FIVE-YEAR REVIEW REPORT

Second Review

For

Lowry Landfill Superfund Site

Arapahoe County, Colorado

Prepared by
U.S. Environmental Protection Agency
Region 8

Date
February 2007

Approved by:

Carol Rushin

2/7/2007
Date

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LIST OF ACRONYMS

°C	degrees Celsius
°F	degrees Fahrenheit
µg/L	micrograms per liter
ARAR	Applicable or Relevant and Appropriate Requirement
BTS	Biological Treatment System
CBSGW	Colorado Basic Standards for Groundwater
CBSSW	Colorado Basic Standards for Surface Water
CCR	Code of Colorado Regulations
CDH	Colorado Department of Health (former name of CDPHE)
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CLLEAN	Citizens for Lowry Landfill Environmental Action Now
COC	Contaminant of Concern
CSM	Conceptual Site Model
CWA	Clean Water Act
CWM	Chemical Waste Management, Inc.
DADS	Denver Arapahoe Disposal Site
DNAPLs	Dense Non-Aqueous Phase Liquids
EE/CA	Engineering Evaluation/Cost Analysis
EPA	Environmental Protection Agency
ESD	Explanation of Significant Differences
E/S/W	East/South/West
FS	Feasibility Study
ft	foot/feet
ft^3	cubic feet
FTO	Flameless Thermal Oxidizer
FTPA	Former Tire Pile Area
GAC	Granular Activated Carbon
GC	Gas Chromatograph
gpm	gallons per minute
GWMP	Groundwater Monitoring Plan
Kg	kilograms
L	liter
LDRs	Land Disposal Restrictions
LFG	Landfill Gas
LFS	Landfill Solids
LNAPL	Light Non-Aqueous Phase Liquids
MCL	Maximum Contaminant Level
mg/kg	milligram per kilogram
mg/L	milligram per liter
mph	miles per hour
NAPL	Non-Aqueous Phase Liquid

NBBW	North Boundary Barrier Wall
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	Not Detected
NMOC	Non-Methane Organic Compound
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSPS	New Source Performance Standards
NTES	North Toe Extraction System
O&M	Operation & Maintenance
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PA/SI	Preliminary Assessment/Site Inspection
PAH	Polynuclear Aromatic Hydrocarbon
PCB	polychlorinated biphenyl
POA	Point of Action
POC	Point of Compliance
POTW	Publicly Owned Treatment Works
PQL	Practical Quantitation Limit
PRP	Potentially Responsible Party
QA	Quality Assurance
QC	Quality Control
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RD/RA	Remedial Design/Remedial Action
Respondents	Denver, WMC, and CWM
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
RWST	raw water storage tank
SARA	Superfund Amendments and Reauthorization Act of 1986
scfm	standard cubic feet per minute
SDWA	Safe Drinking Water Act
SF	slope factor
Site	Lowry Landfill Superfund Site
Superfund	Comprehensive Environmental Response, Compensation and Liability Act
SVOC	Semivolatile Organic Compounds
SWRA	Surface Water Removal Action
TBC	To be Considered
TCHD	Tri-County Health Department
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
UV-Ox	UV-Oxidation
VOC	Volatile Organic Compound
WMC	Waste Management of Colorado, Inc.
WSDs	Work Settling Defendants
WTP	water treatment plant

EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) Region 8 conducted a second five-year review of the remedial actions implemented at the Lowry Landfill Superfund Site (the Site) in Arapahoe County, Colorado. The purpose of the five-year review is to determine if the remedy at the Site is or will be protective of human health and the environment. This is the second five-year review for the Site. The triggering action for this review is the date of completion of the first five-year review, as shown in EPA's WasteLAN database: September 28, 2001. EPA selected a remedy for the Site that, upon completion, will leave hazardous substances, pollutants, or contaminants on-Site above levels that allow for unlimited use and unrestricted exposure. Therefore, five-year reviews of the remedy are required by statute.

The remedy for the Site included remedial actions for each of six operable units to address groundwater, surface water, landfill gas, landfill solids, soils and sediments. The selected Site-wide remedy utilizes containment, collection, treatment, and monitoring to address the contamination at the Site.

The remedy required a combination of engineered components to be constructed and operated to prevent off-Site migration of contamination above performance standards. If performance standards are not met during implementation or operation, the remedy requires appropriate contingency measures to be implemented. The selected Site-wide remedy also required the implementation of on-Site and off-Site institutional controls. The Site achieved construction completion with the signing of the Preliminary Close Out Report on September 28, 2006.

Three issues were identified during this second five-year review:

(1) The chemicals nitrate and 1,4-dioxane have been detected at levels above performance standards in groundwater wells north of the Site outside the groundwater containment components and area of hydraulic control. In accordance with the Sitewide Groundwater Monitoring Plan (GWMP), a groundwater investigation has been implemented north of the Site and is ongoing. The investigation found 1,4-dioxane above performance standards in shallow groundwater and above current State standards in surface water in Murphy Creek 2 ½ miles downstream of the Site. There is no current or reasonably anticipated future exposure to the impacted surface water or groundwater via the drinking water pathway or the vapor intrusion to indoor air pathway and the potential incidental exposures to surface water by nearby residents or recreational users such as golfers are not considered to be a public health threat. Response actions to limit groundwater migration and lower the concentrations of contaminants in groundwater are required by the GWMP and are ongoing as part of the implementation of the selected remedy.

(2) Recent groundwater sampling results indicate that monitoring well MW05-WD, designated as representative of background groundwater quality for inorganic contaminants, may have been impacted by the Site. The groundwater performance standards for inorganics were established based on background concentrations. It may be inappropriate to include groundwater quality data from well MW05-WD in the population of data used to calculate statistics on

background levels of inorganics in groundwater in the vicinity of the Site. The Work Settling Defendants should evaluate the need to replace this well and if necessary, recalculate background concentrations for inorganics in shallow groundwater using data from the replacement well.

(3) The current interim compliance monitoring program for surface water has been in place since 1996 and has not been re-considered or developed into a long-term compliance monitoring program for surface water. The Work Settling Defendants should develop a long-term compliance monitoring plan for surface water.

The assessment of this second five-year review is that the remedy for all six operable units is functioning as intended by the decision documents. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection remain valid. No other information has come to light that could call into question the protectiveness of the remedy. The remedy for all six operable units is protective of human health and the environment. Because the remedy for all six operable units is protective, the Site is protective of human health and the environment.

FIVE-YEAR REVIEW SUMMARY FORM

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Lowry Landfill Superfund Site		
EPA ID *(from WasteLAN)*: *COD 980499248*		
Region: 8	**State:** CO	**City/County:** Aurora/Arapahoe
SITE STATUS		
NPL status: Final		
Remediation status (choose all that apply): Under Construction X Operating X Construction Complete		
Multiple OUs?* YES	**Construction completion date:** September 29, 2006	
Has site been put into reuse? NO		
REVIEW STATUS		
Lead agency: X EPA State Tribe Other Federal Agency		
Author name: Bonnie Lavelle		
Author title: Remedial Project Manager	**Author affiliation:** EPA Region 8	
Review period:** April 2006 to January 2007		
Date(s) of site inspection: May 31 – June 1, 2006		
Type of review: Statutory		
Review number: : 2 (second)		
Triggering action: Previous Five-Year Review Report		
Triggering action date *(from WasteLAN)*: September 2001		
Due date *(five years after triggering action date)*: September 2006		

* ["OU" refers to operable unit.]
** [Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.]

FIVE-YEAR REVIEW SUMMARY FORM (continued)

Issues:

Issues	Affects Protectiveness (Y/N)	
	Current	Future
Surface water monitoring has been performed since 1996 in accordance with the *"Final Interim Compliance Monitoring Plan" (February 1996)*. The interim compliance monitoring program for surface water was intended to provide a technical basis for development of a long-term surface water monitoring program to be implemented during and following remedial action at the Site. However, the current program has been in place since 1996 and has not been re-considered or developed into a long-term compliance monitoring program for surface water.	N	N
Recent groundwater sampling results indicate that monitoring well MW05-WD, designated as representative of background groundwater quality for inorganic contaminants, may have been impacted by the Site. The groundwater performance standards for inorganics were established based on background concentrations. It may be inappropriate to include groundwater quality data from well MW05-WD in the population of data used to calculate statistics on background levels of inorganics in groundwater in the vicinity of the Site. Groundwater quality data collected from an alternate monitoring well in the vicinity of MW05-WD may be more appropriate. This does not affect protectiveness since there is no current or reasonably anticipated future exposure via the drinking water pathway.	N	N
The chemicals 1,4 dioxane and nitrate have been detected at levels above performance standards in wells north of the Site outside the effective groundwater hydraulic control area of the NBBW. The GWMP, enforceable under the Consent Decree, contains provisions for investigating the extent of the groundwater impacts and for implementing response actions to limit contaminant migration and lower the concentrations of contaminants in groundwater. In accordance with the GWMP, a groundwater investigation has been implemented north of the Site and is ongoing. The investigation found 1,4-dioxane above performance standards in shallow groundwater and above State standards in surface water in Murphy Creek 2 ½ miles downstream of the Site. There is no current or reasonably anticipated future exposure to the impacted surface water or groundwater via the drinking water or vapor intrusion pathways and the potential incidental exposures to surface water by nearby residents or recreational users such as golfers are not considered to be a public health threat. Response actions to limit migration and lower the concentrations of contaminants in groundwater are required by the GWMP and are ongoing as part of the implementation of the selected remedy.	N	N

Recommendations and Follow-up Actions:

Recommendations/ Follow-up Actions	Parties Responsible	Oversight Agency	Milestone Date	Follow-up Actions: Affects Protectiveness (Y/N)	
				Current	Future
Develop long-term compliance monitoring plan for surface water.	WSDs	EPA	9/30/2007	N	N
Evaluate the need to replace MW05-WD as a background well and if necessary, recalculate background concentrations for inorganics in shallow groundwater using data from samples collected from the replacement well as part of the background population.	WSDs	EPA	9/30/2007	N	N

Protectiveness Statements:

OUs 1 & 6: Shallow Groundwater and Surface Liquids and Deep Groundwater

The remedy for OUs 1 and 6 is protective of human health and the environment. The remedy is functioning as intended by the decision documents. The GWMP component of the remedy for OUs 1 and 6 is functioning to identify areas where concentrations of Site-related chemicals are out of compliance with performance standards at the point of compliance and to evaluate the effectiveness of the groundwater containment features of the remedy. In addition, the GWMP requires the implementation of response actions in the event that it is determined that containment may not be effective or that groundwater is out of compliance with performance standards, assuring remedial action objectives will be met and maintained. The remedy for OUs 1 and 6 also contains contingency measures which may be implemented if performance standards are not met at the point of compliance. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection remain valid.

The North End Investigation and response action have been implemented as required by the GWMP. The extent of 1,4 dioxane in shallow groundwater north of the Site boundary has been determined. There are no uncontrolled exposure pathways that could result in unacceptable risks to human health and the environment. The data collected during the North End Investigation indicates there are no unacceptable risks associated with potential exposures to the levels found in groundwater and surface water, even using very conservative assumptions. Therefore, the data indicates the remedy for OUs 1 and 6 is protective.

No other information has come to light that could call into question the protectiveness of the remedy.

OUs 2 & 3: Landfill Solids and Landfill Gas

The remedy for OUs 2 and 3 is protective of human health and the environment. The remedy is functioning as intended by the decision documents. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection remain valid. No other information has come to light that could call into question the protectiveness of the remedy at OUs 2 and 3.

OUs 4 & 5: Soils and Surface Water and Sediment

The remedy for OUs 4 and 5 is protective of human health and the environment. The remedy is functioning as intended by the decision documents. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection remain valid. No other information has come to light that could call into question the protectiveness of the remedy for OUs 4 and 5.

Comprehensive Protectiveness Statement

Because the remedy for all six OUs is protective, the Site is protective of human health and the environment.

I. Introduction

The purpose of five-year reviews is to evaluate the implementation and performance of the remedy at a Superfund site in order to determine if the remedy is or will 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.

The U.S. Environmental Protection Agency (EPA) Region 8 conducted this second five-year review for the Lowry Landfill Superfund Site (the Site) pursuant to Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP). CERCLA Section 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.*

EPA interpreted this requirement further in the NCP; 40 CFR Section 300.430(f) (4) (ii) states:

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.

The Site is a CERCLA Enforcement-lead site. In accordance with EPA guidance contained in "Comprehensive Five-Year Review Guidance", Office of Solid Waste and Emergency Response (OSWER) Directive No. 9355.7-03B-P, the ultimate responsibility for the quality and completeness of five-year review activities and the content and protectiveness determinations of the five-year review report rests with EPA.

EPA Region 8 has conducted a five-year review of the remedial actions implemented at the Site. This review was conducted from April 2006 through September 2006. This report documents the results of the review. The U.S. Army Corps of Engineers (USACE) conducted the Site inspection and provided technical assistance to EPA in conducting the five-year review for the Site. EPA funded the USACE's work through an Interagency Agreement with USACE.

This is the second five-year review for the Site. The triggering action for this review is the date of completion of the first five-year review, as shown in EPA's WasteLAN database:

September 28, 2001. In the March 1994 Record of Decision, and in subsequent remedial decision documents for the Site (described in Section IV of this five-year review report), EPA selected a remedial action that, upon completion, will leave hazardous substances, pollutants, or contaminants on-Site above levels that allow for unlimited use and unrestricted exposure. Therefore, five-year reviews of the remedy are required by statute.

II. Site Chronology

Table 1: Chronology of Site Events

Event	Date
The City of Denver purchased 60,000 acres southeast of Denver and deeded the land to the federal government.	1939
The Federal government used the 60,000 acres as the Lowry Bombing Range.	1940-1960 (Approximate)
Denver made application to use a portion of the Site as a sanitary landfill. The United States granted the application subject to certain terms and conditions and conveyed all or portions of five sections of the Lowry Bombing Range, including the Site, back to Denver by quitclaim deed.	1964
Denver operated Lowry Landfill as a municipal and industrial landfill. The landfill accepted a variety of wastes, including but not necessarily limited to: municipal refuse, liquid and solid industrial wastes, miscellaneous radioactive wastes, and sewage sludge.	1965-1980
Citizens issued complaints to regulatory authorities regarding odors, fires, and conditions of disposal practices causing spread of contamination to the surrounding area and to groundwater. EPA, the Colorado Department of Health, and Denver engaged in an ongoing process to identify contamination problems and modify operational practices.	1971-1979
Various investigations were conducted by EPA, the United States Geological Survey (USGS), and the Colorado Department of Public Health and Environment (CDPHE), formerly known as the Colorado Department of Health , and were performed by Denver and Waste Management of Colorado, Inc. (WMC).	Mid 1970's – 1984
WMC took over the operation of the landfill under a contract with Denver. The landfill did not accept industrial waste and accepted only municipal refuse.	1980
EPA conducted a Preliminary Assessment and Site Inspection for the Lowry Landfill.	1982
Lowry Landfill was named a Superfund site and placed on the National Priorities List (NPL). Denver implemented an interim remedial measure consisting of a subsurface groundwater drain backed by a compacted clay barrier wall (the North Boundary Barrier Wall [NBBW]) and a water treatment plant (WTP). EPA issued a Community Relations Plan for the Site.	1984
EPA conducted the Phase I Remedial Investigation (RI).	1985-1986
The Agency for Toxic Substances and Disease Registry (ATSDR) completed a public health assessment of the Site.	1987
EPA conducted Phase II RI and designated Operable Units (OUs): OU 1 – Shallow Groundwater and Subsurface Liquids OU 2 – Landfill Solids (LFS) OU 3 – Landfill Gas (LFG) OU 4 – Soils OU 5 – Surface Water (SW) and Sediments OU 6 – Deep Groundwater	1987-1989
EPA completed an Engineering Evaluation/Cost Analysis (EE/CA) of alternatives for the Surface Water Removal Action (SWRA).	1988
EPA issued an update of the Community Relations Plan.	1989
EPA conducted the Drum Removal Action.	1989-1990
Denver implemented a tire-shredding operation to shred approximately 8 million tires stockpiled in Section 6.	1989-1992
The Section 6 landfill stopped accepting municipal solid waste.	1990
Respondents Denver, WMC, and Chemical Waste Management, Inc. (CWM) entered into a Consent Order with EPA governing those parties' implementation of the SWRA which included construction of a blanket drain to separate surface water runoff from contaminated groundwater within the unnamed creek drainage. Design of the system began.	1991

Event	Date
Potentially Responsible Parties comprising the Lowry Coalition performed the RI for OUs 1 and 6.	1991
Upgrades to the water treatment plant were completed.	1992
The Feasibility Study (FS) for OUs 1 and 6 was performed by the Lowry Coalition; the FS for OUs 2 and 3 was performed by Denver, WMC, CWM; and the FS for OUs 4 and 5 was performed by Metro Wastewater Reclamation District [Metro] and Denver.	1992
The RI for OUs 2 and 3 was performed by Denver, WMC, CWM and the RI for OUs 4 and 5 was performed by Metro and Denver.	1992
Construction of SWRA completed.	1992
Section 6 landfill final clay cover construction program completed.	1992
EPA issued Baseline Risk Assessments for all OUs, the Site-wide and Radionuclide Risk Assessment, and the Proposed Plan for Site-wide remedy.	1992
EPA issued the Record of Decision (ROD).	1994
EPA issued the Unilateral Administrative Order (UAO) for Remedial Design/Remedial Action (RD/RA), EPA Docket No. CERCLA VIII-95-05, to 34 PRPs. Respondents Denver, WMC, and CWM agreed to perform the RD/RA on behalf of themselves and 31 other PRPs.	1994
EPA issued an addendum to Community Relations Plan.	1995
EPA issued the First Explanation of Significant Differences (ESD) for the ROD.	1995
EPA approved the Landfill Gas Collection and Treatment System remedial design.	1996
Respondents initiated the Well Plugging Program. EPA approved the Wetlands Mitigation remedial design.	1996
Respondents constructed the Landfill Gas Collection and Treatment System.	1996
EPA approved the East/South/West Barrier Wall remedial design.	1997
EPA approved the North Toe Extraction System remedial design.	1997
Respondents completed Wetlands Mitigation.	1997
Respondents completed Well Plugging System.	1997
Wetlands mitigation damaged by flooding.	1997
EPA issued the Second ESD.	1997
Respondents completed the North Toe Extraction System and East/South/West Barrier Wall.	1998
EPA approved the Former Tire Pile Area (FTPA) remedial design. Respondents completed Publicly Owned Treatment Works (POTW) Pipeline and Potable Waterline remedial design.	1998
Respondents completed FTPA Middle Waste Pit excavation.	1999
EPA issued the second addendum to Community Relations Plan.	1999
Respondents completed the FTPA Middle Waste Pit treatment cell.	1999
Respondents completed reconstruction of Wetlands. Respondents began and then discontinued excavation of the FTPA North Waste Pit. Respondents completed remedial design of the new WTP.	1999
EPA approved the North Face Landfill Cover remedial design.	1999
Respondents completed North Face Landfill Cover.	1999
Respondents completed new WTP.	2000
Respondents connected the Flameless Thermal Oxidizer (FTO) Unit to Treatment Cell containing excavated materials from the FTPA.	2000
EPA conducted the First Five-Year Review.	2000-2001
Denver Arapahoe Disposal Site (DADS) landfill gas was combined with the Site landfill gas and burned at Lowry Landfill flare station.	2001-present
Respondents conducted pilot study of in-situ recovery of liquids and vapor at the South Waste Pit within the FTPA.	2001-2003
EPA issued the First Addendum to the First Five-Year Review Report.	2002

Event	Date
Respondents back-filled and re-graded the Landfill Cover depressions.	2002
EPA approved the Institutional Controls Plan.	2002
Respondents conducted FS for re-evaluation of selected remedy for FTPA waste pits.	2003-2004
Respondents constructed the Biological Treatment System at the WTP.	2005
Groundwater extracted from the North Toe Extraction System is treated in the upgraded WTP.	2005 - present
EPA approved the Site-wide Groundwater Monitoring Plan.	2005
EPA approved the Work Plan for Additional Geologic Characterization of Potential Lineaments (as amended).	2005
Respondents implemented the MW-38 Area Gradient Control Contingency Measure.	2005
EPA issued the ROD Amendment for FTPA remedy.	2005
EPA certified the completion of construction of groundwater monitoring network.	2005
EPA approved the Final Interim Closeout Report, Middle Waste Pit Remediation and Construction of the Treatment Cell, Former Tire Pile Area Waste Pit Remedy.	2005
EPA certified the completion of work for the Wetland Mitigation.	2005
CDPHE approved the Engineering Design and Operations Plan for additional landfilling activities on the Site.	2005
EPA certified the completion of following remedial actions: • Surface Water Removal Action • MW38 Area Gradient Control Contingency Measure • New Water Treatment Plant	2005
United States entered into a consent decree (Civil Action No. 02-cv-1341-EWN-MJW) with Denver, WMC, and CWM (Work Settling Defendants or WSDs), and five other responsible parties for recovery of the United States' costs and performance of remaining work at the Site.	2005
EPA approved Remedial Action Work Plan for remaining work at the FTPA Waste Pits.	2006
EPA issued a Minor Modification to the ROD to identify a new Applicable or Relevant and Appropriate Requirement for the FTPA remedy and to designate a Corrective Action Management Unit at the Site.	2006
WSDs installed ten new landfill gas extraction wells as an enhancement of the remedy for landfill gas.	2006
EPA established a new groundwater performance standard for 1,4 dioxane.	2006
EPA certified construction completion for Site-wide remedy.	2006

III. Background

Physical Characteristics

The 507-acre Site, located in an unincorporated area of Arapahoe County, consists of the western 3/4 of Section 6, Township 5 South, Range 65 West, and the extreme southern portion of Section 31, Township 4 South, Range 65 West . The Site is located northeast of the intersection of Quincy Avenue and Gun Club Road, 15 miles southeast of the City of Denver and 2 miles east of the City of Aurora, Colorado (Figure 1). The Denver Arapahoe Disposal Site (DADS), an operating municipal solid waste landfill northeast of the intersection of Gun Club Road and East Hampden Avenue, forms the northern and eastern boundaries of the Site. The City and County of Denver (Denver) owns the Site.

The Site is located in gently rolling short-grass prairie characteristic of the Great Plains and consists of gentle slopes on the north half of the section and a topographic high on the south half of the section created by past landfilling activities. Historically, the surrounding land was largely undisturbed native prairie, disturbed weedy prairie, and areas of un-irrigated small grain crops.

The Site is currently completely fenced. Waste Management of Colorado, Inc. (WMC), the operator of DADS, regularly patrols the fence. The main entrance to the Site is a gate at the intersection of East Hampden Avenue and Gun Club Road, the northern Site boundary. The DADS municipal solid waste landfill north of the Site operates 24 hours a day, six days a week. The gate provides access to both the Site and DADS and is closed and locked on Sundays.

