 9a and 10.

Changes to the arsenic standards were also effective January 1, 2010. The acute and chronic arsenic standards were set at 340 µg/L (dissolved) and 0.02 µg/L (total recoverable), respectively, for most segments (1, 2a, 2b, 2c, 3a, 3b, 4, 6, 9a, 9b, 10, 11, 12 and 13a). New chronic standards for arsenic were applied to segment 5 (7.6 µg/L total recoverable) and segment 13b (100 µg/L total recoverable).

The classifications and standards for the Clear Creek Basin effective April 30, 2014, were used for this five-year review and are provided in Attachment B.

6.2.2 Soil Applicable or Relevant and Appropriate Requirements

During the Phase II studies, the potential risk from lead in soil was evaluated by estimating blood lead levels using the Integrated Exposure Uptake Biokinetic (IEUBK) model. The model inputs included a conservative exposure scenario and minimum and maximum lead concentrations in sampled waste piles. The estimated blood lead level ranged from 22 micrograms lead per deciliter blood (µg/dL) to 30 µg/dL, above the range of concern of 10 – 15 µg/dL established by EPA in 1988.

The 1988 IEUBK modeling used an average residential scenario for children aged 0 to 72 months; a soil lead concentration of 500 mg/kg; assumed both indoor and outdoor exposures; and used 12.5 µg/dL as the cutoff blood lead concentration. Based on this scenario, 95.54 percent of the population was protected using a remedial action benchmark of 500 mg/kg.

A voluntary blood lead survey was conducted during September 1990 in the communities of Idaho Springs, Black Hawk and Central City. A total of 105 children under age six participated. The average blood lead level was 5.9 µg/dL. Fifty-five children had blood lead levels less than 5 µg/dL. Nine children (8.6 percent) were found to have blood lead concentrations between 10 µg/dL and 15 µg/dL. The survey concluded that children with blood lead levels of 10 µg/dL or greater tended to have backyard soil lead levels equal to or greater than 500 mg/kg.

In 1989, the EPA Office of Solid Waste and Emergency Response (OSWER) issued Directive 9355.4-02 recommending an interim soil cleanup level for lead at 500 to 1,000 mg/kg. This range was considered protective for direct contact at residential settings.

Based on the IEUBK model, blood lead survey and EPA Directive 9355.4-02, a remedial action benchmark for lead of 500 mg/kg was used.

In August 1994, OSWER issued Directive 9355.4-12, *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*. This directive recommends using 400 mg/kg soil lead (based on application of the IEUBK model) as a screening level for lead in soil for residential scenarios at CERCLA sites and at RCRA Corrective Action sites. Residential areas with soil lead below 400 mg/kg generally require no further action, while at sites where the screening level is exceeded, OSWER recommends using the IEUBK model during the Remedial Investigation or the RCRA Facility Investigation for evaluating potential risks to humans from environmental exposures to lead under residential scenarios. EPA further recommended that a soil lead concentration be determined so that a typical child or group of children exposed to lead at this level would have an estimated risk of no more than 5 percent of exceeding a blood lead of 10 µg/dL. In applying the IEUBK model for this purpose, appropriate site-specific data on model input parameters, including background exposures to lead, would be identified.

Until recently, the U.S. Centers for Disease Control and Prevention (CDC) had established a level of concern for case management of 10 µg/dL. Recent scientific research, however, has shown that blood lead levels below 10 µg/dL can cause serious and irreversible health effects in children. Blood lead levels below 10 µg/dL have been associated with neurological, behavioral, immunological and developmental effects in young children. On January 4, 2012, CDC's Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended that CDC adopt the 97.5 percentile blood lead level of children in the United States (ages 1 to 5 years old) as the reference value for designating elevated blood lead levels in children. Based on the latest National Health and Nutrition Examination Survey (NHANES) data, the 97.5 percent currently is 5 µg/dL. On June 7, 2012, the CDC released a statement indicating concurrence with the recommendations of the ACCLPP. CDC plans to use the reference value as defined to identify high-risk childhood populations and geographic areas most in need of primary prevention.

On August 11, 2015, in response to CDC's statement and an effort to update the IEUBK model used for risk analysis at the at the site, EPA collected and analyzed soil samples from various waste piles in Central City. The samples were analyzed for lead and arsenic speciation and bioavailability determination using both *in vivo* and *in vitro* methods. The study results lacked sufficient location-specific data to evaluate potential residential exposure levels relative to soil concentrations of lead and arsenic, as discussed in Section 6.2.2 and the Draft Technical Memorandum titled *"Characterization of Waste Rock Piles in the Central City/Clear Creek Superfund Site:Pb and As speciation at the Advanced Photon Source (Argon National Laboratory) and Bioavailability determination using both in vivo and in vitro methods"*, dated November 16, 2016.

The lead cleanup at the Site integrates EPA's 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities (Office of Solid Waste and Emergency Response [OSWER] Directive 9355.4-12) and the 1998 update to this guidance (Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities (OSWER Directive 9200.4-27P). However, in 2016, EPA's Office of Land and Emergency Management (OLEM) released Directive 9200.2-167, which updates the scientific considerations to be used at lead cleanups conducted according to EPA's 1994 and 1998 directives. EPA's experience has demonstrated that lead-contaminated soil responses are more effective when they employ a multi-pathway approach. Thus, the 2016 directive highlights the current science and risk assessment tools that EPA may consider when implementing lead cleanups. A similar evaluation to the one completed on August 11, 2015, is planned for the near future which will include addressing the deficiencies of the previous study, which will include, among other objectives, the collection and analysis of more robust location-specific data and consider current guidance to determine if any changes are warranted to ensure future protectiveness.

A copy of the 2016 directive can be found at https://semspub.epa.gov/src/document/08/1884174.pdf.

6.3 Data Review

Surface water sampling has been conducted at the Clear Creek/Central City Superfund Site since the early 1980s. For this five-year review, an evaluation of surface water data collected from 2010 through 2013 was evaluated. Soil sampling conducted during August 2015 was also reviewed, as discussed in Section 6.2.2.

6.3.1 Operable Unit 3

The 2010 through 2013 surface water data was reviewed and the current water quality by stream segment was compared to the water quality standards in effect at the time of remedy decision (OU3 ROD, September 1991) and in effect as of March 2014.

Stream segment descriptions are provided in Table 12, and are depicted on Figure 6.

Table 12: Segmentation of Study Area (1991 and 2014)

Segment ID	1991 Description	2014 Description
01	Mainstem of Clear Creek, including all tributaries, lakes, and reservoirs, from the source to the I-70 bridge above Silver Plume	
02	Mainstem of Clear Creek, including all of the tributaries, lakes and reservoirs, from the I-70 bridge above Silver Plume to the Argo Tunnel discharge, except for the specific listings in Segments 3 through 9	
2a		Mainstem of Clear Creek, including all of the tributaries **and wetlands**, from the I-70 bridge above Silver Plume to **a point just above the confluence with West Fork Clear Creek**, except for the specific listings in Segments **3a and 3b**
2b		Mainstem of Clear Creek, including all of the tributaries **and wetlands**, from **the confluence with West Fork Clear Creek to a point just below the confluence with Mill Creek**, except for the specific listings in Segments **4 through 8**
2c		Mainstem of Clear Creek, including all of the tributaries **and wetlands**, from **a point just below the confluence with Mill Creek** to a point just above the Argo Tunnel discharge, except for the specific listings in Segments **9a, 9b, and 10**
03	Mainstem of South Clear Creek, including all tributaries, lakes, and reservoirs, from the source to the confluence with Clear Creek, except for the specific listing in 3b	
3a		Mainstem of South Clear Creek, including all tributaries **and wetlands**, from the source to the confluence with Clear Creek, except for the specific listing in 3b **and 19**
3b	Mainstem of Leavenworth Creek from source to confluence with South Clear Creek	
04	Mainstem of West Clear Creek from the source to the confluence with Woods Creek	

Table 12: Segmentation of Study Area (1991 and 2014)

Segment ID	1991 Description	2014 Description
05	Mainstem of West Clear Creek from the confluence with Woods Creek to the confluence with Clear Creek	
06	All tributaries to West Clear Creek, including all lakes and reservoirs, from the source to the confluence with Clear Creek, except for the specific listings in Segments 7 and 8	
07	Mainstem of Woods Creek from the outlet of Upper Urad Reservoir to the confluence with West Clear Creek	Mainstem of Woods Creek from the outlet of Upper Urad Reservoir to the confluence with West Clear Creek, **including Lower Urad Reservoir**
08	Mainstem of Lion Creek from the source to the confluence with West Clear Creek	
09	Mainstem of Fall River, including all tributaries, lakes, and reservoirs, from the source to the confluence with Clear Creek	
9a		Mainstem of Fall River, including all tributaries **and wetlands,** from the source to the confluence with Clear Creek
9b		Mainstem **of Trail Creek, including all tributaries and wetlands,** from the source to the confluence with Clear Creek
10	Mainstem of Chicago Creek, including all tributaries, lakes, and reservoirs, from the source to the confluence with Clear Creek	Mainstem of Chicago Creek, including all tributaries **and wetlands,** from the source to the confluence with Clear Creek, **except for specific listings in Segment 19**
11	Mainstem of Clear Creek from the Argo Tunnel discharge to the Farmers Highline Canal diversion in Golden	Mainstem of Clear Creek from **a point just above** the Argo Tunnel discharge to the Farmers Highline Canal diversion in Golden, Colorado
12	All tributaries to Clear Creek, including all lakes and reservoirs, from the Argo Tunnel discharge to the Farmers Highline Canal diversion in Golden, except for specific listings in Segment 13	All tributaries to Clear Creek, including all **wetlands,** from the Argo Tunnel discharge to the Farmers Highline Canal diversion in Golden, Colorado, except for specific listings in Segment **13a and 13b**
13	Mainstem of North Clear Creek, including all tributaries, lakes and reservoirs, from the source to the confluence	
13a		Mainstem of North Clear Creek, including all tributaries **and wetlands,** from its source to its confluence **with Chase Gulch. And Four Mile Gulch, including all tributaries and wetlands, from their sources to their confluence with North Clear Creek and Eureka Gulch, including all tributaries and wetlands, from its source to its confluence with Gregory Gulch**
13b		Mainstem of North Clear Creek, including all tributaries **and wetlands,** from **a point just below the confluence with Chase Gulch to the confluence with Clear Creek, except for the specific listings in Segment 13a**
19		All tributaries to Clear Creek, including wetlands, within the Mt. Evans Wilderness Area

*Bold text added to highlight changes in text from 1991 to 2014

Using the Water Quality Control Division's 2012 303(D) Listing Methodology, an evaluation of attainment of the 1991 and 2014 water quality standards was performed for each segment. In addition, Macroinvertebrate Multi-Metric Index data was reviewed using methods described in Water Quality Control Commission Policy 10-1.

A summary of the attainment of the water quality criteria in effect at the OU3 ROD is provided in Table 13. As detailed in Section 6.2.1, the OU3 remedial actions have occurred with the general objective of protecting brown trout in Clear Creek's mainstem as well as major tributaries. While no numeric criteria were established in the OU3 ROD, the agencies have continually evaluated the goal of compliance with ARARs by comparing ambient water quality to the water quality criteria outlined in regulations promulgated under the Colorado Water Quality Control Act.

In segments where an impairment was indicated, the source data was further evaluated to see if there is a discernible cause of impairment.

Segment 2a – zinc impairment

As noted in previous five-year review reports, the zinc concentration in Segment 2a is above the water quality criteria in place at the time of the 1991 ROD (280 µg/L), with an 85th percentile value of 303 µg/L. To address this issue, CDPHE and EPA planned to conduct an evaluation of aquatic conditions, including habitat, to determine the appropriate biological expected condition for the segment. While a habitat assessment was conducted by CDPHE with assistance from the Colorado Parks and Wildlife division, no formal report was generated. However, data reviewed as part of the assessment indicated that the target area is too steep and aquatic conditions would not provide sufficient habitat to support fish.

The Burleigh Tunnel was originally identified as a priority mine discharge for remedial action. However, annual high-flow and low-flow monitoring conducted between 1999 and 2001 indicated that the in-steam concentrations of dissolved zinc downstream of the Burleigh Tunnel were significantly below the aquatic stream standard. Additionally, the local municipality, the town of Silver Plume, does not extract water for domestic use from either ground or surface water downstream of the discharge. Therefore, it was concluded that the Burleigh Tunnel discharge does not pose a threat to human health or the environment. An amendment to the OU3 ROD was issued in September 2003 to select the No Action Alternative as the remedy for the Burleigh Tunnel.

Table 13: Summary of Non-Attainment of 2010-2013 Data Compared to 1991 Water Quality Standards within the Clear Creek Watershed Study Area

Segment[2]	Designated Use	Causes of Impairment[1]
COSPCL01	Aquatic Life- Cold 1	*No Data*
COSPCL02 (a,b,&c)[3]	Aquatic Life- Cold 1	Zinc
COSPCL02a	Aquatic Life- Cold 1	Zinc
COSPCL02b	Aquatic Life- Cold 1	
COSPCL02c	Aquatic Life- Cold 1	Cadmium, Copper, Tot. Rec. Iron, Lead, Manganese, Nickel, Zinc
COSPCL03a	Aquatic Life- Cold 1	*No Data*
COSPCL03b	Aquatic Life- Cold 2	*No Data*
COSPCL04	Aquatic Life- Cold 1	*No Data*
COSPCL05	Aquatic Life- Cold 1	Silver
COSPCL06	Aquatic Life- Cold 1	Copper (ac), Zinc (ch)
COSPCL07	Aquatic Life- Cold 2	*No Data*
COSPCL08	Aquatic Life- Cold 2	*No standards applied in Regulation 38*
COSPCL09 (a & b)[3]	Aquatic Life- Cold 1	Cadmium (ac/ch), Copper (ac/ch), Lead (ch), Manganese (ch), Zinc (ch)
COSPCL09a	Aquatic Life- Cold 1	Copper (ac/ch), Zinc (ac/ch)
COSPCL09b	Aquatic Life- Cold 1	Cadmium (ac/ch), Copper (ac/ch), Lead (ch), Manganese (ch), Silver (ac), Zinc (ac/ch)
COSPCL10	Aquatic Life- Cold 1	*No Data*
COSPCL11	Aquatic Life- Cold 1	Sulfate (ch)
COSPCL12	Aquatic Life- Cold 2	*No Data*

[1] Causes of impairment based on the water quality standards applicable at the time of the 1991 ROD and evaluated using the detailed assessment procedure with paired hardness values for hardness dependent standards.

[2] Refer to Figure 6.

[3] Historical (1991) stream segmentation

Segment 2c – cadmium, copper, iron (total recoverable), lead, manganese, nickel and zinc impairments

Based on the attainment assessment, Segment 2c appears to exceed 1991 water quality standards for several parameters. However, a review of the 2010 – 2013 data indicates it is heavily influenced by sampling of Turkey Gulch near the Rockford Tunnel discharge (approximately 40 percent of samples). When the Segment 2a, 2b, and 2c data is combined into one segment as was the case in 1991, attainment is achieved for all parameters except for zinc.

Segment 5 – silver impairment

Segment 5, mainstem West Clear Creek, exceeds the 1991 water quality criteria for silver. Based on a review of the 2010-2013 sampling data, the silver detections are located high in the watershed (downstream of Hoop Creek). No contaminant source areas were identified in this reach of West Clear Creek during the Phase II investigations, with the exception of the Urad Mine. The Urad treatment plant is regulated under the Colorado Discharge Permit System.

Segment 6 – acute copper and chronic zinc impairments

Segment 6 has very low average hardness (11 mg/L), which leads to stringent calculated table value standards for copper and zinc. During the 2010-2013 data period, all samples were collected on Mad Creek above the confluence with West Clear Creek. No source areas were identified along Mad Creek during the Phase II investigations.

Segment 9a – acute and chronic copper and zinc impairments
No sources of metals contamination were identified along Fall River during the Phase II investigations. While the attainment analysis indicates that copper and zinc are above the 1991 water quality criteria, Segment 9a has very low hardness (26 mg/L). This translates to stringent calculated table value standards.

Segment 9b – acute silver, chronic lead and manganese; and acute and chronic cadmium, copper and zinc impairments
Trail Creek (Segment 9b) contains elevated concentrations of several metals. During the Phase II investigations, it was determined that while Trail Creek exceeded state stream standards, the flow was low enough to not impact mainstem Clear Creek. Therefore, no remedial actions were performed.

Segment 11 – sulfate impairment
Segment 11 indicates non-attainment for sulfate; however there was no remediation goal established for sulfate. In addition, there were only two samples within the period of analysis. Data sets comprised of three or fewer samples that indicate impairment of the chronic standard will result in placement on the WQCC Regulation 93 – *Colorado's Section 303(D) List of Impaired Waters and Monitoring and Evaluation List* Monitoring and Evaluation List (M&E List) which identifies water bodies where there is reason to suspect water quality problems, but there is also uncertainty regarding one or more factors, such as the representative nature of the data.

The attainment of the new arsenic standards was also assessed. All segments for which data was available indicated an attainment with the arsenic standards in effect in 2014 with the exception of segment 12. However, the detection limit for total recoverable arsenic was generally higher than the new chronic standard of 0.02 µg/L. The 85th percentile total recoverable arsenic in segment 12 was 13 µg/L, but all of the arsenic data for segment 12 was collected from Gilson Gulch and its tributaries during 2010 and 2011, to characterize the potential sources prior to the remedial actions performed by the Clear Creek Watershed Foundation.

A thorough review of the data used in the attainment analysis shows that there may be bias in the sampling method, where several data points within a segment are collected from one or two locations as opposed to being evenly distributed throughout the segment. Additionally, there is a tendency to sample near known or suspected sources. A revised sampling program will be developed and implemented so that a determination of protectiveness can be made.

6.3.2 Operable Unit 4

Using the Water Quality Control Division's 2012 303(D) Listing Methodology, the OU4 Remediation Goals (RGs) were also compared to the data collected between 2010 and 2013 for segment 13b at the confluence with mainstem Clear Creek, and for the lower portion of segment 11. The data is presented in Table 14.

With the exception of copper, the lower portion of segment 11 is in attainment of the OU4 RGs. The RGs for segment 13b, North Clear Creek, have not been attained; however remedial actions are not complete.

Table 14: Summary of OU4 Remedial Goals and Current Water Quality (µg/L)

Contaminant of Concern	Remediation Goals			2010 – 2013 85th Percentile	
	Flow Regime	North Fork (Segment 13b)	Clear Creek Below North Clear Creek (Segment 11 – lower portion)	CC-50 North Clear Creek above Confluence with Mainstem	CC-60 Clear Creek at Church Ditch
Zinc (dissolved)	High-Flow	381	200	458	99
	Low-Flow	675	300	1,116	199
Copper (dissolved)	High-Flow	7.4	5.2	20.9	7.8
	Low-Flow	15.1	9.2	14.4	6.7
Cadmium (dissolved)	High-Flow	1.9	1.4	2.2	0.4
	Low-Flow	3.5	2.3	3.3	0.7
Manganese (dissolved)	High-Flow	1,531	600	984	96
	Low-Flow	2,021	600	2,093	170

6.3.3 Summary

In some segments, completion of planned response actions should result in significant water quality improvements. For example, once the OU4 remedy is completed, water quality is expected to improve in segments 13b and 11. As response actions continue, the agencies will evaluate improvements in water quality to determine if existing standards are being attained. If standards are not attained, the agencies will evaluate the need for additional remedial actions or for site-specific water quality criteria that remain protective of the designated uses. Where appropriate, the agencies may propose revisions to existing water quality criteria.

Although future response actions will improve water quality in some segments, other segments, including some that periodically exceed standards for one or more metals, will not be improved by the future response actions. The most notable of these segments is Segment 2a, where zinc levels frequently exceed existing standards. To address this issue, the agencies plan to conduct an evaluation of aquatic conditions, including habitat, to determine the appropriate biological expected condition for this segment. The results of this investigation will help determine if existing standards might be attained, or if additional remedial actions or site-specific water quality criteria are necessary for this segment.

Continued monitoring and evaluation is planned by the CDPHE and supported by the EPA to evaluate the protectiveness of the remedy.

6.4 Site Inspection

Because remedial and operation and maintenance activities continue at the Site, various CDPHE and EPA project managers make routine visits to specific portions of the Site. Annual O&M inspections are also conducted. For this five-year review, a Site-wide visit was conducted June 30 through July 3, 2014. Additionally, in an effort to update the IEUBK model used for risk analysis at the site, a number of waste rock piles in Central City were sampled and analyzed for lead and arsenic concentrations and bioavailability. The purpose of these efforts were to assess the protectiveness of the remedies that have been completed and to evaluate the integrity and success of previously constructed remedy components including:

- Waste pile characterization, slope stabilization and capping;
- Revegetation efforts and
- Discharge or run-on conveyance structures

A more detailed description of Site observations and findings relative to these efforts is provided in the discussion of each operable unit.

CDPHE staff visited each OU2, OU3 and OU4 Site feature during the week of June 30, 2014. The implemented remedies appear to be operating as designed. Notably, the sediment retention structures located in Willis and Russell gulches have captured significant sediment. The Willis Gulch and Russell Gulch drop structures were nearly or completely full of sediment; however these basins are located up gradient of the Russell Gulch Sediment Dam. The Russell Gulch Sediment Dam contained approximately 2.5 feet of sediment, with ample capacity remaining.

The Recommended Annual O&M/Remedy Evaluation Checklist provided in OSWER 9355.0-87 was completed and is attached. No significant findings were discovered.

6.5 Local Interviews

Between June and August 2014, CDPHE and EPA community involvement coordinators conducted interviews of various parties in person and by telephone. Interviewees included citizens residing within the Site, public officials and members of the Upper Clear Creek Watershed Association. The results of the interviews are presented in the 2014 update of the Clear Creek/Central City Community Involvement Plan (See Attachment G).

7.0 TECHNICAL ASSESSMENT

The following conclusions have been determined for the remedies at the Clear Creek/Central City Superfund Site:

7.1 Operable Unit 1

Question A: Is the remedy functioning as intended by the decision documents?

The OU3 ROD superseded the OU1 ROD, therefore no remedies were implemented under the heading of OU1.

Question B: Are the assumptions made at the time of the remedy selection still valid?

Not applicable.

Question C: *Has any other information come to light that could call into question the protectiveness of the remedy?*

Not applicable.

7.2 Operable Unit 2

Question A: *Is the remedy functioning as intended by the decision documents?*

Yes. The intent of the OU2 ROD was to minimize the potential for specific mine waste piles to contribute metal and sediment loading to Clear Creek through collapsing of unstable slopes and through runoff. Additionally, the human uptake of metals from the inhalation of dust or ingestion of materials from the piles was to be minimized. These objectives have been accomplished at the five waste piles identified in the OU2 ROD.

Question B: *Are the assumptions made at the time of the remedy selection still valid?*

Yes. The OU2 Remedial Investigation and Feasibility Study included a Public Health Evaluation (PHE) to identify contaminants of concern that could pose significant risk to human health and the environment, and to evaluate the potential impacts in absence of any remedial actions being performed. The PHE estimated the total excess upper-bound lifetime cancer risk associated with the following activities:

- Swimming in Clear Creek;
- Consuming fish from Clear Creek or North Clear Creek;
- Inhalation of dust at the Gregory waste pile or Argo waste pile;
- Inhalation of dust caused by motorcycles atop the Gregory waste pile and
- Incidental ingestion of soil from the Gregory waste pile or the Argo waste pile.

During the Phase II investigations, a Baseline Risk Assessment was completed for the Site and further evaluated the potential exposures that were found to be associated with potential risks in the PHE. The Phase II assessment established human health action levels for lead and arsenic in soil. The established action levels were 500 mg/kg for lead and 130 mg/kg for arsenic. These action levels were set based on incidental ingestion of mine waste under a residential exposure scenario. Since the Big Five and Argo mine waste piles exhibited soil concentrations of lead and arsenic greater than the risk-based action levels, an explanation of significant differences was issued to incorporate capping into the remedy at these two piles. However, due to concerns of the local State Historic Preservation Office and the property owner, the Argo waste pile was not capped. The Argo waste pile is privately owned, and access to the pile is controlled. Therefore, actual human exposure by incidental ingestion is less than under the residential scenario.

Question C: *Has any other information come to light that could call into question the protectiveness of the remedy?*

No other information has come to light since the previous five-year review that could call into question the protectiveness of the remedy relative to OU 2.

7.3 Operable Unit 3

Question A: Is the remedy functioning as intended by the decision documents?

Yes. Remedial actions at OU3 have been completed. The flow through bulkhead is construction complete and functioning as designed to eliminate surge events and control flows that could potentially overwhelm the Argo Tunnel WTP (reducing treatment costs and eliminating the need to by-pass during the spring recharge). The Argo Tunnel WTP continues to achieve a 99.9 percent reduction in metals loading from the tunnel into Clear Creek. The Virginia Canyon Ground Water Project was completed, treating this non-point source load at the Argo Tunnel WTP and eliminating between 200 and 500 pounds of zinc per day to the mainstem. The Big Five discharge also was collected and conveyed to the Argo Tunnel WTP, eliminating another 50 pounds per day of metals contamination to the mainstem. OU3 waste piles that have been regraded and/or capped are stable and show no evidence of erosion into adjacent streams. Human exposure to contaminated water is being minimized by removing direct contact with tunnel discharges. Residences previously identified as being exposed to unacceptable metal concentrations in their drinking water have been supplied point-of-use water treatment systems or an alternate water supply.

Question B: Are the assumptions made at the time of the remedy selection still valid?

Yes. The data used during the previous risk assessment was reviewed, see Attachment C. Based on that review, and in light of the December 2916 memo, the risk evaluation for lead needs to be updated in accordance with EPA's new guidance on blood lead levels ranging from 2-8 μg/dL (vs. old value of 10 μg/dL, and in this case of the baseline risk performed prior to signing the ROD, 12.5 μg/dL). It would also be prudent to do location-specific risk evaluation based on the residential location and soil concentrations for lead and arsenic. In an attempt to update the IEUBK model for the site, EPA collected and analyzed waste rock soil samples for lead and arsenic speciation and bioavailability using both in vivo and in vitro methods. The study results lacked sufficient location-specific data to evaluate potential RBC levels relative to soil concentrations of lead and arsenic, as discussed in Section 6.2.2. A similar evaluation is planned for the near future and will be revised to address the deficiencies of the previous study, which will include, among other objectives, the collection and analysis of more robust location-specific data, consistent with Region 8 strategy for risk evaluation of lead.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No. As described in the 2008 O&M Inspection Report, the Chase Gulch #2 Mine Waste Pile and Clay County Mill Site property owners have made some land-use modifications (i.e., road building, construction fill placement). CDPHE will continue to monitor these and other changes for potential impacts to the remedies, including changes in land use (i.e. additional residential development).

7.4 Operable Unit 4

Question A: Is the remedy functioning as intended by the decision documents?

Yes, for those portions of the remedy constructed. The overall OU4 remedy has yet to be finalized. However, significant portions of the remedy have been completed as presented in Section 4.4.4.

The OU4 tasks yet to be completed, as prescribed in the OU4 ROD, are described in Section 9.0.

Question B: Are the assumptions made at the time of the remedy selection still valid?

Yes. No new toxicological information was discovered during the five-year review that would indicate the risk assessment for OU4 is no longer appropriate.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No other information was discovered during this fifth five-year review that calls into question the remedy protectiveness.

7.5 Technical Assessment Summary

According to the data reviewed, the Site inspection and the interviews, the remedies that have been completed are functioning as intended by the decision documents. There have been no changes in the physical conditions of the Site that would affect the protectiveness of the remedy. There have been no changes in the ARARs that impact the remedy selected and implemented at the Site. There is no information that calls into question the protectiveness of the remedies constructed to date.

Following completion of all of the prescribed OU4 remedial actions, the concentrations of metals in Clear Creek below Idaho Springs (Segment 11) are expected to be significantly reduced. At that time, compliance with the remedial action objectives can be assessed. CDPHE and EPA may want to participate in a use attainability analysis to determine whether numeric remediation goals are appropriate and whether additional remediation efforts are warranted.

8.0 ISSUES

Although no serious deficiencies were discovered during the five-year review, the following issues should be resolved:

Table 15: Issues

Issues	Affects Current Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
Compliance with surface water ARARs cannot be assessed due to bias in the sampling program	N	Y
Remedial actions along Clear Creek Segment 2a may not be able to achieve attainment of the water quality standard for zinc	N	Y
Cattle encroachment is occurring at the Church Placer mine water repository and may impact the vegetated cover	N	Y
Seep water from the Church Placer mine waste repository is migrating onto an adjacent property.	N	Y
In an attempt to update the 1988 IEUBK model used at the site, EPA completed lead and arsenic speciation and bioavailability on several waste rock piles. However, the study lacked sufficient location-specific data to evaluate potential RBC levels relative to soil concentrations. A similar evaluation is planned for the near future and will be revised to address the deficiencies of the previous study, which will include the collection of more robust location-specific data.	N	Y
Exercising of new water rights acquired by local municipalities may substantially dewater portions of North Clear Creek, and may impact the ability of the remedy to attain RAOs	N	Y

9.0 RECOMMENDATION AND FOLLOW-UP ACTIONS

With EPA and CDPHE oversight, the corresponding recommendations and follow-up actions are as follows:

Table 16: Recommendations and Follow-Up Actions

Issue	Recommendation and Follow-up Action	Party Responsible	Milestone Date	Affects Protectiveness (Y/N)	
				Current	Future
Compliance with surface water ARARs cannot be assessed due to bias in the sampling program.	A systematic, representative sampling program should be developed and implemented, including appropriate arsenic detection limits, to determine compliance with surface water quality criteria.	EPA and CDPHE	9/2018	N	Y
Remedial actions along Clear Creek Segment 2a may not be able to achieve attainment of the water quality standard for zinc.	Additional water quality and aquatic sampling will provide information on protectiveness. Resegmentation or a site-specific stream standard may be proposed at the 2015 triennial hearing.	EPA and CDPHE	6/2015	N	N
Cattle encroachment is occurring at Church Placer repository and may impact the vegetated cover.	Continue frequent site visits and fence repairs	CDPHE	6/2015	N	Y
An intermittent seep was discovered during a routine inspection of the repository. A grab sampled collected of the seep revealed elevated levels of zinc.	Assess the nature and extent of the seep and mitigate as determined appropriate	CDPHE	9/2018	N	Y
The IEUBK model used for the determination of the remedial action goal for lead in soil needs to be revised to reflect the most current guidance	Run the IEUBK model using the current default values and target blood lead levels. Address deficiencies of previous study and consider current guidance to determine if any changes are warranted to ensure protectiveness.	EPA and CDPHE	9/2018	N	Y
Exercising of new water rights acquired by local municipalities may substantially dewater portions of North Clear Creek, and may impact the ability of the remedy to attain the RAO of supporting the survival of a brown trout population in the North Fork of Clear Creek.	Obtain an agreement with the city of Black Hawk and Gilpin County to maintain minimum instream flows in North Clear Creek	EPA and CDPHE	9/2016	Y	Y

10.0 PROTECTIVENESS STATEMENT

OU2 The remedy at OU2 is expected to be protective of human health and the environment upon completion. In the interim, remedial activities completed to date have adequately addressed all exposure pathways that could result in unacceptable risks in these areas.

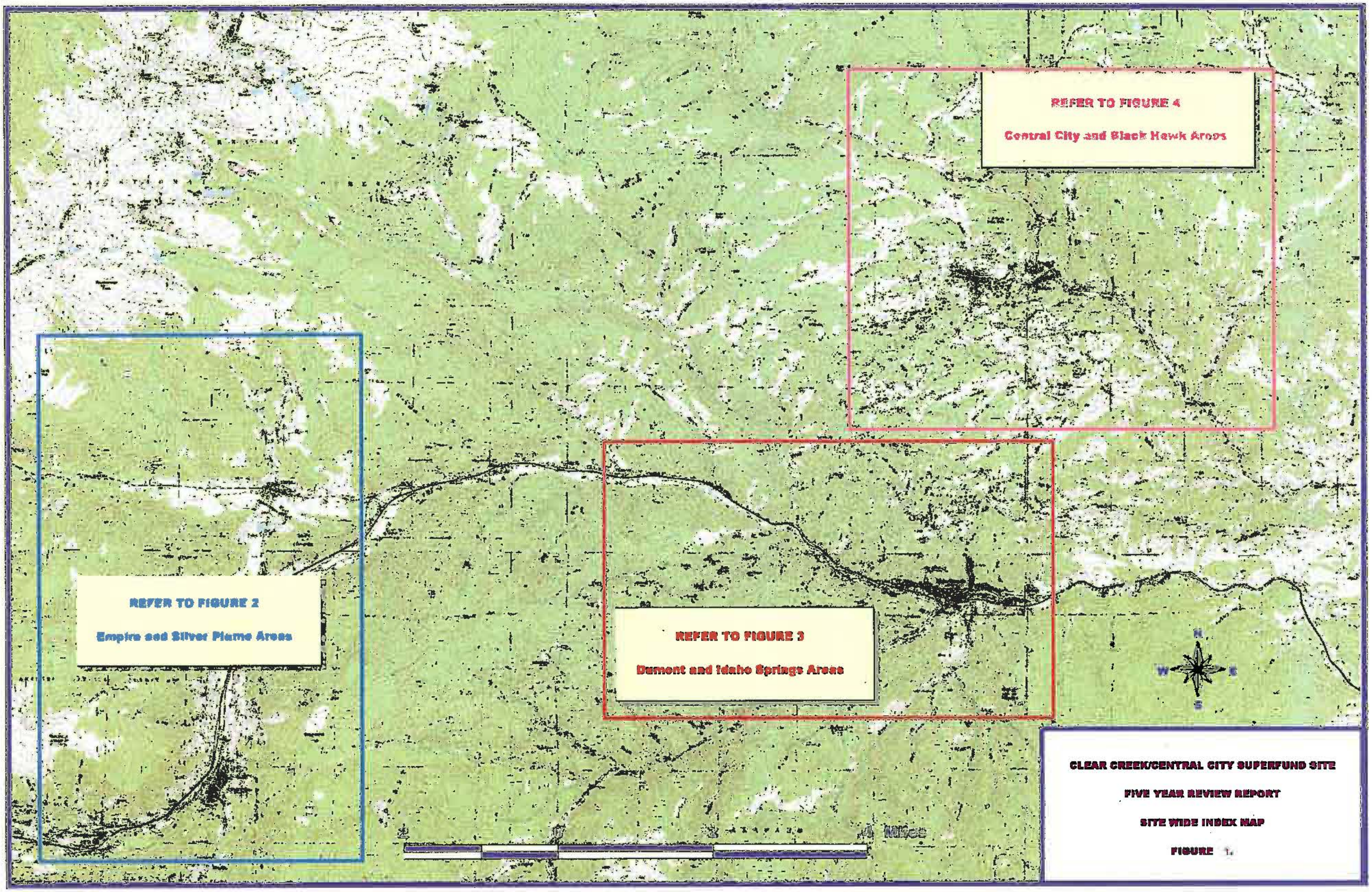
OU3 A protectiveness determination of the remedy at OU3 cannot be made at this time until further information is obtained. Further information will be obtained by taking the following actions: Develop and implement a systematic, representative sampling program, including appropriate arsenic detection limits, to determine compliance with surface water quality criteria. Conduct additional water quality and aquatic life sampling to assess protectiveness. Propose re-segmentation or a site-specific stream standard to the Water Quality Control Commission. Address deficiencies of previous study including the collection and analysis of more robust location-specific data, and consider current guidance to determine if any changes are warranted to ensure protectiveness. It is expected that these actions will take approximately one year to complete, at which time a protectiveness determination will be made.

OU4 A protectiveness determination of the remedy at OU4 cannot be made at this time until further information is obtained. Further information will be obtained by taking the following actions: Establish long term intergovernmental agreement with the City of Black Hawk to provide augmentation water to ensure the new OU4 water treatment plant can operate uncurtailed and continue to monitor water rights applications and participate in cases as a stakeholder when appropriate. It is expected that this action will take approximately one year to complete, at which time a protectiveness determination will be made

11.0 NEXT REVIEW

The next five-year review for the Clear Creek/Central City Superfund Site is required by five years from the date of this review.

ATTACHMENT A: SITE MAPS

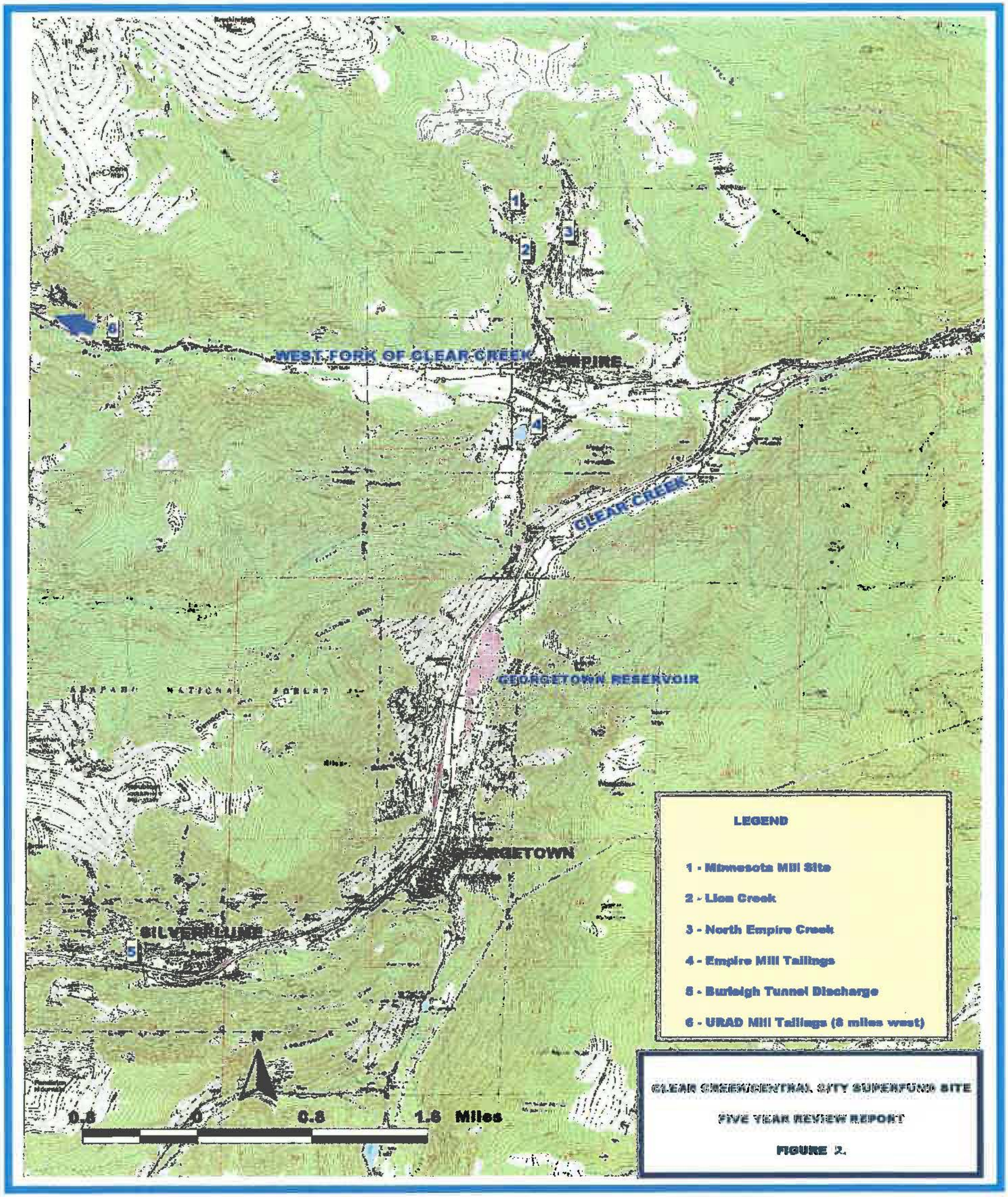


CLEAR CREEK/CENTRAL CITY SUPERFUND SITE

FIVE YEAR REVIEW REPORT

SITE WIDE INDEX MAP

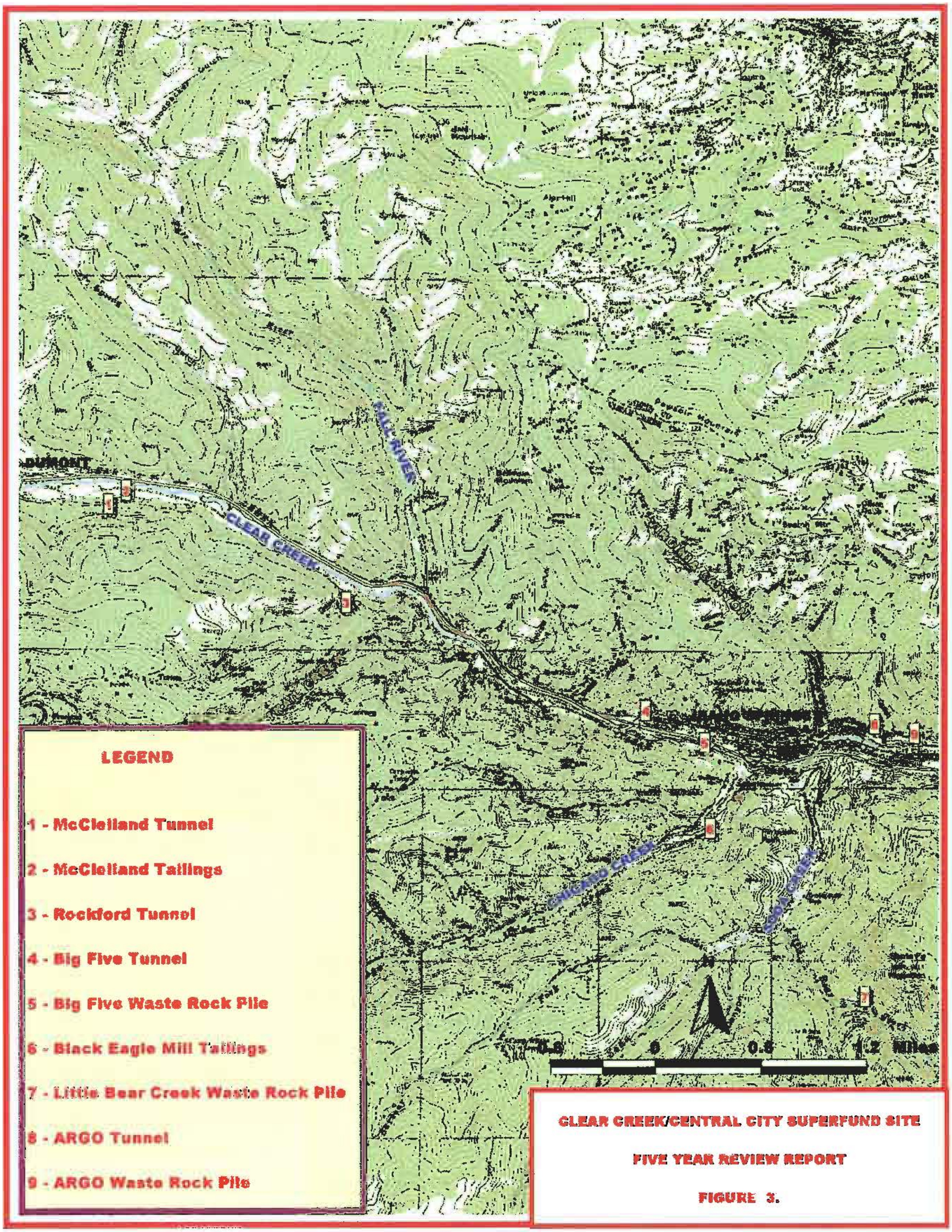
FIGURE 1.



CLEAR CREEK/CENTRAL CITY SUPERFUND SITE

FIVE YEAR REVIEW REPORT

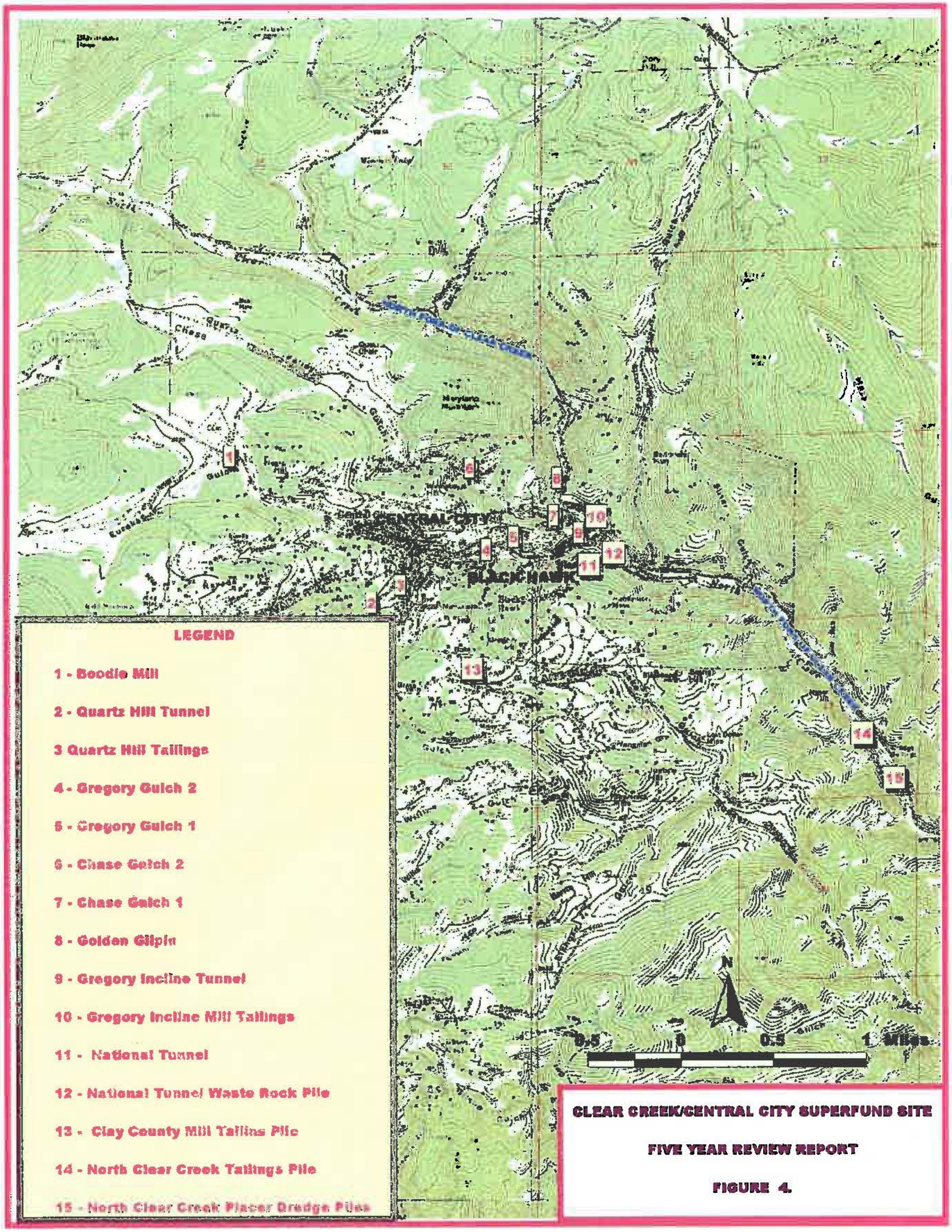
FIGURE 2.



CLEAR CREEK/CENTRAL CITY SUPERFUND SITE

FIVE YEAR REVIEW REPORT

FIGURE 3.



LEGEND

1 - Boodie Mill

2 - Quartz Hill Tunnel

3 Quartz Hill Tailings

4 - Gregory Gulch 2

5 - Gregory Gulch 1

6 - Chase Gulch 2

7 - Chase Gulch 1

8 - Golden Gilpin

9 - Gregory Incline Tunnel

10 - Gregory Incline Mill Tailings

11 - National Tunnel

12 - National Tunnel Waste Rock Pile

13 - Clay County Mill Tailins Pile

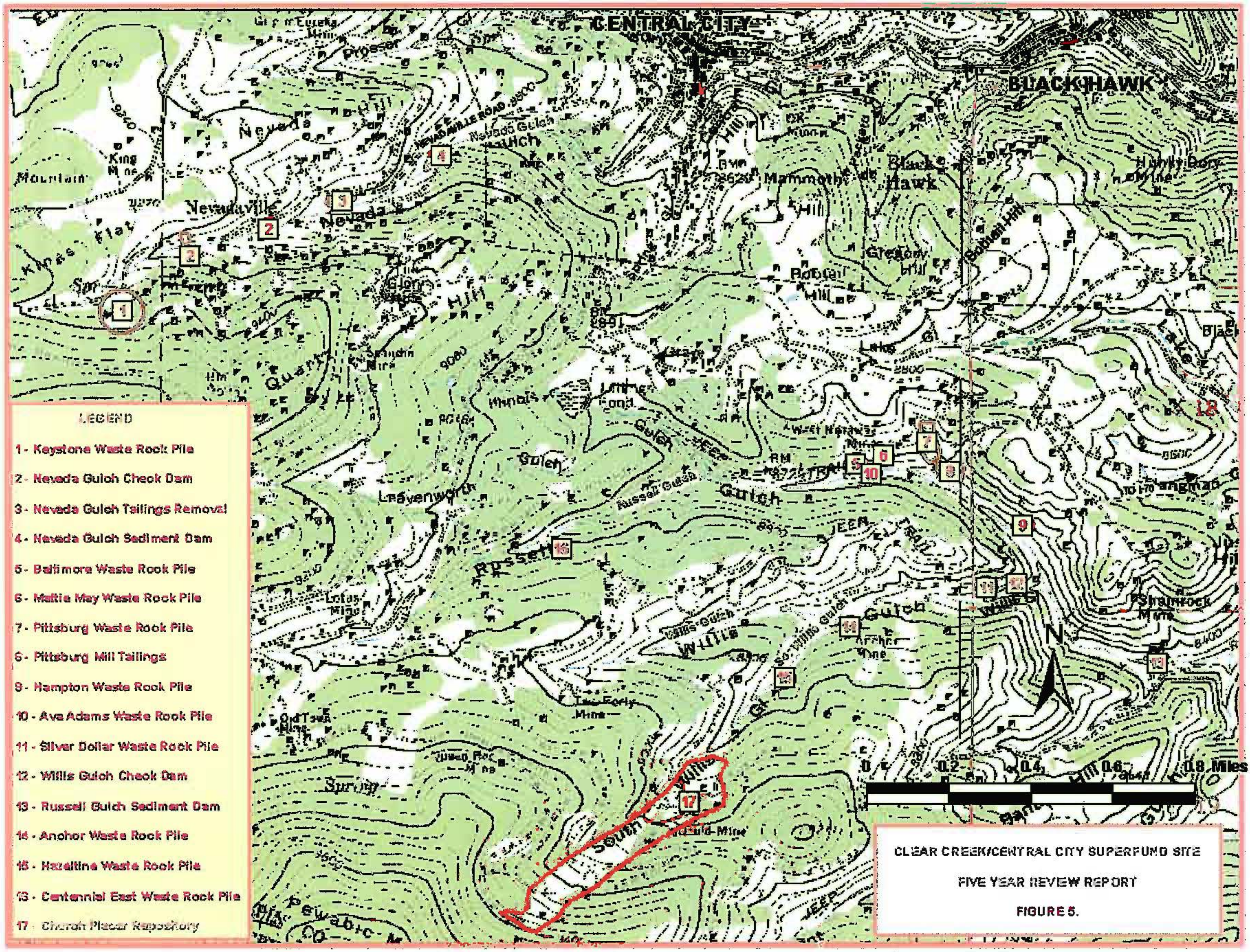
14 - North Clear Creek Tailings Pile

15 - North Clear Creek Placer Dredge Piles

CLEAR CREEK/CENTRAL CITY SUPERFUND SITE

FIVE YEAR REVIEW REPORT

FIGURE 4.



CLEAR CREEK/CENTRAL CITY SUPERFUND SITE

FIVE YEAR REVIEW REPORT

FIGURE 5.

CENTRAL CITY/CLEAR CREEK SUPERFUND SITE
FIVE YEAR REVIEW REPORT
FIGURE 6.