The Site is located within the Murphy Creek drainage system, which covers approximately 7,800 acres. The unnamed creek and its tributaries in Section 6 and Murphy Creek and its tributaries to the east and north of Section 6 are included in this system. These streams generally flow north, and flow is ephemeral, usually in response to storm events or snowmelt. Precipitation runoff entering the unnamed creek depression on the Site is separated from seepage emanating from subsurface contamination sources located within the area by the SWRA implemented at the Site in 1992.

Groundwater exists within four hydrostratigraphic units that have been identified at the Site based on differences in hydraulic conductivity and/or regionally defined boundaries. These four units consist of:

(1) alluvial deposits and the upper weathered portion of the Dawson Formation,
(2) the unweathered portion of the Dawson Formation,
(3) the upper portion of the Denver aquifer (upper Denver), and
(4) the lignite layer.

The alluvium and weathered Dawson unit is approximately 50 feet thick at the Site; however, because the depth of weathering varies across the Site, there are variations in the thickness of this unit. The depth to groundwater in the alluvium and weathered Dawson unit ranges from approximately six feet below ground surface (bgs) along the unnamed creek drainage in the northern portion of the Site to approximately 65 feet bgs in the southwestern portion of the Site.

The unweathered Dawson and upper Denver units are each approximately 100 feet thick. The depth to groundwater in the unweathered Dawson Formation ranges from approximately 10 feet bgs along the unnamed creek drainage in the northern portion of the Site to approximately 80 feet in the northwestern portion of the Site and below the main landfill mass. The lignite layer is approximately 10 feet thick and represents the deepest unit monitored at the Site.

Hydrogeologic conditions at the Site are heterogeneous and anisotropic. Subsurface conditions beneath the Site consist predominantly of low permeability silt and clay deposits with lesser amounts of channel sands and associated fine-grained overbank deposits. Groundwater flow beneath the Site is primarily controlled by the presence of the overall low permeability matrix (siltstone and claystone) of the Dawson Formation. Although channel sands and overbank deposits are present within the Dawson Formation, flow into and out of the channel deposits and overbank sands is primarily controlled by the overall lower permeability matrix of the surrounding and encompassing claystones and siltstones of the Dawson Formation. Channel deposits within the Dawson Formation that have a relatively high degree of interconnection and resultant groundwater flux represent the primary and most significant potential pathways for groundwater migration. Groundwater flow in the less connected channel sands is controlled to a large degree by the rate and volume of groundwater flow within the surrounding clay and silt deposits.

Figure 2 shows the locations of permitted water wells within one mile of the Site, based on records obtained from the Colorado State Engineer's Office in 2006. City of Aurora residents are served by the Aurora municipal water system, which provides water from surface reservoirs rather than groundwater.

Land and Resource Use

The Site is part of the larger DADS which consists of:

- the Site;
- the remainder of Section 31;
- Section 32, Township 4 South, Range 65 West (except that portion owned by Waste Management, Inc.); and
- Section 5, Township 5 South, Range 65 West.

Denver is the sole property owner of all the DADS parcels. DADS operates under a Certificate of Designation for a Solid Waste Disposal Site for sanitary landfill operations issued by Arapahoe County on September 16, 1968. Current landfilling operations are limited to DADS solid waste disposal activities in Sections 31 and 32, and asbestos disposal activities in Sections 31 and 6. Section 32 contains the closed Denver Arapahoe Chemical Waste Processing Facility, owned by Waste Management, Inc. Solid waste disposal operations are expected to continue at DADS under the Certificate of Designation for several decades into the future.

On-Site Land and Groundwater Use

As stated above, Denver owns the on-Site property. On-Site land use is restricted by institutional controls which include restrictive covenants that run with the land, zoning, and an executive

order of the Mayor of Denver. Within the Site boundaries, the restrictive covenants restrict land use to landfilling, monitoring or remediation activities, or other uses not inconsistent with the selected remediation. EPA and the Colorado Department of Public Health and Environment (CDPHE) have the authority to enforce these on-Site land use and groundwater use restrictions.

Water rights within the Lower Dawson, Denver, Upper and Lower Arapahoe, and Laramie-Fox Hills aquifers beneath the Site are also owned by Denver. Denver included language in the water decrees relative to these water rights stating that (1) nothing in the Water Court's ruling or decree shall be construed to override or modify any of the restrictions imposed on the use of groundwater underlying the Site, and (2) in constructing and maintaining wells which penetrate more than one aquifer, Denver shall encase the wells with an impervious lining in accordance with applicable rules and regulations governing the construction of water wells to prevent potential cross-contamination between aquifers or withdrawal of groundwater from other aquifers. The restrictive covenants described above also restrict the drilling of any new wells on-Site except for monitoring or remediation purposes necessary for implementation of the remedy.

Off-Site Land and Groundwater Use

Denver owns off-Site properties consisting of the remainder of Section 31 that is not part of the Site, Section 32, Township 4 South, Range 65 West (except that portion owned by Waste Management, Inc.), and Section 5, Township 5 South, Range 65 West. Denver also owns the water rights within the Lower Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers beneath the remainder of Section 31 that is not part of the Site and the northern three-quarters of Section 32 (except that portion owned by Waste Management, Inc.). Denver included language in the water decrees relative to these water rights stating that (1) nothing in the Water Court's ruling or decree shall be construed to override or modify any of the restrictions imposed on the use of groundwater underlying the Site, and (2) in constructing and maintaining wells which penetrate more than one aquifer, Denver shall encase the wells with an impervious lining in accordance with applicable rules and regulations governing the construction of water wells to prevent potential cross-contamination between aquifers or withdrawal of groundwater from other aquifers.

Denver has placed restrictions on land and groundwater use within that portion of Section 31 that is not part of the Site. The restrictions are in the form of restrictive covenants that run with the land. These restrictive covenants restrict land use to landfilling, monitoring or remediation activities, industrial, commercial, utilities, agricultural, open space, or recreation uses. Groundwater use restrictions preclude drilling new wells for use of groundwater from the Dawson or Denver aquifers except for monitoring or remediation purposes necessary for closure of the landfill located on the property or for implementation of the selected remedy for the Site.

Waste Management, Inc. owns the parcel of property within Section 32 that contains the closed Denver Arapahoe Chemical Waste Processing Facility as well as the water rights within the Lower Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers beneath the parcel.

The Lowry Environmental Protection/Cleanup Trust (Trust) owns off-Site properties adjacent to the east, south and west boundaries of the Site. The Trust, created in 1993, is comprised of

monies collected by responsible parties Denver, WMC, and Chemical Waste Management, Inc. (CWM) in settlement of third-party contribution actions against other responsible parties at the Site. Denver, WMC, and CWM are co-trustees of the Trust. The specific properties owned by the Trust are shown on Figure 3 and consist of:

- the eastern one-half of Section 36, Township 4 South, Range 66 West;
- the eastern one-half of Section 1, Township 5 South, Range 66 West;
- the northern one-half of Section 7, Township 5 South, Range 65 West (except that portion owned by Public Service Company of Colorado); and
- the eastern one-quarter of Section 6, Township 5 South, Range 65 West.

The Trust acquired these properties to implement restrictions on land and groundwater use around the Site. The restrictions are in the form of restrictive covenants that run with the land. These restrictive covenants restrict land use on Trust-owned property to landfilling, monitoring or remediation activities, industrial, commercial, agricultural, transportation, utilities, open space, or recreation uses. These restrictive covenants restrict groundwater use by precluding the drilling of new wells for the use of groundwater from the Dawson or Denver aquifers underneath these properties except for monitoring or remediation purposes necessary for closure of the landfill in Section 31 or for implementation of the selected remedy for the Site.

The Trust acquired the water rights in the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers beneath the eastern one-half of Section 36, Township 4 South, Range 66 West, the eastern one-half of Section 1, Township 5 South, Range 66 West, and the northern half of Section 7, Township 5 South, Range 65 West (except that portion owned by Public Service Company of Colorado). The Trust also acquired the water rights in the Dawson and Denver aquifers beneath the northeastern one-quarter of Section 12, Township 5 South, Range 66 West. Environmental covenants that run with water rights preclude the construction of any wells to withdraw any groundwater from the Dawson and Denver aquifers underlying the northeastern one-quarter of Section 12.

Property immediately west of the Trust-owned east one-half of Section 36 is managed as the Plains Conservation Center Open Space Preserve.

Property immediately west of the Trust-owned east one-half of Section 1 is within the City of Aurora and land use is residential.

Property in Section 12, Township 5 South, Range 66 West is being developed into the mixed use (commercial and residential) Copperleaf Development.

Property in Section 8, Township 5 South, Range 65 West, located southeast of the Site, contains the Arapahoe County Fairgrounds and Arapahoe Park, a horse-racing track.

Property within Section 30, the one-mile section north of Section 31, is currently being developed for commercial, recreational, and residential uses. East Quincy Avenue, immediately south of the Site, has been annexed to Aurora to enable further annexation of lands surrounding Aurora Reservoir, which is located east and south of the Site. It is also expected that the E-470

interchanges at Quincy Avenue and Jewell Avenue will improve access in the area and thereby encourage development. Areas annexed to Aurora are served by the City of Aurora's municipal water supply system.

An Aurora City Ordinance prohibits development or construction of buildings within ¼ mile of the east, south, or west exterior boundaries of Section 6 if the properties are annexed into Aurora. The prohibition does not apply to buildings used for characterizing or remediating the contamination at the Site, nor does it apply to construction of roadways or public utilities. The ordinance also prohibits drilling, development, or use of any wells in the Dawson aquifer within ½ mile of the exterior boundaries of Section 6 except for wells used for monitoring, extracting groundwater for remediation, or re-injecting treated groundwater. Both prohibitions expire upon Aurora's City Council taking action after the five-year review has occurred and EPA determines the remedy is protective at the compliance boundary, provided that (a) the drilling or use of such wells within ½ mile of the boundaries of Section 6 shall only occur with the approval of the City of Aurora and/or (b) development and construction of buildings and structures may be permitted within ¼ mile of Section 6 provided the underlying zoning permits such development.

Figure 4 illustrates property ownership and institutional controls for properties in the immediate vicinity of the Site.

History of Contamination

Beginning in February 1966 and continuing until 1980, Denver operated a "co-disposal" landfill at the Site, accepting liquid and solid municipal refuse and industrial wastes, including sewage sludge. These materials included hazardous substances listed in 40 CFR Section 302.4, such as volatile organic compounds (VOCs) and heavy metals. Approximately 75 unlined waste pits or trenches were excavated to accommodate a mixture of liquids, industrial waste, and municipal waste. In the southern half of Section 6, the pits were filled about three-quarters full with liquid wastes and topped with 25 to 60 feet of municipal waste. In the north-central portion of Section 6, excavated pits were filled with liquid wastes and municipal refuse, and then were covered with 2 to 5 feet of native soil and piles of discarded tires. No measures are known to have been implemented to prevent leachate or liquid waste seepage from the pits. Consequently, over time, the liquid seeped out of the pits and mixed with the surrounding refuse and groundwater.

The types of waste disposed at the Site until 1980 using this practice included acid and alkaline sludges; asbestos; caustic liquids and solids; brines, including plating wastes and other water-based sludges; laboratory wastes; organics, including petroleum-based oils, grease, chlorinated solvents, and sludges; waste solvents, chemicals, and oil; biomedical wastes; low-level radioactive medical wastes; pesticides and garden chemicals; water-soluble oils; sewage sludge; paint and varnish waste, sludge and thinners; photographic chemicals; industrial solvents; construction waste; municipal refuse; household hazardous waste; appliances; tires; livestock carcasses; and metallic wastes.

EPA estimates that over the period of co-disposal operations at the Site, approximately 138 million gallons of liquid wastes were disposed. Nearly all of these wastes were disposed in the southern half of the Site within the 200-acre main landfill. A much smaller volume of waste was disposed north of the main landfill in ponds and waste pits.

From 1969 until 1986, municipal sewage sludge was applied to approximately 160 acres along the northern and eastern boundaries of the Site. The sludge was applied to the surface of the land and then incorporated into the native soils. After 1980, leachate that had been collected in on-Site surface impoundments was injected in the same 160-acre area. Both the municipal sewage sludge and the leachate contained hazardous substances listed in 40 CFR Section 302.4.

During the 1970s, approximately 8 million tires were stockpiled at the Site. Beneath the stockpiles of tires were three separate waste pits, each approximately 20-30 feet deep and north of the main landfill. From 1989 through 1992, Denver and its contractors removed, shredded and consolidated the tires and placed the tire shreds in a monofill on the east side of the Site for potential future re-use as fuel. The area underlying the tires and encompassing the waste pits became known as the Former Tire Pile Area (FTPA).

In 1980, Denver stopped co-disposal practices. From 1980-1990, WMC operated the Site under a contract with Denver. At that time, waste disposal at the Site was restricted to municipal solid waste and asbestos.

The waste disposed at the Site contaminated the soils and eventually contaminated shallow groundwater. Additionally, gases from the buried wastes contaminated the air spaces in subsurface soil.

Initial Response

The public issued complaints to regulatory authorities from 1971 to 1979 regarding odors, fires, and disposal practices which caused concern about the potential for spreading contamination to the surrounding area and groundwater. EPA, CDPHE (at that time, known as the Colorado Department of Health), and Denver worked jointly to identify contamination problems and modify operational practices.

North Boundary Barrier Wall

In 1984, Denver entered into an Administrative Order on Consent with EPA for the design, construction and operation of a groundwater control and treatment system at the northern boundary of the Site, known as the North Boundary Barrier Wall (NBBW). The system includes the following four main components: (1) a 1,000-foot-long and 30-foot-deep subsurface clay wall constructed at the intersection of the unnamed creek alluvial channel and the northern Site boundary to provide a barrier to groundwater flow to the north; (2) a gravel trench located immediately upgradient of the clay wall and associated pump and underground piping to collect and transport shallow groundwater; (3) an on-Site water treatment plant (WTP) for treatment of groundwater from the trench; and (4) a re-injection trench located in the alluvium north and downgradient of the clay wall. The WTP effluent was pumped into the re-injection trench.

Surface Water Removal Action (SWRA)

In May 1988, EPA issued an Engineering Evaluation/Cost Analysis which described and evaluated alternatives for enhancing the existing measures that prevented off-Site migration of contaminants by managing contaminated surface water that had been intermittently flowing off-Site. Between 1988 and 1990, Denver developed preliminary designs of the alternatives. In November 1990, EPA selected the SWRA from among the alternatives. The SWRA consisted of

an upgrade to the WTP and construction of a collection system within unnamed creek designed to segregate contaminated groundwater from uncontaminated surface water using a blanket drain concept. On August 15, 1991, Denver entered into an Administrative Order on Consent with EPA to construct and operate the SWRA.

The SWRA prevents contaminated groundwater from coming into contact with surface water within the unnamed creek streambed. Permeable material has been placed beneath the streambed and covered with a clay layer. The permeable material provides a pathway for groundwater to flow to the NBBW without contacting surface water. The top of the clay cover is now the streambed, allowing uncontaminated surface water to run off the surrounding Site areas and migrate to the north without coming into contact with contaminated groundwater flowing underneath the cover.

Drum Removal Action

EPA initiated a drum removal action at the on-Site drum storage area on March 1, 1989. The removal action consisted of construction of two temporary lined storage pads to contain damaged drums. In 1990, EPA conducted Phase II of the Drum Removal Action in cooperation with Denver. Phase II consisted of re-packaging highly contaminated liquids and solids from the old drums, decontaminating and disposing empty drums, and closing the temporary drum storage pad.

National Priorities List

EPA placed the Site on the National Priorities List on September 21, 1984 (49 Federal Register 37083). EPA conceptually divided the Site into six operable units (OUs) for response, and grouped the OUs according to the media which they address:

- OUs 1 and 6 address shallow groundwater, subsurface liquids, and deep groundwater;
- OUs 2 and 3 address landfill solids and gas; and
- OUs 4 and 5 address soils, surface water and sediments.

From 1984 until 1993, EPA conducted and the responsible parties performed remedial investigations/feasibility studies within the OUs to determine the nature and extent of contamination, assess potential risks to human and ecological receptors, and develop and evaluate remedial alternatives.

In 1990, all municipal solid waste landfill operations stopped at the Site to allow environmental investigations to proceed without interference. WMC constructed a soil cover over the 200-acre main landfill in the southern part of the Site. The landfill cover is approximately 4 feet thick and up to 12 feet thick in some places.

On March 10, 1994, EPA and CDPHE signed the Record of Decision (ROD) for the Site.

Basis for Taking Action

EPA states in the ROD that the primary threats to human health and the environment posed by the Site in the absence of remedial action consist of exposure to and contamination by landfill gas, waste-pit liquids, drums, groundwater, and contaminated seepage in the former unnamed creek drainage. Other threats arise from contaminated landfill solids, soils, sediments, and groundwater.

The contaminants of concern at the Site include VOCs, semi-volatile organic compounds (SVOCs), metals, pesticides, polychlorinated biphenyls, and methane and other gases.

Contaminants of concern in landfill gas (as determined by concentrations at the landfill gas flare inlet relative to allowable concentrations in ambient air) include:

1,1-dichloroethene	tetrachloroethene
1,2-dichloroethane	toluene

Contaminants of concern in subsurface gas (as determined by chemicals for which a performance standard was established in the ROD) are:

1,1,1 –trichloroethane	chloroform
1,1-dichloroethane	ethylbenzene
1,1-dichloroethene	methane
1,2-dichloroethane	methylene chloride
2-butanone	toluene
benzene	xylenes
carbon disulfide	vinyl chloride

Contaminants of concern in groundwater (as determined by frequency of detection above performance standards on-Site, toxicity, and mobility) are:

arsenic	bromodichloromethane
cadmium	bromoform
iron	carbon tetrachloride
nitrate	chlorobenzene
nitrite	chloroform
1,1,1-trichloroethane	cis- 1,2-dichloroethene
1,1,2,2-tetrachloroethane	dibromochloromethane
1,1,2-trichloroethane	ethylbenzene
1,1-dichloroethane	methylene chloride
1,1-dichloroethene	naphthalene
1,2-dichloroethane	tetrachloroethene
1,2-dichloropropane	toluene
1,4-dioxane	trans-1,2-dichlororethene
acetone	trichloroethene
benzene	vinyl chloride

Contaminants of concern in surface soil and surface water as determined in the ROD and the *"Final Interim Compliance Monitoring Plan" (February 1996)* are:

2,3,7,8 – TCDD	barium	cyanide	vanadium
chloroform	beryllium	lead	zinc
PCB-1260	cadmium	manganese	
toluene	chromium	mercury	
aluminum	cobalt	nickel	
arsenic	copper	silver	

IV. Remedial Actions

In the March 10, 1994 ROD, EPA selected and CDPHE concurred on a Site-wide remedy that consists of remedial actions for each of the six OUs to address groundwater, surface water, landfill gas, landfill solids, soils and sediments. The selected Site-wide remedy utilizes containment, collection, treatment, and monitoring to address the contamination at the Site.

The remedy requires a combination of engineered components to be constructed and operated to prevent off-Site migration of contamination above performance standards (performance standards can be found in Appendix A). If performance standards are not met during implementation or operation, the remedy requires appropriate contingency measures to be implemented. In the ROD, EPA established points of compliance for the landfill gas remedy and the groundwater remedy at locations inside the Site boundaries. The selected Site-wide remedy also requires the implementation of on-Site and off-Site institutional controls.

Several minor modifications of the ROD, Explanations of Significant Differences (ESDs), and a ROD Amendment followed the signing of the ROD. These documents were as follows:

- Minor Modification of the ROD, August 7, 1995. Clarifies institutional controls and allows on-going permitted waste disposal activities to continue.
- Explanation of Significant Differences, August 1995. Clarifies the basis for establishing performance standards, revises the Point of Action boundary for groundwater, clarifies the point of compliance for air emissions at the WTP, and clarifies the performance standards and points of compliance for the landfill gas component of the selected remedy.
- Minor Modification of the ROD, March 21, 1996. Clarifies the requirements for wetland mitigation.
- Second Explanation of Significant Differences, October 1997. Revises the selected remedy for the FTPA waste pits to allow on-Site treatment and disposal of excavated materials, revises the selected remedy for groundwater to allow off-Site discharge of pre-treated groundwater from the WTP to a Publicly Owned Treatment Works (POTW) under an enforceable discharge permit.
- Minor Modification of the ROD, May 8, 2001. Revises the air quality performance standard for 1,1-dichloroethene (1,1-DCE).
- Minor Modification of the ROD, September 30, 2002. Revises the performance standards for groundwater, surface water, landfill gas, and air.
- Amendment to the ROD, August 12, 2005. Modifies the selected remedy for the FTPA waste pits from excavation and on-Site treatment and disposal to recovery of non-aqueous phase liquids, off-Site disposal of recovered liquids, and capping.
- Minor Modification of the ROD, July 14, 2006. Identifies a new Applicable or Relevant and Appropriate Requirement for the FTPA remedy and designates a Corrective Action Management Unit at the Site.

On November 16, 2005, United States District Judge Nottingham entered a consent decree between the United States and Denver, WMC, CWM, and five other settling defendants (Adolph Coors Company, Conoco Phillips Company, Metro Wastewater Reclamation District (Metro),

Roche Colorado Corporation, and S.W. Shattuck Co., Inc.) relative to the Site. Under the terms of the settlement, the settling defendants agreed to perform and finance the remainder of known work at the Site. Work Settling Defendants (WSDs) Denver, WMC, and CWM are performing and financing this work on behalf of themselves and the other settling defendants.

The Site-wide remedy components, illustrated on Figure 5, are described in the following sections. EPA certified construction completion at the Site on September 28, 2006.

OUs 1 & 6: Shallow Groundwater and Subsurface Liquids and Deep Groundwater

The RAOs for the groundwater remedy are:

- Prevention of exposure to humans and the environment (through ingestion, inhalation, or dermal absorption) from liquids (either groundwater or waste-pit liquids) containing contaminants in excess of the performance standards;
- Prevention of migration of contaminants beyond the compliance boundary in excess of the performance standards;
- Prevention of horizontal migration of dissolved groundwater contaminants off-Site and to surface waters;
- Prevention of vertical migration of dissolved groundwater contaminants beyond the lignite layer;
- Prevention of movement of nonaqueous phase liquids (NAPLs) beyond the compliance boundary and minimization of movement of NAPLs; and
- Minimization of infiltration and leachate production in the waste-pit source area.

Components of the selected remedy for OUs 1 and 6 and current operations of these components are described below:

- Shallow Groundwater Containment, Collection, and Diversion System. An 8,800-foot-long subsurface bentonite clay/soil wall, described in the ROD as the "East/South/West Barrier Wall", encloses the west, south and east sides of the main landfill in the southern part of the Site. The wall is below the ground surface, approximately 40 to 75 feet deep. The wall minimizes the flow of clean groundwater onto the Site from the south and west, and the flow of groundwater away from the Site to the east, reducing the volume of contaminated groundwater produced by contact with the wastes buried in the landfill. During remedial design, EPA determined that the upgradient extraction wells along the southern perimeter of the Site, described in Section 11.2.1 of the ROD, would not be installed.
- North Toe Extraction System (NTES). A groundwater extraction system at the north toe of the main landfill, described in the ROD as the NTES, consists of a 350-foot long collection trench that intercepts groundwater flow within the more permeable alluvium and weathered Dawson formations beneath the unnamed creek drainage at the toe of the landfill. The groundwater collected in the trench is transported via underground pipes to the on-Site WTP.