C:\PROJECT_DATA\ClearCreek\ClearCreek_2014_Segments(2-2).mxd

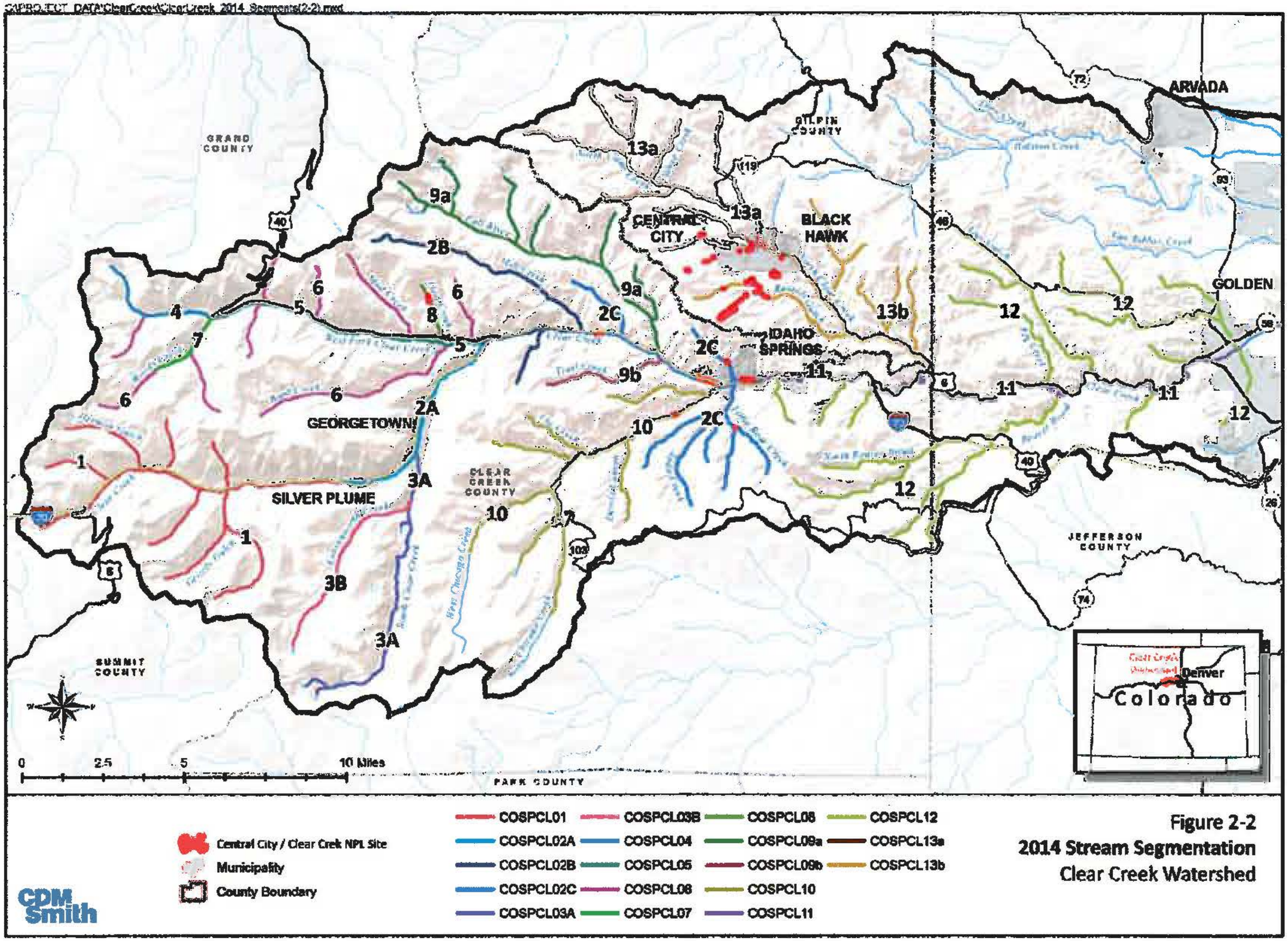


Figure 2-2
2014 Stream Segmentation
Clear Creek Watershed

ATTACHMENT B: WATER QUALITY STANDARDS

B1: Effective September 30 1991

B2: Effective April 30 2014

B1: Effective September 30 1991

REGION: 3

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BASIN: Clear Creek

Stream Segment Description	CLASSIFICATIONS										NUMERIC STANDARDS				TEMPORARY MODIFICATION and QUALIFIERS
	HIGH QUAL.		REC.		AQUATIC LIFE				WATER SUPPLY	AGRICULTURE	PHYSICAL and BIOLOGICAL	INORGANIC mg/l	METALS mg/l		
	CLASS 1	CLASS 2	CLASS 1	CLASS 2	CL. 1 COLD	CL. 1 WARM	CL. 2 COLD	CL. 2 WARM							
1. Mainstem of Clear Creek, including all tributaries, lakes, and reservoirs, from the source to the I-70 bridge above Silverplume.				X	X				X	X	D.O. = 6.0 mg/l. 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliforms = 2000/100 ml	NH_3 = 0.02, unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron = 0.75 Nitrite (NO_2) = 0.05 Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO_4) = 250.0	Arsenic (As) = 0.05 Cadmium (Cd) = 0.0004 Chromium (tri) = 0.05 Chromium (hex) = 0.025 Copper (Cu) = 0.011 Lead (Pb) = 0.000 Iron (Fe, sol) = 0.3 Manganese (Mn,sol)=.05	Mercury (Hg) = 0.00005 Nickel (Ni) = 0.05 Selenium (Se) = 0.01 Silver (Ag) = 0.0001 Zinc (Zn) = 0.08 Iron (Fe,tot) = 1.0 Manganese (Mn,tot)=1.0	
2. Mainstem of Clear Creek, including all tributaries, lakes, and reservoirs, from the I-70 bridge above Silverplume to the Argo Tunnel discharge, except for specific listings in Segments 3 through 10.				X	X					X	D.O. = 6.0 mg/l. 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliforms = 2000/100 ml	NH_3 = 0.02* unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron = 0.75 Nitrite (NO_2) = 0.05*	Arsenic (As) = 0.05 Cadmium (Cd) = 0.002 Chromium (tri) = 0.1 Chromium (hex) = 0.025 Copper (Cu) = 0.01 Lead (Pb) = 0.005	Mercury (Hg) = 0.00005 Nickel (Ni) = 0.05 Selenium (Se) = 0.02 Silver (Ag) = 0.0001 Zinc (Zn) = 0.200 Iron (Fe,tot) = 1.0 Manganese (Mn,tot)=1.0	NH_3, NO_2, see foot-note
3.a. Mainstem of South Clear Creek, including all tributaries, lakes, and reservoirs, from the source to the confluence with Clear Creek, except for the specific listing in 3.b.			X		X				X	X	D.O. = 6.0 mg/l. 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliforms = 200/100 ml	NH_3 = 0.02 unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron = 0.75 Nitrite (NO_2) = 0.05 Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO_4) = 250.0	Arsenic (As) = 0.05 Cadmium (Cd) = 0.004 Chromium (tri) = 0.05 Chromium (hex) = 0.025 Copper (Cu) = 0.005 Lead (Pb) = 0.004 Iron (Fe.sol) = 0.3 Manganese (Mn.sol)=.05	Mercury (Hg) = 0.00005 Nickel (Ni) = 0.05 Selenium (Se) = 0.01 Silver (Ag) = 0.0001 Zinc (Zn) = 0.09 Iron (Fe,tot) = 1.0 Manganese (Mn,tot)=1.0	
3.b. Mainstem of Leavenworth Creek from source to confluence with South Clear Creek.			X				X		X	X	D.O. = 6.0 mg/l. 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliforms = 200/100 ml	NH_3 = 0.02. unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron = 0.75 Nitrite (NO_2) = 0.05 Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO_4) = 250.0	Arsenic (As) = 0.05 Cadmium (Cd) = 0.004 Chromium (tri) = 0.05 Chromium (hex) = 0.01 Copper (Cu) = 0.05 Lead (Pb) = 0.004 Iron (Fe.sol) = 0.3 Manganese (Mn.sol)=.05	Mercury(Hg) = 0.00005 Nickel (Ni) = 0.05 Selenium (Se) = 0.01 Silver (Ag) = 0.0001 Zinc (Zn) = 0.15 Iron (Fe,tot) = 1.0 Manganese (Mn,tot)=1.0	
4. Mainstem of West Clear Creek from the source to the confluence with Woods Creek.			X		X				X	X	D.O. = 6.0 mg/l. 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliforms = 200 /100 ml	NH_3 = 0.02, unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron = 0.75 Nitrite (NO_2) = 0.05 Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO_4) = 250.0	Arsenic (As) = 0.05 Cadmium (Cd) = 0.003 Chromium (tri) = 0.05 Chromium (hex) = 0.025 Copper (Cu) = 0.017 Lead (Pb) = 0.025 Iron (Fe, sol) = 0.3 Manganese (Mn,sol)=.05	Mercury (Hg) = 0.00005 Nickel (Ni) = 0.1 Selenium (Se) = 0.01 Silver (Ag) = 0.0001 Zinc (Zn) = 0.06 Iron (Fe,tot) = 1.0 Manganese (Mn,tot)= 1.225	

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 3

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BASIN: Clear Creek

Stream Segment Description	CLASSIFICATIONS										NUMERIC STANDARDS				TEMPORARY MODIFICATIONS and QUALIFIERS
	HIGH QUAL		REC		AQUATIC LIFE				WATER SUPPLY	AGRICULTURE	PHYSICAL and BIOLOGICAL	INORGANIC mg/l	METALS mg/l		
	CLASS 1	CLASS 2	CLASS 1	CLASS 2	CL 1		CL 2								
					COLD	WARM	COLD	WARM							
5. Mainstem of West Clear Creek from the confluence with Woods Creek to the confluence with Clear Creek.				X	X					X	D.O. = 6.0 mg/l, 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliform = 2000/100 ml	NH_3 = 0.02, unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron ≤ 0.75 Nitrite (NO_2) = 0.05	Arsenic (As) = 0.05 Cadmium (Cd) = 0.003 Chromium (tri) = 0.1 Chromium (hex) = 0.025 Copper (Cu) = 0.023 Lead (Pb) = 0.025	Mercury (Hg) = 0.00005 Nickel (Ni) = 0.1 Selenium (Se) = 0.01 Silver (Ag) = 0.0001 Zinc (Zn) = 0.10 Iron (Fe, tot) = 1.0 Manganese (Mn, tot) = 1.1	
6. All tributaries to West Clear Creek, including all lakes and reservoirs, from the source to the confluence with Clear Creek, except for specific listings in Segments 7 and 8.			X		X				X	X	D.O. = 6.0 mg/l, 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliform = 200 /100 ml	NH_3 = 0.02, unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron ≤ 0.75 Nitrite (NO_2) = 0.05 Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO_4) = 250.0	Arsenic (As) = TVS Cadmium = TVS(TROUT) Chromium (tri) = TVS Chromium (hex) = TVS Copper (Cu) = TVS Lead (Pb) = TVS Iron (Fe, sol) = TVS Manganese (Mn, sol) = TVS (ACUTE AND CHRONIC STANDARDS ADOPTED)	Mercury (Hg) = TVS Nickel (Ni) = TVS Selenium (Se) = TVS Silver = TVS(TROUT) Zinc = TVS(TROUT) Iron (Fe, tot) = TVS Manganese (Mn, tot) = TVS	
7. Mainstem of Woods Creek from the outlet of Upper Urad Reservoir to the confluence with West Clear Creek.				X			X				D.O. = 6.0 mg/l, 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliform = 2000/100 ml	NH_3 = 0.02, unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Nitrite (NO_2) = 0.05	Arsenic (As) = 0.05 Cadmium (Cd) = 0.002 Chromium (tri) = 0.1 Chromium (hex) = 0.025 Copper (Cu) = 0.023 Lead (Pb) = 0.025	Mercury (Hg) = 0.00005 Nickel (Ni) = 0.1 Selenium (Se) = 0.05 Silver (Ag) = 0.0001 Zinc (Zn) = 0.1 Iron (Fe, tot) = 1.0 Manganese (Mn, tot) = 1.1	Temporary Modifications Cadmium (Cd) = 0.014 Zinc (Zn) = 0.74 Manganese (Mn, tot) = 9.4
8. Mainstem of Lion Creek from the source to the confluence with West Clear Creek.				X			X				D.O. = 6.0 mg/l, 7.0 mg/l spawning pH = 3.0 - 9.0 Fecal Coliform = 2000/100 ml				
9. Mainstem of the Fall River, including all tributaries, lakes, and reservoirs, from the source to the confluence with Clear Creek.			X		X				X	X	D.O. = 6.0 mg/l, 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliform = 200 /100 ml	NH_3 = 0.02, unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron ≤ 0.75 Nitrite (NO_2) = 0.05 Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO_4) = 250.0	Arsenic (As) = TVS Cadmium = TVS(TROUT) Chromium (tri) = TVS Chromium (hex) = TVS Copper (Cu) = TVS Lead (Pb) = TVS Iron (Fe, sol) = TVS Manganese(Mn, sol) = TVS (ACUTE AND CHRONIC STANDARDS ADOPTED)	Mercury (Hg) = TVS Nickel (Ni) = TVS Selenium (Se) = TVS Silver = TVS(TROUT) Zinc = TVS(TROUT) Iron (Fe, tot) = TVS Manganese(Mn, tot) = TVS	

April 9, 1~ Revised 1/30/83 and 1/30/84

STREAM CLASSIFICATIONS [illegible] WATER QUALITY STANDARDS

REGION: 3

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BASIN: Clear Creek

Stream Segment Description	CLASSIFICATIONS										NUMERIC STANDARDS				TEMPORARY MODIFICATIONS and QUALIFIERS
	HIGH QUAL.		REC.		AQUATIC LIFE				[illegible]	AGRICULTURE	PHYSICAL and BIOLOGICAL	INORGANIC mg/l	METALS mg/l		
	CLASS 1	CLASS 2	CLASS 1	CLASS 2	CL. 1 COLD	CL. 1 WARM	CL. 2 COLD	CL. 2 WARM							
10. Mainstem of Chicago Creek, including all tributaries, lakes, and reservoirs, from the source to the confluence with Clear Creek.			x		x				x	x	D.O. = 6.0 mg/l, 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliforms = 200 /100 ml	NH_3 = 0.02, unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron = 0.75 Nitrite (NO_2) = 0.05 Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO_4) = 250.0	Arsenic (As) = 0.05 Cadmium (Cd) = 0.0004 Chromium (tri) = 0.05 Chromium (hex) = 0.025 Copper (Cu) = 0.006 Lead (Pb) = 0.004 Iron (Fe, sol) = 0.3 Manganese (Mn, sol) = .05	Mercury (Hg) = 0.00005 Nickel (Ni) = 0.05 Selenium (Se) = 0.01 Silver (Ag) = 0.0001 Zinc (Zn) = 0.11 Iron (Fe, tot) = 1.0 Manganese (Mn, tot) = 1.	
11. Mainstem of Clear Creek from the Argo Tunnel discharge to the Farmers Highline Canal diversion in Golden, Colorado.				x	x				x	x	D.O. = 6.0 mg/l 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliforms = 200 /100 ml	NH_3 = 0.02, unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron = 0.75 Nitrite (NO_2) = 0.05 Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO_4) = 250.0	Arsenic (As) = TVS Cadmium (Cd) = 0.003 Chromium (tri) = TVS Chromium (hex) = TVS Copper (Cu) = 0.017 Lead (Pb) = TVS Iron (Fe, sol) = TVS Manganese (Mn, sol) = TVS (ACUTE AND CHRONIC STANDARDS ADOPTED)	Mercury (Hg) = TVS Nickel (Ni) = TVS Selenium (Se) = TVS Silver (Ag) = TVS(trout) Zinc (Zn) = 0.30 Iron (Fe, tot) = TVS Manganese (Mn, tot) = TVS	
12. All tributaries to Clear Creek, including all lakes and reservoirs, from the Argo Tunnel discharge to the Farmers Highline Canal diversion in Golden, Colorado, except for specific listings in Segment 13.				X			X		X	X	D.O. = 5.0 mg/l pH = 6.5 - 9.0 Fecal Coliforms = 2000/100 ml	Cyanide (tot) = 0.2 Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO_4) = 250.0 Boron = 0.75 S as H_2S = 0.05	Cadmium (Cd) = 0.01 Arsenic (As) = 0.05 Chromium (tri) = 0.05 Chromium (hex) = 0.05 Copper (Cu) = 1.0 Lead (Pb) = 0.05	Mercury (Hg) = 0.002 Selenium (Se) = 0.01 Silver (Ag) = 0.05 Zinc (Zn) = 5.0 Iron (Fe, sol) = 0.3 Manganese (Mn, sol) = .05	
13. Mainstem of North Clear Creek, including all tributaries, lakes, and reservoirs, from the source to the confluence with Clear Creek.				x			X			x	D.O. = 6.0 mg/l, 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliforms = 2000/100 ml	NH_3 = 0.02, unionized Residual Cl_2 = 0.003 Cyanide (free) = .005 S as H_2S = 0.002 undis Boron = 0.75 Nitrite (NO_2) = 0.05	Arsenic (As) = 0.05 Cadmium (Cd) = 0.0004 Chromium (tri) = 0.1 Chromium (hex) = 0.025 Copper (Cu) = 0.564 Lead (Pb) = 0.045	Mercury (Hg) = 0.00005 Nickel (Ni) = 0.05 Selenium (Se) = 0.02 Silver (Ag) = 0.0001 Zinc (Zn) = 0.5 Iron (Fe, tot) = 5.4 Manganese (Mn, tot) = 1.	
14. Mainstem of Clear Creek from the Farmers Highline Canal diversion in Golden, Colorado, to Youngfield Street in Wheatridge, Colorado.				X				X	X	X	D.O. = 5.0 mg/l pH = 6.5 - 9.0 Fecal Coliforms = 2000/100 ml	NH_3 = 0.1* unionized Residual Cl_2 = 0.003 Cyanide (free) = 0.005 S as H_2S = 0.002 undis Boron = 0.75 Nitrite (NO_2) = 0.5* Nitrate (NO_3) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO_4) = 250.0	Arsenic (As) = 0.05 Cadmium (Cd) = 0.001 Chromium (tri) = 0.05 Chromium (hex) = 0.025 Copper (Cu) = 0.04 Lead (Pb) = 0.025 Iron (Fe, sol) = 0.3 Manganese (Mn, sol) = .05	Mercury (Hg) = .00005 Nickel (Ni) = 0.1 Selenium (Se) = 0.01 Silver (Ag) = 0.0001 Zinc (Zn) = 0.36 Iron (Fe, tot) = 1.4 Manganese (Mn, tot) = 1.0 Below Croke Canal: Zinc (Zn) = 0.18 Copper (Cu) = 0.014	NH_3, SO_2: see footnote Temporary Modifications below Croke Canal: Cadmium (Cd) = 0.0033 Zinc (Zn) = 0.3 Copper (Cu) = 0.04 Effective from 6-30-88 to 6-30-89 Mercury (Hg) = 0.00013 Effective from 6-30-88 to 6-30-89

April 9, 1981 REVISED: APRIL 12, 1982, MAY 9, 1983
APRIL 8, 1985

STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 3

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BASIN: Clear Creek

Stream Segment Description	CLASSIFICATIONS HIGH QUAL.		REC.		AQUATIC LIFE CL 1		AQUATIC LIFE CL 2		WATER SUPPLY	AGRICULTURE	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l	METALS mg/l		TEMPORARY MODIFICATIONS and QUALIFIERS
	CLASS 1	CLASS 2	CLASS 1	CLASS 2	COLD	WARM	COLD	WARM							
15. Mainstem of Clear Creek from Youngfield Street in Wheatridge, Colorado, to the confluence with the South Platte River.				X		①			X	X	D.O. = 5.0 mg/l pH = 6.5 - 9.0 Fecal Coliforms = 2000/100 ml	NH$_3$ = 0.06, unionized Residual Cl$_2$ = 0.003 Cyanide (free) = 0.005 S as H$_2$S = 0.002 undis Boron = 0.75 Nitrite (NO$_2$) = 0.50 Nitrate (NO$_3$) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO$_4$) = 250.0	Arsenic (As) = 0.05 Cadmium (Cd) = 0.001 Chromium (tri) = 0.05 Chromium (hex) = 0.025 Copper (Cu) = 0.014 Lead (Pb) = 0.025 Iron (Fe,sol) = 0.65 Manganese (Mn,sol) = .50	Mercury (Hg) = 0.00005 Nickel (Ni) = 0.1 Selenium (Se) = 0.01 Silver (Ag) = 0.0001 Zinc (Zn) = 0.17 Iron (Fe,tot) = 1.2 Manganese (Mn,tot)=1.0	NH$_3$,NO$_2$: See footnote Temporary Modifics. Cadmium(Cd)=0.0033 Zinc(Zn)=0.423 Copper(Cu)=0.06 Effective from 6-30-88 to 6-30-94 Mercury(Hg)=0.00015 NH$_3$ = 0.15 unionized Effective from 6-30-88 to 6-30-90
16. All tributaries to Clear Creek from the Farmers Highline Canal diversion in Golden, Colorado, to the confluence with the South Platte River, except for specific listings in Segments 16, 17, and 18.				X				X		X	D.O. = 5.0 mg/l pH = 6.5 - 9.0 Fecal Coliforms = 2000/100 ml				
17. Mainstem of Ralston Creek from the source to the outlet of Arvada Reservoir, including Ralston Reservoir, Upper Long Lake, and Arvada Reservoir.				X			X		X	X	D.O. = 6.0 mg/l 7.0 mg/l spawning pH = 6.5 - 9.0 Fecal Coliforms = 2000/100 ml	NH$_3$ = 0.02, unionized Residual Cl$_2$ = 0.003 Cyanide (free) = .005 S as H$_2$S = 0.002 undis Boron = 0.75 Nitrite (NO$_2$) = 0.05 Nitrate (NO$_3$) = 10.0 Chloride (Cl) = 250.0 Sulfate (SO$_4$) = 250.0 (Sulfate to be measured in reservoirs)	Arsenic (As) = 0.05 Cadmium (Cd) = 0.0004 Chromium (tri) = 0.05 Chromium (hex) = 0.025 Copper (Cu) = .005* Lead (Pb) = .005** Iron (Fe, sol) = .3*** Manganese (Mn,sol)=.05	Mercury (Hg) = 0.00016 Nickel (Ni) = 0.05 Selenium (Se) = 0.01 Silver (Ag) = 0.0001 Zinc (Zn) = 0.05 Iron (Fe,tot) = 1.0**** Manganese (Mn,tot)=1.0 Uranium (U) = 40 picoCuries/l or radiation from (U)	* measured as soluble **Lead=.025 when streamflow exceeds 30 cfs. ***Iron(sol)=0.3 during months of May and June. ****Iron(tot)standard does not apply when streamflows exceed 30 cfs.
18. Mainstem of Ralston Creek from the outlet of Arvada Reservoir to the confluence with Clear Creek. All tributaries to Ralston Creek, including all lakes and reservoirs, from the source of Ralston Creek to the confluence with Clear Creek, except for specific listings in Segment 17.				X				X		X	D.O. = 5.0 mg/l pH = 6.5 - 9.0 Fecal Coliforms = 2000/100 ml				
19. All tributaries to Clear Creek, including lakes and reservoirs, within the Mt. Evans Wilderness Area.		=											EXISTING	QUALITY	

TABLE III

METAL PARAMETERS
(Concentrations in ug/l)

METAL(1)	AQUATIC LIFE (1)(3)(4)(J)	AGRICULTURE(2)	DRINKING WATER SUPPLY(2)
Aluminum	Acute = 950 Chronic = 150		
Arsenic	Acute = 360 Chronic = 150	100$^{(A)}$ (30-DAY)	50$^{(E)}$ (1-DAY)
Barium			1,000$^{(E)}$ (1-DAY)
Beryllium		100$^{(A,B)}$ (30-DAY)	
Cadmium	Acute = $e^{(1.128[\ln(\text{hardness})]-2.905)}$ "(Trout) = $e^{(1.128[\ln(\text{hardness})]-3.828)}$ Chronic = $e^{(0.7852[\ln(\text{hardness})]-3.490)}$	10(B) (30-DAY)	10(E) (1-DAY)
Chromium III$^{(5)}$	Acute = $e^{(0.819[\ln(\text{hardness})]+3.688)}$ Chronic = $e^{(0.819[\ln(\text{hardness})]+1.561)}$	100$^{(B)}$ (30-DAY)	50$^{(E)}$ (1-DAY)
Chromium VI$^{(5)}$	Acute = 16 Chronic = 11	100$^{(B)}$ (30-DAY)	50$^{(E)}$ (1-DAY)
Copper	Acute = $\frac{1}{2}e^{(0.9422[\ln(\text{hardness})]-0.7703)}$ Chronic = $e^{(0.8545[\ln(\text{hardness})]-1.465)}$	200$^{(B)}$ (30-DAY)	1,000$^{(F)}$ (30-DAY)
Iron	Chronic = 1,000(tot.rec.)$^{(A,C)}$		300(dis)$^{(F)}$ (30-DAY)

(Continued on Next Page)

TABLE III (CONTINUED)

METAL(1)	AQUATIC LIFE (1)(3)(4)(J)	AGRICULTURE(2)	DRINKING WATER SUPPLY(2)
Lead	Acute = $\frac{1}{2}e^{(1.6148[\ln(hardness)]-2.1805)}$ Chronic = $e^{(1.417[\ln(hardness)]-5.167)}$	100(B) (30-DAY)	50(E) (1-DAY)
Manganese	Chronic = 1,000(tot. rec.)(C)	200(B) (30-DAY)	(F) 50(dis) (30-DAY)
Mercury	Acute = 2.4 Chronic = 0.1 FRV(fish) (6) = 0.01		2.0(E) (1-DAY)
Nickel	Acute = $\frac{1}{2}e^{(0.76[\ln(hardness)]+4.02)}$ Chronic = $e^{(0.76[\ln(hardness)]+1.06)}$	200(B) (30-DAY)	
Selenium	Acute = 135 Chronic = 17	20(B,D) (30-DAY)	10(E) (1-DAY)
Silver	Acute = $\frac{1}{2}e^{(1.72[\ln(hardness)]-6.52)}$ Chronic = $e^{(1.72[\ln(hardness)]-9.06)}$ "(Trout) = $e^{(1.72[\ln(hardness)]-10.51)}$		50(E) (1-DAY)
Thallium	Chronic = 15(C)		
Uranium	Acute = $e^{(1.1021[\ln[hardness)]+2.7088)}$ Chronic = $e^{(1.1021[\ln(hardness)]+2.2382)}$		
Zinc	Acute = $\frac{1}{2}e^{(0.809(\ln[hardness)]+2.351)}$ Acute (Trout) = 1/2 Acute Chronic (hardness>200 mg/1) = $e^{(1.924[\ln(hardness)]-6.393)}$ Chronic(hardness ≤ 200 mg/1) = 45	2000(B) (30-DAY)	5000(F) (30-DAY)

NOTE: Capital letters in parentheses refer to references listed in Section 3.1.16(3); Numbers in parentheses refer to Table III footnotes.

TABLE III - FOOTNOTES

(1) Metals for aquatic life use are stated as dissolved unless otherwise specified.

(2) Metals for agricultural and domestic uses are stated as total recoverable unless otherwise specified.

(3) Hardness values to be used in equations are in mg/l as calcium carbonate. The hardness values used in calculating the appropriate metal standard should be based on the 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.

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

(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 50ug/l total chromium in those waters classified for domestic water use.

(6) FRV means final residual value. This value, based on the maximum allowed concentration of a material in the water that can affect marketability through bioaccumulation or bioconcentration, is to be applied as a 30-day average in all water supporting populations of fish or shellfish with a potential for human consumption.