Full-time operation of the NTES began in 2004. The significant lapse in time between construction and full time operation of the NTES (1998-2004) was due to the inability of the WTP to treat water from the NTES that was contaminated with high concentrations of 1,4 dioxane. During this time, treatability studies were performed by Denver, WMC, and CWM to evaluate alternative treatment technologies. The results of bench scale studies performed between October 2001 and March 2002 indicated that biological treatment was a viable candidate technology for removal of 1,4 dioxane from NTES groundwater. In August 2002 a pilot study of biological treatment was initiated. In 2003, EPA approved the design for an upgrade to the WTP. The WTP was upgraded in 2004 to include a biological treatment system (BTS) to treat the NTES waters.

- NBBW. The selected remedy for OUs 1 and 6 includes continued operation of the existing NBBW including evaluating its effectiveness and upgrading, as necessary. Currently, groundwater is continuously extracted from immediately upgradient of the clay wall. Potable water is continuously injected continuously downgradient of the clay wall in order to augment water rights for extracted groundwater. The injected water acts to recharge the alluvium and weathered Dawson and to augment hydraulic control north of the barrier wall.

  Currently, injected water is supplied from a potable source off-Site, but prior to the year 2000 consisted of treated groundwater from the WTP from which VOCs, but not 1,4 dioxane and nitrate, were removed. It is estimated that water with 1,4-dioxane concentrations between 300 ug/L and 2000 ug/L was injected into the alluvium and weathered Dawson downgradient of the NBBW from the time period 1984 until 2000. During this time period, 1,4 dioxane was not known to be a Site contaminant. The 1994 ROD does not identify the chemical as a contaminant of concern. Consequently, the WTP effluent was not tested for the chemical.

- WTP. The selected remedy for OUs 1 and 6 includes design and construction of a new WTP unless it can be demonstrated through pilot-scale testing that the existing WTP can effectively treat the more highly contaminated groundwater to achieve performance standards. The October 1997 Second ESD revised the selected remedy for OUs 1 and 6 to allow off-Site discharge of pre-treated groundwater from the WTP to a POTW under an enforceable discharge permit

  Denver originally built an on-Site WTP in 1984. In accordance with the ROD, the original WTP was replaced with a new on-Site WTP (in 2000) to treat additional influent sources and discharge effluent to an off-Site POTW. As described above, a BTS was added to the new WTP in 2004 to treat waters containing high concentrations of 1,4 dioxane, primarily groundwater from the NTES.

  The current WTP is divided into a main WTP and the BTS. The main WTP processes include water softening, pH adjustment, filtration, Ultraviolet-Oxidation (UV-Ox), and liquid-phase granular activated carbon (GAC) adsorption. Flow equalization and solids handling are also included in this facility. The BTS is housed in a separate building adjacent to the main WTP. A slipstream from the main WTP is pumped to the BTS where it is blended with water from the NTES and biologically treated. Effluent from the

BTS is then returned to the main WTP for additional blending, treatment, and discharge to the POTW.

Water collected from various areas of the Site is treated at the WTP to levels prescribed in an industrial pre-treatment discharge permit. The treated water is discharged into a sanitary sewer line. The discharged water eventually reaches Metro's and the City of Aurora's (Aurora's) off-Site POTWs. Metro and Aurora issued the industrial pretreatment discharge permit for the WTP at the Site. Their off-Site facilities only accept water that complies with the terms of the discharge permit.

The WSDs have made a number of minor modifications and adjustments to the WTP to improve treatment effectiveness and reliability. Some of the notable changes include: reconfiguration of two carbon adsorption units in series, adding a caustic feed loop to the back end of the plant to assure that the pH of plant effluent never drops below the limit specified in the discharge permit; modifying the condensate holding tank to serve as a mixing tank; adding a heated sample chamber to the gas chromatograph; and adding a water chiller to the effluent end of the plant to maintain effluent temperature at or below the permit limit of 20 degrees Celsius (°C).

- SWRA. The selected remedy for OUs 1 and 6 includes continued operation of the SWRA.

- Contingency Measures. The selected remedy for OUs 1 and 6 provides that if, during implementation or operation of the groundwater remedy, contaminant levels exceed performance standards at compliance boundaries, appropriate measures (e.g., pulse pumping or installation of additional extraction wells) shall be taken to prevent and remediate contaminant migration beyond the compliance boundary.

- The MW38 Gradient Control Contingency Measure. The gradient control measure for the MW38 area, located north of the western portion of the East/South/West Barrier Wall, was not specifically described in the ROD as a component of the remedy for OUs 1 and 6. It was implemented as contingency measures in response to groundwater contamination that was detected in the weathered Dawson monitoring well MW38-WD prior to the first five-year review for the Site. The MW38-WD well is completed in a northeast-trending sand channel approximately 100 feet wide that extends from the western Site boundary near the western end of the East/South/West Barrier Wall to the northern Site boundary. The MW38 sand channel is a natural channel which, due to the higher hydraulic conductivity of the channel sand deposits in this feature, results in convergent flow into the channel, thereby restricting offsite flow to the west. When it was discovered that groundwater samples from well MW38-WD contained contamination at levels above performance standards, a characterization program was carried out in the second quarter of 2001 until June of 2002. The results indicated that contamination in the sand channel extends from the western Site boundary (but not beyond) to the northern Site boundary. In response to these findings, two extraction wells were installed (consistent with the contingency measures described in the ROD) to pump groundwater from the MW38 sand channel. Currently, extracted groundwater is pumped via a buried pipeline to the WTP. The existing convergent flow into the channel

has been enhanced by groundwater extraction from the channel which has also resulted in creation of an inward hydraulic gradient along the northern portion of the western Site boundary and at the northern end of the channel.

Table 2 summarizes key remedy implementation dates and documents that describe the operations and maintenance requirements for each component of the selected remedy for OUs 1 and 6.

Table 2: Key Remedy Implementation Dates and Operations and Maintenance Documents for OUs 1 and 6

Remedial Action Component	Remedial Action Start Date	Final Inspection Date	Status	Operations and Maintenance Requirements
Shallow Groundwater Containment, Collection, and Diversion System	March 1997	Final Inspection: June 10, 1998	EPA Certified RA Complete on September 30, 1998 (slurry wall) and January 25, 1999 (monitoring system)	Groundwater Monitoring Plan, February 18, 2005 (as amended)
NTES	April 1997	Final Inspection: August 3, 1998	EPA Certified RA Complete on September 10, 1998	Draft Operations and Maintenance Manual for Groundwater Extraction, December 28, 2005; and Groundwater Monitoring Plan, February 18, 2005 (as amended)
NBBW	January 1984	Final Inspection: May 1984 (subsurface wall) and July 1984 (injection trench)	EPA Certified RA Complete on March 27, 1998	Draft Operations and Maintenance Manual for Groundwater Extraction, December 28, 2005; and Groundwater Monitoring Plan, February 18, 2005 (as amended)
New WTP	September 1999	Final Inspection: May 13, 2004	EPA Certified RA Complete on August 11, 2005	Final Water Treatment Plant Operations and Maintenance Manual, July 21, 2005
SWRA	August 1992	Final Inspection: January 7, 1993	EPA Certified RA Complete on August 11, 2005	Draft Operations and Maintenance Manual for Covers and Stormwater, November 2005
MW38 Area Gradient Control Contingency Measure	July 2002	Final Inspection: February 22, 2005	EPA Certified RA Complete on August 11, 2005	Draft Operations and Maintenance Manual for Groundwater Extraction, December 28, 2005; and Groundwater Monitoring Plan, February 18, 2005 (as amended)
Performance and Compliance Monitoring	March 2005	Final Inspection: June 1, 2005	EPA Certified Construction Complete on August 12, 2005	Groundwater Monitoring Plan, February 18, 2005 (as amended)

OUs 2 & 3: Landfill Solids and Landfill Gas

The RAOs for the landfill solids remedy are:

- Protection of human health and the environment from direct contact or ingestion of landfill solids or soils intermingled with landfill solids containing contaminants;
- Protection of humans from inhalation of volatilized contaminants from landfill solids or soils intermingled with landfill solids, and inhalation of contaminated airborne particulate matter from soils or landfill solids that exceed performance standards;
- Minimization of the production and migration of leachate, from landfill solids or soils intermingled with landfill solids, to the saturated zone and groundwater;
- Minimization of the migration of soils intermingled with solids, caused by erosion or entrainment by wind or water;
- Prevention of off-Site migration of landfill solids and soils intermingled with solids into other media;
- Protection of human health and the environment from direct contact with or ingestion of leachate that exceeds the Performance Standards for shallow groundwater and subsurface liquids; and
- Prevention of off-Site migration of leachate or infiltration into other media.

The RAOs for the landfill gas remedy are:

- Protection of human health from inhalation of landfill gases in excess of the performance standards;
- Protection of human health and the environment from explosion hazards associated with landfill gases; and
- Prevention of off-Site migration of landfill gas or migration to other media.

Components of the selected remedy for OUs 2 and 3 and current operations of these components are described below:

- Maintain Existing Landfill Cover. The cover minimizes the amount of rainwater that can infiltrate into the landfill, thus reducing the amount of potential leachate generation and impacts to groundwater that could become contaminated by contact with the wastes in the landfill.

  The landfill cover is maintained by the WSDs as necessary. Inspections of the landfill covers are performed annually for items such as nuisance conditions, settlement, cover or ditch erosion, ditch sedimentation, and security. Landfill cover monitoring is reported in Remedial Action/Operations and Maintenance status reports. In 2002, the WSDs re-graded closed topographic depressions in the landfill cover using clean fill as required by the operations and maintenance plan for the landfill cover.

The slope of the existing main landfill cover is currently less than the minimum slope required by CDPHE's Solid Waste Regulations (and less than what would be required if the landfill was closed today), increasing the probability of closed depressions and ponding developing in the future. In order to prevent this potential problem, the landfill cover will be re-graded over the next several (up to ten) years by the WSDs. The landfill re-grading project will consist of removing part of the existing cover to leave a minimum of two feet in place, stockpiling this material, bringing in additional fill to increase the slope, and reconstructing the cover. The additional fill will be provided in the form of construction and demolition debris (and other inert materials). The landfilling operations will be performed in accordance with the CDPHE-approved "*Denver Arapahoe Disposal Site (Section 6) Engineering Design and Operations Plan" (October 2005)* and the "*Draft Operations and Maintenance Manual for Covers and Stormwater" (November, 2005).*

- Construct North Face Cover. The selected remedy for OUs 2 and 3 requires the placement of an additional 2-foot cover on the 29-acre north face of the landfill mass.

- Landfill Gas Collection and Treatment System. The selected remedy for OUs 2 and 3 requires installation of a landfill gas collection system and monitoring wells within the former landfill. Treatment of landfill gas using an enclosed flare.

  Operations and maintenance activities for the landfill gas remedy consist of operating the enclosed flare, monitoring the composition and flow rates of gas from extraction wells, and balancing and adjusting the system. The blower/flare station is monitored daily. Inlet monitoring is performed for methane, carbon dioxide, oxygen, and balance gases from both inlet headers (Lowry and DADS), and from the combined header immediately upstream of the flare at least weekly. The flare operates at a set-point temperature of 1,500 degrees Fahrenheit (°F). During continuous operations of the flare, the blowers deliver an average landfill gas flow of approximately 900 standard cubic feet of gas per minute (scfm). This is measured at the blower/flare station at the combined inlet flow meter. The Lowry well field contributes approximately 25% of this flow and 75% is contributed by the DADS well field. The methane content of the Lowry inlet ranges from approximately 41 to 53 percent.

  Between March 27, 2006 and April 1, 2006, ten additional gas extraction wells were installed within the main landfill mass at the Site. These ten new extraction wells will be brought online during the implementation of the landfill re-grading project as an enhancement of the existing system. The ten new wells are deeper than the existing landfill gas extraction wells. The objective is to extract a greater mass of VOCs by extracting landfill gas closer to the waste pits within the landfill mass.

  FTPA. The selected remedy for OUs 2 and 3 required excavation of surface and subsurface drums, and contaminated soils within the three FTPA waste pits, off-Site treatment and disposal of excavated materials, and reclamation of the FTPA. EPA issued an ESD in 1997 modifying the selected remedy to allow on-Site treatment and disposal of the solids excavated from the waste pits. In the ESD, EPA selected drying/controlled aeration as the method of on-Site treatment.

In August 2005, EPA, with concurrence of CDPHE, issued an Amendment to the ROD. In the ROD amendment EPA changed the remedy for the north and south waste pits to:

- Extraction of non-aqueous phase liquids (NAPL) from within and immediately outside the north waste pit and south waste pit using either top-loading or bottom-loading pumps installed in existing wells;
- On-site temporary storage of extracted liquids;
- Transportation and off-Site treatment and disposal of extracted liquids;
- Maintenance of the existing cap on each waste pit; and
- Groundwater monitoring downgradient of the FTPA waste pits.

On May 22, 2006, EPA approved the remedial action work plan for the modified FTPA remedy entitled "*Final Remedial Action Plan, Former Tire Pile Area Waste Pit Remedy" (May, 2006).* EPA approved Amendment No. 1 on June 16, 2006. Both documents were prepared by the WSDs. The remedial action work plan and addendum describe the remaining activities and schedule for completing the recovery of NAPL from the two remaining waste pits, off-Site transport and disposal of the recovered liquids, and relocation of the treated materials (excavated from the middle and north waste pits in 1999) from the on-Site treatment cell to a new on-Site Corrective Action Management Unit within the foot print of the main landfill mass.

Table 3 summarizes key remedy implementation dates and documents that describe the operations and maintenance requirements for each component of the selected remedy for landfill solids and landfill gas.

Table 3: Key Remedy Implementation Dates and Operations and Maintenance Documents for OUs 2 and 3

Remedial Action Component	Remedial Action Start Date	Final Inspection Date	Status	Operations and Maintenance Requirements
Maintain existing landfill cover	On-going	On-going	On-going	Final Operations and Maintenance Plan, Landfill Solids, Soil, and Sediments, June 18, 1999 Draft Operations and Maintenance Manual for Covers and Stormwater, November 2005
North Face Cover	April 1999	Final Inspection: September 10, 1999	EPA Certified RA Complete on January 7, 2000	Final Operations and Maintenance Plan, Landfill Solids, Soil, and Sediments, June 18, 1999 Draft Operations and Maintenance Manual for Covers and Stormwater, November 2005
Landfill Gas (LFG) Extraction and Treatment System	June 1996	Final Inspection: December 16, 1996	EPA Certified RA Complete on February 11, 1998	Final Operations and Maintenance Manual, Landfill Gas Remedy, January 30, 1998 (as amended)
FTPA I	Middle Waste Pit excavation: August 1998 NAPL recovery from North & South Waste Pits and Treatment Cell Closure: June 2006	Pre-Final Inspection (Middle Pit) : May 26, 1999 Final Inspection (Middle Pit): June 11, 1999 Pre-Final Inspection (South Pit, North Pit, Treatment Cell): September 2006	EPA Certified that treatment cell Performance Standards have been met on August 12, 2005 EPA approved the Interim Close-Out Report for the Middle Waste Pit Remediation and Construction of the Treatment Cell on August 3, 2005	Final Operations and Maintenance Plan, Landfill Solids, Soil, and Sediments, June 18, 1999 Draft Operations and Maintenance Manual for Covers and Stormwater, November 2005
Performance and Compliance Monitoring	June 1996	Final Inspection: February 9, 1997	EPA Certified Construction Complete on August 12, 2005	Final Compliance Monitoring Plan, Landfill Gas Remedy, November 14, 1997

OUs 4 & 5: Soils and Surface Water and Sediment

The RAOs for soils, surface water, and sediment are:

- Protection of human health and the environment from direct contact or ingestion of soils, surface water, and sediments containing contaminants that exceed the performance standards;
- Protection of human health from inhalation of volatilized contaminants from the soils, surface water, or sediments; and inhalation of contaminated airborne particulate matter from soils or sediments that exceeds performance standards;
- Minimization of the production and migration of contaminated surface water to the saturated zone and groundwater;
- Minimization of the migration of soils and sediments by erosion or entrainment by wind or water; and
- Minimization of migration of contaminated surface water off-Site and into other media.

The selected remedy for OUs 4 and 5 is No Further Action. The remedy and current operations are described below:

- Continued maintenance of the existing cover on the landfill mass;
- Continued maintenance of other cover areas, including the unnamed creek drainage, vegetated areas, and the FTPA, including visual monitoring for soil and sediment erosion;
- Periodic monitoring of surface water runoff;
- Continued operation and maintenance of the SWRA and the NBBW; and
- Mitigation of 0.87 acres of wetlands loss through construction of 0.87 acres of new wetlands. EPA certified to the WSDs by letter dated August 12, 2005 that all aspects of the wetlands mitigation work have been fully performed. The wetlands were inspected as a component of this five-year review and were found to be in excellent condition.

Table 4 summarizes key remedy implementation dates and documents that describe the operations and maintenance requirements for each component of the selected remedy for OUs 4 and 5.

Table 4: Key Remedy Implementation Dates and Operations and Maintenance Documents for OUs 4 and 5

Remedial Action Component	Remedial Action Start Date	Final Inspection Date	Status	Operations and Maintenance Requirements
SWRA	August 1992	Final Inspection: January 7, 1993	EPA Certified RA Complete on August 11, 2005	Draft Operations and Maintenance Manual for Groundwater Extraction, December 28, 2005 Final Operations and Maintenance Plan, Landfill Solids, Soil, and Sediments, June 18, 1999 Draft Operations and Maintenance Manual for Covers and Stormwater, November 2005
Wetlands Mitigation	August 1996	Final Inspection: May 21, 1999	EPA Certified RA Complete on December 23, 1999 EPA Certified Work Complete on August 12, 2005	Not applicable
Performance and Compliance Monitoring	February 1996	Surface water: February 1996	EPA Certified Construction Complete on August 12, 2005	Final Interim Compliance Monitoring Plan, February 16, 1996

Operations and Maintenance Costs

Operations and maintenance for the entire Site-wide remedy includes operations of all containment components, treatment systems, and groundwater extraction systems, as well as inspections, performance and compliance monitoring, and reporting. Over the last five years, annual operations and maintenance costs have averaged approximately $3.8 million. The estimated cost for annual operations and maintenance in the ROD was $3.2 million.

V. Progress Since the Last Five-Year Review

EPA issued the first five-year review report in September 2001 and issued an addendum to the first five-year review report in September 2002. The purpose of the addendum was to review the issues of concern that were identified in the first five-year review report as requiring further data to determine the protectiveness of the individual components of remedy. The findings of the

addendum, as well as events occurring after the addendum, are summarized in the following tables, sorted by remedy component.

Table 5: North Boundary Barrier Wall

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
NBBW may not be completely effective in containing all target ground water	Prepare Work Plan for investigations needed to define capture at NBBW and to determine any needed remedial measures.	Respondents	12/31/01	Respondents submitted a Work Plan to EPA. EPA approved the plan on 3/11/02.	2/17/02
	Perform and document investigations defined by Work Plan.	Respondents	6/30/02	Respondents submitted *"North Boundary Barrier Wall Effectiveness Evaluation"* to EPA. Work was used in development of Site-wide groundwater monitoring plan.	7/3/03
	Perform and document necessary response actions.	Respondents	Not applicable	Capture zone downgradient of NBBW was defined and determined to be effective in containing target groundwater. No response action required.	
There is not an ongoing groundwater monitoring system to demonstrate ongoing containment at the NBBW	Prepare Work Plan for investigations needed to install complete groundwater monitoring system at the NBBW that can verify ongoing containment.	Respondents	12/31/01	Respondents submitted the following plans to EPA : • Work Plan • Groundwater Monitoring Plan (GWMP) • Work Plan for Add'l Geologic Characterization • Lineament Work Plan • Addendum #1 to GWMP • Addendum #2 to GWMP	 • 2/17/02 • 2/2005 • 2/2005 • 2/2005 • 8/2005 • 2006

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
	Perform and document investigations defined by Work Plan.	Respondents	6/30/02	All work plans have been implemented and a compliance monitoring network has been established.	8/2005
	Perform and document necessary response actions.	WSDs	On-going	Specific responses will be implemented in accordance with the GWMP as part of ongoing operations and maintenance.	

Table 6: North Toe Extraction System

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
North Toe Extraction System not operating	Complete WTP upgrade, then operate NTES as required by ROD.	Respondents	Coordinate with WTP upgrade	Upgrades to the WTP completed in 2004. NTES is operating and extracted groundwater is being sent to WTP.	2004
Overflowing Water from NTES *Drum Staging* Area	Implement and document recently submitted plan to *manage and treat such* water as needed.	Respondents	12/31/01	Overflowing water was removed and an *operation plan was in* place to inspect the drum staging after precipitation, and remove and manage water as necessary.	