B2: Effective April 30 2014

REGULATION #38 STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 3 AND 4 BASIN: CLEAR CREEK Stream Segment Description	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS						TEMPORARY MODIFICATIONS AND QUALIFIERS
			PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS µg/l			
1. Mainstem of Clear Creek, including all tributaries and wetlands, from the source to the I-70 bridge above Silver Plume.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	Temporary modification: As(ch)=hybrid Expiration date of 12/31/21
2a. Mainstem of Clear Creek, including all tributaries and wetlands, from the I-70 bridge above Silver Plume to a point just above the confluence with West Fork Clear Creek,except for specific listings in Segments 3a and 3b.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 SO_4=WS Cl=250	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch) = TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Zn(ac)= $0.978e^{(0.8537[\ln(hardness)]+1.9467)}$ Zn(ch)= $0.986e^{(0.8537[\ln(hardness)]+1.8032)}$	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr)	Temporary modifications: Zn(ch)=353 µg/l (dis), Zn(ac)=586 µg/l (dis), (Type I) Cd(ch)=1.54(dis) (type iii) Expiration date of 7/01/2015. Temporary modification: As(ch)=hybrid Expiration date of 12/31/21.
2b. Mainstem of Clear Creek, including all tributaries and wetlands, from the confluence with West Fork Clear Creek to a point just below the confluence with Mill Creek, except for specific listings in Segments 4 through 8.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 SO_4=WS Cl=250	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch) = TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS Zn(ch)=TVS	
2c. Mainstem of Clear Creek, including all tributaries and wetlands, from a point just below the confluence with Mill Creek to a point just above the Argo Tunnel discharge, except for specific listings in Segments 9a, 9b, and 10.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 SO_4=WS Cl=250	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS (tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch) = TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Zn(ac)= $0.978e^{(0.8537[\ln(hardness)]+1.9467)}$ Zn(ch)= $0.986e^{(0.8537[\ln(hardness)]+1.8032)}$	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr)	Temporary modifications: Cu(ch)=11.4 µg/l (dis), (Type iii) Expiration date of 7/01/2015. Temporary modification: As(ch)=hybrid Expiration date of 12/31/21.
3a. Mainstem of South Clear Creek, including all tributaries and wetlands, from the source to the confluence with Clear Creek, except for the specific listings in Segments 3b and 19.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Zn(ac)= $0.978e^{(0.8537[\ln(hardness)]+1.9467)}$ Zn(ch)= $0.986e^{(0.8537[\ln(hardness)]+1.8032)}$	Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr)	Temporary modification: As(ch)=hybrid Expiration date of 12/31/21.
3b. Mainstem of Leavenworth Creek from source to confluence with South Clear Creek.	9/30/00 Baseline does not apply	Aq Life Cold 2 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02-10 (Trec) As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Zn(ac)= $0.978e^{(0.8537[\ln(hardness)]+1.9467)}$ Zn(ch)= $0.986e^{(0.8537[\ln(hardness)]+1.8032)}$	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr)	

REGULATION #38 STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 3 AND 4	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS						TEMPORARY MODIFICATIONS AND QUALIFIERS
BASIN: CLEAR CREEK			PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS µg/l			
Stream Segment Description									
4. Mainstem of West Clear Creek from the source to the confluence with Woods Creek.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
5. Mainstem of West Clear Creek from the confluence with Woods Creek to the confluence with Clear Creek.		Aq Life Cold 1 Recreation E Agriculture	T=TVS (CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05	As(ac)=340 As(ch)=7.6(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot) Ni(ac/ch)=TVS $Zn(ac)=e^{(0.6404[ln(hardness)]+1.6810)}$ $Zn(ch)=e^{(06404[ln(hardness)]+1.5127)}$	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr)	
6. All tributaries to West Clear Creek, including all wetlands, from the source to the confluence with Clear Creek, except for specific listings in Segments 7 and 8.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
7. Mainstem of Woods Creek from the outlet of Upper Urad Reservoir to the confluence with West Clear Creek, including Lower Urad Reservoir.	UP	Aq Life Cold 2 Recreation N	T=TVS(CS-I/CL)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.0-9.0 E.Coli=630/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 NO_2=0.05	$WQS_{WC} = ((Q_{WC} + Q_{WFCC}) X WQS_{WFCC} - (Q_{WFCC} X C_{WFCC}))/Q_{WC}$ WQS_{WC} = Water Quality Standards for Woods Creek Q_{WC} = Flow for Woods Creek Q_{WFCC} = Flow for West Fork Clear Creek WQS_{WFCC} = Water Quality Standards for West Fork Clear Creek C_{WFCC} = Ambient Concentration in West Fork Clear Creek			Standards shall be applied using the Segment 7 equation.
8. Mainstem of Lion Creek from the source to the confluence with West Clear Creek.	UP	Aq Life Cold 2 Recreation E	T=TVS(CS-I)°C D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 3.0-9.0 E.Coli=126/100ml						
9a. Mainstem of the Fall River, including all tributaries and wetlands, from the source to the confluence with Clear Creek.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	Temporary modification: Cu(ch)=9.6 µg/l (dis), (type III) Expiration date of 7/01/2015.
9b. Mainstem of Trail Creek, including all tributaries and wetlands from the source to the confluence with Clear Creek.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 SO_4=WS NO_3=10 Cl=250	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch) = TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS Zn(ch)=200	
10. Mainstem of Chicago Creek, including all tributaries and wetlands, from the source to the confluence with Clear Creek, except for specific listings in Segment 19.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	Temporary modification: As(ch)=hybrid Expiration date of 12/31/21.

REGULATION #38 STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 3 AND 4 BASIN: CLEAR CREEK Stream Segment Description	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS						TEMPORARY MODIFICATIONS AND QUALIFIERS
			PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS µg/l			
11. Mainstem of Clear Creek from a point just above the Argo Tunnel discharge to the Farmers Highline Canal diversion in Golden, Colorado.	UP	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ch)=17	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot) Zn(ac)= $0.978e^{(0.8537[\ln(hardness)]+1.9467)}$ Zn(ch)= $0.986e^{(0.8537[\ln(hardness)]+1.8032)}$	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr)	Temporary modification: Cd(ch)=1.42 µg/l (dis), (type iii) Expiration date of 7/01/2015. Temporary modification: As(ch)=hybrid Expiration date of 12/31/21
12. All tributaries to Clear Creek, including all wetlands, from the Argo Tunnel discharge to the Farmers Highline Canal diversion in Golden, Colorado, except for specific listings in Segments 13a and 13b.	9/30/00 Baseline does not apply	Aq Life Cold 2 Recreation E Water Supply Agriculture	T=TVS(CS-II) °C D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02-10(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec)CrVI(ac/ch)=TVSCu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
13a. Mainstem of North Clear Creek, including all tributaries and wetlands, from its source to its confluence with Chase Gulch. and Four Mile Gulch, including all tributaries and wetlands, from their sources to their confluence with North Clear Creek and Eureka Gulch, including all tributaries and wetlands, from its source to its confluence with Gregory Gulch.	9/30/00 Baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS (CS-I)°C D.O. = 6.0 mg/l D.O.(sp)=7.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS	Cu(ac/ch)=TVS Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	Temporary modification: As(ch)=hybrid Expiration date of 12/31/21.
13b. Mainstem of North Clear Creek including all tributaries and wetlands from a point just below the confluence with Chase Gulch to the confluence with Clear Creek, except for the specific listings in Segment 13a.	UP	Aq Life Cold 2 Recreation E Agriculture	T=TVS (CS-I)°C D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05	As(ac)=340 As(ch)=100 (Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS	Cu(ch)=64 Fe(ch)=5400(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ch)=740	Temporary modifications: Cd(ch)=4.7 µg/l (dis), Mn(ch)=3841 µg/l (dis), Zn(ch)=1582 µg/l (dis), Fe(ch)=7941 (Trec), T=current condition (type iii) Expiration date of 7/01/2015.
14a. Mainstem of Clear Creek from the Farmers Highline Canal diversion in Golden, Colorado to the Denver Water conduit #16 crossing.	UP	Aq Life Warm 2 Recreation N Water Supply Agriculture	T=TVS (WS-II)°C D.O.= 5.0 mg/l pH = 6.5-9.0 E.Coli=630/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02-10(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac)=TVS Mn(ch)=244 Hg(ch)=0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVSx 1.57*	Temporary modifications: Cu(ac/ch)=TVSx3.66*, T=current condition (type iii) Expiration date of 12/31/2015.
14b. Mainstem of Clear Creek from the Denver Water conduit #16 crossing to a point just below Youngfield Street in Wheat Ridge, Colorado.	UP	Aq Life Warm 2 Recreation E Water Supply Agriculture	T=TVS (WS-II)°C D.O.= 5.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02-10(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac)=TVS Mn(ch)=244 Hg(ch)=0.01(tot) Ni(ac/ch)=TVS	Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVSx 1.57*	Temporary modifications: Cu(ac/ch)=TVSx3.66*, T=current condition (type iii) Expiration date of 12/31/2015.
15. Mainstem of Clear Creek from Youngfield Street in Wheat Ridge, Colorado, to the confluence with the South Platte River.		Aq Life Warm 1 Recreation E Water Supply Agriculture	T=TVS(WS-II)°C D.O.=5.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Trec)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVSx 1.57*	Aquatic life warm 1 goal qualifier. Temporary Modifications: Cu(ac/ch)=TVSx3.66*, T=current condition (Type iii) Expiration date of 12/31/2015. Temporary modification: As(ch)=hybrid Expiration date of 12/31/21.

* TVS x (times) the FWER (final water effect ratio) = site-specific standard or value of temporary modification.

REGULATION #38 STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 3 AND 4 **BASIN: CLEAR CREEK** Stream Segment Description	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS						TEMPORARY MODIFICATIONS AND QUALIFIERS
			PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS µg/l			
16a. Mainstem of Lena Gulch including all tributaries and wetlands from its source to the inlet of Maple Grove Reservoir.	UP	Aq Life Warm 2 Recreation E Water Supply Agriculture	T=TVS(WS-II)°C D.O.=5.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02-10(Trec) Cd(ac)=TVS Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
16b. All tributaries to Clear Creek from the Farmers Highline Canal diversion in Golden, Colorado to the confluence with the South Platte River, except for specific listings in Segments 16a, 17a, 17b, 18a and 18b.	UP	Aq Life Warm 2 Recreation N Agriculture	T=TVS(WS-II)°C D.O.=5.0 mg/l pH=6.5-9.0 E.Coli=630/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5	As(ac)=340 As(ch)=100(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Trec)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
17a. Arvada Reservoir.	UP	Aq Life Cold 2 Recreation N Water Supply Agriculture	T=TVS(CLL)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Water + Fish Standards
17b. Mainstem of Ralston Creek, including all tributaries and wetlands, from the source to the inlet of Arvada Reservoir.		Aq Life Cold 2 Recreation U Water Supply Agriculture	T=TVS(CS-II)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Water + Fish Standards Temporary modification: As(ch)=hybrid Expiration date of 12/31/21.
18a. Mainstem of Ralston Creek, including all tributaries and wetlands, from the outlet of Arvada Reservoir to the confluence with Clear Creek.	UP	Aq Life Warm 2 Recreation E Water Supply Agriculture	T=TVS(WS-II) °C D.O. = 5.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02-10(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
18b. Mainstem of Leyden Creek and Van Bibber Creek from their source to their confluence with Ralston Creek. Mainstem of Little Dry Creek from its source to its confluence with Clear Creek.	UP	Aq Life Warm 2 Recreation N Water Supply Agriculture	T=TVS(WS-II) °C D.O.=5.0 mg/l pH=6.5-9.0 E.Coli=630/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=340 As(ch)=0.02-10(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
19. All tributaries to Clear Creek, including wetlands, within the Mt. Evans Wilderness Area.	OW	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CS-I)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=340 As(ch)=0.02Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
20. Lakes and reservoirs in the Clear Creek system that are within the boundary of the Mt. Evans Wilderness Area.	OW	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CL)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH_3(ac/ch)=TVS Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrIII(ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	

REGULATION #38 STREAM CLASSIFICATIONS and WATER QUALITY STANDARDS

REGION: 3 AND 4 **BASIN: CLEAR CREEK**	DESIG	CLASSIFICATIONS	NUMERIC STANDARDS						TEMPORARY MODIFICATIONS AND QUALIFIERS
Stream Segment Description			PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS µg/l			
21. Lakes and reservoirs in the Clear Creek system from sources to the Farmer's Highline Canal diversion in Golden, CO,, except as specified in Segments 7, 20, 22 and 25. Upper Long Lake.	9/30/00 baseline does not apply	Aq Life Cold 1 Recreation E Water Supply Agriculture	T=TVS(CL)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH$_3$(ac/ch)=TVS Cl$_2$(ac)=0.019 Cl$_2$(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO$_2$=0.05 NO$_3$=10 Cl=250 SO$_4$=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	Temporary modification: As(ch)=hybrid Expiration date of 12/31/21.
22. Lakes and reservoirs in the North Clear Creek drainage from a point just below the confluence with Chase Gulch to the confluence with Clear Creek.	9/30/00 baseline does not apply	Aq Life Cold 1 Recreation E Agriculture	T=TVS (CL)°C D.O. = 6.0 mg/l D.O.(sp)=7.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH$_3$(ac/ch)=TVS Cl$_2$(ac)=0.019 Cl$_2$(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO$_2$=0.05	As(ac)=340 As(ch)=7.6Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS	Cu(ac/ch)=TVS Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
23. Ralston Reservoir		Aq Life Cold 2 Recreation U Water Supply Agriculture	T=TVS(CLL)°C D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 E.Coli=126/100ml	NH$_3$(ac/ch)=TVS Cl$_2$(ac)=0.019 Cl$_2$(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO$_2$=0.05 NO$_3$=10 Cl=250 SO$_4$=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec)CrVI(ac/ch)=TVSCu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	Water + Fish Standards
24. Lakes and reservoirs in the Clear Creek system from the Farmers Highline Canal diversion in Golden, Colorado to the confluence with the South Platte River, except for specific listings in Segment s 17a, 21 and 23.		Aq Life Warm 1 Recreation U Water Supply Agriculture	T=TVS(WL)°C D.O.=5.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH$_3$(ac/ch)=TVS Cl$_2$(ac)=0.019 Cl$_2$(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO$_2$=0.5 NO$_3$=10 Cl=250 SO$_4$=WS	As(ac)=340 As(ch)=0.02(Trec) Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	Temporary modification: As(ch)=hybrid Expiration date of 12/31/21.
25. Guanella Reservoir		Aq Life Cold 1 Recreation E Agriculture	T=TVS (CL)°C D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH=6.5-9.0 E.Coli=126/100ml	NH$_3$(ac/ch)=TVS Cl$_2$(ac)=0.019 Cl$_2$(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO$_2$=0.05	As(ac)=340 As(ch)=7.6(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS	Cu(ac/ch)=TVS Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	

TABLE III METAL PARAMETERS (Concentration in ug/l)

METAL$^{(1)}$	AQUATIC LIFE$^{(1)(3)(4)(J)}$		AGRICULTURE$^{(2)}$	DOMESTIC WATER-SUPPLY$^{(2)}$	WATER + FISH$^{(7)}$	FISH INGESTION$^{(10)}$
	ACUTE	CHRONIC				
Aluminum	$e^{(1.3695[\ln(hardness)]+1.8308)}$ (tot.rec.)	87 or $e^{(1.3695[\ln(hardness)]-0.1158}$ (tot.rec.)$^{(11)}$			---	—
Antimony				6.0 (30-day)	5.6	640
Arsenic	340	150	100$^{(A)}$ (30-day)	0.02 – 10$^{(13)}$ (30-day)$^{(14)}$	0.02	7.6
Barium				1,000$^{(E)}$(1-day) 490 (30-day)	---	---
Beryllium			100$^{(A,B)}$ (30-day)	4.0 (30-day)	—	—
Cadmium	$(1.136672-[\ln(hardness) \times (0.041838)]) \times e^{0.9151[\ln(hardness)]-3.1485}$ (Trout)=$(1.136672-[\ln(hardness) \times (0.041838)]) \times e^{0.9151[\ln(hardness)]-3.6236}$	$(1.101672-[\ln(hardness) \times (0.041838)] \times e^{0.7998[\ln(hardness)]-4.4451}$	10$^{(B)}$ (30-day)	5.0$^{(E)}$ (1-day)	---	—
Chromium III$^{(5)}$	$e^{(0.819[\ln(hardness)]+2.5736)}$	$e^{(0.819[\ln(hardness)]+0.5340)}$	100$^{(B)}$ (30-day)	50$^{(E)}$ (1-day)	---	—
Chromium VI$^{(5)}$	16	11	100$^{(B)}$ (30-day)	50$^{(E)}$ (1-day)	100(30-day)	---
Copper	$e^{(0.9422[\ln(hardness)]-1.7408)}$	$e^{(0.8545[\ln(hardness)]-1.7428)}$	200$^{(B)}$	1,000$^{(F)}$ (30-day)	1,300	—
Iron		1,000(tot.rec.)$^{(A,C)}$		300(dis)$^{(F)}$ (30-day)	—	—
Lead	$(1.46203-[(\ln(hardness)*(0.145712)])*e^{(1.273[\ln(hardness)]-1.46)}$	$(1.46203-[(\ln(hardness)*(0.145712)])*e^{(1.273[\ln(hardness)]-4.705)}$	100$^{(B)}$ (30-day)	50$^{(E)}$ (1-day)	—	—
Manganese	$e^{(0.3331[\ln(hardness)]+6.4676)}$	$e^{(0.3331[\ln(hardness)]+5.8743)}$	200$^{(B)}$ (30-day)$^{(12)}$	50(dis)$^{(F)}$ (30-day)	—	—
Mercury		FRV(fish)$^{(6)}$ = 0.01 (Total)		2.0$^{(E)}$ (1-day)	—	—
Molybdenum			300$^{(O)}$ (30-day)$^{(16)}$	210 (30-day)		

TABLE III METAL PARAMETERS (Concentration in ug/l)						
METAL(1)	AQUATIC LIFE(1)(3)(4)(J)		AGRICULTURE(2)	DOMESTIC WATER-SUPPLY(2)	WATER + FISH(7)	FISH INGESTION(10)
	ACUTE	CHRONIC				
Nickel	$e^{(0.846[\ln(\text{hardness})]+2.253)}$	$e^{(0.846[\ln(\text{hardness})]+0.0554)}$	200(B) (30-day)	100(E) (30-day)	610	4,600
Selenium(9)	18.4	4.6	20(B,D) (30-day)	50(E) (30-day)	170	4,200
Silver	$\frac{1}{2}e^{(1.72[\ln(\text{hardness})]-6.52)}$	$e^{(1.72[\ln(\text{hardness})]-9.06)}$ (Trout) = $e^{(1.72[\ln(\text{hardness})]-10.51)}$		100(F) (1-day)	—	---
Thallium		15(C)		0.5 (30-day)	0.24	0.47
Uranium(17)	$e^{(1{:}1021[\ln(\text{hardness})]+2.7088)}$	$e^{(1.1021[\ln(\text{hardness})]+2.2382)}$		16.8 – 30(13) (30-day)	—	---
Zinc	$0.978{*}e^{(0.9094[\ln(\text{hardness})]+0.9095)}$	$0.986{*}e^{(0.9094[\ln(\text{hardness})]+0.6235)}$ (sculpin)(15) = $e^{(2.140[\ln(\text{hardness})]-5.084)}$	2000(B) (30-day)	5,000(F) (30-day)	7,400	26,000
NOTE: Capital letters in parentheses refer to references listed in section 31.16(3); Numbers in parentheses refer to Table III footnote						

Table III – Footnotes

(1) Metals for aquatic life use are stated as dissolved unless otherwise specified.

Where the hardness-based equations in Table III are applied as table value water quality standards for individual water segments, those equations define the applicable numerical standards. As an aid to persons using this regulation, Table IV provides illustrative examples of approximate metals values associated with a range of hardness levels. This table is provided for informational purposes only.

(2) Metals for agricultural and domestic uses are stated as total recoverable unless otherwise specified.

(3) Hardness values to be used in equations are in mg/l as calcium carbonate and shall be no greater than 400 mg/l. The exception is for Al, where the upper cap on calculations is a hardness of 220 mg/l. For permit effluent limit calculations, 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 possible, a site-specific method should be used, e.g., where hardness data exists without paired flow data, the mean of the hardness during the low flow season established in the permit shall be used. In calculating a hardness value, regression analyses should not be extrapolated past the point that data exist. For determination of standards attainment, where paired metal/hardness data is available, attainment will be determined for individual sampling events. Where paired data is not available, the mean hardness will be used.

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

(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 50ug/l total chromium in those waters classified for domestic water use.

(6) FRV means Final Residue Value and should be expressed as "Total" because many forms of mercury are readily converted to toxic forms under natural conditions. The FRV value of 0.01 ug/liter is the maximum allowed concentration of total mercury in the water that will present bioconcentration or bioaccumulation of methylmercury in edible fish tissue at the U.S. Food and Drug Administration's (FDA) action level of 1 ppm. The FDA action level is intended to protect the average consumer of commercial fish; it is not stratified for sensitive populations who may regularly eat fish.

A 1990 health risk assessment conducted by the Colorado Department of Public Health and Environment indicates that when sensitive subpopulations are considered, methylmercury levels, in sport-caught fish as much as one-fifth lower (0.2 ppm) than the FDA level may pose a health risk.

In waters supporting populations of fish or shellfish with a potential for human consumption, the Commission can adopt the FRV as the stream standard to be applied as a 30-day average. Alternatively, the Commission can adopt site-specific ambient based standards for mercury in accordance with section 31.7(1)(b)(ii) and (iii). When this option is selected by a proponent for a particular segment, information must be presented that (1) ambient water concentrations of total mercury are detectable and exceed the FRV, (2) that there are detectable levels of mercury in the proponent's discharge and that are contributing to the ambient levels and (3) that concentrations of methylmercury in the fish exposed to these ambient levels do not exceed the maximum levels suggested in the CDH Health Advisory for sensitive populations of humans. Alternatively or in addition the proponent may submit information showing that human consumption of fish from the particular segment is not occurring at a level which poses a risk to the general population and/or sensitive populations.

(7) Applicable to all Class 1 aquatic life segments which also have a water supply classification or Class 2 aquatic life segments which also have a water supply classification designated by the Commission after rulemaking hearing. These Class 2 segments will generally be those where fish of a catchable size and which are normally consumed are present, and where there is evidence that fishing takes place on a recurring basis. The Commission may also consider additional evidence that may be relevant to a determination whether the conditions applicable to a particular segment are similar enough to the assumptions underlying the water plus fish ingestion criteria to warrant the adoption of water plus fish ingestion standards for the segment in question.

(8) The use of 0.1 micron pore size filtration for determining dissolved iron is allowed as an option in assessing compliance with the drinking water standard.

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

(10) Applicable to the following segments which do not have a water supply classification: all Class 1 aquatic life segments or Class 2 aquatic life segments designated by the Commission after rulemaking hearing. These class 2 segments will generally be those where fish of a catchable size and which are normally consumed are present, and where there is evidence that fishing takes place on a recurring basis. The Commission may also consider additional evidence that may be relevant to a determination whether the conditions applicable to a particular segment are similar enough to the assumptions underlying the fish ingestion criteria to warrant the adoption of fish ingestion standards for the segment in question.

(11) Where the pH is equal to or greater than 7.0 in the receiving water after mixing, the chronic hardness-dependent equation will apply. Where pH is less than 7.0 in the receiving water after mixing, either the 87 µg/l chronic total recoverable aluminum criterion or the criterion resulting from the chronic hardness-dependent equation will apply, whichever is more stringent.

(12) This standard is only appropriate where irrigation water is applied to soils with pH values lower than 6.0.

(13) Whenever a range of standards is listed and referenced to this footnote, the first number in the range is a strictly health-based value, based on the Commission's established methodology for human health-based standards. The second number in the range is a maximum contaminant level, established under the federal Safe Drinking Water Act that has been determined to be an acceptable level of this chemical in public water supplies, taking treatability and laboratory detection limits into account. 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. Water bodies will be considered in attainment of this standard, and not included on the Section 303(d) List, so long as the existing ambient quality does not exceed the second number in the range.

(14) The arsenic limit shall be calculated to meet the relevant standard in accordance with the provisions of Section 31.10 of this regulation unless:

a. The permittee provides documentation that a reasonable level of inquiry demonstrates that there is no actual domestic water supply use of the waters in question or of hydrologically connected ground water, or

b. The arsenic concentration at the point of intake to the domestic water supply will not exceed the standard as demonstrated through modeling or other scientifically supportable analysis.

(15) The chronic zinc equation for sculpin applies in areas where mottled sculpin are expected to occur and hardness is less than 102 ppm $CaCO_3$. The regular chronic zinc equation applies in areas where mottled sculpin are expected to occur, but the hardness is greater than 102 ppm $CaCO_3$.

(16) In determining whether adoption of a molybdenum standard is appropriate for a segment, the Commission will consider whether livestock or irrigated forage is present or expected to be present. The table value assumes that copper and molybdenum concentrations in forage are 7 mg/kg and 0.5 mg/kg respectively, forage intake is 6.8 kg/day, copper concentration in water is 0.008 mg/l, water intake is 54.6 l/day, copper supplementation is 48 mg/day, and that a Cu:Mo ratio of 4:1 is appropriate with a 0.075 mg/l molybdenum margin of safety. Numeric standards different than the table-value may be adopted on a site-specific basis where appropriate justification is presented to the Commission. In evaluating site-specific standards, the relevant factors that should be considered include the presence of livestock or irrigated forage, and the total intake of copper, molybdenum, and sulfur from all sources (i.e., food, water, and dietary supplements). In general, site-specific standards should be based on achieving a safe copper:molybdenum total exposure ratio, with due consideration given to the sulfur exposure. A higher Cu:Mo ratio may be necessary where livestock exposure to sulfur is also high. Species specific information shall be considered where cattle are not the most sensitive species.

(17) When applying the table value standards for uranium to individual segments, the Commission shall consider the need to maintain radioactive materials at the lowest practical level as required by Section 31.11(2) of the Basic Standards regulation.

Table IV
Table Value Standards for Selected Hardnesses
(concentration in ug/L, dissolved)

		Mean Hardness in mg/L calcium carbonate									
		25	50	75	100	150	200	250	300	350	400
Aluminum	Acute	512	1324	2307	3421	5960	8838	10071	10071	10071	10071
	Chronic	73	189	329	488	851	1262	1438	1438	1438	1438
Cadmium	Acute trout	0.5	0.9	1.3	1.7	2.4	3.1	3.8	4.4	5.1	5.7
	Acute	0.8	1.5	2.1	2.7	3.9	5.0	6.1	7.1	8.1	9.2
	Chronic	.15	.25	0.34	0.42	0.58	0.72	0.85	0.97	1.1	1.2
Chromium III	Acute	183	323	450	570	794	1005	1207	1401	1590	1773
	Chronic	24	42	59	74	103	131	157	182	207	231
Copper	Acute	3.6	7.0	10	13	20	26	32	38	44	50
	Chronic	2.7	5.0	7.0	9.0	13	16	20	23	26	29
Lead	Acute	14	30	47	65	100	136	172	209	245	281
	Chronic	0.5	1.2	1.8	2.5	3.9	5.3	6.7	8.1	9.5	11
Manganese	Acute	1881	2370	2713	2986	3417	3761	4051	4305	4532	4738
	Chronic	1040	1310	1499	1650	1888	2078	2238	2379	2504	2618
Nickel	Acute	145	260	367	468	660	842	1017	1186	1351	1513
	Chronic	16	29	41	52	72	94	113	132	150	168
Silver	Acute	0.19	0.62	1.2	2.0	4.1	6.7	9.8	13	18	22
	Chronic Trout	0.01	0.02	0.05	0.08	0.15	0.25	0.36	0.50	0.65	0.81
	Chronic	0.03	0.10	0.20	0.32	0.64	1.0	1.6	2.1	2.8	3.5
Uranium	Acute	521	1119	1750	2402	3756	5157	6595	8062	9555	11070
	Chronic	326	699	1093	1501	2346	3221	4119	5036	5968	6915
Zinc	Acute	45	85	123	160	231	301	368	435	500	565
	Chronic sculpin	6.1	27	64	118	N/A	N/A	N/A	N/A	N/A	N/A
	Chronic	34	65	93	121	175	228	279	329	379	428

Shaded values exceed drinking water supply standards.

ATTACHMENT C: RISK ASSESSMENT DATA REVIEW

A baseline risk assessment was performed as part of the Phase II Remedial Investigation. The Phase II risk assessment utilized the chemicals of potential concern (COPC) identified during the Phase I evaluation. Those were: aluminum, arsenic, cadmium, chromium, copper, fluoride, lead, manganese, nickel, silver and zinc. In addition, iron was selected for evaluation because it was detected in surface water at levels potentially toxic to aquatic life. Similarly, mercury (in fish) and beryllium (in air) were evaluated due to their potential toxicity to humans.