Table 7: East/South/West Barrier Wall

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
MW39-WD-VOC exceedances (up to approximately 4 times performance standards)	Prepare Work Plan to complete investigation of conditions at MW39-WD to identify nature and extent of contamination, and to identify required response activities.	Respondents	12/31/01	Respondents submitted a Work Plan to EPA. EPA approved the plan on 1/18/02.	12/31/01
	Perform and document investigations defined by Work Plan.	Respondents	3/31/02	"*Draft Investigation of the Nature and Extent of PCE in MW-39 Area*" submitted by Respondents. No response action recommended other than monitoring.	4/26/02
	Perform and document necessary response actions.	Respondents	Not applicable	No response action necessary. Monitoring is performed per the GWMP as operations and maintenance.	
MW43-WD-Inorganic exceedances (up to approximately 10 times performance standards)	Prepare Work Plan to define final sitewide inorganic background level, to determine that conditions at MW43-WD are Site-related, and to identify required response activities, if any.	Respondents	12/31/01	Respondents submitted a Work Plan to EPA.	6/26/02
	Perform and document investigations defined by Work Plan.	Respondents/ WSDs	3/31/02	Monitoring is performed per the GWMP as operations and maintenance.	Ongoing
	Perform and document necessary response actions.	Respondents	Not applicable	No response action necessary.	
MW51-WD-VOC exceedances (up to approximately 3 times performance standards)	Prepare Work Plan for continued investigation of conditions at MW51-WD to identify nature and extent of contamination, and to identify required response activities.	Respondents	12/31/01	Respondents submitted a Work Plan to EPA. EPA approved the plan on 1/18/02.	12/31/01
	Perform and document investigations defined by Work Plan	Respondents	3/30/02	"Draft Investigation of the Nature and Extent of VOCs in the MW51-WD Area" submitted by WSDs.	4/29/02

	Perform and document necessary response actions.	WSDs	TBD	Vapor and groundwater extraction and monitoring are ongoing.	Ongoing
PM-4 Area-VOC exceedances at interior well (up to approximately 3 times performance standards), lack of inward gradient, and saturated sand layer below the East/South/West Barrier Wall	Continue implementing Performance and Compliance Monitoring Plan (PCMP).	Respondents	Per schedule in the PCMP	Site-wide GWMP (as amended) developed in 2005 and supersedes the PCMP.	2/2005
	Prepare Work Plan for investigation of sand layer beneath East/South/ West Barrier Wall to determine if it is a pathway for offsite migration of contamination.	Respondents	9/30/01	Respondents submitted a Work Plan to EPA. EPA approved the plan on 1/18/02.	12/31/01
	Perform and document investigations defined by Work Plan.	Respondents	12/31/01	Respondents *submitted "Draft Report on the Investigation of VOCs in the PM-4 Area"*.	4/10/02
	Perform and document necessary response actions.	Respondents/ WSDs	TBD	Groundwater extraction and monitoring are ongoing and documented in operations and maintenance status reports. In addition, well MW42-UD installed.	Ongoing MW42-UD installed in 2002
PM-15 Area-VOC exceedances beyond the point of compliance (up to approximately 28 times performance standards) and lack of inward gradient	Prepare Work Plan for complete investigations to identify nature and extent of contaminations, and to identify required response activities.	Respondents	12/31/01	Respondents submitted a Work Plan to EPA. EPA approved the plan on 3/6/02.	2/4/02
	Perform and document investigations defined by Work Plan.	Respondents	3/30/02	*"Draft Investigation of the Nature and Extent of VOCs in the PM-15 Area"* was submitted by Respondents.	6/21/02
	Perform and document necessary response actions.	WSDs	TBD	Vapor and groundwater extraction, and monitoring are ongoing.	Ongoing

Table 8: Groundwater Monitoring Wells and Compliance

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
Lateral spacing between individual monitoring wells is too large in some areas to detect possible exceedances beyond the point of compliance	Prepare Work Plan to identify required spacing.	Respondents	12/31/01	Respondents developed and EPA approved GWMP and Addendum #1.	2005
	Perform and document investigations defined by Work Plan.	Respondents	3/31/02	Respondents implemented Work Plan for Add'l Geologic Characterization and Lineament Work Plan. Compliance monitoring network was certified complete by EPA in 2005.	2005 and 2006
	Perform and document necessary response actions.	WSDs	TBD	Specific responses will be implemented in accordance with GWMP.	Ongoing
Lignite layer has too few monitoring wells to verify containment	Prepare Work Plan to identify approach to define the required number and location of wells.	Respondents	12/31/01	Respondents developed GWMP and Addendum #1. Compliance monitoring network for lignite layer was certified complete by EPA in 2005.	2005
	Perform and document investigations defined by Work Plan.	Respondents	3/31/02	Compliance monitoring network for lignite layer was certified complete by EPA in 2005.	2005
	Perform and document necessary response actions	WSDs	TBD	Specific responses will be implemented in accordance with GWMP.	Ongoing

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
Unlocked monitoring well caps	1. Lock all unlocked wells except during sampling, sounding, maintenance, and similar activities, and 2. Implement system to keep wells locked in future.	Respondents	10/31/01	Respondents corrected the problems and instituted an inspection program.	2002
Performance standards exceedances at MW38-WD Area	Prepare Work Plan for remainder of ongoing investigations of conditions at MW38-WD to identify nature and extent of contamination, and to identify required response activities.	Respondents	12/31/01	Additional monitoring wells installed for vertical and horizontal groundwater sampling to characterize nature and extent of contamination and to conduct a pilot groundwater extraction test. Investigation report submitted to EPA in June 2002.	6/2002
	Perform and document investigations defined by Work Plan.	Respondents	6/30/02	WSDs submitted Pilot Test Report and Construction Close-out report to EPA 4/2005.	4/2005
	Perform and document necessary response actions.	Respondents	TBD	MW38 gradient control contingency measure was implemented by the WSDs and certified complete by EPA in 2005. Extracted groundwater is treated in the WTP.	2005

Table 9: Water Treatment Plant

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
Water Treatment Plant is not yet able to treat 1,4-dioxane in water from NTES	Prepare Work Plan to identify required plant modifications.	Respondents	12/31/01	Respondents submitted and EPA approved the *"Final Technical Memorandum Design of the Water Treatment Plant Upgrade and Operation of the NTES, Lowry Landfill Superfund Site Remedial Action".*	12/ 2003
	Perform and document investigations defined by Work Plan.	Respondents	4/15/02	See above	12/2003
	Implement and document conclusion of investigations	Respondents	9/30/02	Respondents constructed an upgrade to the WTP – added a bio-treatment system to treat 1,4 dioxane. EPA certified completion of remedial action for WTP on August 11, 2005.	2004 8/2005
	Operate WTP as required by ROD.	Respondents/ WSDs	9/30/02	Ongoing operations and maintenance in accordance with the Operations and Maintenance Manual for the WTP.	Manual July 12, 2005 Addendum January 23, 2006

Table 10: Maintenance of the Existing Cover on the Landfill Mass

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
Depressions in southwestern portion of cover and near north center of cover	Prepare drainage plan and design to correct landfill cover drainage.	Respondents	10/31/01 12/31/01	Landfill cover was re-graded to provide positive drainage.	2002

Table 11: Former Tire Pile Area Waste Pits

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
FTPA North and South Waste Pits: Work is ongoing but incomplete	Continue work.	WSDs	Per approved work plan and schedule	In August 2005 EPA issued an Amendment to the ROD. Remedial action began on remaining pits in July, 2006. Pre-final inspection conducted on September 28, 2006.	In progress

Table 12: Institutional Controls

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
Some incorrect and illegible signage	Review all signage and update.	Work Settling Defendants	12/31/01	Respondents have corrected the signage.	2002
Respondents have not submitted an approvable Institutional Controls Plan	Submit an approvable plan to EPA.	Respondents	1/15/02	EPA approved the Institutional Controls Plan, on September 26, 2002. The plan was supplemented on September 25, 2002.	9/2002

Table 13: Practical Quantitation Limits

Issues from Previous Review	Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Action Taken and Outcome	Date of Action
Practical Quantitation Limits (PQLs) are not regularly updated	Perform annual update of Practical Quantitation Limits, and submit report documenting work performed.	Respondents	12/31/01 and annually thereafter	Respondents developed a program to update PQLs. PQLs are now updated annually as a requirement of the Statement of Work in the Consent Decree.	12/31/01

VI. Five-Year Review Process

Administrative Components

The Site's second five-year review team was led by the EPA Remedial Project Manager (RPM), Bonnie Lavelle. The USACE provided individuals with expertise in the areas of geology and hydrogeology, chemistry, chemical and environmental engineering, geotechnical engineering and a regulatory specialist. The review was initiated in March 2006. The EPA and USACE team members are presented below:

- EPA RPM: Bonnie Lavelle
- USACE Geotechnical Engineer: Don Moses (Lead)
- USACE Chemist: Janie Carrig
- USACE Environmental Engineer: Ted Streckfuss
- USACE Chemical Engineer: Kimberly Witt
- USACE Geologist: Dave Kachek
- USACE Risk Assessor: Kathy Englert

The following people participated in the second five-year review by attending the Site inspection, providing technical support, or by reviewing components of the draft five-year review report document:

- EPA Region 8 Hydrogeologist: Helen Dawson
- USACE Five-Year Review Coordinator: Greg Mellema
- USACE Center of Expertise Environmental Regulation Specialist: Sandy Frye
- CDPHE Lowry Project Officer: Angus Campbell
- CDPHE Hydrologist: Lee Pivonka
- Tri-County Health Department Field Supervisor: Lynn Wagner
- Supervising Contractor Project Manager: Tim Shangraw

Members of the USACE team conducted a kick-off meeting with EPA at the Site on March 30, 2006. The purpose of the meeting was to meet the EPA RPM, discuss the history of the Site, make initial observations of the remedial components, and identify documents and information that would be needed for the second five-year review. The USACE team, the EPA RPM, and a representative of the Supervising Contractor attended the kick-off meeting. EPA conducted a conference call on April 21, 2006 with the USACE and CDPHE to discuss the schedule for and technical approach to the second five-year review for the Site. The Site inspection took place on May 31 and June 1, 2006. Details of the Site inspection are discussed below. Following the Site inspection, EPA conducted a second conference call on June 8, 2006 during which the representatives of the USACE briefed representatives of EPA, CDPHE, the Tri-County Health Department, the WSDs, and the Supervising Contractor on specific observations the USACE team made during the Site inspection. EPA conducted a third conference call with representatives of the USACE team on June 20, 2006 to discuss the specific details of the groundwater remedy.

EPA and the USACE followed EPA's guidance document *"Comprehensive Five-Year Review Guidance" (June 2001)* in performing the second five-year review for the Site.

Community Notification and Involvement

Citizens for Lowry Landfill Environmental Action Now (CLLEAN) is a nonprofit citizens group that received a Technical Assistance Grant (TAG) from EPA for the Site. EPA notified CLLEAN's Board of Directors as well as representatives of CDPHE, the Tri County Health Department, Arapahoe County, the City of Aurora, and the WSDs that the second five-year review for the Site was underway at a Lowry Landfill Site Stakeholders meeting on January 26, 2006 and at subsequent meetings held on April 27, and August 24, 2006.

Additionally, representatives of owners of parcels of property in the vicinity of the Site were notified of the second five-year review at several meetings of the Lowry Landfill Steering Committee facilitated by the Tri-County Health Department. The meetings were held on January 18, April 19, June 14, and August 9, 2006.

In July 2006, EPA prepared and mailed a fact sheet that provided an update of Site activities and announced that the second five-year review was underway at the Site. The fact sheet was mailed to approximately 1500 residences, businesses, and other interested parties. The mailing targeted an area of approximately two miles surrounding the Site.

Document Review

A list of documents reviewed for this five-year review can be found in Attachment 1.

Data Review

OUs 1 & 6: Shallow Groundwater and Surface Liquids and Deep Groundwater

Since February 2005, performance and compliance groundwater monitoring at the Site has been performed by the Respondents/WSDs in accordance with the Sitewide Groundwater Monitoring Plan for the Lowry Landfill Superfund Site (GWMP), approved by EPA in February 2005 and amended in August, 2005, December, 2005 and April, 2006. Groundwater data collected pursuant to the GWMP is used to evaluate compliance with groundwater performance standards at the point of compliance and to evaluate effectiveness of containment at each of the four engineered components of the containment remedy (NBBW, NTES, perimeter slurry wall, and the MW38 Gradient Control Contingency Measure) in order to confirm that the remedy is achieving the RAOs for OUs 1 and 6.

The GWMP describes specific data collection requirements, laboratory analyses, data evaluations, and decision rules that support:

- Demonstration of compliance with groundwater performance standards along the downgradient portion of the point of compliance;

- Demonstration of the effectiveness of containment provided by the four engineered components of the groundwater containment remedy; and
- Detection of changes in water quality, if any, in deeper bedrock units beneath the interior of the Site to evaluate the potential for migration of groundwater contamination in the vertical direction.

Evaluation of compliance with groundwater performance standards is performed at each of 60 monitoring wells in the compliance monitoring network. These wells, located along the point of compliance, are screened in the weathered Dawson, the unweathered Dawson, and the upper Denver formations, as well as the Lignite layer which is the location of the vertical point of compliance. Compliance with performance standards is assessed by comparing the performance standards for 30 indicator chemicals of compliance to their corresponding long-term average concentrations in groundwater. The decision tree for compliance evaluations is illustrated in Figure 6.

Evaluation of effectiveness is performed at each of the four engineered components of the containment remedy. Effectiveness can be demonstrated one of two ways: water level data is used to assess whether the hydraulic gradients at each component prevent groundwater transport to the downgradient compliance boundary; or alternatively, water quality data is used to assess whether the remedy component minimizes groundwater transport such that chemical concentrations of four indicator chemicals do not increase over time at the compliance boundary. The decision tree for effectiveness evaluations is illustrated in Figure 7.

Evaluation of vertical migration is performed at one unweathered Dawson monitoring well and three upper Denver monitoring wells located in the interior of the Site, north and hydraulically downgradient of the landfill mass. The wells are monitored to assess the vertical migration of contamination from the landfill mass and waste pits and the shallow groundwater (alluvium and weathered Dawson) into the underlying unweathered Dawson and upper Denver units. The decision tree for vertical migration is illustrated in Figure 8.

Groundwater monitoring data and evaluations of compliance, effectiveness, and vertical migration are presented routinely in "Remedial Action/Operations and Maintenance Status Reports" prepared by the WSDs . The most recent status report, submitted to EPA and CDPHE on September 30, 2006, contains data collected during the second quarter of 2006.

Evaluation of Effectiveness

NBBW

The decision rules for determining the effectiveness of containment provided by the NBBW using water level data are:

- If an inward hydraulic gradient is present around the NBBW, as identified from potentiometric maps developed for the NBBW, then the NBBW provides effective hydraulic containment.

- If an inward gradient cannot be identified from the potentiometric maps or if the water level data are otherwise inconclusive, the water quality data obtained from downgradient monitoring wells will be used to assess the effectiveness of the NBBW.

The results of water level monitoring associated with the NBBW and the effectiveness evaluation are presented in Figure 9, originally presented in the quarterly status report for the second quarter of 2006. Figure 9 delineates the potentiometric surface in the weathered Dawson formation in the localized area of the NBBW.

The potentiometric surface indicates that an inward hydraulic gradient is present around the NBBW and therefore demonstrates that the NBBW is effective at containing the target groundwater (shallow groundwater migrating in the unnamed creek drainage in the alluvium, weathered Dawson, and upper unweathered Dawson). An inward hydraulic gradient surrounding the NBBW has been maintained since at least August 2000.

The potentiometric surface is locally impacted by the potable water that is pumped into the injection trench, located downgradient of the NBBW, as part of the routine NBBW operations. During the second quarter of 2006, 3.2 million gallons of potable water were pumped into the injection trench.

NTES

The decision rules for determining the effectiveness of containment provided by the NTES using water level data are:

- If water levels are continuously declining, the amount of water extracted from the NTES is greater than the amount of water flowing into the NTES and the NTES is effectively capturing water flowing within the alluvium at the toe of the landfill.

- If the water levels in the NTES are maintained below the base of the alluvium, regardless of trends, the NTES is effective in capturing highly-contaminated groundwater emanating from the toe of the landfill.

- If neither of these criteria is met, water quality data collection will be initiated and the effectiveness of the NTES will be assessed based on water quality data.

Figure 10 presents the water level data collected during the second quarter of 2006 from piezometers MPZ-10 and MPZ-11, located within the NTES collection trench. Trench water levels have remained below the base of alluvium since approximately March 2005. The data indicates that the NTES is effective at capturing highly-contaminated groundwater emanating from the toe of the landfill.

The Remedial Action/Operations and Maintenance Status Report for the second quarter of 2006 reported that a sheen of Light Non-Aqueous Phase Liquid (LNAPL) was observed in the NTES trench in May 2006. The WSDs reported in a follow-up letter transmitted to EPA by the Supervising Contractor that the thickness has increased over last several months to

approximately four inches in thickness. Field observations indicate that it is originating from the western side of the trench and is maintaining a distinct phase separation above the groundwater.

In response to this observation, the WSDs have characterized the concentrations of VOCs and semi-volatile organic compounds (SVOCs) in the LNAPL, increased to daily the frequency of visual monitoring of the NTES water pumped to the WTP, installed a new four-inch diameter well with product skimmer in the NTES trench and are currently extracting LNAPL and disposing it off-Site. A second skimmer will be fit into the riser pipe of the NTES trench sump and will begin extracting LNAPL as soon as it is functional. Approximately 10 feet of groundwater is maintained vertically between the NTES sump pump intake and the LNAPL layer and the LNAPL layer is phase-separated above the groundwater. As long as these conditions are maintained, introduction of LNAPL into the pump and the WTP will not occur. To ensure maintenance of these conditions, the frequency of monitoring liquid levels in the trench has been increased.

East/South/West Barrier Wall

The decision rules for determining the effectiveness of containment provided by the East/South/West Barrier Wall (the perimeter slurry wall) using water level data are:

- If the average of eight quarters of water level measurements outside the perimeter slurry wall is higher than the average water level inside the perimeter slurry wall (inward hydraulic gradient), the wall provides effective hydraulic containment.

- For those portions of the perimeter slurry wall where hydraulic gradients are outward, water quality data will be used to assess the effectiveness of the perimeter slurry wall.

Table 14 presents the Summary of Perimeter Slurry Wall Gradient Calculations for the second quarter of 2006. Figure 11 presents the locations of the paired wells and the well pair hydrographs.

Table 14: Summary of Perimeter Slurry Wall Gradient Calculations, Second Quarter 2006

WELL PAIR	AVERAGE DIFFERENCE IN WATER LEVELS (OUTSIDE-INSIDE) (FT)	80% LOWER CONFIDENCE INTERVAL ON AVERAGE (FT)	95% UPPER CONFIDENCE INTERVAL ON AVERAGE (FT)	GRADIENT
PM-1	-3.4	-4.7	-0.9	Inward
PM-2	-3.4	-3.7	-2.7	Inward
PM-3	0.1	-0.1	0.5	Outward
PM-4	-5.8	-6.2	-5.0	Inward
PM-5	-3.8	-5.4	-0.5	Inward
PM-6	2.7	2.5	3.2	Outward
PM-7	-5.0	-5.2	-4.5	Inward

WELL PAIR	AVERAGE DIFFERENCE IN WATER LEVELS (OUTSIDE-INSIDE) (FT)	80% LOWER CONFIDENCE INTERVAL ON AVERAGE (FT)	95% UPPER CONFIDENCE INTERVAL ON AVERAGE (FT)	GRADIENT
PM-8	-8.5	-8.8	-8.1	Inward
PM-9	-9.8	-10.2	-9.1	Inward
PM-10	-6.2	-6.4	-5.7	Inward
PM-11	-21.7	-22.0	-21.3	Inward
PM-12	-8.6	-9.3	-7.3	Inward
PM-13	1.1	0.6	2.2	Outward
PM-14	1.1	1.0	1.2	Outward
PM-15	-10.6	-11.5	-9.0	Inward

Review of the monitoring data indicates the following:

- **East Leg of Perimeter Slurry Wall:** Shallow groundwater in the weathered Dawson formation generally flows in a northeasterly direction in the area of the Site. As a result, shallow groundwater flow within the interior of the slurry walls appears to be restricted by the northern half of the east leg of the slurry wall. Consequently, groundwater is mounding on the interior side of the east leg of the slurry wall. This indicates that the slurry wall is functioning as designed. This also creates an outward hydraulic gradient. The WSDs are extracting groundwater from the interior of the slurry wall at several locations along the east leg in order to lower the water level on the inside of the wall and reverse the outward hydraulic gradients. These extractions are occurring at wells PM-11, PM-15 and MW51-WD, and have resulted in inward gradients at these locations. An inward gradient also is present at well pair PM-12. Well pairs PM-13 and 14 display an outward gradient, suggesting that an outward hydraulic gradient exists along the wall for approximately a quarter mile. Since there is an outward gradient at these locations, water quality data was used to assess the effectiveness of the slurry wall. Groundwater samples collected from wells located on the exterior of the slurry wall, PM-13X and PM-14X, were analyzed for the four indicator VOCs 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichlororethane (1,1-DCA), trichloroethene (TCE) and tetrachloroethene (PCE). The data collected for all compounds are below their respective performance standards, indicating that the wall is achieving the RAOs for OUs 1 and 6 and providing effective containment.

- **South Leg of Perimeter Slurry Wall:** With the exception of the PM-6 area, the south leg of the slurry wall appears to be functioning as designed. The hydraulic data for well pairs PM-7 to PM-10 indicate that groundwater levels are building up on the exterior of the wall and on the interior of the wall, levels are lower and fairly stable. An inward hydraulic gradient clearly exists along most of the southern leg of the slurry wall. The exception is at well pair PM-6, located at the southwest corner of the slurry wall, where the groundwater level on the inside of the wall averages approximately 2.7 feet higher than on the outside of the wall.

Groundwater samples collected from a well located on the exterior of the slurry wall, PM-6X, were analyzed for the four indicator VOCs. None of the indicator compounds were detected, indicating that the wall is achieving the RAOs for OUs 1 and 6 and providing effective containment.

- **West Leg of Perimeter Slurry Wall:** The west leg of the slurry wall appears to be functioning as designed with the following minor exceptions. The gradient at well pair PM-4 is inward because of the groundwater extraction on the interior of the slurry wall at that location. The graph of water levels over time at well pair PM-3 indicates that the groundwater levels in exterior and interior wells have been declining and now the hydraulic gradient is outward at this well pair. Since there is now an outward gradient at these locations, water quality data was used to assess the effectiveness of the slurry wall. Groundwater samples were collected from well PM-3X during the second quarter of 2006. The sample results indicated 1 ug/L of PCE and trace levels of the other three indicator chemicals. The data collected for all compounds are below their respective performance standards, indicating that the wall is achieving the RAOs for OUs 1 and 6 and providing effective containment.

MW-38 Gradient Control Contingency Measure

The decision rule for determining the effectiveness of containment provided by the MW-38 Gradient Control Contingency Measure using water level data is:

If an inward hydraulic gradient is present from the west into the MW-38 channel along its entire length, and an inward hydraulic gradient is present at the north end of the channel, the MW-38 channel provides effective hydraulic containment in the northwestern portion of the Site.

Figure 12 presents the potentiometric surface in the weathered Dawson in the MW-38 Area prepared using water level data collected during the second quarter of 2006. The potentiometric surface map shows groundwater in the MW-38 channel is contained such that the hydraulic gradient is inward towards the channel throughout its entire length. This condition has been maintained since July 2004, the date of the completion of the MW38 Area Pilot Test. The data indicate that the MW-38 extraction system is providing effective containment.

Evaluation of Vertical Migration

The decision rules for vertical migration monitoring are:

- If deeper contamination is not detected, or if concentrations are stable or decreasing in the interior deeper wells, vertical migration is not indicated and no adjustments to the compliance monitoring network or frequency are needed.

- If contamination is detected at levels above performance standards, or increasing levels of contamination are detected in the deeper interior monitoring wells, vertical migration of contaminated groundwater is indicated and adjustments to the compliance monitoring

network or frequency will be evaluated to insure detection of such contamination at the point of compliance.

As of the second quarter of 2006, the groundwater samples collected from the deep interior wells described above have been analyzed to determine the concentration of indicator chemicals for compliance. Because the long-term average concentrations of all indicator chemicals are below performance standards, vertical migration is not indicated and no adjustments to the compliance monitoring network or frequency are needed. Additional chemical data will be routinely collected in order to assess long-term trends in water quality in these wells.

Evaluation of Compliance

Sixty monitoring wells are included in the groundwater compliance monitoring network. The wells in the compliance monitoring network for the weathered Dawson, the unweathered Dawson, and the Denver formations were specifically chosen to meet the following criteria:

1) Located along the downgradient (eastern and northern) portion of the point of compliance;
2) Information from the well log indicates the presence of channel sand deposits;
3) Channel sands are expected to be present at the well locations based on the results of previous borings, geophysical investigations, and geological evaluations; and
4) Well purge and recovery rates indicate the presence of permeable materials.

Data presented in the Remedial Action/Operations and Maintenance Status Report for the second quarter of 2006 indicates the following ten compliance monitoring wells are out of compliance with the performance standard for one or more chemicals:

- Two wells adjacent to the eastern leg of the slurry wall contain TCE at levels slightly above the performance standard;
- Four wells in the NBBW area contain 1,4 dioxane and/or nitrate at levels above performance standards;
- The compliance monitoring well located at the north end of the MW38 sand channel contains 1,4 dioxane, chloroform, PCE, and TCE at levels above performance standards;
- Three wells adjacent to the east leg of the slurry wall contain iron at levels above the performance standard; and
- One well adjacent to the southwest corner of the slurry wall contains iron at levels above the performance standard.

The locations of these wells, as well as all other compliance monitoring wells, are shown on Figure 13. As illustrated in Figure 6, the GWMP requires specific responses to be taken if a compliance monitoring well is determined to be out of compliance. The response to an out-of-compliance situation depends on an assessment of the time trend of the chemical concentrations and an assessment of the likelihood that the chemical will be transported off-Site at levels above the performance standard. The GWMP identifies three specific cases, each of which requires a specific response:

- Case 1: The presence of an out-of-compliance condition coupled with a downward trend in chemical concentration indicates that the well will likely be in compliance in the future. This observation combined with an assessment that groundwater exceeding performance standards is unlikely to migrate off-Site allows for a determination that the remedy is protective because the RAO of preventing exposure is met. The required response is to continue to monitor to verify continuing improvements in water quality.

- Case 2: The presence of an out-of-compliance condition coupled with a lack of a downward trend in chemical concentration indicates uncertainty with regard to how long it will take for the well to be back in compliance. An assessment that the potential for off-Site migration is low allows for a determination that the remedy is protective because the RAO of preventing exposure is met. The required response is to continue to monitor and as necessary to conduct additional investigation and/or evaluation to verify that the potential for off-Site migration is low.

- Case 3: The presence of an out-of-compliance condition coupled with an increasing trend in chemical concentration indicates that a potential for off-Site migration exists. This condition results in uncertainty with respect to the protectiveness of the remedy. The required response is to submit a work plan to take actions necessary to limit migration and lower the concentrations of contaminants in groundwater.

Each of the ten monitoring wells that are out of compliance with one or more performance standards has been determined to be one of the three cases described above. The required responses have been initiated as described below.

NBBW Area Compliance Wells

Four compliance wells in the vicinity of the NBBW are out of compliance with the performance standard for one or more chemicals. The conditions at all four wells represent Case 3 for the following reasons:

Well B326-WD, located downgradient of the NBBW and its capture zone, is out of compliance with performance standards for 1,4-dioxane (average concentration is 543 ug/L compared to the performance standard of 6.1 ug/L) and for nitrate (average concentration is 49,889 ug/L compared to the performance standard of 29,100 ug/L). The concentrations of both of these chemicals appear stable over time (i.e., there is neither an increasing nor decreasing trend). An inward hydraulic gradient is present around the NBBW, providing effective containment of groundwater flow in the weathered Dawson and alluvium. Additionally, there is no increasing trend to indicate uncertainty with respect to the protectiveness of the remedy. However, since well B326-WD is downgradient of the NBBW, there is a potential that 1,4 dioxane and nitrate detected in the well will migrate off-Site. This represents a Case 3 condition.

Well B326-UD, located north of the NBBW, is out of compliance with the performance standard for 1,4 dioxane (average concentration is 22 ug/L compared to the performance standard of 6.1 ug/L). There is currently an insufficient number of sampling results at the

required detection limit to assess the time trend in concentration at this well. Nevertheless, because well B326-UD is located downgradient of the NBBW and there is thus a potential that 1,4-dioxane detected in the well will migrate off-Site, this represents a Case 3 condition.

Well MW77-WD, located approximately 450 feet east of the NBBW and to the east and outside of the unnamed creek drainage, is out of compliance with performance standards for 1,4-dioxane (average concentration is 53.9 ug/L compared to the performance standard of 6.1 ug/L) and nitrate (average concentration is 64,900 ug/L compared to the performance standard of 29,100 ug/L). The concentrations of both chemicals appear stable over time so there is no indication of uncertainly with respect to the protectiveness of the remedy. Because a groundwater divide occurs between the NBBW and well MW77-WD, that well is not impacted by the operations at the NBBW. Therefore, there is a potential that chemicals in well MW77-WD will migrate off-Site, representing a Case 3 condition.

Well MW62-WD, located north east of the eastern end of the NBBW, is out of compliance with the nitrate performance standard (average concentration is 48,745 ug/L compared to the performance standard of 29,100 ug/L). The sampling results indicate an increasing trend in nitrate concentrations over time. Since the hydraulics at the well location are not influenced by the operations at the NBBW, there is a potential that the nitrate will migrate off-Site, representing a Case 3 condition.

As illustrated in Figure 6, the GWMP requires that a work plan be submitted to EPA if Case 3 conditions are present. Therefore, as a result of the Case 3 conditions relative to these four wells, the WSDs prepared and EPA approved a work plan in January 2006 to assess the extent of occurrences of chemicals in groundwater at levels above performance standards north of the northern point of compliance. The implementation of that work plan is ongoing. In September 2006, the WSDs prepared an addendum to the work plan to implement an initial response action to limit migration of contaminated groundwater. This is the first step in the cleanup of the impacted groundwater north of the northern point of compliance. The investigation and initial response described in the EPA-approved work plan is called the "North End Investigation".

A review of the data from the ongoing North End Investigation indicates the following key findings, illustrated in Figures 14 and 15:

- 1,4 dioxane was detected in groundwater samples from wells installed in the alluvium/weathered Dawson formation upgradient (south) of the confluence of unnamed creek and Murphy Creek and east of unnamed creek in Section 31. The concentrations of 1,4-dioxane range from 13 ug/L to 43 ug/L compared to the performance standard for 1,4-dioxane, 6.1 ug/L.

- 1,4-dioxane was detected in groundwater samples from a well installed in the alluvium/weathered Dawson formation downgradient (north) of the confluence of unnamed creek and Murphy Creek and east of unnamed creek in Section 31. The concentration of 1,4 dioxane detected in this well is 110 ug/L.

- 1,4 dioxane was detected in a surface water sample collected from the permanent surface water monitoring point SW-3, located downgradient of the confluence of unnamed creek and Murphy Creek. The concentration of 1,4 dioxane detected in this surface water sample is 79 ug/L.

- 1,4 dioxane was detected in groundwater samples from shallow wells located along the northern boundary of Section 31. Concentrations above the performance standard of 6.1 ug/L are limited to the alluvium/weathered Dawson formation which extends to depths of approximately 35 feet beneath ground surface in this area. The concentrations range from 12 ug/L to 38 ug/L. Concentrations of nitrate detected in all these wells were below the performance standard of 29,100 ug/l.

- 1,4 dioxane was not detected in groundwater samples from two upper Denver wells located near the northern boundary of Section 31. The screened intervals of these two wells are between 63 feet and 117 feet beneath ground surface.

- 1,4 dioxane was not detected in groundwater samples from two deep water supply wells located near the north end of Section 30. Nitrate was also not detected in groundwater samples from these wells. These wells are several hundred feet deep and are the nearest wells to the Site that are currently used as a private water supply for two residences. Results indicate there is no current exposure to 1,4 dioxane via the drinking water exposure pathway.

- Surface water samples were collected from seven separate locations along Murphy Creek downgradient of the northern boundary of Section 31. Two of the samples had concentrations of 1,4 dioxane above 6.1 ug/L (6.2 ug/L and 10 ug/L). These two samples were collected from locations in Murphy Creek approximately 2 ½ miles from the northern Site boundary. Concentrations of 1,4-dioxane in all seven samples ranged from non-detect to 10 ug/l. Concentrations of nitrate in the seven samples ranged from non-detect to 7,600 ug/l.

- Groundwater flow appears to converge in the vicinity of well MW05-WD and flow parallel or sub-parallel to a historic surface water diversion ditch. This diversion ditch no longer exists but appears to have provided an historic connection between the main stem of Murphy Creek in Section 31 and the western branch of Murphy Creek in Section 30.

- 1,4 dioxane was detected in groundwater samples from shallow wells located approximately 1000 feet north of the northern boundary of Section 31. Seven wells were installed at this location. Three of the seven wells had detections of 1,4 dioxane above 6.1 ug/L that ranged from 9.5 ug/L to 42 ug/L.

- 1,4 dioxane was not detected above the performance standard of 6.1 ug/L in samples from shallow wells installed within the Murphy Creek drainage in the north western portion of Section 19 and the northeastern portion of Section 24, approximately 3 miles from the northern Site boundary.

- Samples collected from monitoring wells located along the northern boundary of Section 31 indicate that the highest 1,4-dioxane concentration (38 ug/L) occurs in well MW05-WD at the northeast edge of the DADS landfill and the concentrations gradually decrease to non-detects to the east and west. Samples from wells installed upgradient of well MW05-WD to monitor the DADS landfill in the area west of the unnamed creek drainage contain only low levels of 1,4-dioxane, indicating that the DADS landfill is not a likely source of 1,4-dioxane in groundwater.

There are several possible explanations for the occurrence of 1,4-dioxane and nitrate in groundwater at levels above their respective performance standards in compliance wells along the northern point of compliance. Given that the NBBW is effectively containing shallow groundwater migrating in the unnamed creek drainage in the alluvium, weathered Dawson, and upper unweathered Dawson, four hypotheses have been developed as possible alternative explanations for the elevated concentrations in the compliance wells. EPA is considering each of the following four hypotheses in the ongoing North End Investigation data collection and response action design:

- Based on a review of groundwater levels and the geologic layers in the area east of the NBBW, it appears that in the past, there may have been a groundwater flow path located east of the NBBW that may have hydraulically connected the MW77-WD area to an upgradient contaminant source. Historically, this may have been a migration pathway for groundwater contamination to the MW77-WD area. Currently, water levels are lower than in the past and the hydraulic connection between the two areas no longer exists.

- The nitrate concentrations observed in well MW62-WD may be the result of historical land-farming of sewage sludge in the area downgradient of the NBBW. Past land-farming over an extensive area may also explain the presence of nitrate in the other compliance wells.

- The 1,4-dioxane concentrations detected in wells B326-WD and B326-UD may be due to re-injection of treated effluent from the WTP. Prior to 2001, groundwater was not treated for 1,4-dioxane or nitrate in the WTP and effluent was routinely re-injected into the existing injection trench over a 16 year period. Re-injection of WTP effluent no longer occurs at the Site.

- There may be one or more groundwater migration pathways beneath the NBBW that are not contained by the groundwater extraction and re-injection operations of the NBBW system.

The results of the North End Investigation also provide information to support analysis of the protectiveness of the selected remedy for OUs 1 and 6. EPA considered the public health implications of the 1,4 dioxane and nitrate levels detected in groundwater north of the Site in the North End Investigation.

Groundwater samples from the nearest wells to the Site that are currently used as a private water supply for two residences were non-detect for both chemicals, indicating there is no current exposure to 1,4 dioxane or nitrate via the drinking water pathway. Since new developments in

the area will be supplied with drinking water from the City of Aurora's municipal water supply, there is also no reasonably anticipated future exposure to groundwater via the drinking water pathway.

There is a potentially complete inhalation exposure pathway to future residents via vapor intrusion to indoor air if residential development occurs in Section 31 or Section 19 in the area where 1,4 dioxane has been detected in groundwater above performance standards in the North End Investigation. EPA's *"Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils" (November 2002)* recommends that this pathway be considered if volatile chemicals (defined as having a Henry's Law Constant greater than 10^{-5} atm m^3/mol) are present or suspected to be present in groundwater at a site at a depth of 100 feet or less or located in close proximity to existing buildings or future buildings, or located in close proximity to the expected footprint of potential future buildings (for non-Environmental Indicator determinations). The published Henry's law constant for 1,4 dioxane is 4.88×10^{-6} atm m^3/mol, indicating it is not a chemical for which inhalation exposure via the vapor intrusion to indoor air pathway should be considered.

Current and potential future exposure to surface water within Murphy Creek is possible for adults who golf at the Murphy Creek Golf Course that extends along Murphy Creek from Section 30, Township 4 South, Range 65 West north into Section 19, Township 4 South, Range 65 West and for adults and children who reside in the nearby development. For recreational golfers, the potentially complete exposure pathways are dermal contact and incidental ingestion of surface water while retrieving golf balls. Likewise, for children and adult residents, the potentially complete exposure pathways are dermal contact and incidental ingestion while wading or playing within Murphy Creek. EPA performed a screening-level risk assessment of these exposures and found that risks are at the low (protective) end of the acceptable risk range. The screening-level risk assessment can be found in Appendix C.

By definition, a Case 3 condition results in uncertainty with respect to the protectiveness of the remedy. The subsequent North End Investigation was implemented to generate data to answer questions about the uncertainties. The data collected during the North End Investigation indicates there are no unacceptable risks associated with potential exposures to the levels found in groundwater and surface water, even using very conservative assumptions. Therefore, the data indicates the remedy for OUs 1 and 6 is protective.

Compliance Wells Adjacent to the Perimeter Slurry Wall

Well MW90-UD, located along the eastern point of compliance just north of the perimeter slurry wall, is out of compliance with the performance standard for iron (average concentration is 2288.9 ug/L compared to the performance standard of 2060.4 ug/L). The concentration of iron appears to be stable over time and, based on the geochemistry of iron, the migration potential of iron at this location is low. This represents a Case 2 condition.

Well MW106-UD, located along the eastern point of compliance adjacent to the perimeter slurry wall, is out of compliance with the performance standard for iron (average

concentration is 5000 ug/L compared to the performance standard of 2060.4 ug/L). There is currently an insufficient number of sampling results to assess the time trend in concentration at this well. However, based on the geochemistry of iron, the migration potential of iron at this location is low. This represents a Case 2 condition.

Wells BM-11X-100N and BM-11X-100S, located along the eastern point of compliance adjacent to the southeast end of the perimeter slurry wall, are out of compliance with the performance standard for TCE (average concentration is 5.7 ug/L at both wells compared to the performance standard of 5 ug/L). Similar to well MW106-UD, there is currently an insufficient number of sampling results to assess the time trend in concentration at these wells. This represents a Case 2 condition.

Well PM-6X-UD, located along the southern point of compliance adjacent to the southwest corner of the perimeter slurry wall, is out of compliance with the performance standard for iron (average concentration is 12,800 ug/L compared to the performance standard of 2060.4 ug/L). There are currently an insufficient number of sample results to assess the time trend in concentration at this well. However, based on the geochemistry of iron, the migration potential of iron at this location is low. This represents a Case 2 condition.

Since all five wells indicate Case 2 conditions, they will continue to be monitored and the potential for off-Site migration of chemicals at levels above the performance standard will be evaluated. The mobility of TCE in groundwater and the location of wells BM-11X-100N and BM-11X-100S in an area where the hydraulic gradient is towards the Site boundary introduce some uncertainty about the potential for the chemical to be transported off-Site at levels above the performance standard. However, the average concentration of TCE in both wells (5.7 ug/L) is very close to the performance standard of 5 ug/L. A quantitative evaluation of the fate and transport of TCE in groundwater from wells BM-11X-100N and BM-11X-100S is underway and being performed by the WSDs in accordance with the GWMP.

Compliance Well in the MW38 Area

Well MW38-830N-230E, located at the northern end of the MW38 sand channel and upgradient of the northern extraction well in the MW38 contingency measure, is out of compliance with performance standards for 1,4 dioxane (average concentration is 152 ug/L compared to the performance standard of 6.1 ug/L), chloroform (average concentration is 52 ug/L compared to the performance standard of 3.5 ug/L), TCE (average concentration is 40 ug/L compared to the performance standard of 5 ug/L), and PCE (average concentration is 7.3 ug/L compared to the performance standard of 5 ug/L). There is currently an insufficient number of sampling results to assess the time trend in concentration of these chemicals at this well. However, an inward gradient has been induced by the northern extraction well, located 100 feet downgradient of the point of compliance and well MW38-830N-230E. This represents a likely Case 1 condition since the inward gradient prevents migration of contamination off-Site more than approximately 100 feet to the location of the extraction well. The final determination of

whether this represents a Case 1 or a Case 2 condition will be made when sufficient data is available to assess trends. This does not, however, represent a Case 3 condition.

WTP

Compliance monitoring of the WTP consists of sampling WTP effluent at monitoring port MP-001 in accordance with the Industrial Discharge Permit No. I-218, issued jointly by Metro and Aurora on August 1, 2004. Performance and early warning monitoring consists of monthly sampling of WTP influent from individual influent sources, including the raw water storage tank, the NBBW, the NTES, the PM-11, PM-15, and PM-4 tanks, as well as sampling of the combined influent from the MW38 area extraction wells and the MW-51 tank.

Operations, maintenance, and monitoring activities associated with the WTP are also routinely presented by the WSDs in Remedial Action/Operations and Maintenance Status Reports. Data from the second quarter of 2006 indicate that the WTP treated Site waters originating from the NBBW, the NTES sump, extraction wells along the eastern slurry walls, (PM-11, PM-15 and MW-51 areas), an extraction well along the western slurry wall (PM-4 extraction well), MW38 area extraction wells, the decontamination pad at the command post, landfill gas condensate, and miscellaneous sources such as well sampling and purge waters, and potable water used for plant wash-down. Following treatment, all of these waters were discharged to Metro's and Aurora's POTWs in accordance with the Industrial Discharge Permit No. I-218, issued jointly by those parties on August 1, 2004.

Throughout the second quarter of 2006, the WTP operated approximately 98 percent of the time period defined by the amount of time the plant processed water, divided by calendar time.

All operations and maintenance activities were documented on checklists, in manual entries by the plant operator in the daily logs, and/or on electronic logs entered automatically into the WTP database by the WTP operating software. Completed checklists and monthly summaries of pertinent information are routinely provided in the Remedial Action/Operations and Maintenance Status Reports submitted by the WSDs. Compliance monitoring during the second quarter of 2006 consisted of sampling WTP effluent in accordance with the discharge permit. All discharge standards were met. Additionally, analytical results from the influent sources showed consistent water chemistry over time.

OUs 2 & 3: Landfill Solids and Landfill Gas

Landfill Cover Maintenance and North Face Landfill Cover

The "*Final Operations and Maintenance Plan Landfill Solids, Soils, and Sediments*" *(June 18, 1999)* describes inspection and maintenance procedures for the landfill cover, including the north face of the landfill. There are no specific data collection requirements to monitor the performance of the landfill cover. Settlement monitoring plates were installed as part of the landfill cap fill and re-grade project that was completed in 2002. The settlement plates were placed at locations where the greatest settlement was expected to occur during construction, and were surveyed before and after construction. Long-term settlement is monitored by inspections performed by the WSDs in accordance with the "*Final Operations and Maintenance Plan for*

Landfill Solids, Soils, and Sediments". The most recent inspections were performed in July 2006 and results were provided to EPA in a letter dated July 13, 2006. During the inspections, no ponding was observed on the vegetated cover. Minor ponding was observed on the roadways where vehicle tracks or excessive road grading had occurred. The WSDs have since filled these areas.

The landfill cover will be re-graded to promote long-term positive drainage and to reduce future maintenance problems by removing part of the existing cover to leave a minimum of two feet in place, stockpiling the material, placing additional fill to increase the slope to achieve a final grade of approximately five percent, and reconstructing the cover. The additional fill will be provided in the form of construction and demolition debris (and other inert materials). The re-grading project will be performed by the WSDs in accordance with the "*Draft Operations and Maintenance Manual for Covers and Stormwater" (November 2005),* which incorporates the document "*Denver Arapahoe Disposal Site (Section 6) Engineering Design and Operations Plan" (October 2005).* The landfill cover re-grading project is expected to start in the spring of 2007.

Landfill Gas Collection and Treatment System

The *"Final Compliance Monitoring Plan, Landfill Gas Remedy" (December 1997),* describes procedures for collection and evaluation of data to determine compliance with performance standards for the landfill gas remedy. The plan requires flare emissions and subsurface gas to be monitored.

Flare emissions are monitored at the flare outlet. The emissions are compared to allowable air concentrations for VOCs and SVOCs, calculated to ensure compliance with ambient air standards at a point of compliance that represents the nearest location of an unrestricted public receptor and at a point of compliance that represents the location of an on-Site worker who could be exposed to emissions.

Flare emissions are also monitored to ensure compliance with State of Colorado Applicable or Relevant and Appropriate Requirements and New Source Performance Standards (40 CFR Section 60.18). The flare exhaust is monitored for VOCs and SVOCs, particulate emissions, carbon monoxide, nitrogen oxides, sulfur oxides, opacity, odor and destruction of non-methane organic compounds. Opacity is monitored above the flare and odor is monitored downwind of the flare.

The most recent data from monitoring of flare emissions is reported in the "*Remedial Action/Operations and Maintenance Status Report, Third Quarter 2005" (March 2006).* The flare outlet VOC and SVOC concentrations were all measured below allowable emission limits. NDMA was not detected. Emissions of nitrogen oxides, sulfur oxides, particulates, carbon monoxide, and non-methane organic compounds were also below their respective allowable limits. Opacity observations were in compliance with short and long term criteria. No odors unique to flare emission were detected within 2,000 feet downwind of the flare.

Subsurface gas is monitored to ensure compliance with performance standards established for the landfill gas remedy at the point of compliance and at the point of action. There are twenty-one

point of compliance gas probes located outside of the perimeter of the landfill on the east, west and south sides. The purpose of the point of compliance gas probes is to detect any releases of landfill gas at levels above performance standards for the landfill gas remedy. These probes are monitored for methane on a quarterly basis and for VOCs annually.

There are four point of action gas probes located north of the landfill mass. The purpose of the four gas probes is to provide early warning of landfill gas migration to the north, at locations upgradient of the point of compliance. These probes are monitored for methane on a quarterly basis and for VOCs annually.

The most recent sampling for VOCs at the point of compliance and the point of action landfill gas probes was performed by the WSDs in February 2006. The data from this sampling event is reported in the "*Remedial Action/Operations and Maintenance Status Report, First Quarter 2006" (June 2006).* All sampling results were below the performance standards established for the landfill gas remedy.

The most recent results of methane sampling at the point of compliance and the point of action landfill gas probes are reported in the "*Remedial Action/Operations and Maintenance Status Report, Second Quarter 2006" (September 2006).* All sampling results showed concentrations of methane below the performance standard established for the landfill gas remedy.

FTPA Waste Pits

Activities to complete remedial action at the FTPA began in July 2006. The activities include:

- Relocation of the treated soils from an on-Site treatment cell, constructed in 1999, to an on-Site Corrective Action Management Unit within the footprint of the main landfill mass;
- Extraction of NAPL from within and immediately outside the north waste pit and south waste pit;
- On-Site temporary storage of extracted materials;
- Transport of extracted materials to an off-Site treatment facility;
- Maintenance of the existing cap on each waste pit; and
- Groundwater monitoring downgradient of the FTPA waste pits.