Human Health Assessment

Generally, a risk assessment is determined using a combination of exposure dose estimations and biokinetic modeling. For metal contaminants of potential concern other than lead (arsenic, cadmium, chromium and manganese), the estimated doses for non-cancer health effects are divided by the appropriate health-based guidelines to calculate the hazard quotient (HQ). The cumulative non-cancer hazard (or hazard index; HI) of multiple contaminants is estimated by adding all HQs together. A HQ greater than one indicates the estimated exposure exceeds the non-cancer health-based guideline and requires further evaluation by comparison of estimated exposure doses or concentrations with health effects levels known to be associated with harmful effects in animal and/or human studies.

The estimated doses for cancer health effects are calculated in a similar manner to non-cancer health effects; however, the cancer doses are averaged over a lifetime and are multiplied by oral slope factors, developed by the EPA and other agencies. The resulting risks are compared to the EPA target cancer risk level of 1×10^{-6} to 1×10^{-4}, or 1 excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals.

The Phase II risk assessment used a "reverse" approach. Due to the number of potential sources associated with the Site, and assessment of the risk associated with each source was deemed too cumbersome. Instead, the evaluation calculated a concentration of chemical in a given medium that would correspond with a particular level of risk. Risk-based concentrations (RBC) were developed for each exposure pathway for the average exposure case and a maximum plausible case.

RBCs were calculated for the following exposure pathways:

- Incidental ingestion of surface water while swimming;
- Ingestion of fish;
- Residential ingestion of drinking water;
- Incidental ingestion of tailings and
- Residential inhalation.

The concentration of each COPC was calculated for specific medium to determine the individual 10^{-6} risk level for carcinogens, or a hazard index of 1 for noncarcinogens.

The equations used were developed as follows.

$$I = \frac{C \times CR \times EF \times ED}{BW \times AT} \qquad \text{(EQ 1)}$$

Where

I = Intake
C = Concentration
CR = Contact Rate
EF = Exposure Frequency
ED = Exposure Duration
BW = Body Weight
AT = Averaging Time

For carcinogens, the target risk level is 10^{-6}, or

$$I \times SF = 1 \times 10^{-6} \qquad \text{(EQ 2)}$$

Where

SF = Slope Factor

Substituting the expression for intake (EQ 1) into EQ2, concentration can be calculated as follows:

$$C = 1 \times 10^{-6} \times \frac{BW \times AT}{SF \times CR \times EF \times ED} \qquad \text{(EQ 3)}$$

For noncarcinogens, the target risk level hazard index is 1.

$$\frac{I}{RfD} = 1 \qquad \text{(EQ 4)}$$

Substituting the expression for intake (EQ 1) into EQ 4, concentration can be calculated as follows:

$$C = 1 \times RfD \times \frac{BW \times AT}{CR \times EF \times ED} \qquad \text{(EQ 5)}$$

Oral or inhalation slope factors or reference dose values have changed for several of the COPCs, as detailed in Table C-1.

Using the same exposure assumptions, which remain valid, the risk-based target concentrations can be calculated with the 1991 and 2014 values for reference dose or slope factor.

Risk-based concentrations used in the OU3 ROD and calculated during May 2014 are presented in Table C-2. The RBC calculated in May 2014 was lower than the OU3 RBC for arsenic, cadmium, chromium and manganese in one or more exposure pathway scenario. The May 2014 calculated target concentrations were compared to the remediation goals or Site data for each medium.

Table C-1: Chronic Health Effects Criteria for Phase II Chemicals of Potential Concern

COPC	Phase II Risk Assessment			May 2014		
	Oral Reference Dose (RfD) mg/kg-day	Oral Slope Factor $(mg/ kg-day)^{-1}$	Inhalation Slope Factor $(mg/ kg-day)^{-1}$	Oral Reference Dose (RfD) mg/ kg-day	Oral Slope Factor $(mg/ kg-day)^{-1}$	Inhalation Slope Factor $(mg/ kg-day)^{-1}$
Aluminum	-	-	-	1.0	-	-
Arsenic	0.001	1.75	50	0.0003	1.5	15
Beryllium	0.005	4.3	8.4	0.002	-	8.4
Cadmium	0.001 (food) 0.0005 (water)	-	6.1	0.001 (food) 0.0005 (water)	-	6.3
Chromium (VI)	0.005	-	41	0.003	0.5	42
Copper	0.04	-	-	0.04	-	-
Fluoride	0.06	-	-	0.04		
Iron	-	-	-	0.7	-	-
Lead	-	-	-	-	-	-
Manganese	0.2	-	-	0.14	-	-
Mercury	0.0003[1]	-	-	0.0003[2]	-	-
Nickel	0.02	-	1.7 (as NiS)	0.02[2]	-	1.6
Silver	0.003	-	-	0.005	-	-
Zinc	0.2	-	-	0.3	-	-

[1] elemental

[2] salts

Surface Water

The remediation goal for surface water (see Table 10) is less than the May 2014 RBC for each COPC, except for the 10^{-6} carcinogenic risk for arsenic. The exposure scenario assumes an exposure frequency of 36 days per year for 10 years, using a child between the ages of 9 and 18 with an average body weight of 45 kilograms. Reviewing the surface water data collected from 2010 until May 2014, the average arsenic concentration is well below the RBC of 42 µg/L. Only samples from two dates (July 30, 2010 and August 3, 2010), collected during storm events, exceed this value.

Fish Tissue

The RBC calculated in May 2014 is lower than the OU3 RBC for cadmium in fish tissue. No fish tissue data has been collected since the Phase II baseline risk assessment. However, the data collected during the Phase II assessment indicated concentrations of cadmium in fish tissue were approximately one order of magnitude lower than the May 2014 RBC.

Drinking (Ground) Water

The RBC for arsenic in drinking water calculated during the Phase II risk assessment was lower than the drinking water standard. The OU3 ROD deemed using the drinking water standard was appropriate for arsenic in ground water. In 2001, the maximum contaminant level for arsenic in drinking water was lowered from 50 µg/L to 10 µg/L. The impact of the new arsenic standard was discussed in the 2009 Fourth Five-Year Review.

Table C-2: Risk-Based Target Concentrations for Potential Human Exposure

COPC	Phase II Risk Assessment					May 2014				
	Incidental Ingestion of Surface Water While Swimming (mg/L)	Ingestion of Fish (mg/kg)	Residential Ingestion of Drinking Water (mg/L)	Incidental Ingestion of Tailings (mg/kg)	Residential Inhalation (µg/m³)	Incidental Ingestion of Surface Water While Swimming (mg/L)	Ingestion of Fish (mg/kg)	Residential Ingestion of Drinking Water (mg/L)	Incidental Ingestion of Tailings (mg/kg)	Residential Inhalation (µg/m³)
Aluminum[a]	-	-	-	-	-	-	-	-	-	-
Arsenic	9.1	NA	0.035	1,600	NC	2.7	NC	0.01	470	NC
	0.037[b]	NA	0.000047[b]	13[b]	0.00011[b]	0.042[b]	NC	0.000054[b]	15[b]	0.00011[b]
Beryllium	NA	NA	NA	NA	0.00065[b]	NC	NC	NC	NC	0.00065[b]
Cadmium	4.6	1.3	0.018	1,600	0.00089[b]	4.6	1.3	0.018	1,600	0.00086[b]
Chromium (VI)	46	NA	0.175	7,900	0.00013[b]	27	NC	0.105	4,700	0.00013[b]
Copper	370	NA	1.4	63,000	NC	370	NC	1.4	63,000	NC
Fluoride	550	NA	2.1	NA	NA	365	NC	1.4	NC	NC
Iron	-	-	-	-	-	-	-	-	-	-
Lead	-	-	-	-	-	-	-	-	-	-
Manganese	1,800	NA	7	790,000	NA	1,270	NC	4.9	220,000	NC
Mercury (elemental)	NA	0.40	NA	NA	NA	NC	0.40	NC	NC	NC
Nickel	180	NA	0.7	31,000	0.0032[b]	180	NC	0.7	31,000	0.0034[b]
Silver	27	NA	0.11	4,700	NA	46	NC	0.17	7,900	NC
Zinc	1,800	NA	7	310,000	NC	2,700	NC	10.5	470,000	NC

[a] – Contaminant of Potential Concern for Aquatic Life only.

[b] - Target concentration derived to protect against carcinogenic effects.

NA – Not analyzed in this medium.

NC – Not calculated. Toxicity criteria are not available.

The May 2014 RBC is lower than the Phase II RBC for chromium, but both RBCs are higher than the drinking water Maximum Contaminant Level of 0.1 mg/L. The May 2014 RBC is also lower than the Phase II RBC for manganese. During the Site drinking water sampling program conducted by CDPHE between 1994 and 1996, samples were collected from 67 domestic ground water wells. Four samples contained concentrations of one or more contaminant above the Phase II RBC, and these residences were provided a point-of-use water treatment system or connected to a municipal water supply. A review of the sampling data confirmed that none of the sampled wells contained chromium or manganese in concentrations between the RBC levels established during the Phase II risk assessment and the May 2014 review. Ground water contamination does not appear to be a widespread concern at the Site.

Tailings and Mine Waste

The May 2014 RBC values for arsenic, cadmium and chromium are significantly lower than the Phase II RBC using the incidental ingestion of tailings exposure pathway.

Contaminant concentration data collected from waste piles sampled during the Phase II remedial investigation were compared to the RBC values (Table C-3).

For all metals but arsenic, the concentrations detected in the mine waste were orders of magnitude lower than the RBCs calculated during the Phase II RI and in May 2014. Concentrations of arsenic exceed the RBC values for the 10^{-6} carcinogenic risk for 11 of the 12 waste piles. The OU3 ROD established a remedial action benchmark for arsenic of 130 mg/kg. This equated to an excess carcinogenic risk of more than one cancer incidence per 100,000 persons (10^{-5}). Based on the May 2014 RBCs, a 10^{-5} carcinogenic risk would be associated with an arsenic concentration of 150 mg/kg.

Per OSWER directive 9355.0-30, where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, action generally is not warranted unless there are adverse environmental impacts.

Air

The Phase II risk assessment identified air quality in the Central City area as a potentially completed pathway. However, the risk could not be attributed to any individual or group of mine waste piles. The combined excess carcinogenic risk range for inhalation of all eight metals (arsenic, beryllium, cadmium, chromium, copper, lead, nickel and zinc) was four cancer incidences per 100,000 people under the average exposure scenario, and 9 cancer incidences per 100,000 people for the "maximum" exposure scenario. The largest proportion of the risk was attributed to chromium. The OU3 ROD stated:

> *Since the selected cleanup alternative involves capping of mine waste piles where possible, the inhalation risk at each of the capped piles will be eliminated and the overall risk reduced. Furthermore, the reasonable maximum potential excess carcinogenic risk estimate of nine cancer incidences per 100,000 people for the air exposure pathway is currently within the risk range which should be attained by Superfund cleanups.*

Table C-3: Average Metals Concentrations in Sampled Waste Piles, Phase II RI (mg/kg)

COPC	Phase II RBC	May 2014 RBC	Black Eagle Tailings	Boodle Mill Tailings	Boodle Mill Waste Rock	Clay County Tailings	Clay County Waste Rock	Empire Tailings
Aluminum	-	-	2,917	4,510	5,175	6,527	6,770	4,592
Arsenic	1,600	470	299	24	47	84	65	2
	13[a]	15[a]						
Cadmium	1,600	1,600	7	18	16	4	2	1
Chromium	7,900	4,700	12	11	18	30	34	10
Copper	63,000	63,000	435	168	210	314	206	66
Iron	-	-	44,367	20,850	26,950	29,267	35,200	15,657
Lead	-	-	2,810	1,117	1,460	938	486	15
Manganese	790,000	220,000	1,318	3,490	3,034	1,436	280	225
Nickel	31,000	31,000	8	10	15	21	34	6
Silver	4,700	7,900	34	5	22	8	5	1
Zinc	310,000	470,000	1,557	3,640	3,263	1,322	183	369

COPC	Phase II RBC	May 2014 RBC	Golden Gilpin Tailings	Golden Gilpin Waste Rock	Gregory #2 Waste Rock	Little Bear Waste Rock	McClelland Tailings	NCC Dredge Tailings
Aluminum	-	-	4,860	20,600	9,660	7,540	2,043	6,220
Arsenic	1,600	470	399	33	62	143	40	47
	13[a]	15[a]						
Cadmium	1,600	1,600	12	4	6	1	5	7
Chromium	7,900	4,700	26	83	14	21	10	20
Copper	63,000	63,000	434	172	365	168	141	776
Iron	-	-	34,200	49,600	52,150	60,950	21,733	24,525
Lead	-	-	2,305	613	708	1,004	1,142	515
Manganese	790,000	220,000	2,580	1,140	1,807	176	796	205
Nickel	31,000	31,000	20	38	16	13	7	12
Silver	4,700	7,900	17	6	5	15	19	8
Zinc	310,000	470,000	2,480	929	1,117	260	979	803

[a] Target concentration derived to protect against carcinogenic effects.

Since the Phase II studies were completed, several mine waste piles have been remediated, both under CERCLA and during the gaming industry development.

ATTACHMENT D: INSPECTION CHECKLIST

RECOMMENDED ANNUAL O&M /REMEDY EVALUATION CHECKLIST

Introduction and Purpose

Effective operation and maintenance (O&M) at Superfund sites generally is critical to ensure that remedies remain protective of human health and the environment.

The recommended Annual O&M Remedy Evaluation Checklist has been designed to help the Remedial Project Manager (RPM) capture data routinely collected during O&M in a way that can better evaluate the efficiency and effectiveness of the remedial action. This recommended checklist may also be used to evaluate an operating remedy prior to transferring the site to the State for O&M. In addition, remedy performance summarized using this recommended checklist can be used to communicate remedy progress to the local community, highlight potential issues before they become problems and help the RPM complete five-year reviews more efficiently.

The information that you collect using this recommended form should help you answer the following questions:

- Is the remedy achieving the remedial action objectives (RAOs), maintaining cleanup goals and/or achieving technology-specific performance goals?
- If the remedy is not achieving the established objectives and goals, what must I do to correct this and how can I document this?
- If the remedy is achieving the performance goals, objectives and performance standards, are there any opportunities to optimize the remedy to make it work more efficiently?

This recommended checklist is intended to be completed annually. It is recommended that any data that you use to complete this evaluation be attached to the checklist, as this will make completing the next year's evaluation easier.

This recommended checklist does not recommend the level of review carried out in the U.S. Environmental Protection Agency (EPA) five-year review process. However the recommended checklist contains review elements that are consistent with a five-year review process.

Instructions:

The recommended checklist is in Microsoft Word and was designed to be completed electronically. Most questions involve a short answer, yes/no response or simply checking the box. Questions that involve a short answer will have an expandable text box. For responses that ask to you to "select one," please double click on "select one" and choose the correct answer. If the information is not available for a particular question, please indicate this with a N/A. A site visit is strongly encouraged, but not required prior to completing the recommended checklist.

1. This evaluation is intended to be completed yearly once O&M activities have begun at a site and can be stored and maintained in an electronic format.
2. For large complex sites, consider completing a separate checklist for each Operable Unit (OU).
3. This evaluation should be based on information and documentation (e.g., O&M reports and monitoring data) that is readily available to the RPM.
4. Section VIII, "Technical Data and Remedy Performance," provides specific instructions regarding what data and information are important for this section. Data entered in Section VIII are used to evaluate the specific technology used in that remedial action (RA). Please note: *Section VIII, Appendix E, Other Remedy Types/ Components* was designed to be used by the RPM for the annual review of O&M remedies and remedy components that are not addressed in Appendices A through D or by the separate *Recommended Annual O&M Remedy Evaluation Checklist for Contaminated Sediment Remedies*, OSWER #9355.0-118.
5. When you have completed the recommended checklist, please sign and date page 1 and place the completed document in the site file. Additionally, we recommend that you save the completed checklist electronically for use in completing the next year's evaluation.

Generally, including the Recommended Annual O&M/Remedy Evaluation Checklist in the site repository can provide the community with information about O&M status and remedy performance and can demonstrate that the Region is tracking performance to ensure that the remedy remains protective.

Acronym List

AS	Air Sparging	PCOR	Preliminary Close Out Report
CSM	Conceptual Site Model	PRGs	Preliminary Remediation Goals
GAC	Granular Activated Carbon	PRP	Potentially Responsible Party
ICs	Institutional Controls	RAO	Remedial Action Objective
LEL	Lower Explosive Limit	ROD	Record of Decision
LTRA	Long-Term Response Action	RPM	Remedial Project Manager
MNA	Monitored Natural Attenuation	RSE	Remediation System Evaluation
NPL	National Priorities List	SVE	Soil Vapor Extraction
O&F	Operational and Functional	TI Waivers	Technical Impracticability Waivers
O&M	Operation and Maintenance	USACE	U.S. Army Corps of Engineers
OSHA	Occupational Safety and Health Administration	VEB	Vertical Engineered Barrier
OU	Operable Unit	VOCs	Volatile Organic Compounds

RECOMMENDED ANNUAL O&M /REMEDY EVALUATION CHECKLIST

Please save electronically and send this completed checklist and any attachments to the site file and site repository.

I. SIGNATURES AND APPROVALS

RPM			**RPM (If appropriate)**		
Name:	Leslie Sims		Name:		
Telephone:	303-312-6224		Telephone:		
Signature:		Date:	Signature:		Date:

State Contact (if appropriate)

Name:	Mary Boardman	
Telephone:	303-692-3413	
Signature:		Date:

II. GENERAL SITE INFORMATION

Site Name:	Central City/Clear Creek Superfund Site		
State:	CO		
Period Covered:	01/10/2009	to 30/09/2014	EPA Site ID:COD980717557
Site Lead:	State	Other, specify:	
Organization responsible for O&M operations:	State in-house		

Other, specify:

Site Remedy Components (ref. Section VIII):	Soil Containment, Other - Active Treatment		
Preliminary Close Out Report (PCOR) date:			
Operational & Functional (O&F) date:	Varies		
Last five-year review date:	30/09/2009		
NPL deletion date:			
Did you make a site visit during this review?	☒ Yes	☐ No	Date: 7/3/14

If no, why:

Date of next planned checklist evaluation:	
Location of Administrative Record/Site Files:	EPA VIII, CDPHE

During the site visit, was monitoring equipment operational? ☐ Yes ☐ No ☒ N/A

Please elaborate:

Has an Optimization Study been conducted at the site? ☐ N/A ☒ Yes ☐ No Date: 27/09/2007

If not, is one planned?

List all site events since the last evaluation that impact or may impact remedy performance.

Chronology of events since last report (e.g., site visits, receipt of reports, equipment failures, shutdowns, vandalism, storm events):

Elaborate on significant site events or visits to site:

III. DOCUMENTS AND RECORDS

Because these documents may be required for the five-year review, verify what documents are currently available on-site, or note off-site location:

Document	Required	Not required	On-site	Off-site (indicate where)
O&M Manual	☐	☐	☒	☒ CDPHE
O&M Maintenance Logs	☐	☐	☐	☒ CDPHE
O&M Annual Reports	☐	☐	☐	☒ CDPHE

RA as-built drawings modified during O&M	☐	☐	☒	☒ CDPHE
Site-Specific Health and Safety Plan	☐	☐	☒	☒ CDPHE
Contingency/Emergency Response Plan	☐	☐	☒	☐
O&M/Occupational Safety and Health Administration (OSHA) Training Records	☐	☐	☒	☒ CDPHE
Settlement Monument Records	☐	☒	☐	☐
Gas Generation Records	☐	☒	☐	☐
Ground Water Monitoring Records	☐	☒	☐	☐
Surface Water/Sediment/Fish Monitoring Records**	☐	☐	☐	☒ CDPHE
Cap/Cover System Inspection Records	☐	☐	☐	☒ CDPHE
Leachate Extraction Records	☐	☒	☐	☐
Discharge Compliance Records	☐	☐	☒	☒ CDPHE
Institutional Controls (ICs) Review	☐	☐	☐	☒ CDPHE
Other(s) (Please name each)	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐

** Note: A separate O&M checklist has been developed for surface water/sediment remedies. For completeness, answer this question regarding documentation requirements and availability, and enter more detailed information in the surface water/sediment checklist.

IV. ADMINISTRATIVE ISSUES

Check all that apply:	Date Initiated:
☐ Explanation of Significant Differences in progress	
☐ Record of Decision (ROD) Amendment in progress	
☐ Site in O&F period	
☐ Long-Term Response Action (LTRA) in progress	
☐ LTRA Transition to O&M in progress	
☐ Notice of Intent to Delete site in progress	
☐ Partial Site Deletion in progress	
☐ Technical Impracticability (TI) Waivers in progress	
☐ Reuse Assessment or Reuse Plan in progress	
☐ Revised Risk Assessment in progress ☐ Ecological OR ☐ Human Health	
☐ Other administrative issues:	

VI. O&M COSTS

The purpose of this section is to document what is known about O&M costs for this site. It is realized that not all cost information will be readily available, but to the extent possible, please provide the following information, as this will help identify cost increases and flag potential budget issues before they arise.

What was the total annual O&M cost for the previous year?	$983,000
What is the expected total annual O&M cost for the upcoming year?	$1,000,000

Please provide an approximate breakout of the previous year's O&M costs below.	**Use either $ or %**
Analytical (e.g., lab costs):	$9,200
Materials (e.g., treatment chemicals, cap materials):	$167,000
Oversight (e.g., project management):	$20,000
Monitoring (e.g., ground water sampling):	
Utilities (e.g., electric, gas, phone, water):	$48,000
ICs (implementation and enforcement):	
Other (e.g., capital improvements, equipment repairs):	$178,000

Describe any unanticipated/unusually high or low O&M costs and potential future O&M funding issues.

Costs are for active treatment only. Contract labor $537,000. Additional Site O&M costs include annual inspections, report and maintenance if required.

VII. INSTITUTIONAL CONTROLS (ICs)**

The purpose of the IC evaluation at the O&M phase is to determine if the ICs are implemented, effective and durable. The following references may be useful for completing this evaluation:

- *Institutional Controls Bibliography: Institutional Control, Remedy Selection, and Post Construction Completion Guidance and Policy* (OSWER 9355.0110, December 2005);
- *Supplement to the Comprehensive Five-Year Review Guidance; Evaluation of Institutional Controls* (OSWER 9355.7-12, working draft 3/17/05);
- *National IC Strategy to Ensure Institutional Controls Implementation at Superfund Sites* (OSWER 9355.0-106, September 2004); and
- *Institutional Controls: A Site Manager's Guide to Identifying, Evaluating and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanup* (OSWER 9355.0-7-4FS-P, September 2000).

** Note: A separate O&M checklist has been developed for surface water/sediment remedies. For completeness, answer this question regarding ICs, and enter more detailed information in the surface water/sediment checklist.

Identify each IC (media, objective, and instrument) implemented/to be implemented at the site. Attach an extra sheet if necessary. Colorado environmental covenants	
Are the ICs adequate to minimize the potential for human exposure and protect the integrity of the remedy? If no, please explain.	☒ Yes ☐ No
Please identify the party responsible for compliance and enforcement of the IC. property owner and CDPHE	
Please describe what the ICs are intended to accomplish, who they are designed to inform, the source document for the IC, and where the IC information is located. protection of remedy by informing current and future property owners, recorded with local county	
Please identify the date when the ICs were implemented. If the ICs have yet to be implemented, please identify the party responsible for implementing the ICs and the scheduled implementation date. varies	
If the ICs have been implemented, are they still in place? If the ICs remain in place, please identify whether there is a planned termination date and, if so, what it is. yes, indefinate	
Are there reasons to clarify or modify the appropriate decision document(s) to improve the effectiveness and/or durability of the ICs? If yes, please explain and describe any plans to clarify/modify the document(s).	☐ Yes ☒ No

VIII. TECHNICAL DATA AND REMEDY PERFORMANCE

The purpose of this section is to help prompt questions about remedy performance over the past year, the adequacy of monitoring activities to assess remedy performance, and changes in field conditions or understanding that could affect the remedy. Specific sections also prompt questions about remedy optimization. Addressing these questions on an annual basis can help to flag opportunities and potential issues to watch in the coming year and help inform future improvements in remedy O&M. The collection of annual checklists can also serve as documentation of when a potential issue was first identified, what was done to address it, and when it was addressed. Thus, an annual checklist can be a useful, succinct source of information to help RPMs recount O&M history.

Questions for specific remedy types (e.g., ground water pump-and-treat) are contained in Appendices A through D at the end of the form. Appendix E contains general questions that can be used to document technical data and remedy performance for remedies and remedy components that do not fit within the specific categories identified in the remainder of this checklist. Identify the remedy types in Section VIII.A, below, and complete a copy of each appendix that is applicable to the site. If the site includes multiple remedies or remedy components of the same type, please complete a copy of the applicable appendix for each remedy/component (e.g., if the remedy includes two separately managed containment areas, complete two copies of Appendix C, one for each area). A separate O&M checklist has been developed for surface water/sediment remedies and remedy components. If the site includes a surface water/sediment remedy, note this below and complete the surface water/sediment checklist.

A. Please identify the type(s) of remedy(ies) this Annual O&M Remedy Evaluation Checklist addresses:

☐ Ground Water Pump-and-Treat (please complete Appendix A)
☐ Ground Water Monitored Natural Attenuation (MNA) (please complete Appendix B)
☒ Ground Water or Soil Containment (please complete Appendix C)
☐ Soil Vapor Extraction/Air Sparging (please complete Appendix D)
☒ Other Remedy Types (please complete Appendix E)

IX. RECOMMENDATIONS

New Recommendations, from this annual review:

Recommendation	Party Responsible	Milestone Date

APPENDICES

TECHNICAL DATA AND REMEDY PERFORMANCE
ANNUAL O&M /REMEDY EVALUATION CHECKLIST

RECOMMENDED APPENDIX A. GROUND WATER PUMP-AND-TREAT REMEDIES

The following checklist is an abbreviated set of questions that could be used by an EPA RPM for annually reviewing the O&M of a ground water pump-and-treat remedy, including pump-and-treat remedies designed for hydraulic containment. This checklist was developed using concepts presented in EPA guidance, *Elements for Effective Management of Operating Pump and Treat Systems* (EPA 542-R-02-009, December 2002). This guidance is part of a series of fact sheets that EPA OSRTI has prepared as guidance to the ground water remediation community on effectively and efficiently designing and operating long-term ground water remedies. For more information, including the guidance *O&M Report Template for Ground Water Remedies (with Emphasis on Pump and Treat Systems)* (EPA 542-R-05-010, April 2005) and report *Pilot Project to Optimize Superfund-Financed Pump and Treat Systems: Summary Report and Lessons Learned* (EPA 542-R-02-008a), visit EPA's CLU-IN Website (www.cluin.org/).

A. Remedy Goals and Conceptual Site Model (CSM)

1. Review of the current remedy goals and measurements: Remedy goals may be expressed in terms of a broad, long-term purpose or intent specified in a decision document (e.g., cleanup to a specified concentration), a performance-based metric or milestone intermediate in duration (e.g., a 20% decrease in monthly influent concentrations within 24 months of operation); or a specific and short-term objective (e.g., demonstration of plume containment).