A pre-final inspection of the physical construction of the CAMU and the extraction wells was completed on September 28, 2006. No punch list items were identified. EPA certified physical construction completion for OUs 2 and 3 and the entire Site on September 29, 2006. Although construction is complete, remedial action at the FTPA will continue for several more years. Remedial action at the FTPA is expected to be complete in July 2009. The WSDs will routinely report the progress of remedial action in the Remedial Action/Operations and Maintenance Status Reports. The following information will be reported:

- Product thickness measurements and maps;
- Volume of product recovered;
- Recovered volume versus time for each pit and/recovery well;
- Summary of amounts and location of product disposal or treatment;

- Change directives if they affect final design;
- Test and survey reports including a summary of quality control testing results; and
- Schedule updates.

OUs 4 & 5: Soils and Surface Water and Sediment

SWRA

The unnamed creek had no flow in it on May 31, 2006, the date of the Site inspection for this five-year review. Information reported in the most recent quarterly status reports indicates the unnamed creek has routinely been dry. Information on groundwater levels from the existing piezometers installed within the unnamed creek channel and screened in the alluvium indicate that at least five feet of clearance exists between the streambed and the water table. The piezometer data indicates that groundwater is adequately separated from the streambed clay lining.

Surface Water Monitoring

Surface water monitoring has been performed by the Respondents/WSDs since 1996 in accordance with the *"Final Interim Compliance Monitoring Plan" (February 1996).* Surface water samples are collected annually during significant precipitation events at three locations within the unnamed creek drainage in order to evaluate the potential for contaminant migration. Since continued operation of the SWRA ensures that the production and migration of contaminated surface water from subsurface liquids is minimized, the remaining potential source of contamination in surface water is erosion of contaminated soil and subsequent contamination of the surface water runoff during precipitation events. Therefore, the current surface water monitoring program is designed to determine if contaminants are migrating from the soil to the surface water. The surface water monitoring locations were selected based on observed erosion activity in the adjacent area and the potential for standing water to collect at these locations after precipitation events. The locations are at the confluence of unnamed creek and Murphy Creek, on the western edge of the former landfill mass in a perimeter drainage ditch and in the unnamed creek drainage. The samples are analyzed to determine the concentrations of surficial soil contaminants of concern identified in the ROD. Results are compared to criteria based on surface water performance standards and background concentrations. The interim compliance monitoring plan for surface water was intended to provide a technical basis for development of a long-term surface water monitoring program to be implemented during and following remedial action at the Site. However, the current program, in place since 1996, has not been reconsidered or developed into a long-term compliance monitoring program for surface water.

The most recent surface water sampling event occurred in June 2005 and the results were reported in the *"Remedial Action /Operations and Maintenance Status Report, Second Quarter 2005" (September 2005).* Surface water samples were analyzed for metals in both the total and dissolved fractions to assess the effect of sediment loads. Aluminum was measured in the total fraction at levels above the performance standard at all three sampling locations. However, all

contaminants of concern were measured at levels below performance standards in the dissolved fraction.

Wetlands Mitigation

EPA certified completion of work on the wetlands mitigation portion of the remedy on August 12, 2005. The wetlands were inspected as a component of this five-year review and were found to be in excellent condition. There is no new data to review.

Institutional Controls

In accordance with the "*Final Institutional Controls Plan Lowry Landfill Superfund Site" (September 2002),* the WSDs have developed a plan for performing a regular survey of wells constructed within ½ mile of the Site. This plan has been incorporated into the GWMP. Additionally, Denver included language in the water decrees relative to the water rights within the Lower Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers underlying the on- and off-Site properties stating that (1) nothing in the Water Court's ruling or decree shall be construed to override or modify any of the restrictions imposed on the use of groundwater underlying the Site, and (2) in constructing and maintaining wells which penetrate more than one aquifer, Denver shall encase the wells with an impervious lining in accordance with applicable rules and regulations governing the construction of water wells to prevent potential cross-contamination between aquifers or withdrawal of groundwater from other aquifers.

Other than the regular survey of wells constructed within ½ mile of the Site, there is no data collected for the purpose of monitoring the performance of the institutional controls. However, fences and signs were observed during the Site inspection and were found to be adequate.

Site Inspection

The Site inspection took place on May 31, and June 1, 2006. A completed Site inspection checklist can be found in Attachment 2. The following is a list of participants in the Site inspection:

- EPA RPM: Bonnie Lavelle
- USACE Geotechnical Engineer: Don Moses (Lead)
- USACE Chemist: Janie Carrig
- USACE Environmental Engineer: Ted Streckfuss
- USACE Chemical Engineer: Kimberly Witt
- USACE Geologist: Dave Kachek
- CDPHE Hydrogeologist: Lee Pivonka
- Tri-County Health Department Field Supervisor: Lynn Robbio-Wagner
- EMSI (Supervising Contractor) Principal Engineer: Tim Shangraw
- Parsons Engineering Science, Inc. WTP Operator: Chris Carlson

On the morning of May 31, the participants separated into two groups. The first group inspected the WTP. This group included USACE Chemist (Janie Carrig) and Engineers (Ted Streckfuss

and Kimberly Witt). EMSI's Principal Engineer (Tim Shangraw) accompanied the group. They were assisted at the plant by the WTP Operator (Chris Carlson).

The second group inspected the surface features of the East/South/West Barrier Wall along with adjacent groundwater extraction systems. This group included the EPA RPM (Bonnie Lavelle), USACE Geotechnical Engineer (Don Moses), USACE Geologist (Dave Kachek), CDPHE Hydrogeologist (Lee Pivonka), and Tri-County Health Department Field Supervisor (Lynn Robbio-Wagner). In the afternoon, the joint group inspected the SWRA, the FTPA waste pits, the NTES, the NBBW, the landfill gas flare, and the wetlands mitigation area.

On the morning of June 1, 2006, the joint group inspected the landfill cover, including the north face cover. The group then drove off-Site to the north in order to observe the locations of monitoring wells installed as part of the North End Investigation and to understand the current scope of the North End Investigation and the 1,4-dioxane concentrations in shallow groundwater north of the Site. The group stopped at the north end of the DADS Landfill on East Yale Avenue to observe monitoring wells and stopped again near the north end of Murphy Creek golf course to observe a surface water sampling location.

East/South/West Barrier Wall: The second group walked the entire perimeter of the East/South/West Barrier Wall stopping at wells PM-15, MW51-WD, PM-11, PM-4 and MW39-WD to observe the extraction systems and monitoring wells and to discuss the data. No problems were noted with the above-ground components of these areas.

SWRA: Inspectors walked the entire length of unnamed creek within the Site to observe the above-ground features of the SWRA. The unnamed creek had no flow in it. Several areas were observed to be eroded and devoid of vegetation, exposing the clay barrier that separates the stream channel from the underlying permeable groundwater collection layer. The WSDs were informed of these observations during a conference call conducted on June 8, 2006 and they have since corrected the observed problems. No other problems were noted with the above ground components of the SWRA.

FTPA Waste Pits: The caps over all three FTPA waste pits were inspected. No problems were noted with the above-ground components of the FTPA.

NTES: The above-ground features of the NTES were inspected. During the inspection, the group discussed data on the pumping rates and water levels, noting that extraction rates and water levels have stabilized. No problems were noted with the above-ground components of the NTES.

NBBW: The above-ground features of the NBBW were inspected. The group spent considerable time discussing the 1,4-dioxane concentrations detected in off-Site shallow groundwater wells and the re-injection system. Representatives of CDPHE expressed concern that the injection rate of the potable water downgradient of the NBBW far exceeded augmentation requirements and that the potable water could be diluting contaminants in groundwater that have migrated beyond the NBBW. However, no VOCs have been detected above performance standards in groundwater compliance wells along the point of compliance in

the vicinity of the NBBW, yet 1,4-dioxane and nitrate have been detected above performance standards in several compliance wells. It is unlikely that if dilution were occurring, 1,4-dioxane and nitrate would still be present. No problems were noted with the above-ground components of the NBBW.

Wetland Mitigation Area: The mitigation wetlands constructed in and adjacent to Murphy Creek were inspected. No problems were noted. The vegetation cover had good growth diversity and density. There were no signs of erosion, siltation, or slope instability.

Landfill Gas Collection, Conveyance and Treatment System: The components of the landfill gas system were observed during various parts of the Site inspection. The only problem noted was that a lid on a manhole to a header gate valve structure needed to be secured. The structure is located approximately 150 feet west of the PM-15 area. The WSDs have since secured the cover. No other problems were noted with the above-ground components of the landfill gas collections, conveyance and treatment system.

Landfill Cover: Inspectors walked the landfill cover surface, including the north face cover. No problems were noted with the above-ground components of the landfill cover.

Fences and Signage: As noted above, the security fences and signage were observed to be well-maintained.

WTP: The Supervising Contractor's Principal Engineer (Tim Shangraw) led a tour of the entire WTP and provided explanations with specific details about all of the equipment. Inspectors observed all treatment components including tanks, sampling ports, and electrical panels, and all were found to be in good condition. The tour of the WTP included an inspection of the BTS. The team discussed the optimal conditions (including flow rates) for the microbes in the BTS to provide effective treatment of 1,4-dioxane. Inspectors observed the on-line chemical analysis by gas chromatography. No problems were noted with the WTP or BTS.

Interviews

EPA interviewed representatives of several stakeholders. Documentation of the interviews is in Appendix B. This section summarizes the main discussion points.

Bonnie and Richard Rader and Fred Mould of CLLEAN were interviewed on March 23, 2006. The Raders live about 4 miles to the north of the Site in Thunderbird Estates. Fred Mould lives 3 miles north of the Site in Gun Club Estates. CLLEAN is concerned about the detection of contaminants in groundwater at levels above performance standards in compliance wells located in the MW-38 area and in the north area outside of the point of compliance. They are also concerned about contaminants detected in deep wells located on the interior of the Site such as unweathered Dawson monitoring well B-712-LD, and are worried that the Site may act as a conduit for contaminants to migrate downward. They are worried about both horizontal and vertical migration of contaminants from the Site. CLLEAN is concerned that developers do not inform new residents about the Site. CLLEAN is not often contacted by new community members but occasionally receives calls from concerned citizens. They think that homeowners

in the area may become concerned about property values as a result of their proximity to the Site. CLLEAN commented that it may take years to demonstrate that the containment remedy is failing. They said that they are concerned that the regulatory agencies will wait until there is a documented problem rather than avoid problems with more aggressive remediation. They stated that if it takes twenty years to demonstrate that there are exceedances beyond the point of compliance, and that these exceedances are indicative of non-containment, the problem may be more difficult to address than if more proactive measures are taken to avoid problems. CLLEAN hopes that the five-year review may result in more proactive methods to assure protectiveness at this Site. CLLEAN does not believe that the remedy is protective and hopes this will be shown in the next five-year review.

EPA interviewed James Schrack, Environmental Program Supervisor at the City of Aurora, on May 18, 2006. Mr. Schrack believes the WSDs are acting very responsibly. He stated that issues and problems identified in the extensive monitoring program at the Site are openly discussed and responses are appropriate. Mr. Schrack indicated that people are concerned about the detection of 1,4 dioxane in shallow groundwater and surface water north of the Site, and that the landfill re-grading project soon to be visible from Quincy Avenue is a concern primarily because it may trigger community questions and may be aesthetically disruptive. Mr. Schrack also indicated that the results of the second five-year review will be an important consideration in the City of Aurora's determination about whether to grant requests for annexation, particularly in the northern portion of Section 7, south of Quincy Avenue and adjacent to the Site. Mr. Schrack commented that the recent tightening of the 1,4 dioxane performance standard brought about awareness that the parameters used to determine the effectiveness of the remedy may have to be periodically adjusted to coincide with this regulatory change and those that might come in the future. Finally, he noted that recent proposals to the State Land Board for development of properties east of the Site may result in increased traffic. The encroachment of residential areas from proposed annexation of properties to the south of the Site and from the Copperleaf development located in Section 12, southwest of the Site, may require increased Site security diligence, although Site security has not been a concern or issue to the City of Aurora to date.

EPA interviewed Lynn Robbio-Wagner, Field Supervisor, Tri-County Health Department (TCHD), and Ken Conright of TCHD on May 24, 2006. Both expressed the view that the remedial actions are being performed in accordance with the ROD and are protective of human health and the environment. Ms. Robbio-Wagner and Mr. Conright further stated that TCHD is confident that the residents living in the vicinity of the Site are currently protected and has found the WSDs to be very responsive when there is a concern. TCHD has noted significant progress at the Site since the Consent Decree was entered in 2005; more work has been completed in the last two years than in the previous 10 years. Ms. Robbio-Wagner and Mr. Conright recommended that EPA broaden its community involvement efforts and establish a means of evaluating the effectiveness of the community involvement program at the Site.

VII. Technical Assessment

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

East/South/West Barrier Wall: The selected remedy for OUs 1 and 6 included a Shallow Groundwater Containment, Collection, and Diversion System around the main landfill in the southern part of the Site. Due to a modification during remedial design, groundwater collection and diversion systems were not built in conjunction with the East/South/West Barrier Wall. In lieu of the groundwater collection systems, separate groundwater extraction systems have been installed along the East/South/West Barrier Wall at the PM-15, MW51-WD, and PM-11 areas on the east, and PM-4 area on the west, in response to localized outward hydraulic gradients at several locations along the East/South/West Groundwater Barrier Wall. The observations made during the Site inspection and the evaluation of water quality data for chemicals that are indicators of effectiveness show this remedy component to be functioning as intended by the decision documents.

FTPA Waste Pits: EPA has certified completion of construction or remedial action for all components of the selected remedy except for the FTPA waste pits, where remedial action is on-going. In August 2005, EPA issued a ROD Amendment for the FTPA waste pits. Implementation of the remaining remedial actions at the FTPA began in July 2006. These will include extraction of NAPL from within and immediately outside the north waste pit and south waste pit, placement of extracted liquids in on-Site temporary storage, and transportation of extracted liquids to an off-Site treatment facility. The selected remedy for the FTPA also includes maintenance of the existing cap on each waste pit, groundwater monitoring downgradient of the FTPA waste pits, and closure of the FTPA Treatment Cell. The observations made during the Site inspection and the evaluation of data contained in the status reports indicate that the remedy for the middle waste pit is functioning as intended and the remedy for the remaining waste pits is expected to achieve performance standards established in the ROD Amendment.

NBBW: Review of water level data indicates that an inward hydraulic gradient is present around the NBBW and therefore demonstrates that the NBBW is effective at containing the target groundwater (shallow groundwater migrating in the unnamed creek drainage in the alluvium, weathered Dawson, and upper unweathered Dawson). The inward hydraulic gradient imposed by pumping at the NBBW, coupled with the groundwater mounding caused by the injection trench, generate a groundwater divide to the north of the NBBW. This divide ensures that groundwater to the south of the divide does not flow off-Site to the north. Review of water level data, along with the observations made during the Site inspection indicate that the NBBW is functioning as intended by decision documents.

NTES: Trench water levels have remained below the base of alluvium since approximately March 2005, indicating that the NTES is effective at capturing highly-contaminated groundwater emanating from the toe of the landfill. Review of water level data, along with the observations made during the Site inspection indicate that the NTES is functioning as intended by decision documents.

Landfill Gas Remedy: Review of performance and compliance monitoring data, along with the observations made during the Site inspection indicate that the landfill gas remedy is functioning as intended by decision documents.

WTP: Review of performance and compliance monitoring data, along with the observations made during the Site inspection indicate that the WTP is functioning as intended by decision documents.

MW38 Gradient Control Contingency Measure: Review of water level data indicates that groundwater in the MW-38 channel is contained such that the hydraulic gradient is inward towards the channel throughout its entire length. This condition has been maintained since July 2004, the date of completion of the MW38 Area Pilot Test. The data indicate that the MW-38 extraction system is providing effective containment and is functioning as an effective contingency measure as intended by decision documents.

SWRA: During the five-year review inspection, erosion approximately one foot deep was noted in several areas along the surface cover of the drain, which is the present-day streambed of unnamed creek. The eroded areas have been since been repaired as part of routine operations and maintenance. Therefore, the SWRA is functioning as intended by decision documents.

Groundwater Monitoring Plan: The GWMP is effectively evaluating compliance with performance standards at the point of compliance and effectiveness of containment. The GWMP requires specific responses to be implemented in cases where containment is determined to be ineffective or compliance wells are determined to be out of compliance with performance standards. The GWMP is functioning as intended by decision documents.

Institutional Controls: Since the first five-year review, the WSDs developed an Institutional Controls Plan that was approved by EPA in 2002. In accordance with the "*Final Institutional Controls Plan Lowry Landfill Superfund Site" (September 2002),* the WSDs have developed a plan for performing a regular survey of wells constructed within ½ mile of the Site. This plan has been incorporated into the GWMP and a regular survey of wells constructed within ½ mile of the Site is now conducted by the WSDs. Additionally, Denver included language in the water decrees relative to the water rights within the Lower Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers underlying the on- and off-Site properties stating that (1) nothing in the Water Court's ruling or decree shall be construed to override or modify any of the restrictions imposed on the use of groundwater underlying the Site, and (2) in constructing and maintaining wells which penetrate more than one aquifer, Denver shall encase the wells with an impervious lining in accordance with applicable rules and regulations governing the construction of water wells to prevent potential cross-contamination between aquifers or withdrawal of groundwater from other aquifers. The institutional controls have resulted in appropriate restrictions on land and groundwater use both on-Site and off-Site. The institutional controls are functioning as intended by the decision documents.

Operations and Maintenance Costs: As discussed in Section IV, over the last five years annual operations and maintenance costs have averaged approximately $3.8 million. These costs are 18.8% higher than the operations and maintenance costs estimated in the ROD. However, based on other information reviewed, the higher-than-estimated operations and maintenance costs do not indicate potential remedy problems.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

Exposure Assumptions: The baseline risk assessment, summarized in the ROD, assumed future residential use of both the on-Site and off-Site areas. There have been no changes in the physical conditions of the Site. However, current restrictions on land and groundwater use on-Site and in certain off-Site areas indicate that the exposure assumptions used at the time of the ROD are no longer valid and were very conservative. Land use is now restricted by institutional controls over the entire on-Site area and in certain off-Site areas (described in Section III). Therefore, the exposure assumptions used at the time of the remedy selection do not represent the reasonably anticipated future land use under current conditions and are conservative.

Toxicity data: The toxicity values used at the time of remedy selection are still valid with the exception of that for acetone. In the case of acetone, the toxicity value for non-cancer effects, the oral reference dose (R_fD), was updated by EPA in July 2003. The updated oral R_fD for acetone is 0.9 milligrams per kilogram per day (mg/kg-day). At the time of remedy selection, the oral R_fD for acetone was 0.1 mg/kg-day.-day. The oral R_fD for acetone used at the time of remedy selection is considered to be protective since it is less than the currently accepted value.

Cleanup Levels: In the August 14, 1995 ESD, EPA established the following hierarchy for establishing performance standards:

> There are several risk-based groundwater performance standards whose values are less than those for Maximum Contaminant Levels (MCLs) or Colorado Basic Standards for Groundwater (CBSGWs). Risk-based standards are derived from slope factors and reference doses (RfDs). Slope factors estimate excess lifetime cancer risk associated with exposure to potentially carcinogenic contaminants. Slope factors are based on the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied. RfDs are used to indicate the potential for adverse health effects from exposure to contaminants exhibiting non-carcinogenic effects. RfDs are based on the results of human epidemiological studies or chronic animal bioassays. MCLs establish health-based standards for public drinking water systems. CBSGWs establish water quality standards for both classified and unclassified groundwater.
>
> Where an MCL or a CBSGW exists for a given contaminant, the MCL or CBSGW standard shall be met instead of the risk-based standard.

The August 14, 1995 ESD states the following about practical quantitation limits (PQLs):

> For those contaminants where the PQL exceeds the regulatory value, the PQL shall be the standard.

The September 30, 2002 Minor Modification of the ROD further states the following about PQLs:

> If the PQL is greater than the performance standard, then analyzing to the PQL is adequate to show the standard is achieved.

Performance standards for the indicator chemicals for compliance monitoring identified in the GWMP were compared to the performance standards identified in the September 30, 2002 Minor Modification of the ROD. Table 15 summarizes the result of this comparison.

Table 15: Comparison of Performance Standards from the GWMP and the September 30, 2002 Minor Modification of the ROD

Contaminant	Performance Standard from the September 30, 2002 Minor Modification of the ROD (ug/L)	Performance Standard identified in the GWMP (ug/L)
arsenic	52.18	52.18
cadmium	5.48	5.48
iron	2060	2060.4
nitrogen, nitrate	29100	29100
nitrogen, nitrite	1000	1000
1,1,1-trichloroethane	200	200
1,1,2,2-tetrachloroethane	0.055	1 *
1,1,2-trichloroethane	3	5 *
1,1-dichloroethane	990	990
1,1-Dichloroethene	7	7
1,2-dichloroethane	0.4	5 *
1,2-dichloropropane	0.56	5 *
1,4-dioxane	8	6.1
acetone	1600	1600
benzene	5	5
bromodichloromethane (BDCM)	0.3	1 (BDCM) & 80 (trihalomethanes (THMs)) *
bromoform	4	4(bromoform) & 80 (THMs)
carbon tetrachloride	0.3	5 *
chlorobenzene	100	100
Chloroform	6	3.5 (chloroform) & 80 (THMs) *
cis-1,2-dichloroethene	70	70
dibromochloromethane (DBCM)	0.42	14 (DBCM) & 80 (THMs) *
ethylbenzene	680	700 *
methylene chloride	5	5
naphthalene	6.2	140 *
tetrachloroethene	5	5
Toluene	1000	1000
trans-1,2-dichloroethene	100	100
Trichloroethene	5	5
vinyl chloride	2	2

*- Asterisk indicates current performance standard is different from performance standard established in September 30, 2002 Minor Modification of the ROD

Current groundwater performance standards identified in the GWMP for several organic contaminants appear to be different from the performance standards established in the September 30, 2002 Minor Modification of ROD for these contaminants and are highlighted with an asterisk in Table 15. Since the first five-year review for the Site, the WSDs have annually submitted to EPA and CDPHE updated PQLs for all contaminants. Table 16 compares the most recent PQL, the most current regulatory standards, and the performance standards identified in the September 30, 2002 Minor Modification of the ROD for those contaminants identified by an asterisk in Table 15.