List the short-term objectives and intermediate system goals:

List the final system goals:

What metrics (performance criteria) are being implemented to measure project progress towards meeting each goal?

What schedule has been established for measuring and reporting each metric?

Based on new information or events since the last O&M review, is there a reason to re-evaluate the system goals? Note: this might be due to factors such as regulatory framework has been revised; better technology/strategy alternatives available; existing goals appear unrealistic; costs greater than originally anticipated; extent of plume has changed; new sources of contamination removed and/or discovered; or land use or ground water production near site has changed. If yes, identify the remedy goals that should be re-evaluated, the rationale, and any plans for re-evaluating the goals.	☐ Yes ☐ No

2. Review of changes to the CSM: The CSM is a combination of text and figures that describe the hydrogeologic system, the cause of the ground water impacts, and the fate and transport of the ground water contaminants. If monitoring data during active remediation do not agree with expectations, this could point to a gap in the conceptual model that should be addressed with a focused investigation. This does not imply a return to the "remedial investigation" phase. The CSM should evolve over time, including during active remediation, as more information about the site becomes available. The following questions may be used to evaluate the need for updating the CSM:

Since the last time you completed the O&M checklist for this system, have new contaminant sources been identified or have previously suspected contaminant sources been eliminated from further consideration? If yes, use this space to comment.	☐ Yes ☐ No
Since the last time you completed an O&M checklist for this system, have new contaminants been identified in the ground water that could affect remedy effectiveness? If yes, use this space to comment.	☐ Yes ☐ No
Based on your answers to the above questions, would it be useful to update the CSM at this time? If yes, please describe any plans to update the CSM.	☐ Yes ☐ No

B. Remedy Performance Assessment

1. Evaluate remedy effectiveness: The following questions are intended to review whether the ground water pump-and-treat remedy is performing as intended and whether there are opportunities for optimizing the remedy.

Plume Capture

When addressing these questions, it may be useful to refer to *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 600/R-08/003, January 2008).

Has a three-dimensional target capture zone been clearly defined?
If no, use this space to explain why not.
☐ Yes
☐ No

If not clearly defined, describe plans to better define the target capture zone.

What lines of evidence have been used to evaluate actual capture achieved (e.g., flow budget and/or capture zone width calculations, potentiometric surface maps, water elevation pairs, concentration trends at wells beyond the target capture zone, particle tracking in conjunction with ground water modeling, tracer tests)

System Equipment/Structures (e.g., extraction wells, collection systems)

Since the last time you completed an O&M checklist for this system, has the downtime associated with non-routine operations and maintenance exceeded expectations?
If yes, what systems have been responsible for unplanned downtime (e.g., extraction pumps, wastewater facilities)?
If yes, what corrections have been or are being made to minimize downtime?
☐ Yes
☐ No

Since the last time you completed the O&M checklist for this remedy/remedy component, have any major repairs to the pump-and-treat system(s) been required?
If yes, describe the repairs, their impact on progress toward remediation milestones, and actions taken to minimize similar repairs in the future.
☐ Yes
☐ No

Since the last time you completed an O&M checklist for this system, have the extraction/injection well rates changed significantly?
If yes, describe the known/suspected source of the change, if identified.
If yes, is the change reflective of a long-term condition and, if so, how will this be addressed in the O&M of the system?
☐ Yes
☐ No

Since the last time an O&M checklist was completed for this system, have air emissions from the system met permit requirements, if any?
If not, what is being done to meet the permit requirements?
☐ Yes
☐ No
☐ N/A

Since the last time an O&M checklist was completed for this system, has effluent discharge met permit requirements?
If not, what was (is) the problem and what was (or will be) done to correct it?
☐ Yes
☐ No

Optimization

Has an optimization study been conducted for this system?
☐ Yes
☐ No

If an optimization study has been conducted, have any of the optimization recommendations been implemented since the last time an O&M checklist was completed for this system?
☐ Yes
☐ No
☐ N/A

If optimization recommendations have been implemented (during this or prior review periods), describe any new results observed or conclusions drawn since the last time an O&M checklist was completed for this system.

If optimization recommendations have not been implemented, why not?

2. Evaluate collection and analysis of performance monitoring data	
Do the approaches used to interpret ground water monitoring data (e.g., concentration trend analyses, plume contour and/or bubble maps, plume cross-sections, potentiometric surface maps) provide adequate information to assess the performance of the pump-and-treat remedy? If no, describe plans, if any, to implement new approaches.	☐ Yes ☐ No
Based on information collected since the last O&M review, is there a need to re-evaluate the parameters, sampling methods, sampling frequency, and monitoring locations used to evaluate remedy performance?	☐ Yes ☐ No
Are ground water data managed electronically? If no, use this space to explain why not.	☐ Yes ☐ No
Are performance-monitoring reports of sufficient quality and frequency to evaluate the efficacy of the remedy and recognize protectiveness problems in time for effective action? If no, what actions, if any, have been taken or are planned to address this situation?	☐ Yes ☐ No
C. Cost Effectiveness	
Are actual parameters consistent with design parameters (based on process monitoring)? If not, how do they differ? (check all that apply) ☐ Influent rate to treatment plant ☐ Influent concentrations ☐ Mass loading to the system ☐ Removal efficiency for each treatment component ☐ Air to water ratio (air strippers) ☐ Materials usage (e.g., granular activated carbon (GAC), chemicals) ☐ Other (please explain)	☐ Yes ☐ No
Based on the above comparisons, have any above ground systems or process monitoring procedures been evaluated/implemented to reduce costs? If yes, please identify which of the following have been done to reduce costs. (check all that apply) ☐ Ensuring proper maintenance and efficiency of equipment ☐ Replacing treatment components with alternate technologies (e.g., replace UV/Oxidation with air stripping) or more appropriately sized components ☐ Eliminating unnecessary or redundant treatment components that are no longer needed (e.g., metals removal or GAC polishing system) ☐ Changing discharge ☐ Automating system to reduce labor ☐ Optimizing ground water extraction rates and/or locations ☐ Other (please explain)	☐ Yes ☐ No
D. Remedial Decisions: Indicate which of the following remedial decisions is appropriate at the present time and provide the basis for the decision.	
☐ No Change to the System ☐ Modify/Optimize System ☐ Modify/Optimize Monitoring Program ☐ IC Modifications ☐ Implementation of Contingency/Alternative Remedy	
Basis for decision:	

RECOMMENDED APPENDIX B. GROUND WATER MONITORED NATURAL ATTENUATION (MNA) REMEDIES

The following checklist is an abbreviated set of questions that could be used by an EPA RPM for annually reviewing the O&M of a MNA remedy for ground water. This MNA guidance checklist was developed using concepts presented in EPA guidance, *Performance Monitoring of MNA Remedies for* [volatile organic compounds] *(VOCs) in Ground Water* (EPA/600/R-04/027; April 2004). For some approaches, a more detailed remedy optimization study or remediation system evaluation (RSE) may be beneficial. For guidance on remedy optimization studies or RSEs , visit EPA's CLU-IN Website (www.cluin.org/) or the U.S. Army Corps of Engineers (USACE) Hazardous, Toxic and Radioactive Waste Center of Expertise RSE Website (www.environmental.usace.army.mil/)—

A. Remedy Goals and Conceptual Site Model (CSM)

1. Review of the current remedy goals and measurements: The remedy goals may be expressed in the ROD as remedial action objectives (RAOs) and preliminary remediation goals (PRGs). RAOs provide a general description of what the cleanup will accomplish (e.g., restoration of ground water). PRGs are the more specific statements of the desired endpoint concentrations or risk levels, for each exposure route, that are believed to provide adequate protection of human health and the environment.	
List the intermediate system goals (RAOs and PRGs).	
List the final system goals (RAOs and PRGs).	
What metrics (performance criteria) are being implemented to measure project progress towards meeting each goal?	
What schedule has been established for measuring and reporting each metric?	
Based on new information or events since the last review, is there a need to re-evaluate the remedy goals? Note: this might be due to factors such as whether the regulatory framework has been revised, whether existing goals appear realistic, and if there have been changes to land use or ground water production near the site. If yes, identify the remedy goals that should be re-evaluated, the rationale, and any plans for re-evaluating the goals.	☐ Yes ☐ No
2. Review of changes to the CSM: The CSM for natural attenuation is the site-specific qualitative and quantitative description of the migration and fate of contaminants with respect to possible receptors and the geologic, hydrologic, biologic, geochemical and anthropogenic factors that control contaminant distribution. Because the CSM provides the basis for the remedy and monitoring plan, it can be reevaluated as new data are developed throughout the lifetime of the remedy. The following questions may be used to evaluate the need for updating the CSM:	
Have new contaminant sources been identified or have previously suspected contaminant sources been eliminated from further consideration since the last time you completed the O&M checklist for this remedy? If yes, use this space to comment.	☐ Yes ☐ No
Has there been an increase or decrease in size of the plume since the last time you completed an O&M checklist for this remedy? Comments (e.g., what is the nature and magnitude of the change).	☐ Increase ☐ Decrease ☐ No change
Has there been an increase or decrease in vertical extents of the plume since the last time you completed an O&M checklist for this remedy? Comments (e.g., what is the nature and magnitude of the change).	☐ Increase ☐ Decrease ☐ No change
Has there been an increase or decrease in the maximum contaminant concentrations in the plume since the last time you completed an O&M checklist for this remedy? Comments (e.g., have maximum concentrations changed for all or a subset of contaminants, which ones, and by how much).	☐ Increase ☐ Decrease ☐ No change
What types of reaction zone(s) are present in the plume (aerobic, anaerobic, or both)?	
Based on information collected since the last O&M review, is there a need to re-evaluate the number and/or location of monitoring points in the reaction zone(s)?	☐ Yes ☐ No

If yes, use this space to comment.	
Based on information collected since the last O&M review, is there a need to re-evaluate the number and/or location of monitoring points in the target zones? If yes, use this space to comment.	☐ Yes ☐ No
Has there been a change in ground water flow rate or direction that may suggest monitoring frequency or locations may need to be reevaluated? If yes, use this space to comment.	☐ Yes ☐ No
Is there evidence of periodic pulses of residual contamination from the vadose zone that suggest new monitoring points should be added in the vadose zone? If yes, use this space to comment.	☐ Yes ☐ No
If there is reason to re-evaluate the number and location of monitoring points and/or monitoring frequency (as indicated in above responses), identify any plans for re-evaluating the monitoring program.	
Based on your responses to the above questions, would it be useful to update the CSM at this time? If yes, please describe any plans to update the CSM.	☐ Yes ☐ No

B. Remedy Performance Assessment

1. Review performance monitoring objectives. The OSWER Directive 9200.4-17P (U.S. EPA, 1999a) provides eight specific objectives for the performance-monitoring program of an MNA remedy.

For each of the following eight performance monitoring objectives, identify which are currently being met, which are currently being met but could benefit from further review, and which are currently not being met.

Objective	**Status**		
	Being met	*Benefit from review*	*Not being met*
1) Demonstrate that natural attenuation is occurring according to expectations	☐	☐	☐
2) Detect changes in environmental conditions that may reduce the efficacy of any of the natural attenuation processes	☐	☐	☐
3) Identify any potentially toxic and/or mobile transformation products	☐	☐	☐
4) Verify that the plume(s) is not expanding downgradient, laterally or vertically	☐	☐	☐
5) Verify no unacceptable impact to downgradient receptors	☐	☐	☐
6) Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy	☐	☐	☐
7) Demonstrate the efficacy of ICs that were put in place to protect potential receptors	☐	☐	☐
8) Verify attainment of remediation objectives	☐	☐	☐

If any of these objectives are not being met or would benefit from review, please describe (e.g., in what way is the objective not being met, why might the objective benefit from further review).

Describe any plans to review and/or change the location, frequency or types of samples and measurements to meet this (these) objective(s).

2. Evaluate remedy effectiveness: The following questions are intended to review whether the MNA remedy is performing as intended, or whether there may be a need to implement a contingency remedy. A contingency remedy is a cleanup technology or approach that functions as a backup remedy in the event that the selected remedy fails to perform as anticipated.	
Since the last O&M review, have contaminant concentrations in soil or ground water at specified locations exhibited an increasing trend not originally predicted during remedy selection?	☐ Yes ☐ No
Since the last O&M review, have near-source wells exhibited large concentration increases indicative of a new or renewed release?	☐ Yes ☐ No
Since the last O&M review, have contaminants been detected in monitoring wells located outside of the original plume boundary or other compliance-monitoring boundary?	☐ Yes ☐ No
Since the last O&M review, have analyses concluded that the rate of decrease of contaminant concentrations may be inadequate to meet the remediation objectives?	☐ Yes ☐ No
Since the last O&M review, have changes in land and/or ground water use been suggested and or implemented that have the potential to reduce the protectiveness of the MNA remedy?	☐ Yes ☐ No
Since the last review, have contaminants been identified in locations that pose or have the potential to pose unacceptable risk to receptors?	☐ Yes ☐ No
If you answered yes to any of the above questions, did the information suggest the need for immediate action or is the condition being monitored to evaluate the need for future action? Use this space to comment.	☐ Immediate action ☐ Monitored for future ☐ N/A
Based on your answers to the above questions, is there reason to evaluate the need for a contingent remedy at this time? If yes, use this space to comment.	☐ Yes ☐ No
3. Evaluate collection and analysis of performance monitoring data	
What evidence has been used to evaluate actual plume dissipation (e.g., temporal trends in individual wells, estimation of mass reduction, comparisons of observed contaminant distributions with predictions and required milestones, comparison of field-scale attenuation rates)?	
Since the last O&M review, has it been necessary to modify the site-specific plans (e.g., Sampling and Analysis Plan, Quality Assurance Project Plan, Data Management Plan) to account for new information and/or unforeseen circumstances? If yes, use this space to comment.	☐ Yes ☐ No
Does information collected since the last O&M review suggest the need to evaluate whether field parameters that are critical to an MNA evaluation (e.g., dissolved oxygen, redox potential) are being collected at appropriate monitoring points? If yes, use this space to comment.	☐ Yes ☐ No
Do the approaches used to interpret ground water monitoring data (e.g., concentration trend analyses, plume contour and/or bubble maps, plume cross-sections, potentiometric surface maps) provide adequate information to assess the performance of the natural attenuation remedy? If no, describe plans, if any, to implement new approaches.	☐ Yes ☐ No
Does information collected since the last O&M review suggest the need to re-evaluate the ground water and soil-monitoring program to more accurately delineate and monitor the plume boundary? If yes, use this space to comment.	☐ Yes ☐ No
Since the last O&M review, has it been necessary to modify the data quality assessment, including statistical tests (if appropriate), regression analysis, scatter plots, etc. to account for new information and/or unforeseen circumstances? If yes, use this space to comment.	☐ Yes ☐ No
Are ground water data managed electronically? If no, use this space to explain why not.	☐ Yes ☐ No

If statistical tests are used, do the data meet the assumptions of the statistical test?	☐ Yes ☐ No
If no, does this suggest the need to change the monitoring program or re-evaluate the statistical approach? Use this space to comment.	☐ Evaluate monitoring program ☐ Evaluate statistical approach ☐ Neither
Is high variability in the data interfering with or preventing a meaningful interpretation of the data?	☐ Yes ☐ No
If yes, could this situation be mitigated by increasing the density or frequency of sampling? Use this space to comment.	☐ Yes ☐ No
Are performance-monitoring reports of sufficient quality and frequency to evaluate the efficacy of MNA as a remedy and recognize protectiveness problems in time for effective action? If no, what actions, if any, have been taken or are planned to address this situation?	☐ Yes ☐ No
Are techniques or models being used to evaluate adequacy/redundancy of individual wells in the monitoring network, and adequacy/redundancy of sampling frequency? Note that techniques may range from statistical trend analysis to application of ~~a~~ decision support tool.	☐ Yes ☐ No
If no, are there plans to evaluate the adequacy/redundancy of individual monitoring wells and/or sampling frequency? Use this space to comment.	☐ Yes ☐ No

C. Cost Effectiveness: Key considerations in looking at cost-effectiveness of an MNA remedy are the list of parameters for monitoring, as well as the frequency and location of monitoring. Decreases in monitoring parameters, frequency or locations may be appropriate and allow for reductions in project monitoring costs. For example, decreases in monitoring frequency for certain parameters may be warranted if the remedy is proceeding according to expectations and trends are stable after evaluation of data from a sufficient number of monitoring periods (e.g., many years). To support such a decision, the available data generally cover a time period sufficient to allow for an evaluation of seasonal trends and other long-term cycles and trends.

Does information collected since the last O&M review suggest opportunities to eliminate monitoring points (e.g., because of redundancy, unreliability, or changes in program objectives)? If yes, use this space to comment.	☐ Yes ☐ No
Does information collected since the last O&M review suggest opportunities to replace current analytical and sampling methods with less expensive methods and still meet the data quality objectives? If yes, use this space to comment.	☐ Yes ☐ No
Can the analyte list be shortened to focus on the known contaminants of concern?	☐ Yes ☐ No

D. Remedial Decisions: Following data evaluation, decisions are routinely made regarding the effectiveness of the MNA remedy, monitoring program, and ICs, and the need for contingency or alternative remedies. The following remedial decisions are discussed in Section 4 of the EPA guidance document *Performance Monitoring of MNA Remedies for VOCs in Ground Water* (EPA/600/R-04/027; April 2004). Indicate which of the following remedial decisions is appropriate at the present time and provide the basis for the decision.

☐ No Change to the Monitoring Program
☐ Modify/Optimize Monitoring Program
☐ IC Modifications
☐ Implementation of Contingency/Alternative Remedy
☐ Terminate Performance Monitoring and Initiate Verification Monitoring

Basis for decision:

RECOMMENDED APPENDIX C. CONTAINMENT REMEDIES

The following checklist is an abbreviated set of questions that could be used by a EPA RPMs for an annual review of the O&M of a containment remedy and associated off-gas treatment system. This checklist focuses on engineered containment remedies, including landfill caps, covers, and vertical engineered barriers (VEB). Containment by other means such as hydraulic control and in-situ sediment containment remedies are not addressed by this appendix. See separate surface water/sediment remedy checklist for sediment remedies. Although the checklist includes items for off-gas systems, it focuses on off-gas collection. The checklist does not address off-gas management using combustion systems because such systems are uncommon at Superfund sites.

A. Remedy Description, Goals and Conceptual Site Model (CSM)

1. Review of the current remedy

Identify the containment systems in place:

☒ Cap/cover
☐ VEB
☐ Liner
☐ Landfill gas collection
☐ Landfill gas management
☐ Leachate detection
☐ Leachate collection
☐ Leachate management
☐ Other (Describe:)

Identify the O&M components:

☒ Inspection
☐ Monitoring
☐ Testing
☐ Ground water monitoring
☒ Surface water monitoring
☐ Landfill gas monitoring
☐ Vapor intrusion monitoring
☐ Leachate monitoring
☐ Other (Describe:)

2. Review of the current remedy goals

Identify the remedy goals (RAOs):

☒ Prevent direct contact with a contaminant source
☒ Prevent migration of a contaminant source to:
  ☐ A drinking water aquifer
  ☒ Surface water
  ☐ Soil or other solid media
  ☒ Air (via wind-borne material)
  ☐ Air (via volatilization)
  ☐ Other (Describe:)
☐ Prevent migration of contaminated ground water
☐ Prevent vapor intrusion or indoor air exposure
☐ Control off-gas
☐ Other remedy goals (Describe:)

What metrics (performance criteria) are being implemented to measure project progress towards meeting each goal? visual observation of vegetative cover, erosion, rills, soil movement

What schedule has been established for measuring and reporting each metric? annual

Based on new information or events since the last O&M review, is there a need to re-evaluate the remedy goals? This might be due to factors such as whether the regulatory framework has been revised, whether existing goals appear to be realistic, and whether there have been changes in land use or ground water production near the site. If yes, identify the remedy goals that should be re-evaluated, the rationale, and any plans for re-evaluating the goals.

☐ Yes
☒ No

3. Review of changes to the CSM: The CSM for a containment remedy is the site-specific, qualitative and quantitative description of the migration and fate of contaminants with respect to possible receptors and the geologic, hydrologic, biological, geochemical and anthropogenic factors that control contaminant distribution. Because the CSM provides the basis for the remedy and the post-closure maintenance plan or O&M plan, the model should be re-evaluated as new data are collected throughout the lifetime of the remedy.

Does new information gathered or conclusions reached since the last time the O&M checklist was completed indicate a change in understanding about the sources, types, migration, and fate of contaminants? *Note that indicators could include (1) the remedy not functioning as designed, (2) unexpected contaminants or contaminant concentrations above the required levels at the point of compliance, (3) unexpected trends in contaminant concentrations, (4) unexpected changes in the flow rate or direction of ground water, (5) unexpected changes in off-gas characteristics, or (6) unexpected evidence of vapor intrusion in nearby structures.*	☐ Yes ☒ No
Based on new information and/or conclusions, would it be useful to update the CSM at this time? If yes, please describe any plans to update the CSM.	☐ Yes ☒ No

B. Remedy Performance Assessment

This section contains a series of questions that can be used to help assess a containment remedy's effectiveness and evaluate the collection and analysis of performance monitoring data. For each potential problem identified, an analysis should be performed to determine what, if anything should be done.

1. Evaluate remedy effectiveness: The following questions are intended to review whether the containment remedy is performing as intended or whether there is a need to implement a contingency remedy. A contingency remedy is a cleanup technology or approach that functions as a backup remedy in the event that the selected remedy fails to perform as anticipated. A contingency remedy may be considered if there is a "yes" answer to one or more of the following three questions.

Note that additional measures and methods for evaluating the effectiveness of containment remedies can be found in "EPA/USACE Draft Technical Guidance for RCRA/CERCLA Final Covers" (EPA 540-R-04-007) and "EPA Comprehensive 5-Year Review Guidance, Appendix D, Five-Year Review Site Inspection Checklist" (OSWER Directive 9355.7-03B-P).

Since the last O&M review, has inspection or testing of the cap, cover, liner, or VEB indicated that the system is failing or could eventually fail?	☐ Yes ☒ No
Since the last O&M review, have changes in land, surface water, or ground water use been suggested and or implemented that have the potential to reduce the protectiveness of the containment remedy?	☐ Yes ☒ No
Since the last O&M review, have contaminants been identified in new locations or at higher concentrations where they pose or have the potential to pose unacceptable risks to receptors?	☐ Yes ☒ No
If you answered yes to any of the above questions, did the information suggest the need for immediate action or is the condition being monitored to evaluate the need for future action? Use this space to comment. What actions, if any, have been taken and/or are planned in response to the new information?	☐ Immediate action ☐ Monitored for future ☐ N/A

For VEB Only: Note that additional measures and methods for evaluating VEB effectiveness can be found in "EPA Evaluation of Subsurface Engineered Barriers at Waste Sites".

Have bulk integrity tests been performed since the last O&M review?	☐ Yes ☐ No
If bulk integrity tests have been performed since the last review, do test results indicate that need to evaluate possible breaches or excessive leakage in the VEB over the short and long terms? If yes, what actions have been taken and/or are planned in response?	☐ Yes ☐ No ☐ N/A
Based on information collected since the last O&M review, do contaminant concentrations upgradient of the VEB indicate the need to evaluate actions to prevent possible contaminant migration? If yes, what actions have been taken and/or are planned in response?	☐ Yes ☐ No
Does information collected since the last O&M review suggest the need to evaluate hydraulic controls as an additional measure to control possible contaminant migration around the VEB (answer N/A if hydraulic controls are already part of the remedy)? If yes, what actions have been taken and/or are planned in response?	☐ Yes ☐ No ☐ N/A
For Off-Gas Collection Management Only: Note that additional measures and methods for evaluating off-gas collection and management effectiveness can be found in "USACE Landfill Off-Gas Treatment, Thermal Oxidation Checklist".	
Since the last O&M review for this system, have off-gas volume and composition been consistently within equipment design parameters? If no, what actions have been taken and/or are planned in response?	☐ Yes ☐ No
Since the last O&M review for this system, have off-gas system operational characteristics, such as required temperatures and pressures, been maintained within system design parameters? If no, what actions have been taken and/or are planned in response?	☐ Yes ☐ No
Since the last time an O&M checklist was completed for this system, have off-gas emissions met all federal, state, and local regulatory requirements? If no, what is being done to meet these requirements?	☐ Yes ☐ No
Based on information collected since the last O&M review, is there any evidence of unacceptable vapor intrusion in nearby structures? If yes, what actions have been taken and/or are planned in response?	☐ Yes ☐ No
Based on information collected since the last O&M review, have concentrations of off-gases inside buildings or at the site fence line suggested the need to assess safety and human health threats? If yes, what actions have been taken and/or are planned in response?	☐ Yes ☐ No
2. Evaluate collection and analysis of performance monitoring data Note that more detailed information about performance parameters can be found in the following documents: "EPA/USACE Draft Technical Guidance for RCRA/CERCLA Final Covers" (EPA 540-R-04-007) "EPA Comprehensive 5-Year Review Guidance, Appendix D, Five-Year Review Site Inspection Checklist" (OSWER Directive 9355.7-03B-P) "USACE Landfill Off-Gas Treatment, Thermal Oxidation Checklist" "EPA Evaluation of Subsurface Engineered Barriers at Waste Sites" (EPA 542-R-98-005; August 1998).	
Since the last O&M review, has it been necessary to modify planned inspections, sampling events, and sample analyses, as reflected in the site post-closure maintenance plan or O&M plans, to account for new information and/or unforeseen circumstances? If yes, use this space to comment.	☐ Yes ☒ No

Has information collected since the last O&M review suggested the need to re-evaluate whether performance parameters that are critical to evaluation of the containment remedy are being collected at appropriate monitoring points? If yes, what actions have been taken and/or are planned in response? Need systematic sampling of surface waters to determine attainment with ARARs	☒ Yes ☐ No
Are ground water and off-gas system monitoring data managed electronically? If no, use this space to explain why not.	☐ Yes ☐ No
Since the last O&M review, have monitoring data been analyzed to identify trends and their significance? If no, use this space to explain why not.	☒ Yes ☐ No
Is high variability in the data interfering with or preventing a meaningful interpretation of the data?	☐ Yes ☒ No
If yes, could this situation be mitigated by increasing the density or frequency of data collection? Use this space to comment.	☐ Yes ☐ No
Are inspection and performance monitoring reports of sufficient quality and frequency to evaluate the efficacy of containment as a remedy and recognize protectiveness problems in time for effective action? If no, what actions, if any, have been taken or are planned to address this situation?	☒ Yes ☐ No
C. Cost-Effectiveness	
If off-gas is currently being treated, can it be vented to the atmosphere without treatment in compliance with all applicable federal, state, and local regulations?	☐ Yes ☐ No ☐ N/A
If yes, has the possibility of discontinuing off-gas treatment been explored? Use this space to comment.	☐ Yes ☐ No ☐ N/A
If leachate is currently being collected and treated, is operation of the leachate system necessary for proper functioning of the containment system?	☐ Yes ☐ No ☐ N/A
If no, has the possibility of discontinuing leachate collection and treatment been explored? Use this space to comment.	☐ Yes ☐ No ☐ N/A
If hydraulic controls are being used in conjunction with a VEB, would the VEB provide passive containment without these controls?	☐ Yes ☐ No ☐ N/A
If yes, has the possibility of discontinuing the hydraulic controls been explored? Use this space to comment.	☐ Yes ☐ No ☐ N/A
D. Remedial Decisions: Indicate which of the following remedial decisions is appropriate at the present time and provide the basis for the decision.	
☒ No change to the remedy ☐ Modify or optimize remedy ☐ Modify or optimize O&M ☐ Modify ICs ☐ Implement contingency or alternative remedy ☐ Terminate inspections or monitoring	

Basis for decision: Additional data is required to determine if modification or optimization is necessary

RECOMMENDED APPENDIX D. SOIL VAPOR EXTRACTION/AIR SPARGING REMEDIES

- The following checklist is an abbreviated set of questions that EPA RPMs could use when conducting an annual review of the O&M of a soil vapor extraction (SVE), air sparging (AS), or combined SVE/AS remedy. This checklist does not represent the level of review used in EPA's five-year review process to determine whether the remedy is or will be protective of human health and the environment. However, the checklist does contain review elements regarding the performance of SVE and/or AS remedies that are consistent with the comprehensive five-year review process.

A. Remedy Description, Goals and Conceptual Site Model (CSM)

1. Review of the current remedy

Identify the current remedy:

- ☐ SVE
- ☐ AS

How many extraction wells or trenches are used for SVE (if applicable)?

How many injection wells are used for AS (if applicable)?

2. Review of the current remedy goals

List the remedy goals (RAOs):

- ☐ Prevent migration of a contaminant source to:
  - ☐ A drinking water aquifer
  - ☐ Surface water
  - ☐ Soil or other solid media
- ☐ Prevent migration of contaminated ground water
- ☐ Restore ground water
- ☐ Other (Describe:)

List the short-term objectives and intermediate system goals.

List the long-term soil and ground water cleanup goals.

What metrics (performance criteria) are being implemented to measure project progress towards meeting each goal?

What schedule has been established for measuring and reporting each metric?

Based on new information or events since the last O&M review, is there a reason to re-evaluate the remedy goals? Note that this might be due to factors such as whether the regulatory framework has been revised, whether existing goals appear to be realistic, and whether there have been changes in land or ground water use near the site. If yes, identify the remedy goals that should be re-evaluated, the rationale, and any plans for re-evaluating the goals.	☐ Yes ☐ No

3. Review of changes to the CSM: The CSM for a SVE/AS remedy is the site-specific, qualitative and quantitative description of the migration and fate of contaminants with respect to possible receptors and the geologic, hydrologic, biological, geochemical and anthropogenic factors that control contaminant distribution. Because the CSM provides the basis for the remedy and the O&M plan, the model should be re-evaluated as new data are collected throughout the lifetime of the remedy.

Does new information gathered or conclusions reached since the last time the O&M checklist was completed indicate a change in understanding about the sources, types, migration, and fate of contaminants? *Note that indicators could include: (1) the remedy not functioning as designed, (2) unexpected contaminants or contaminant concentrations above the required levels at the point of complian*	☐ Yes ☐ No
Based on new information and/or conclusions, would it be useful to update the CSM at this time? If yes, please describe any plans to update the CSM.	☐ Yes ☐ No

B. Remedy Performance Assessment

This section contains a series of questions that can be used to help assess a SVE/AS remedy's effectiveness and evaluate the collection and analysis of performance monitoring data.

1. Evaluate remedy effectiveness: The following questions are intended to review whether the SVE/AS remedy is performing as intended, or whether there is a need to implement a contingency remedy. A contingency remedy is a cleanup technology or approach that functions as a backup remedy in the event that the selected remedy fails to perform as anticipated. A contingency remedy may be considered if there is a "yes" answer to either of the following five questions.

Based on information collected since the last O&M review, do monitoring data indicate that the system is failing or could eventually fail to meet remedy goals?	☐ Yes ☐ No
Since the last O&M review, has the areal extent of contamination (or plume) increased in a manner not originally predicted during remedy selection?	☐ Yes ☐ No
Since the last O&M review, have monitoring data exhibited trends indicative of a new or renewed release?	☐ Yes ☐ No
Since the last O&M review, have changes in land and/or ground water use been suggested and or implemented that have the potential to reduce the protectiveness of the SVE/AS remedy?	☐ Yes ☐ No
Since the last O&M review, have contaminants been identified in new locations or at higher concentrations where they pose or have the potential to pose unacceptable risks to receptors?	☐ Yes ☐ No
If you answered yes to any of the above questions, did the information suggest the need for immediate action or is the condition being monitored to evaluate the need for future action? Use this space to comment. What actions, if any, have been taken and/or are planned in response to the new information?	☐ Immediate action ☐ Monitored for future ☐ N/A
Based on your answers to the above questions, is there reason to evaluate the need for a contingent remedy at this time? If yes, use this space to comment.	☐ Yes ☐ No

Blowers and Piping	
Since the last O&M review for this system, has evidence of excessive corrosion of system components been observed? If yes, what actions have been taken and/or are planned in response?	☐ Yes ☐ No
Since the last O&M review, if blowers are operated intermittently, do VOC concentrations increase after they are shut off? How has this information been interpreted and what actions, if any, have been taken and/or are planned in response?	☐ Yes ☐ No ☐ N/A
Since the last O&M review, have blower operational characteristics, such as flow rate, pressure, and discharge temperatures, been consistently within equipment design parameters? If no, what actions have been taken and/or are planned in response?	☐ Yes ☐ No
Since the last O&M review, if water is manually removed from the extraction blower water separator, has water accumulation been observed that could adversely impact blower operation? If yes, what actions have been taken and/or are planned in response?	☐ Yes ☐ No ☐ N/A
Since the last O&M review, have all blowers, water separators, valves, and piping components been consistently operational?	☐ Yes ☐ No
Has the downtime associated with non-routine operations and maintenance of the blowers since the last time you completed an O&M checklist for this system exceeded expectations? If yes, what have been identified as the causes? If yes, what corrections have been or are being made to minimize downtime?	☐ Yes ☐ No
Does the operational history suggest that the preventative maintenance plan for the blowers needs to be re-evaluated? If yes, what actions have been taken and/or are planned in response?	☐ Yes ☐ No
Soil Vapor Extraction System	
Identify the SVE system characteristics, if any, that have deviated consistently/frequently from operational expectations since the last time an O&M checklist was completed for this system: ☐ Vapor flow rates at one or more extraction wells ☐ Vapor compositions (VOCs, CO_2, O_2) at one or more extraction wells ☐ Pressures at one or more extraction wells ☐ Flow at blower (prior to entry of any dilution air if used) ☐ Accumulation of water in the water separator	
Does this (do these) deviation(s) indicate a new condition since the last O&M review or an ongoing trend?	☐ New condition ☐ Ongoing trend ☐ N/A
What has been identified as the cause for this (these) deviation(s)?	
What actions, if any, have been or are being taken in response to this (these) deviation(s)?	
Based on information collected since the last O&M review, is there any evidence of unacceptable vapor intrusion in nearby structures? If yes, what actions have been taken and/or are planned in response?	☐ Yes ☐ No

Since the last O&M review, have gas concentrations in the blower discharge been running close enough to the lower explosive limit (LEL) or shown an increasing trend that suggests the need for action? *Note that specific compound LEL data are available in many chemistry texts as well as National Fire Protection Agency guidelines.* What actions, if any, have been taken and/or are planned in response to the new information?	☐ Yes ☐ No
Air Sparging System	
Since the last O&M review of the AS system, have flow rates at each injection well been consistently maintained within system design parameters? If no, what actions, if any, have been or are being taken in response?	☐ Yes ☐ No
Based on information collected since the last O&M review, have dissolved oxygen concentrations been maintained at a level sufficient to promote biological activity? If no, what actions, if any, have been or are being taken in response?	☐ Yes ☐ No
Since the last O&M review, are measured dissolved oxygen concentrations consistently indicative of good air/water contact rates (i.e., are concentrations near saturation)? If no, what actions, if any, have been or are being taken in response?	☐ Yes ☐ No
VOC Control System	
If the SVE system contains a VOC control device, has the device consistently met performance and compliance monitoring requirements (e.g., total VOC emission limits, specific compound limits, monitoring, air permit) since the last O&M review for this system? If no, what actions have been taken and/or planned in response?	☐ Yes ☐ No ☐ N/A
Since the last O&M review, has the VOC control system consistently meet required destruction and removal efficiencies? If no, what actions have been taken and/or planned in response?	☐ Yes ☐ No
Since the last O&M review, have any violations of air permits been reported? If yes, what has been or is being done to meet permit requirements?	☐ Yes ☐ No
Since the last time you completed an O&M checklist for this system, has the VOC control system been responsible for downtime associated with non-routine operations and maintenance? If yes, What was (were) the cause(s) for unplanned shutdown(s)? What has been done or is being done to minimize future downtime?	☐ Yes ☐ No
Thermal Oxidizers	
Since the last O&M review for this system, have the operational characteristics (e.g., LEL history of feed gas, operating temperature, inlet flow, oxygen level in flue gas, fuel use) been consistently within equipment design parameters? If no, what actions, if any, have been or are being taken in response?	☐ Yes ☐ No ☐ N/A
Since the last O&M review, has there been any indication of improper operation of flashback protection equipment (e.g., detonation arrestor, sealed drum)? If yes, what actions have been taken and/or planned in response?	☐ Yes ☐ No

Since the last O&M review, has there been any indication of improper operation of safety interlocks (e.g., high LEL, high oxidizer temperature, loss of flame, low fuel pressures)? If yes, what actions have been taken and/or planned in response?	☐ Yes ☐ No
If acid gases are present, have scrubber operations (e.g., scrubber liquid flow and pH, caustic use, scrubber blowdown and its treatment) been consistent with operational expectations since the last O&M review? If no, what actions have been taken and/or planned in response?	☐ Yes ☐ No
Carbon Adsorbers	
Does the unit have humidity controls?	☐ Yes ☐ No
Since the last O&M review for this system, have the operational characteristics (e.g., relative humidity data at adsorber inlet, adsorber operating temperature, carbon breakthrough, carbon change out history, operating velocity through adsorbers, adsorber discharge VOC data) been consistently within equipment design parameters? If no, what actions, if any, have been or are being taken in response?	☐ Yes ☐ No ☐ N/A
Other Control Devices	
Since the last O&M review for this system, have the operational characteristics (e.g., biofiltration media surface loading rate, temperature controls, nutrient addition rate) been consistently within equipment design parameters? If no, what actions, if any, have been or are being taken in response?	☐ Yes ☐ No ☐ N/A
2. Evaluate collection and analysis of performance monitoring data	
Since the last O&M review, has it been necessary to modify sampling frequency relative to the original O&M plan to account for new information and/or unforeseen circumstances? If yes, use this space to comment.	☐ Yes ☐ No
Does soil and/or ground water data collected since the previous O&M review (e.g., VOCs concentrations, ground water elevations) suggest the need to re-evaluate other aspects of the monitoring program (e.g., monitoring locations, test parameters) to account for new information/unforeseen circumstances? If yes, use this space to comment.	☐ Yes ☐ No
C. Cost Effectiveness: Key considerations in looking at cost-effectiveness are the O&M costs incurred relative to design and reduction in VOC removal rates. **Opportunities to reduce costs can be potentially found** in the following areas:	
Does information collected since the last O&M review suggest that flows could be redistributed to speed overall remediation (i.e., reduce or eliminate flow to/from wells where removals have reached near asymptotic conditions or where cleanup goals have been achieved)? Use this space to comment.	☐ Yes ☐ No
Does information collected since the last O&M review show evidence of diffusion-limited VOC movement?	☐ Yes ☐ No
If yes, has the idea of modifying operation to pulsing (intermittent) been considered to speed overall remediation? Use this space to comment.	☐ Yes ☐ No

Does information collected since the last O&M review show reduced VOC removal rates that might warrant a reduction in monitoring frequencies? Use this space to comment.	☐ Yes ☐ No
Does information collected since the last O&M review suggest that VOC recovery rates have been reduced to the extent that the VOC control device can be eliminated? Use this space to comment.	☐ Yes ☐ No ☐ N/A
Does information collected since the last O&M review suggest that an alternative, lower cost VOC control device could be used? Use this space to comment.	☐ Yes ☐ No
Does information collected since the last O&M review suggest that operation of the VOC control device could be modified to reduce costs, e.g., operate thermal oxidizer at lower temperatures or lower dilution air flows (e.g., when LEL basis no longer requires design flow) or use larger carbon beds to reduce carbon supplier charges for change outs? Use this space to comment.	☐ Yes ☐ No
Has maintenance history since the last O&M review identified high-maintenance equipment that could be replaced? Use this space to comment.	☐ Yes ☐ No

E. Remedial Decisions: Indicate which of the following remedial decisions are appropriate at the present time and provide a basis for each decision:

- ☐ Continue current remedy
- ☐ Goals have been achieved -- system can be shutdown in favor of MNA
- ☐ Modify/optimize remedial system(s) – use intermittent operation; optimize flows to/from wells to promote increased removals; increase use of sparging to promote biodegradation; add new wells if contaminant movement is indicated to areas currently not being influenced; implement cost reduction measures; conduct more detailed evaluation of the contaminated zone using a tool such as Pneulog.
- ☐ Modify/optimize O&M – increase monitoring to provide additional data for more definitive assessment at the next review
- ☐ Modify ICs
- ☐ Implement contingent or alternative remedy

Basis for decision:

RECOMMENDED APPENDIX E. OTHER REMEDY TYPES/COMPONENTS

The following checklist is a set of questions that may be used by EPA RPMs for an annual review of the O&M of remedies and remedy components that are not addressed in Appendices A through D or the separate surface water/sediment remedy O&M checklist. This could include remedies/components that involve a technology that is not covered in these other materials or remedies/components where the O&M can be more efficiently reviewed using the more streamlined questions below. If the site includes multiple remedy components that are not covered elsewhere, multiple copies of this appendix, each applying to a different component or related set of components, could be completed.

A. Remedy Description and Goals

1. Review of current remedy goals, and measurements

The following questions can be used to document basic information about the remedy and remedy goals to provide context for the remainder of the information in this appendix.

Identify the remedy component(s) and associated systems and technologies being covered on this form: Active treatment of AMD

What are the intermediate and final system goals? Contaminant removal

What metrics (performance criteria) are being implemented to measure project progress towards meeting each goal? effluent water quality

What schedule has been established for measuring and reporting each metric? monthly-

Based on new information or events since the last O&M review of this system/technology, is there a need to re-evaluate the remedy goals? ☐ Yes ☒ No

If yes, identify the remedy goals that should be re-evaluated, the rationale, and any plans for re-evaluating the goals.

2. Review of changes to the CSM

The following questions ask about changes in contamination and other field conditions that could affect the monitoring program, system operations, and other aspects of O&M. They provide context for questions in subsequent sections that ask whether action should be taken to modify the O&M program.

Do monitoring data indicate trends/patterns that are inconsistent with the CSM (or similar conceptual understanding of site conditions) that was used as the basis for design of the remedy/remedial component(s)? ☐ Yes ☒ No

If yes, use this space to comment.

Have there been changes in field conditions (e.g., change in land/water use) that differ significantly from the conditions incorporated in the CSM (or similar conceptual understanding of site conditions) that was used as the basis for design of the remedy/remedial component(s)? ☐ Yes ☒ No

If yes, use this space to comment.

Have new contaminant sources been identified? ☐ Yes ☒ No

If yes, please describe the new sources and how they are they being addressed:

B. Remedy Performance Assessment

This section contains a series of questions that can be used to help assess whether the monitoring program and remediation systems O&M should be adjusted.

1. Monitoring Program

Describe changes to the monitoring program that have been made since the last time you completed the O&M checklist for this remedy component. effluent water quality analysis decreased from weekly to bi-weekly

Are the baseline data and post-remedy data adequate to perform statistical comparisons and evaluate remedy performance? If no, what actions have been or are being taken in response?	☒ Yes ☐ No
Is high variability in the data interfering with or preventing a meaningful interpretation of the data?	☐ Yes ☒ No
If yes, could this situation be mitigated by increasing the density or frequency of data collection? Use this space to comment.	☐ Yes ☐ No
Based on changes in contamination or field conditions (see A.2 of this appendix), is there reason to modify the monitoring program? If yes, describe changes to the monitoring program that are most necessary.	☐ Yes ☒ No
Has the adequacy/redundancy and cost-effectiveness of the monitoring program been evaluated, including evaluation of sampling locations, frequency, sampling and analytical methods, monitoring parameters, and test methods? Use this space to comment. reductions in monitoring have occurred as appropriate	☒ Yes ☐ No
Is there reason to modify the monitoring program to address inadequacies, remove redundancies, and/or improve its cost-effectiveness? If yes, describe changes to the monitoring program that would likely have the greatest impact.	☐ Yes ☒ No
Do you have adequate documentation (e.g., good quality O&M reports) and tools (e.g., software) to effectively manage and interpret monitoring data? If no, please explain how documentation and/or tools could be improved.	☒ Yes ☐ No
2. System Operations	
Describe changes to system operations that have been made since the last time you completed the O&M checklist for this remedy component. Process was modified during 2012-2013 to improve efficiency	
Is (are) the remedial system(s) covered under this appendix performing as expected relative to the remediation milestones and goal(s)? If no, what actions have been or are being taken in response?	☒ Yes ☐ No
Do monitoring data indicate trends/patterns that are consistent with remedial design expectations? If no, what actions have been or are being taken in response?	☒ Yes ☐ No
Based on observations regarding contamination or field conditions (see A.2 of this appendix and previous questions in this section), is there reason to modify systems operations to improve remedy performance? If yes, describe changes to system operations that are most necessary.	☐ Yes ☒ No
Has an optimization study been conducted for the remedy/remedy component(s)? Use this space to comment.	☒ Yes ☐ No
Has the downtime associated with non-routine operations and maintenance exceeded expectations? If yes, what actions have been or are being taken to minimize downtime?	☐ Yes ☒ No
Based on optimization and downtime considerations, is there reason to modify systems operations to improve remedy performance? If yes, describe changes to system operations that are most necessary. modifications were completed	☐ Yes ☒ No
3. Maintenance	

Are routine maintenance activities adequate to ensure the reliable operation of the remedial system(s)? If no, what changes to the maintenance program are most necessary?	☒ Yes ☐ No
Have any major repairs to the remedial system(s) been required since the last time you completed the O&M checklist for this remedy/remedy component? If yes, describe the repairs, their impact on progress toward remediation milestones, and actions taken to minimize similar repairs in the future.	☐ Yes ☒ No

C. Cost Effectiveness

Does information collected since the last O&M review suggest opportunities to reduce costs associated with equipment operations and maintenance? If yes, use this space to comment. implemented 2012-2013	☐ Yes ☒ No
Does information collected since the last O&M review suggest opportunities to reduce costs associated with the monitoring program? If yes, use this space to comment. eligible for further reduction in effluent monitoring	☒ Yes ☐ No

D. Remedial Decisions: Indicate which of the following remedial decisions is appropriate at the present time and provide the basis for the decision.

☒ No Change
☐ Modify/Optimize System
☐ Modify/Optimize Monitoring Program
☐ Modify ICs
☐ Implement Contingency/Alternative Remedy

Basis for decision:

ATTACHMENT E: SITE PHOTOGRAPHS

Argo Tunnel Water Treatment Plant (WTP) in Idaho Springs

Church Placer Repository

NCC WTP Site

NCC Improvements, at NCC Tailings

Russell Gulch Drop Structures

Russel Gulch Check Dam

Willis Gulch Drop Structure

Russell Gulch Sediment Dam

August 2015 Soil Sampling CC-WR-02

August 2015 Soil Sampling CC-WR-11

ATTACHMENT F: COMMUNITY INVOLVEMENT PLAN UPDATE

Central City/Clear Creek Superfund Site

Community Involvement Plan Update

Gilpin and Clear Creek Counties, Colorado

September 2014

Colorado Department of Public Health and Environment
Hazardous Materials and Waste Management Division
4300 Cherry Creek Drive South, B2
Denver, CO 80246-1530
303-692-3373

CDPHE
CO
COLORADO
Department of Public
Health & Environment

United States Environmental Protection Agency

Central City/Clear Creek Community Involvement Plan Update

SECTION 1
Background

This Community Involvement Plan revision for the Central City/Clear Creek Superfund Site (Site) is intended to reflect the changes, both actual and as perceived by the community, since the original 1989 plan was last revised in September 2009.

This Central City/Clear Creek Community Involvement Plan (CIP)* has been prepared pursuant to Sections 113(k)(13)(i-v) and 117 of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and in accordance with the current U.S. Environmental Protection Agency (EPA) Superfund guidance, including the *Superfund Community Involvement Handbook* (2005). The handbook outlines the community involvement requirements of CERCLA and regulations that interpret the Superfund legislation, i.e., the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

Once the Site has been listed on the National Priorities List (NPL) for Superfund, community involvement efforts become an integral part of Site activities. The Site was originally listed on the NPL September 8, 1983. The Superfund Study Area covers the 400-square-mile mine drainage basin of Clear Creek, which includes parts of Clear Creek and Gilpin counties. The water quality of the watershed is compromised by metals contamination from historic mining operations. The Site, originally made up of five mines, was modified to encompass the entire basin as its study area in 1998. For the first two Records of Decision (RODs), the EPA was the lead agency. For RODs 3 and 4, the state assumed the lead.

This Community Involvement Plan, based on community interviews, describes the community involvement and public participation program developed for the Central City/Clear Creek Superfund Site by the EPA and the Colorado Department of Public Health and Environment (CDPHE). The original plan was developed by the EPA in 1987; a new plan was produced by the state again in June 1989, followed by a broad communications strategy in November 1990. The plan was revised by the state in 1994 and again in 2004 and 2009. The current revision was triggered by the Five Year Review of the whole Site.

Purpose

The purpose of community involvement is to provide opportunities for the community to learn about the Site, to provide the public adequate opportunities for public involvement in remediation decisions and to determine, based on community interviews and other relevant information, appropriate community involvement

*An acronym list appears in Appendix F.

activities. The community interviews form the foundation for developing the most effective means of disseminating information to the community.

Objectives of the Community Involvement Plan

- To ensure communication among the community, EPA and CDPHE
- To develop and maintain open communication with community leaders and any other interested or affected groups
- To provide appropriate opportunities for the community to learn about the Central City/Clear Creek Superfund Site and to inform community members about the environmental remediation actions and administrative matters at the various locations within the Site
- To ensure appropriate opportunities for public involvement and to receive feedback from the community
- To identify and monitor community concerns and information needs

SECTION 2
Site Location and Description

Since this Site was listed on the NPL in 1983, focus has shifted from the original task of dealing with five specific mining tunnels, recommending passive water treatment (Phase I, Record of Decision (ROD) 1). A second ROD addressed the waste piles of those five tunnels. In both of those efforts, EPA was the lead agency. Phase II of the project included reassessing the Site using a watershed approach and included the Phase II the Remedial Investigation/Feasibility Study (RI/FS). The Operable Unit 3 (OU3) ROD calls for remediation of the Argo Tunnel and approximately 20 waste piles, as well as an assessment of private drinking water wells in the area, with the state of Colorado in the lead role.

The Operable Unit 4 (OU4) ROD called for the treatment of contaminated mine discharges and remediation of mine waste rock piles and tailings through erosion control, capping or removal. The remedial actions for Operable Unit 4 was initiated in 2007. Sediment dams and other water-control structures were constructed in Russell and Nevada gulches. Additionally, the state acquired a mining-impacted property in 2008 for the purpose of constructing a Site-wide mine waste repository. The repository was constructed to consolidate and manage mine waste rock and tailings on-site, opposed to transporting the wastes off-site to a landfill. In 2012, CDPHE constructed a mine drainage pipeline to convey historic mine drainage and mining-impacted water to the site of a future water treatment plant. The Quartz Hill Tailings Pile was stabilized during the summer of 2014. In 2010-2013, CDPHE and EPA implemented certain components of the OU4 ROD (e.g., removal of mill tailings, sediment reduction measures and preparation for a future water treatment facility site) by funding CDOT to construct these three projects while constructing the State Highway 119 Main Street South Project.

Despite the significant progress made, remedial actions are not complete at this Site. An active water treatment plant to treat discharges from the Gregory Incline, National Tunnel and Gregory Gulch is on hold due to the uncertainty of ongoing water use negotiations. A flow-through bulkhead, considered under OU3 for the Argo Tunnel to eliminate future surge events, will be constructed in 2014.

Site History

Joint remediation efforts on this Site have been cooperative between EPA and CDPHE, regardless of which agency has had the lead on a particular aspect of the project.

Much has changed in the area since the original Site investigation in 1983. In November 1990 limited stakes gambling was approved by Colorado voters for the towns of Black Hawk and Central City, both in Gilpin County. Relying increasingly on a tourism, rather than a mining economy, Gilpin County began low-stakes gaming in October 1991, and much of the property in those towns was bought for casino development and related uses, such as parking, administrative offices, etc. Land, which had been held by families for years, or which had been bought with a view toward future reprocessing of mine tailings, increased in value many times over, as did property taxes. Relatively unusable parcels of land within the gaming district were reassessed, and in some cases the new taxes were prohibitive for the owner, even though there was no perceived market for the property at the new price. Over the years since, large casinos have come to dominate Black Hawk, while many smaller casinos, in some cases preserving the original store fronts, are more the norm in Central City. As the economy shifted quickly toward gaming, local community shops and services, many in buildings from the early 1900s, were rapidly converted to casinos, and the characteristics of the historic mining towns changed dramatically.

In 2008, voters approved Amendment 50, which allowed the gaming towns of Black Hawk, Cripple Creek and Central City to vote to keep casinos open 24 hours a day, seven days a week, increase the betting limit to $100, and to add roulette and craps to the previously allowed poker, black jack and slot machines. Citizens of the three towns voted overwhelmingly for the change, which took effect July 1, 2009, further changing the character of Black Hawk, in particular.

The results of increased land values also affected the Superfund process in the area. Casino developers eagerly excavated soil and rock, removed tailings, and rerouted water in consultation with state and EPA project staff to make room for the ancillary services they needed. Roadways were expanded, and Black Hawk and Central City experienced a building boom. The state proposed that a consortium of town and Gilpin County officials draft procedures and criteria for property development that would be provided to individuals along with their building permits, informing them about the Superfund cleanup and the problems and legal liabilities in moving contaminated soils.

A step-by-step document developed with the assistance of the state became an ordinance for the town of Black Hawk in 1993. Soil metals concentrations were taken from that document and now are used as a standard in Gilpin County. Central City adopted the soil concentration levels via a City Council resolution.

Because visitors taking State Highway 119 must drive through Black Hawk to get to Central City, the Central City Business Improvement District spearheaded the construction of the Central City Parkway to take cars directly to Central City from I-70 at exit 243. The 8.4-mile, four-lane highway cost an estimated $38 million, and was built through a combination of private funding and bonds. The parkway opened in November 2004.

Search for Potentially Responsible Parties (PRPs)

As with many Superfund sites, the question, "who is responsible," is difficult. Investigations to identify PRPs seek to find out whether property has a financially viable owner to bear the costs of necessary cleanup. Are the owners of problematic former mining sites liable, even if they did nothing to contribute to the contamination? Should anyone be surprised that the ground is laden with minerals in the Colorado Mineral Belt? At all stages of work on theses sites, some local residents have said that the Superfund process, devised for industrial sites, is not appropriate for mining sites. Early on, residents required convincing that the metals in the soil could potentially cause human health problems, such as learning and behavioral deficits in children and other neurological problems continuing into later life. The desire for historic preservation sometimes clashed with cleanup proposals, and it was important to avoid interfering with tourist activities and traffic whenever possible.