Table16: Further Comparison of PQLs and Current Standards with Performance Standards Identified in the September 30, 2002 Minor Modification of the ROD

Contaminant	Performance Standard from the 2002 Minor Modification of the ROD (ug/L)	Performance Standard from the GWMP (ug/L)	Most Current CBSGW (ug/L)*	Most Current MCL (ug/L)	Most Current PQL (ug/L)	Basis of GWMP Performance Standard
1,1,2-trichloroethane	3	5	2.8-5	5	1	MCL
1,1,2,2-tetrachloroethane	0.055	1	0.18	NA	1	PQL
1,2-dichloroethane	0.4	5	0.38-5	5	1	MCL
1,2-dichloropropane	0.56	5	0.52-5	5	1	MCL
1,4 –dioxane	8	6.1	6.1	NA	5	CBSGW
BDCM	0.3	1	0.56	NA	1	PQL
carbon tetrachloride	0.3	5	0.27-5	5	1	MCL
chloroform	6	3.5	3.5	NA	1	CBSGW
DBCM	14	14	14	NA	1	CBSGW
ethylbenzene	680	700	700	700	1	CBSGW
naphthalene	6.2	140	140	NA	10	CBSGW

NA – Not Available
* Several of the CBSGWs are given in ranges

In the case of 1,1,2-trichloroethane, 1,2-dichloroethane, 1,2-dichloropropane, and carbon tetrachloride, the MCL is the basis for the performance standard in the GWMP for each of these contaminants. The current MCL is higher than the previous performance standard identified in the September 30, 2002 Minor Modification to the ROD. Likewise, the CBSGW has become the performance standard in the GWMP for chloroform, dibromochloromethane, ethylbenzene, and naphthalene. In the case of 1,4-dioxane, in September 2005, the State of Colorado established 6.1 ug/L as the new basic standard for groundwater for 1,4 dioxane. In 2005 -2006, the WSDs performed a Site-specific method detection limit study for 1,4-dioxane using a more sensitive analytical method. Based on the results of the method detection limit study, a new PQL of 5 ug/L has been established for 1,4 dioxane. Since the new PQL for 1,4-dioxane is less than the CBSGW for this chemical, the CBSGW of 6.1 ug/L is the current groundwater performance standard for 1,4 dioxane.

The performance standards for 1,1,2,2-tetrachloroethane and BDCM have been established at their respective PQLs since the PQL is greater than the performance standard for both chemicals.

This analysis verifies that the cleanup levels used at the time of remedy selection are still valid for organics. All of the performance standards for inorganics in groundwater are based on background concentrations. However, one of the designated background wells, MW05-WD, has recently been sampled as part of the North End Investigation. The contaminant 1,4 dioxane has been detected in a sample from this well at a concentration of 38 ug/L. This result suggests that MW05-WD may have been impacted by the Site and may not be an appropriate background well. However, the use of background levels as the basis for the cleanup levels for inorganics is still valid.

Remedial Action Objectives: The remedial action objectives used at the time of remedy selection are still valid.

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

No unacceptable ecological risks, natural disaster impacts, or other information have come to light that would call into question the protectiveness of the remedy.

Technical Assessment Summary

According to the data reviewed, the Site inspection, and the interviews, the remedy is functioning as intended by the ROD as modified by the Minor Modifications, ESDs, and ROD Amendment. There have been no changes in the physical conditions of the Site that would affect the protectiveness of the remedy. The remedial action at the FTPA is on-going and is expected to achieve performance standards. The other components of the Site-wide remedy have achieved and are expected to maintain performance standards with the exception of the selected remedy for OUs 1 and 6.

Performance standards are not currently achieved at all groundwater compliance monitoring locations. However, the GWMP, a component of the selected remedy for OUs 1 and 6, requires an investigation of the extent of the groundwater impacts and implementation of response actions to stop contaminant migration in cases where compliance monitoring wells are out of compliance with performance standards and there is a likelihood of off-Site migration of contaminated groundwater. These actions are ongoing and are expected to result in the achievement of groundwater performance standards.

By definition, a Case 3 condition results in uncertainty with respect to the protectiveness of the remedy. The subsequent North End Investigation was implemented to generate data to answer questions about the uncertainties. The data collected during the North End Investigation indicates there are no unacceptable risks associated with potential exposures to the levels found in groundwater and surface water, even using very conservative assumptions. Therefore, the data indicates the remedy for OUs 1 and 6 is protective. Section VI provides further explanation and a screening level risk assessment to support this determination can be found in Appendix C.

VIII. Issues

Based on the information reviewed during the second five-year review, the following issues were identified:

Table 17: Issues

Issues	Affects Protectiveness (Y/N)	
	Current	Future
Surface water monitoring has been performed since 1996 in accordance with the *"Final Interim Compliance Monitoring Plan" (February 1996)*. The interim compliance monitoring program for surface water was intended to provide a technical basis for development of a long-term surface water monitoring program to be implemented during and following remedial action at the Site. However, the current program has been in place since 1996 and has not been re-considered or developed into a long-term compliance monitoring program for surface water.	N	N
Recent groundwater sampling results indicate that monitoring well MW05-WD, designated as representative of background groundwater quality for inorganic contaminants, may have been impacted by the Site. The groundwater performance standards for inorganics were established based on background concentrations. It may be inappropriate to include groundwater quality data from well MW05-WD in the population of data used to calculate statistics on background levels of inorganics in groundwater in the vicinity of the Site. Groundwater quality data collected from an alternate monitoring well in the vicinity of MW05-WD may be more appropriate. This does not affect protectiveness since there is no current or reasonably anticipated future exposure via the drinking water pathway.	N	N
The chemicals 1,4 dioxane and nitrate have been detected at levels above performance standards in wells north of the Site outside the effective groundwater hydraulic control area of the NBBW. The GWMP, enforceable under the Consent Decree, contains provisions for investigating the extent of the groundwater impacts and for implementing response actions to limit contaminant migration and lower the concentrations of contaminants in groundwater. In accordance with the GWMP, a groundwater investigation has been implemented north of the Site and is ongoing. The investigation found 1,4-dioxane above performance standards in shallow groundwater and above State standards in surface water in Murphy Creek 2 ½ miles downstream of the Site. There is no current or reasonably anticipated future exposure to the impacted surface water or groundwater via the drinking water or vapor intrusion to indoor air pathways and the potential incidental exposures to surface water by nearby residents or recreational users such as golfers are not considered to be a public health threat. Response actions to limit migration and lower the concentrations of contaminants in groundwater are required by the GWMP and are ongoing as part of the implementation of the selected remedy.	N	N

IX. Recommendations and Follow-up Actions

Table 18: Recommendations and Follow-up Actions

Recommendations/ Follow-up Actions	Parties Responsible	Oversight Agency	Milestone Date	Follow-up Actions: Affects Protectiveness (Y/N)	
				Current	Future
Develop long-term compliance monitoring plan for surface water.	WSDs	EPA	9/30/2007	N	N
Evaluate the need to replace MW05-WD as a background well and if necessary, recalculate background concentrations for inorganics in shallow groundwater using data from samples collected from the replacement well as part of the background population.	WSDs	EPA	9/30/2007	N	N

X. Protectiveness Statements

OUs 1 & 6: Shallow Groundwater and Surface Liquids and Deep Groundwater

The remedy for OUs 1 and 6 is protective of human health and the environment. The remedy is functioning as intended by the decision documents. The GWMP component of the remedy for OUs 1 and 6 is functioning to identify areas where concentrations of Site-related chemicals are out of compliance with performance standards at the point of compliance and to evaluate the effectiveness of the groundwater containment features of the remedy. In addition, the GWMP requires the implementation of response actions in the event that it is determined that containment may not be effective or that groundwater is out of compliance with performance standards, assuring remedial action objectives will be met and maintained. The remedy for OUs 1 and 6 also contains contingency measures which may be implemented if performance standards are not met at the point of compliance. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection remain valid.

The North End Investigation and response action have been implemented as required by the GWMP. The extent of 1,4 dioxane in shallow groundwater north of the Site boundary has been determined. There are no uncontrolled exposure pathways that could result in unacceptable risks to human health and the environment. The data collected during the North End Investigation indicates there are no unacceptable risks associated with potential exposures to the levels found in groundwater and surface water, even using very conservative assumptions. Therefore, the data indicates the remedy for OUs 1 and 6 is protective.

No other information has come to light that could call into question the protectiveness of the remedy.

OUs 2 & 3: Landfill Solids and Landfill Gas

The remedy for OUs 2 and 3 is protective of human health and the environment. The remedy is functioning as intended by the decision documents. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection remain valid. No other information has come to light that could call into question the protectiveness of the remedy at OUs 2 and 3.

OUs 4 & 5: Soils and Surface Water and Sediment

The remedy for OUs 4 and 5 is protective of human health and the environment. The remedy is functioning as intended by the decision documents. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection remain valid. No other information has come to light that could call into question the protectiveness of the remedy for OUs 4 and 5.

Comprehensive Protectiveness Statement

Because the remedy for all six OUs is protective, the Site is protective of human health and the environment.

XI. Next Review

The next five-year review for the Lowry Landfill Superfund Site is scheduled to be completed by September 30, 2011.

FIGURES

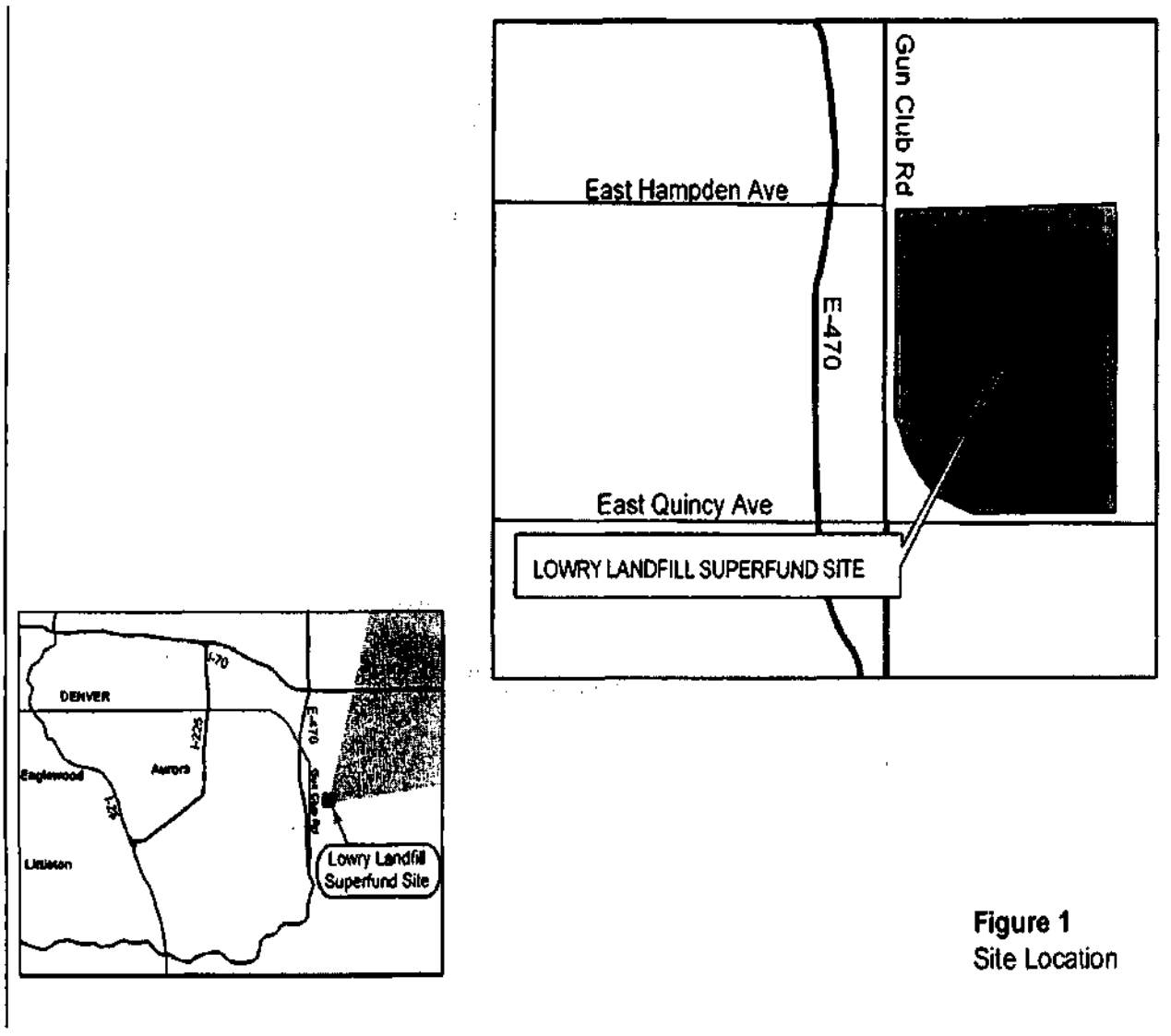

Figure 1
Site Location

Color Map(s)

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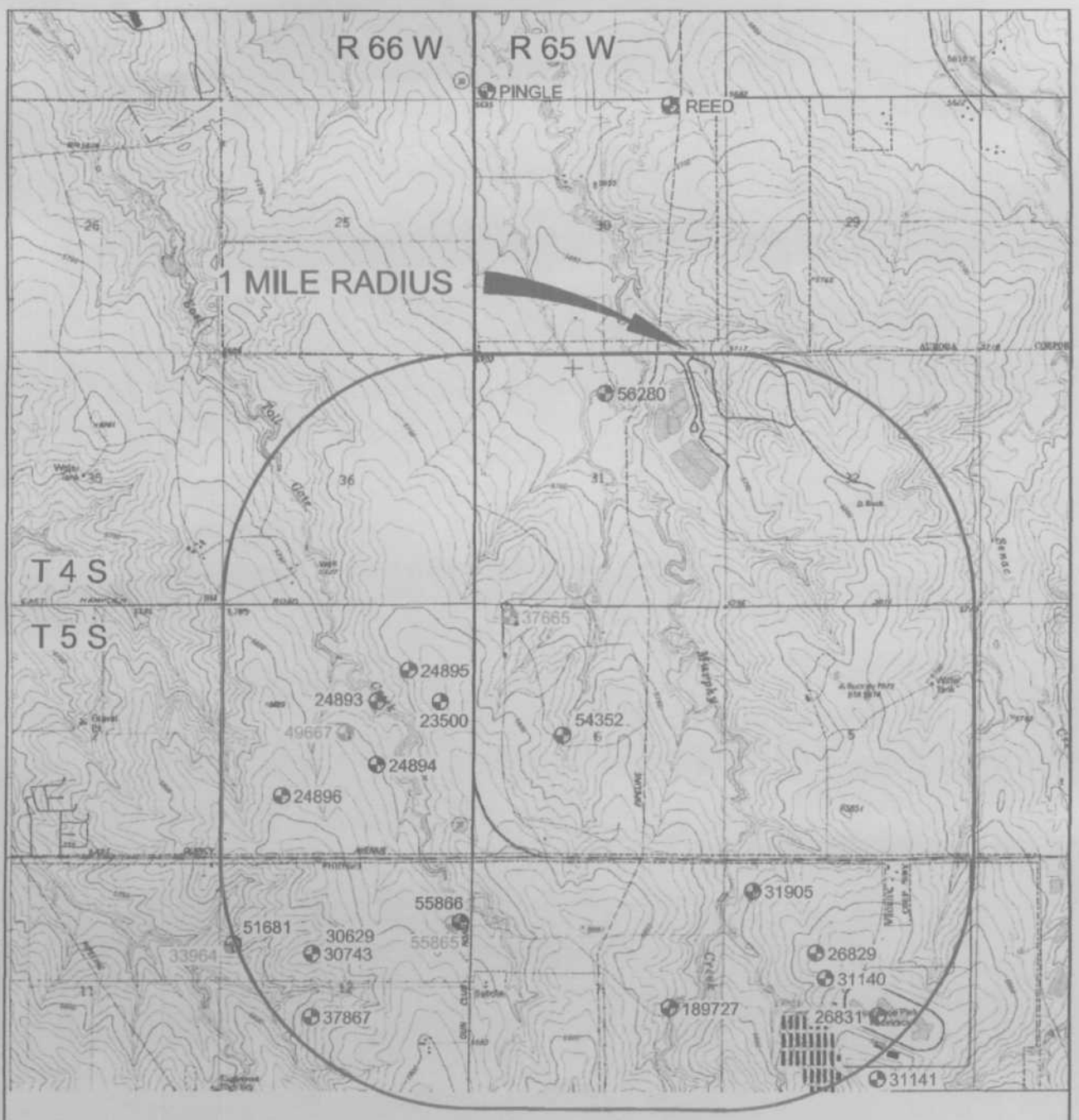

LEGEND

- KA - AQUIFER
- KLF - AQUIFER
- ? - AQUIFER
- TDW - AQUIFER
- TKD - AQUIFER

N

0 1500 3000

FEET

Figure 2

Private Water Wells
Within one Mile Radius of Lowry Land Fill

Arapahoe County, Colorado

EMSI Engineering Management Support, Inc.

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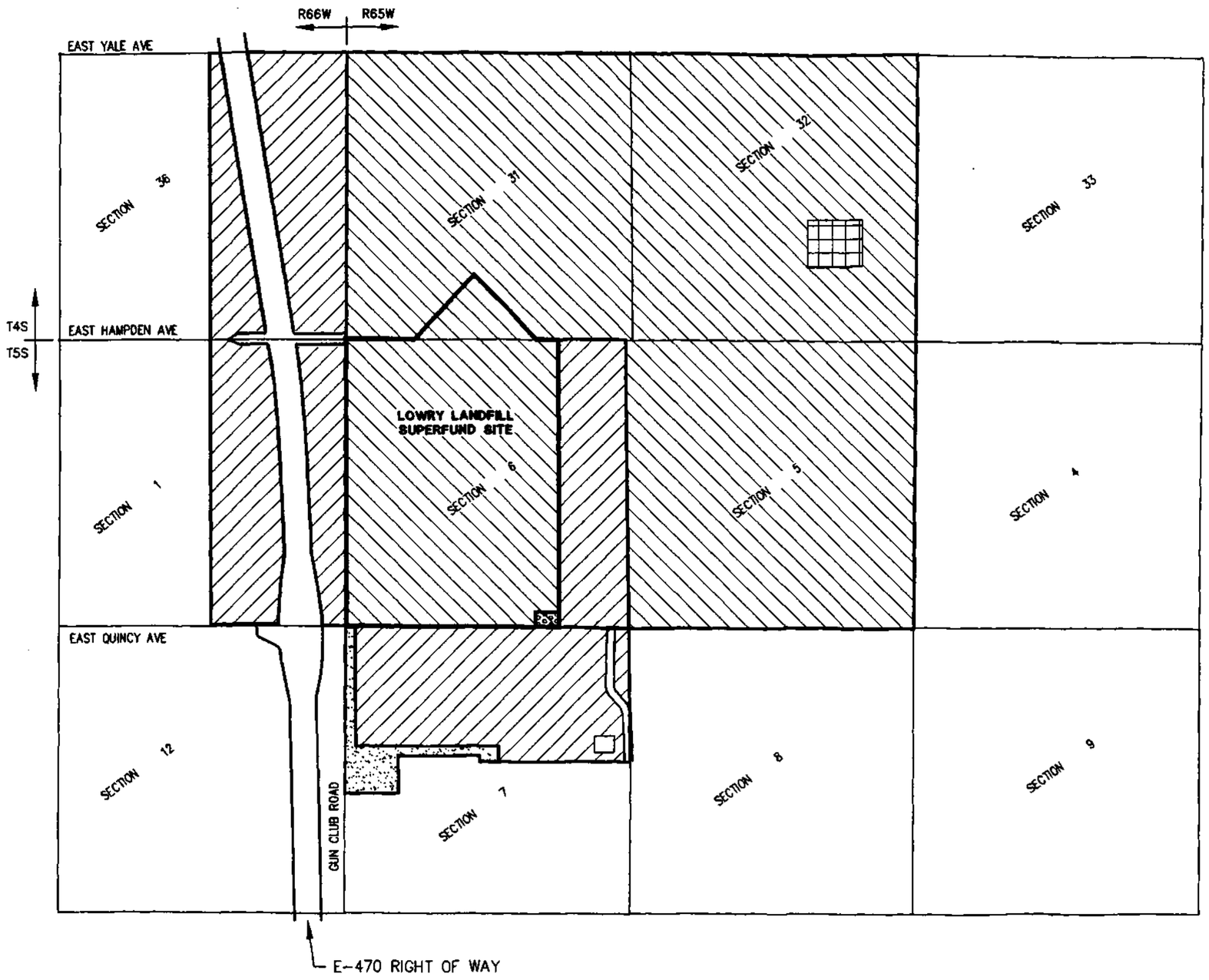

PROPERTY OWNERSHIP LEGEND

- CITY AND COUNTY OF DENVER
- LOWRY LANDFILL ENVIRONMENTAL PROTECTION/CLEANUP FUND
- PUBLIC SERVICE COMPANY OF COLORADO
- OTHERS
- COLORADO INTERSTATE GAS COMPANY
- WASTE MANAGEMENT, INC. PROPERTY
- E-470 RIGHT-OF-WAY

0 1000 2000 4000

SCALE: 1" = 2000'

FIGURE 3

PROPERTY OWNERSHIP MAP
LOWRY LANDFILL SUPERFUND SITE
(FEBRUARY, 2005)

Arapahoe County, Colorado

PARSONS

Denver, Colorado

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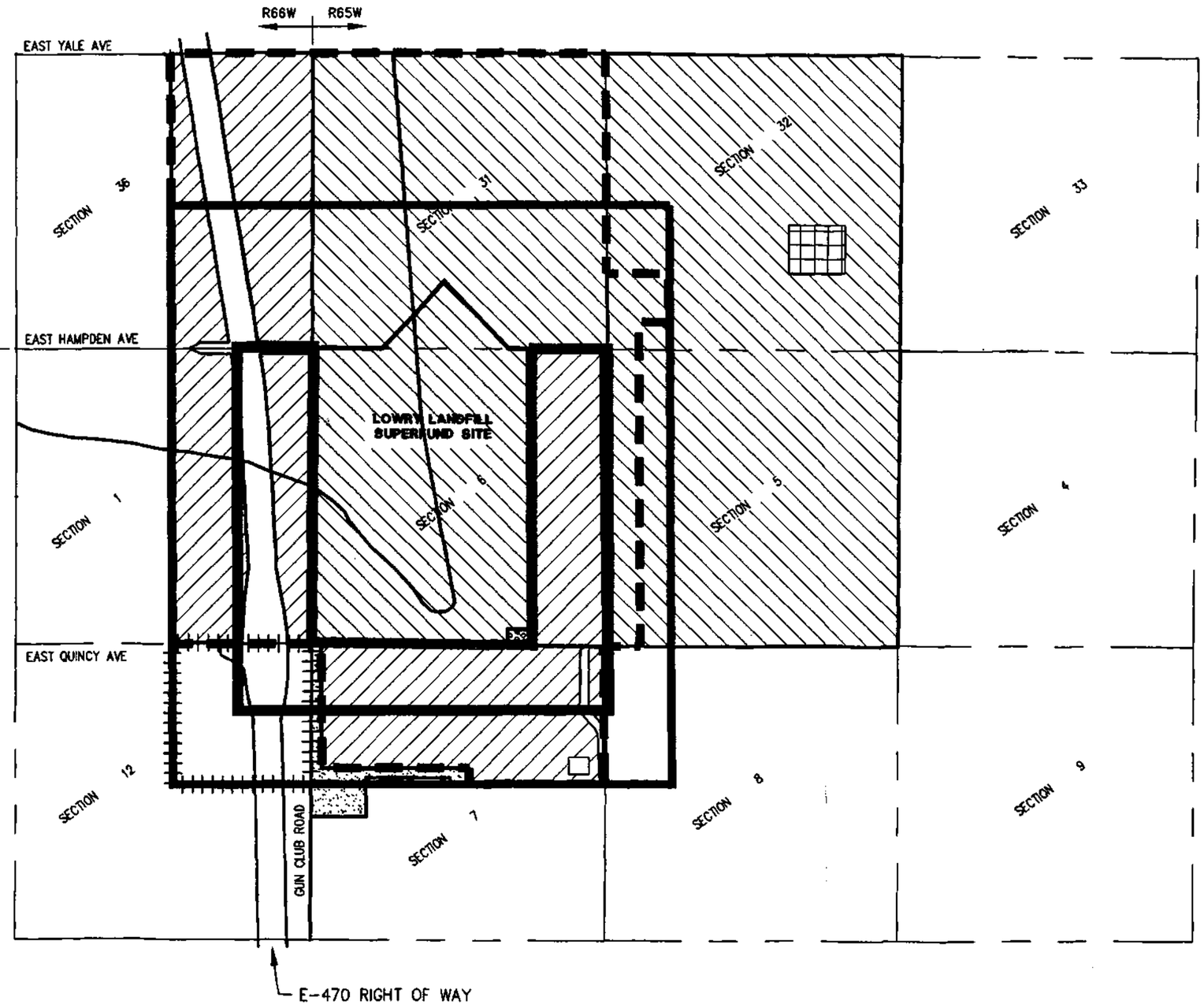