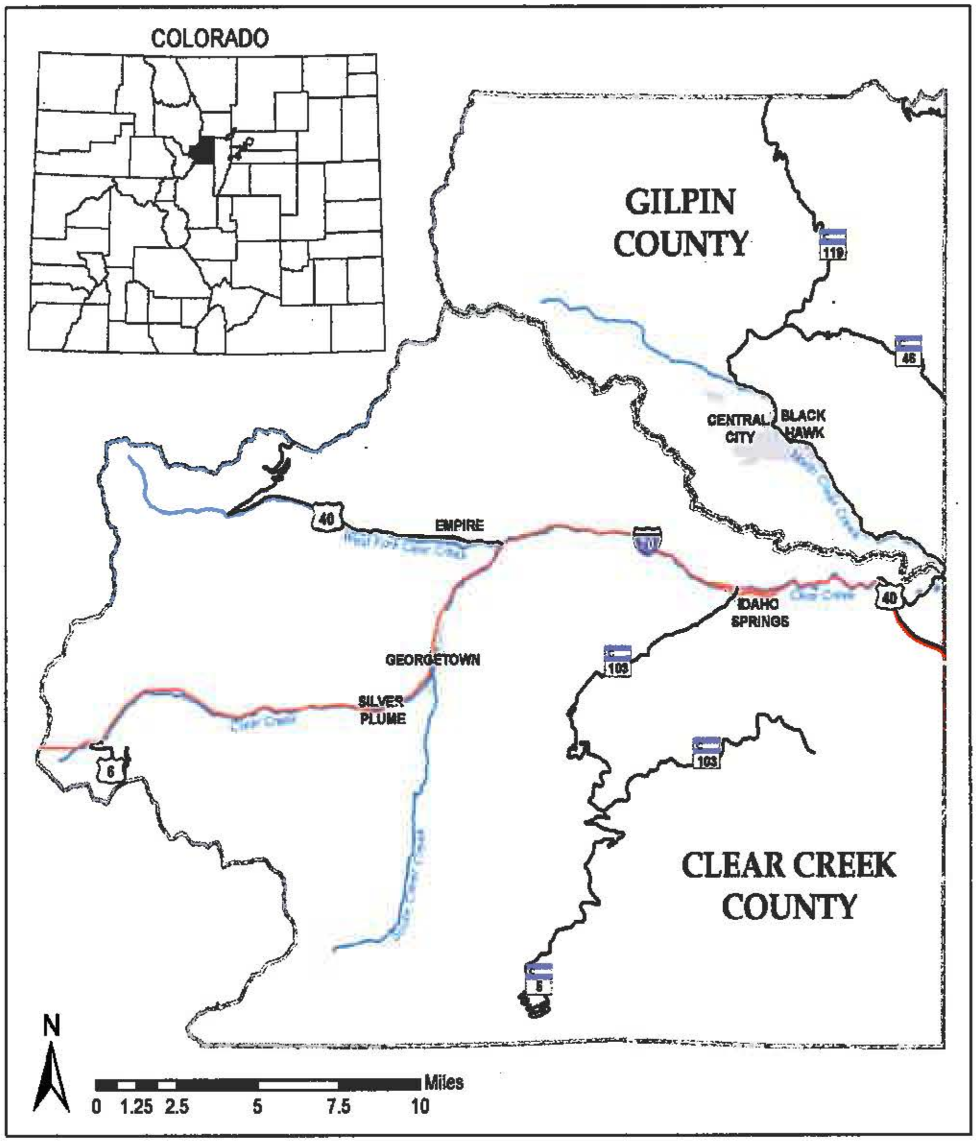
No PRPs were identified in Phase I. In Phase II and following phases, EPA and the state have treated each property individually, location by location. Developers and some mining companies conducted their own cleanups, approved by the state and EPA, using their own funds.

Site Description

The Site is about 30 to 40 miles directly west of Denver. The Site name refers to the town of Central City and the Clear Creek watershed. Because the two Colorado counties involved are Clear Creek and Gilpin, some of those interviewed previously have said that the site name was a source of some confusion.

Elevations at the Site range from about 5,700 feet at the Golden gauging station to more than 14,000 feet along the Continental Divide. Average annual precipitation ranges from less than 15 inches per year in the foothills to more than 40 inches in the high mountains. The basin is drained by Clear Creek, which has three major tributaries, the South Fork, West Fork and North Fork.

Figure 2


COLORADO
GILPIN COUNTY
CLEAR CREEK COUNTY
CENTRAL CITY
BLACK HAWK
EMPIRE
IDAHO SPRINGS
GEORGETOWN
SILVER PLUME
119
46
40
70
103
6
West Fork Clear Creek
Clear Creek
North Clear Creek
South Clear Creek
N
Miles
0 1.25 2.5 5 7.5 10

Clear Creek water is used for recreational, industrial, agricultural and municipal purposes. Most of the water appropriations occur between Idaho Springs and Golden. A number of Colorado cities (Georgetown, Idaho Springs, Black Hawk, Arvada, Golden, Northglenn, Thornton and Westminster) use Clear Creek water or water from tributaries of Clear Creek for public purposes. Recreational use includes fishing, kayaking, rafting, picnicking, camping and hiking.

Ground water in the Clear Creek basin is found in alluvial aquifers along streams, and in shallow fractures, faults and joints that form the fractured bedrock aquifer. The extensive network of mine workings throughout the area provides preferred pathways for ground water.

Vegetation includes Ponderosa pine, juniper and mountain mahogany grasslands on south facing slopes and lower elevations, with Douglas fir communities established on north-facing slopes and at higher elevations. Aspen groves are interspersed, and valley bottom vegetation includes blue spruce, narrow-leaf cottonwood, with willow and river birch at the edge of the floodplains. Alpine tundra is found above the 11,800-foot timberline.

Site Study Organization

Central City/Clear Creek was proposed for the National Priorities List in 1982, and was listed in 1983. At that time the focus was on five mine tunnels: the Gregory Incline and the National (near the Black Hawk), the Argo and the Big Five in Idaho Springs, and the Quartz Hill near Central City, plus a remedy for potential surge events at the Argo tunnel near Idaho Springs. The five mine tunnels were classified as Operable Unit (OU) 1, and its Record of Decision was signed in September 1987. The ROD called for passive treatment of mine discharges as the preferred remedial alternative, if passive treatment could be shown via treatability studies to be effective. The ROD allowed the flexibility to install active and passive treatment systems in combination, if necessary. Passive treatment was tested in a project with the Colorado School of Mines in constructed wetlands at the Big Five Tunnel in Idaho Springs and at the Burleigh tunnel with a large pilot-scale test. The results showed that passive treatment at the Burleigh was not practical. Subsequently, pilot test results paired with data from other aspects of the project showed that the Burleigh's contribution to elevated metals in Clear Creek (zinc, lead and manganese being of greatest concern) was not as significant as originally thought. A no action remedy was selected as part of OU3.

The Operable Unit 2 (OU2) remedy, which addressed the waste piles adjacent to the five original tunnels, was established by a Record of Decision signed in March 1988, calling for run-on and run-off controls and slope stabilization of the mine tailings and waste rock piles.

Originally OU3 was intended to address surge events at the Argo tunnel. Its Record of Decision was delayed pending the outcome of what became the Phase II Remedial Investigation/Feasibility Study (RI/FS), which looked at the Site using a watershed approach. Several additional waste piles were selected for remediation, along with the five original tunnels.

The need for OU4 was identified in the OU3 ROD and was developed specifically for the North Fork of the Clear Creek sub-watershed. The OU4 remedial actions address contaminated surface water, ground water and sediment. The cleanup strategies address threats through the capping or removal of waste piles and treatment of point and non-point sources of surface water contamination.

Potential Risks

The threat to public health and the environment at the site derives from heavy metals liberated by mining and the effects of acid mine drainage (AMD) into Clear Creek. The metals of primary concern for aquatic life include aluminum, arsenic, cadmium, chromium, copper, manganese, silver and zinc. The metals of primary concern for human health are arsenic and lead.

Ingested lead can delay and impede neurological growth in children from birth to 72 months. Exposure to high amounts of lead can be responsible for reductions in gross intelligence and for other neurological deficits. Although in extreme cases action may be taken to purge lead from the body, the primary recommendation to reduce effects in humans is to remove the source of the lead. Lead can cause many symptoms, including fatigue, paleness, irritability, loss of appetite, sleep disturbance, behavior change, kidney damage and abdominal pain.

Symptoms of arsenic exposure include both carcinogenic (cancerous) and noncarcinogenic effects associated with long-term low-level exposures to arsenic. The effects include lung cancer (through inhalation), skin cancer (through ingestion), non-cancerous skin lesions, peripheral nervous system effects and cardiovascular changes. There also is an association between ingestion of inorganic arsenic and lung, liver, kidney and bladder cancers.

In parts of the study area, drinking water from private wells was of concern and, as part of OU3, EPA and CDPHE offered to test wells at no charge and to provide bottled water as a short-term solution if water was not drinkable. Beginning in 1994, 60 homes were tested, and four were found to have water significantly contaminated by metals from the Site. Those four homes received bottled water at no charge until August 2003, when reverse osmosis and other water treatment systems were installed at three homes, and one home was connected to a municipal water supply. No one is being supplied with bottled water currently.

Danger from falls into open mine shafts also was mentioned as a human health risk in the 2004 interviews. Problems with abandoned mines are neither in the scope of EPA nor CDPHE and are addressed to the Division of Reclamation, Mining and Safety (DRMS) in the Colorado Department of Natural Resources (DNR).

Under an interagency agreement with CDPHE, DRMS closed four mine adits that are located at mine waste piles where CDPHE is or has implemented erosion-protection measures. The State Historical Preservation Office provided coordination and concurrence. These closures were completed in summer 2009.

Heavy metals present a significant risk to aquatic species. Zinc concentrations consistently exceed aquatic-life criteria at many locations in the basin, and copper, cadmium and manganese concentrations frequently exceed standards in specific stream segments.

Contamination also poses a threat to macroinvertebrates, the small insects that are a food source for fish. The water quality in some sections of Clear Creek and its tributaries may be lethal to some species of macroinvertebrates, and acute (short-term) effects can be expected in some areas. Other areas have chronic effects that result in less population diversity than would be expected without mining impacts.

Community Background

Clear Creek and Gilpin counties historically had mining as the basis of their economies, with a lesser emphasis on ranching. Gold was discovered near Idaho Springs in 1859 and in the Black Hawk/Central City area in 1860. For the next 20 years, the Black Hawk/Central City area was the leading mining center in Colorado with the construction of mills to process the gold and silver found through placer and hard rock mining. The decline of mining in the area began with the silver crash in the 1890s and the rise of mining in Leadville. However, mining continued to be an important industry in Clear Creek and Gilpin counties from the turn of the century until approximately 1950. Since 1950, mining in the area has been limited, with only a handful of mines currently operating. Tourism and recreation have become an increasingly important part of the counties' economies.

Clear Creek County

Clear Creek County is located 35 miles west of Denver on Interstate 70. The U.S. Census Bureau estimates the 2013 population at 9,031, while the Colorado State Demography Office puts the 2013 estimate at 9,029, making Clear Creek County the state's 39th most populous county. Major towns include the county seat of Georgetown (population: 3007), Idaho Springs (population 1,717), Empire (population 282) and Silver Plume (population 170).

The population is predominately Caucasian, with Hispanics, American Indians and Asians forming the largest minority groups. The population is split evenly between males (51.7 percent) and females (48.3 percent). The Bureau of Economic Analysis estimates the 2012 per capita personal income to be $60,556. Tourism and retail services play a significant role in the county's economy, particularly in Idaho Springs and Empire.

Gilpin County

Gilpin County is a rural community in Colorado's high country, neighboring the Continental Divide less than an hour west of downtown Denver. It is the state's second-smallest county in geographical area, and ranks 50th in population out of Colorado's 64 counties. The U.S. Census Bureau estimates the 2013 population at 5,601, while the Colorado State Demography Office estimates the 2013 population at 5,588. Major towns are the county seat of Central City (population: 663) and Black Hawk (population 118).

The population is predominately Caucasian, with Hispanics and American Indians forming the largest minority groups. Males outnumber females only slightly. The Bureau of Economic Analysis estimates the 2012 per capita personal income to be $44,375. The most recent statistics available showed adjusted gross proceeds from gaming of $553,082,797 in Black Hawk for 2013, and $67,592,801 in Central City in the same year.

Community Issues and Concerns

During the early years much of the planning and development for this Site was discussed and developed with the assistance of a Technical Review Committee consisting of local residents and mining professionals committed to improving the watershed. A later group, which received an EPA Technical Advisory Group (TAG) grant, was referred to as the Watershed Advisory Group. Their guidance, input and time commitment should be acknowledged as an essential part of the development of sound and practical clean-up plans.

At this time there is no active Community Advisory Group (CAG) for the Site. The Upper Clear Creek Watershed Association (UCCWA), which meets monthly, is an active forum in which project issues are discussed. Many watershed stakeholders and opinion leaders participate in this group, and it has been a sounding board for clean-up possibilities for Superfund site projects. Updates are provided frequently by the state and EPA.

The Clear Creek Watershed Foundation (CCWF) also is a major clearinghouse of information. The organization operates under an action memorandum from EPA, designating the foundation as a Good Samaritan Action Agent. With funding from EPA, the U.S. Forest Service and the state's Water Quality Control Division, the foundation has conducted a number of small clean-up projects that have had a positive effect on water quality in Clear Creek. Since 2009, CCWF has hosted the Clear Creek Watershed Festival, an annual public education and outreach fair. EPA and CDPHE have participated during most years of the event.

Historic Issues

It appears that there has always been competition between Gilpin and Clear Creek counties. In the early phases of this project, some Gilpin County residents felt that undue attention was paid to Clear Creek issues, at their expense. The easy access to some Clear Creek destinations that can be seen from I-70 may have given that county more ability to attract tourists than Gilpin County, which was reachable only by Highway 119, a moderately twisting mountain road, until the Central City Parkway was opened in November 2004.

In the early years of this project, there was lively debate over whether the habitat in the North Fork of Clear Creek itself could ever support fish and whether or not it was worth cleaning up in terms of cost/benefit. It was doubtful that a trout fishery could be established. That debate continued, both in the community and within the regulatory agencies, over many years, until a Remedial Investigation/Feasibility Study was conducted for OU4 (North Fork of Clear Creek), beginning in 2000. Findings showed that with cleanup of mine waste piles and sediment reduction, it is anticipated that fish could at least survive in the North Fork, if not breed there. The proposed plan was made available to the public July 23, 2004 and proposed combined active and passive water treatment with sediment reduction in the tributaries and the North Fork of Clear Creek itself. Several public meetings were held to present the proposed alternatives to citizens and elected officials in July and August 2004. Another public meeting was held in January 2010 to present EPA and CDPHE's proposal to amend the OU4 ROD to change the location of active water treatment for the Gregory Incline and Gregory Gulch water and to replace passive treatment at the National Tunnel discharge with active treatment. A ROD amendment was finalized in April 2010.

Remedial construction projects in OU4 focused on mine waste remediation and sediment control, including consolidation of mine wastes at the Church Placer Repository. During 2014, capping and stabilization of the Quartz Hill Tailings Pile in Central City was completed. The only remaining uncompleted projects in OU4 are construction of an active water treatment plant for the North Fork of Clear Creek and the construction of a bulkhead in the Argo Tunnel.

Due to the uncertainty of ongoing water rights negotiations with the City of Black Hawk and Gilpin County, construction of the North Clear Creek mine water treatment plant is on hold. CDPHE and the EPA will issue an Explanation of Significant Differences for the Argo Tunnel Discharge Flow Control Bulkhead. The bulkhead will not change the performance of the existing treatment technology or function of the Argo Tunnel Water Treatment Plant in Idaho Springs. The bulkhead will prevent future surge events from impacting Clear Creek and control flow volume to the plant, resulting in reduced treatment costs.

Project Perception

During the summer of 2014 community involvement professionals from CDPHE and EPA interviewed a cross section of community members including public officials, watershed activists, a wastewater treatment plant operator and a business owner. Interview questions appear in Appendix B. The information obtained through community interviews represents the interviewee's opinions, concerns and preferences, regardless of whether the responses are factually accurate or technically correct. Comments, while sometimes quoted exactly, are not attributed to individuals in order to promote candor.

People interviewed seemed to have a positive attitude about the project, although many expressed concern that more could be done.

Information Transfer

Several interview subjects commented that project communication from the agencies has been lacking recently, largely because there was no Update Fact Sheet published during 2013. A 2014 edition is in the works. Citizens in both counties read the *Denver Post* and their local county weeklies, including the Clear Creek Courant, the Mountain-Ear and the Weekly Register-Call. More and more people are getting the majority of their general information from the Internet. Much of the stakeholder information comes through the Upper Clear Creek Watershed Association and the Clear Creek Watershed Foundation, and people value the ongoing contacts with CDPHE and EPA project managers.

Summary of Most Frequent Comments

1. Many of the people we spoke to were concerned that the agencies would declare the project completed prematurely. Several people spoke of the need to stabilize or remove additional waste rock piles in OU4.

2. Many interview subjects stressed the importance of completing the proposed North Clear Creek Water Treatment Plant, while acknowledging that there were significant issues to overcome during water use negotiations.

3. UCCWA members who have been involved with the project for many years expressed satisfaction with how much has been accomplished, yet remain concerned about the 2003 decision to change the selected remedial action for the Burleigh Tunnel from passive treatment to no action. Stakeholders also cited several discharging mines that add metals load to Clear Creek.

4. Asked about project impacts on the surrounding community, many people cited positive effects, including:

- An improved tourism and recreation economy with thriving rafting and fishing industries, as well as greater use of the trail system;

- Better drinking water quality affecting 300,000 people in Clear Creek, Gilpin and Jefferson counties, along with lower costs of treating water for public supplies;
- Increased awareness of Clear Creek as an environmental resource; and
- Increased property values, including previously unusable properties that now are both usable and valuable.

One respondent said: "Colorado Parks and Wildlife now views Clear Creek as an important resource... It's a highly valued sport fishery; a robust, reproducing brown trout fishery with a proximity to a major metropolitan area, which increases its value."

Highlights of the CIP/Recommendations

- Project managers should continue to attend UCCWA meetings to brief the membership and should continue to provide informal updates to UCCWA, the CCWF and local officials as needed.

- Community involvement staff should continue to publish an annual fact sheet detailing milestones from the previous construction season and plans for the upcoming construction season.

- Staff should continue to update the CDPHE and EPA websites.

- The agencies should distribute e-mail updates to UCCWA, CCWF, local officials and other stakeholders as needed.

- Community involvement staff should send project updates, fact sheets and other materials to the media, as well as to the public.

- Community involvement staff should make courtesy calls to the local media as appropriate.

Appendix A - Officials

Colorado Department of Public Health and Environment

Hazardous Materials and Waste Management Division
4300 Cherry Creek Drive South
Denver, CO 80246
(303) 759-5355 fax

Barbara Nabors, Unit Leader (303) 692-3393 barbara.nabors@state.co.us	Mary Boardman, Project Manager, Argo Tunnel Treatment Plant, OU4 Water Treatment (303) 692-3413 mary.boardman@state.co.us
Steve Laudeman, Project Manager, Overall Coordination (303) 692-3381 steve.laudeman@state.co.us	Warren Smith, Community Involvement Manager (303) 692-3373 warren.smith@state.co.us
Jim Lewis, Project Manager, Operation and Maintenance of Waste Piles, Argo Tunnel Bulkhead (303) 692-3390 jim.lewis@state.co.us	

U.S. Environmental Protection Agency (EPA), Region 8

1595 Wynkoop St., 80C
Denver, CO 80202-1129

Leslie Sims Remedial Project Manager (303) 312-6224 sims.leslie@epa.gov	Jasmin Guerra Community Involvement Coordinator (303) 312-6508 guerra.jasmin@epa.gov

Federal Elected Officials

Senate	House of Representatives Second Congressional District
Mark Udall Hart Office Building, Suite SH-730 Washington D.C. 20510 (202) 224-5941 1-877-768-3255 (CO residents only) Denver Office 999 Eighteenth Street, Ste. N1525 Denver, CO 80202 (303) 650-7820 markudall@senate.gov **Mike Bennett** 458 Russell Senate Office Building Washington, DC 20510 (202) 224-5852 Denver Office 1127 Sherman St., Suite 150 Denver, Colorado 80203 (303) 455-7600 bennett@senate.gov	**Jared Polis** 1433 Longworth House Office Building Washington, DC 20515 (202) 225-2161 Boulder Office 4770 Baseline Drive #220 Boulder, CO 80303 (303) 484-9596

State Elected Officials

State Senate District 16	**State House of Representatives District 13**
Senator Jeanne Nicholson (303) 866-4873 jeanne.nicholson.senate@state.co.us	Representative KC Becker (303) 866-2578 kcbecker.house@state.co.us

County Elected Officials

Clear Creek County	Gilpin County
Tom Hayden, (D-2), Commission Chair Tim Mauck, (D-1), Commissioner Phil Buckland, (D-3), Commissioner	Gail Watson, (D-3), Commission Chair Connie McLain, (D-2), Commissioner Buddy Schmalz, (D-1), Commissioner
Clear Creek County Courthouse Box 2000 Ph: (303) 679-2312 Fax: (303) 679-2440	Gilpin County Courthouse P.O. Box 366 203 Eureka Central City, CO 80427 (303) 582-5214 (303) 582-5440 (fax)

City Officials

Black Hawk	Central City
David Spellman, Mayor Jack D. Lewis, City Manager	Ron Engels, Mayor Vacant, City Manager
Linda Armbright, Alderman Paul G. Bennett, Alderman Jim Johnson, Alderman Hal Midcap, Alderman Greg Moates, Alderman Benito Torres, Alderman	Bob Spain, Councilman Shirley Voorhies, Councilwoman Gloria Gaines, Councilwoman Kathy Heider, Councilwoman
City of Black Hawk P.O. Box 68 Black Hawk, CO 80422 (303) 582-5221 (303) 582-0429 (fax)	Central City City Hall P.O. Box 249 Central City, CO 80427 (303) 582-5251 (303) 582-5817 (fax)

City Officials, continued

Georgetown	Idaho Springs
Craig Abrahamson, ex officio Mayor Tom Hale, Town Administrator	Michael Hillman , Mayor Phyllis Adams, City Administrator
Selectmen Craig Abrahamson, Police Judge Keith D. Holmes, Ward I Henry Ehrgott, Ward I Bob Smith, Ward II, Police Judge pro tem Lynette Kelsey, Ward II James Billingsley, Ward III Ed Hoover, Ward III	Council Members Marilyn Anderson, Ward I Denise Deese, Ward I Kate Collier, Ward II Deloris Munchiando, Ward II Robert Bowland, Ward III Lisa Highley, Ward III
Town Hall 406 6th Street P.O. Box 426 Georgetown, CO 80444 (303) 569-2555 (303) 569-2705 (fax)	City of Idaho Springs P.O. Box 907 Idaho Springs, CO80452-0907 (303) 567-4421 (303) 567-4955 (fax)

Appendix B - 2014 Interview Questions

What do you know about the Central City Clear Creek Superfund Site?

What cleanup activities are you aware of involving the site?

What is your overall impression of the cleanup?

What impact, if any have the cleanup operations had on the surrounding community?

Do you have any concerns about the cleanup?

Have you been satisfied with communication and coordination relating to the cleanup?

Have you asked for information? Where did you go or who did you ask, and what information did you get?

Where do you get your news and information?

Can you recommend other people we should talk to?

Do you have anything to add?

Appendix C - Media

Canyon Courier 27902 Meadow Drive #200 Evergreen, CO 80439 www.canyoncourier.com Doug Bell, Editor 303-350-1039 Ian Neligh, Clear Creek Editor 303-567-4491	**KCNC - CBS4** 1044 Lincoln Street Denver, CO 80203 303-861-4444 www.cbs4denver.com Mountain Bureau Jeff Todd, Reporter
Clear Creek Courant 1634 Miner Street PO Box 2020 Idaho Springs, CO 80452-2020 www.clearcreekcourant.com Ian Neligh, Clear Creek Editor 303-567-4491 Doug Bell, Editor 303-350-1039 Fax 303-567-0520	**KUSA - 9NEWS** 500 Speer Blvd. Denver, CO 80203 303-871-1491 www.9news.com Mountain Newsroom Nick McGurk
Denver Post 1560 Broadway Denver, CO 80202 www.denverpost.com 303-954-1201 newsroom@denverpost.com	**The Mountain-Ear** P.O. Box 99 Nederland, CO 80466 www.themountainear.com Linn Hirshman, Editor editor@themountainear.com
Golden Transcript 1000 10th St. Golden, CO 80401 fax 303-279-7157 Mikkel Kelly, Golden Editor 303-279-5541 mkelly@coloradocommunitymedia.com	**Weekly Register-Call/Gilpin County News** P.O. Box 93 Black Hawk, CO 80422 303-582-0133 www.gilpincountynews.com Aaron Storms, Co-Publisher & Managing Editor David Spellman, Co-Publisher

Appendix D - Information Repositories

Gilpin County Court House
203 Eureka Street
Central City, CO 80427

Clear Creek Watershed Foundation
2060 Miner Street
Idaho Springs, CO 80452
(303) 567-2699
Please call to schedule an appointment.

Colorado Department of Public Health and Environment
Hazardous Materials and Waste
Management Division
4300 Cherry Creek Drive South
Denver, CO 80246
(303) 692-3331
M-F, 8 a.m.-Noon and 1 p.m.-5 p.m.
An appointment is recommended.

EPA Superfund Records Center
1595 Wynkoop Street
Denver, CO 80202
(303) 312-6473
M-F, 8 a.m.-4:30 p.m.
An appointment is recommended.

View Documents on the Web at:
https://www.colorado.gov/pacific/cdphe/central-city-clear-creek
www.epa.gov/region08/superfund/co/ccclearcreek

Appendix E - Publications since Last Community Involvement Plan

Colorado Water Quality Control Commission. 2010. Aquatic Life Use Attainment. Methodology to Determine Use Attainment for Rivers and Streams. Policy Statement 10-1.

Colorado Department of Public Health and Environment. April 2010. Central City/Clear Creek Superfund Site, Amendment to the Operable Unit 4 Record of Decision for the Active Treatment of the National Tunnel, Gregory Incline and Gregory Gulch.

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Appendix F - Acronyms

AMD	Acid Mine Drainage
CAG	Community Advisory Group
CCWF	Clear Creek Watershed Foundation
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (the Superfund law)
CIP	Community Involvement Plan
DNR	Department of Natural Resources
DRMS	Division of Reclamation Mining and Safety
EPA	United States Environmental Protection Agency
HMWMD	Hazardous Materials and Waste Management Division
NCP	National Oil and Hazardous Substances Contingency Plan
NPL	National Priorities List
OU	Operable Unit
PRP	Potentially Responsible Party
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SDMD	Silver Dollar Metropolitan District
TAG	Technical Assistance Grant
UCCWA	Upper Clear Creek Watershed Association

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