LEGEND

PROPERTY OWNERSHIP

- CITY AND COUNTY OF DENVER
- LOWRY LANDFILL ENVIRONMENTAL PROTECTION/CLEANUP FUND
- PUBLIC SERVICE COMPANY OF COLORADO
- OTHERS
- COLORADO INTERSTATE GAS COMPANY
- WASTE MANAGEMENT, INC. PROPERTY

INSTITUTIONAL CONTROLS

- LAND USE AND GROUNDWATER USE RESTRICTIONS IN DAWSON AND DENVER AQUIFERS
- GROUNDWATER USE RESTRICTIONS IN DAWSON AND DENVER AQUIFERS
- BUCKLEY LDN 60 (DAY-NIGHT AVERAGE SOUND LEVEL)
- AURORA ORDINANCE 93-98 WATER USE RESTRICTIONS
- AURORA ORDINANCE 93-98 LAND USE RESTRICTIONS

0 1000 2000 4000

SCALE: 1" = 2000'

FIGURE 4

PROPERTY OWNERSHIP, INSTITUTIONAL CONTROLS, AND LAND USE RESTRICTIONS LOWRY LANDFILL SUPERFUND SITE (FEBRUARY, 2005)

Arapahoe County, Colorado

PARSONS

Denver, Colorado

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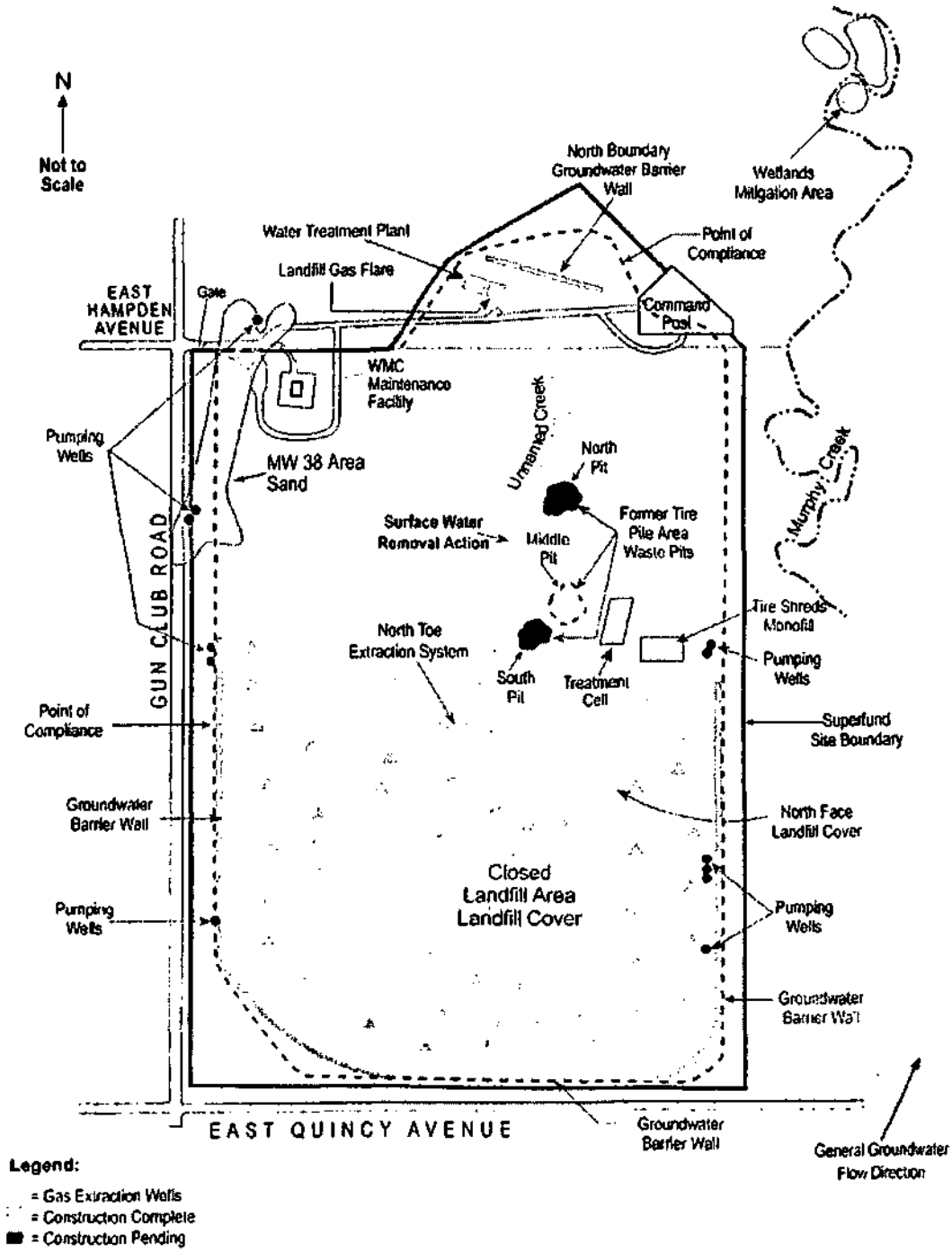

Figure 5: Site-wide Remedy Components

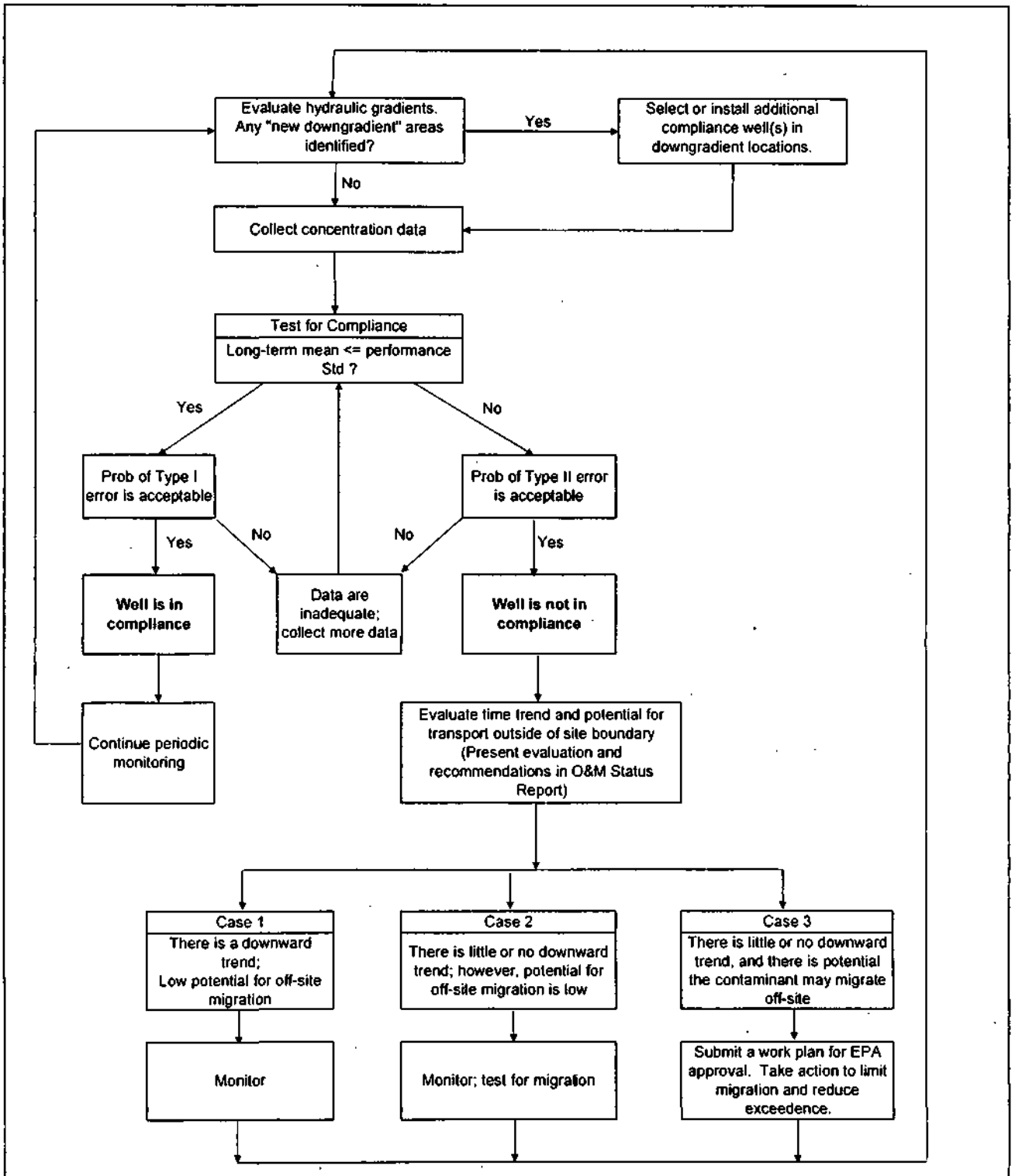

Figure 6

Decision Tree for Evaluation of Groundwater Compliance Monitoring Data

Lowry Landfill Superfund Site

EMSI Engineering Management Support, Inc.

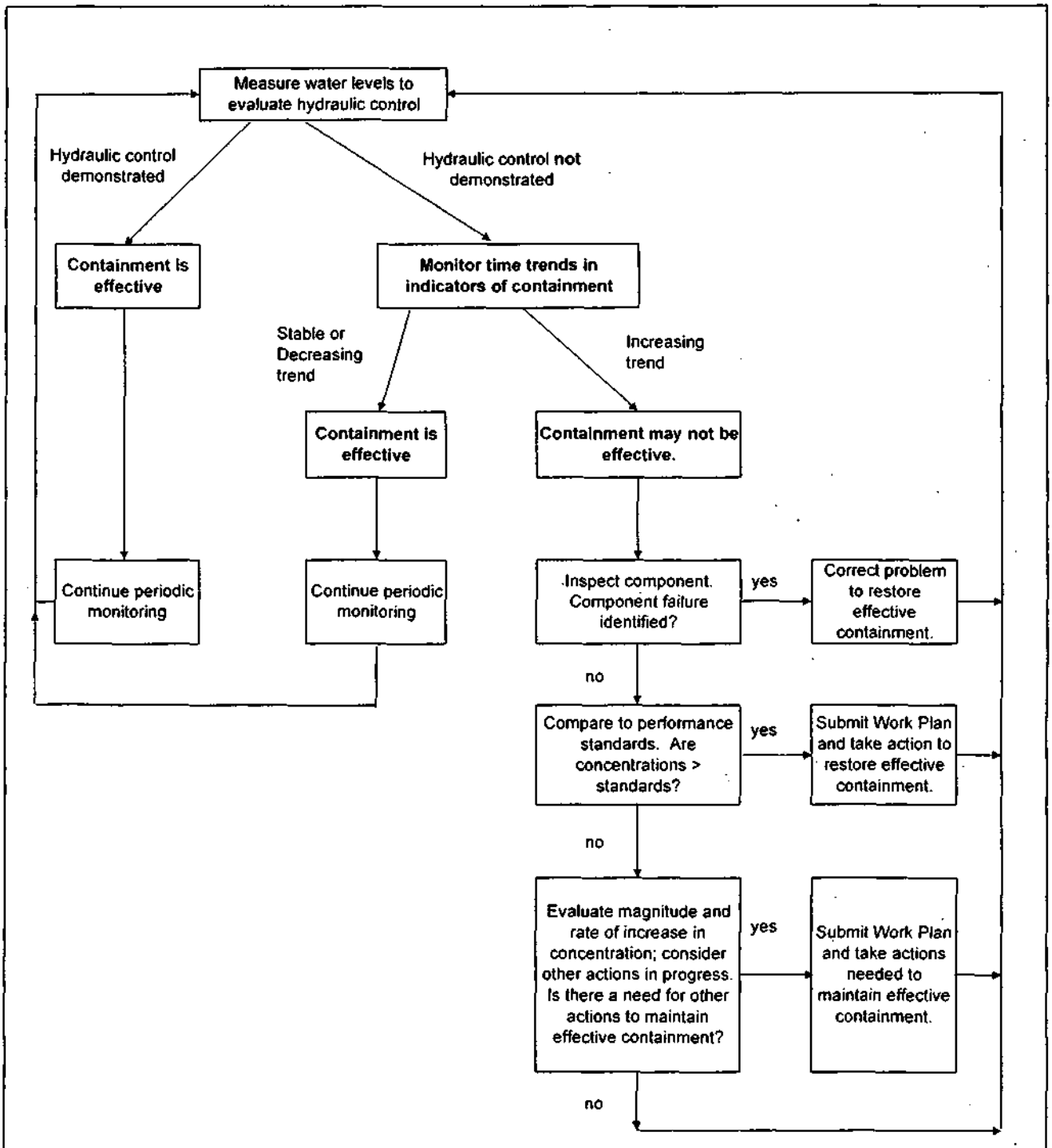

Figure 7

Decision Tree for Evaluation of Effectiveness of Groundwater Containment Components

Lowry Landfill Superfund Site

EMSI Engineering Management Support, Inc.

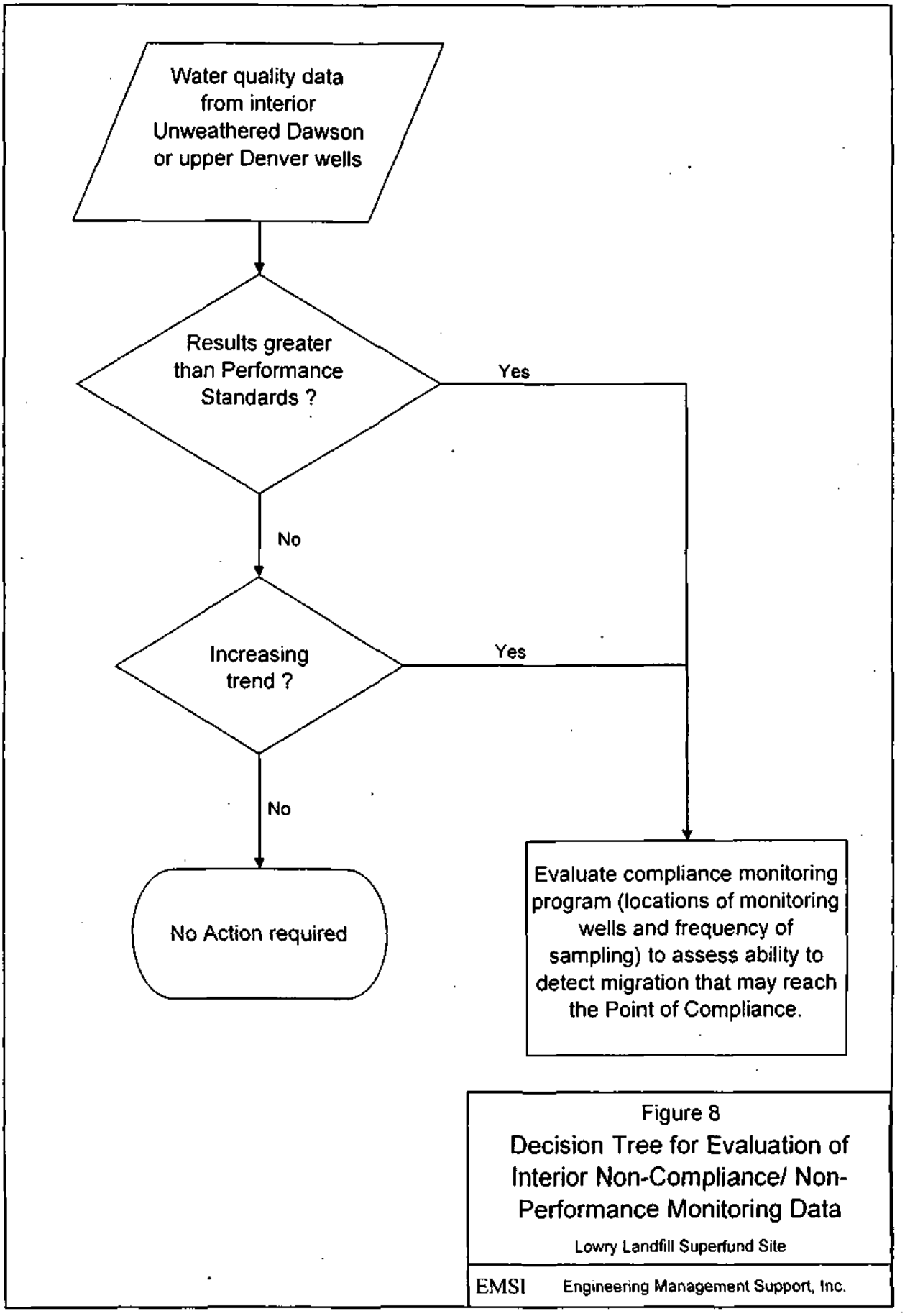

Figure 8

Decision Tree for Evaluation of Interior Non-Compliance/ Non-Performance Monitoring Data

Lowry Landfill Superfund Site

EMSI Engineering Management Support, Inc.

Injection Trench

NBBW

Note: The water elevation value for the fully penetrating well when twinned by a partially penetrating piezometer was honored for contouring

N

0 37.5 75 150 225 300 Feet

1 inch equals 150 feet

Legend

- Potentiometric Surface (dashed where inferred)
- Injection Trench
- Groundwater Monitoring Well
- Compliance Wells highlighted with blue
- Zone of Containment
- NBBW

FIGURE 9
NBBW AREA
WEATHERED DAWSON
POTENTIOMETRIC SURFACE

3 APRIL 2006

O&M Status Report - 2nd Quarter 2006
Lowry Landfill Superfund Site

PARSONS
Denver, Colorado

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Color Chart(s)

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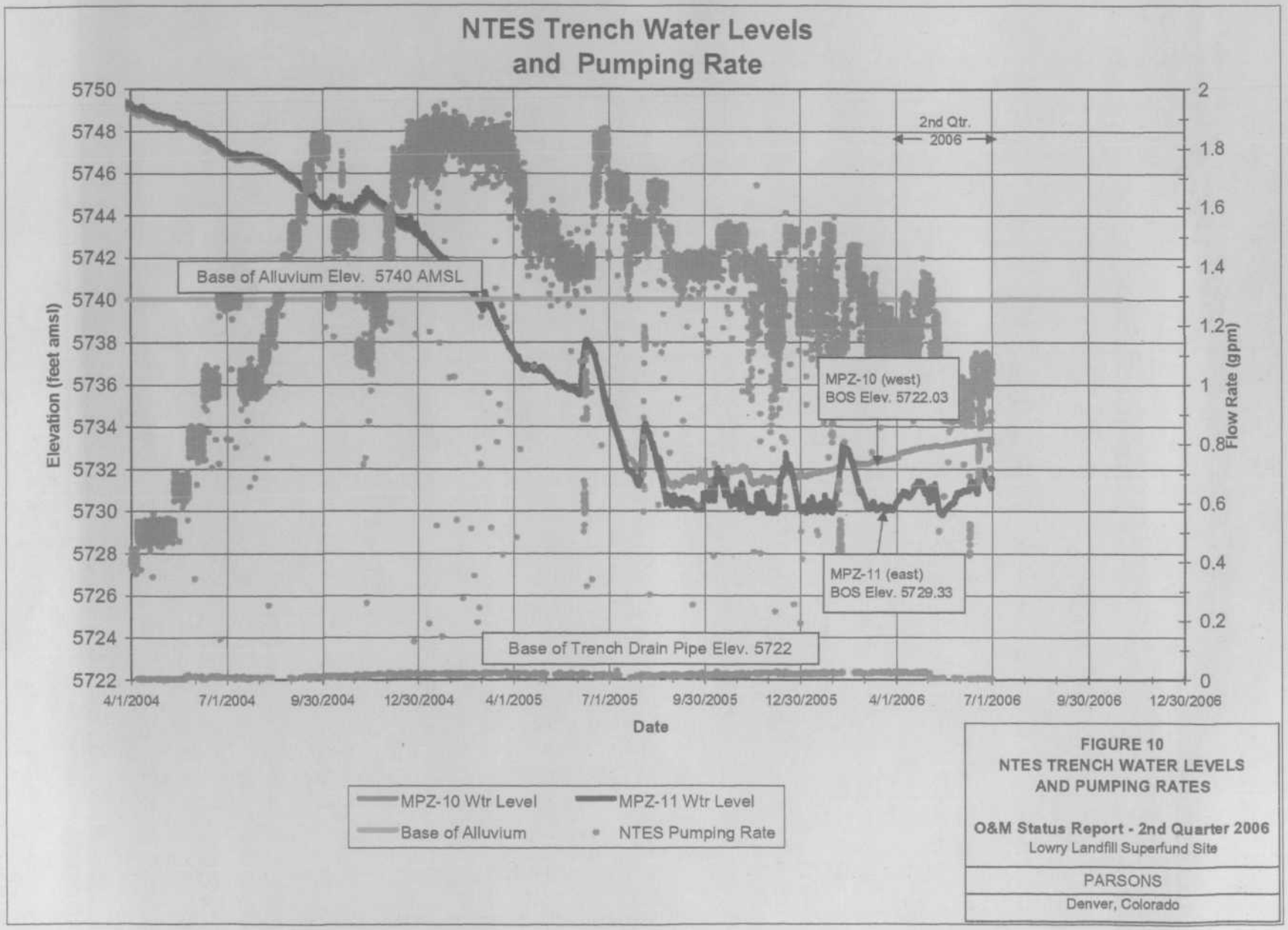

FIGURE 10
NTES TRENCH WATER LEVELS AND PUMPING RATES

O&M Status Report - 2nd Quarter 2006
Lowry Landfill Superfund Site

PARSONS
Denver, Colorado

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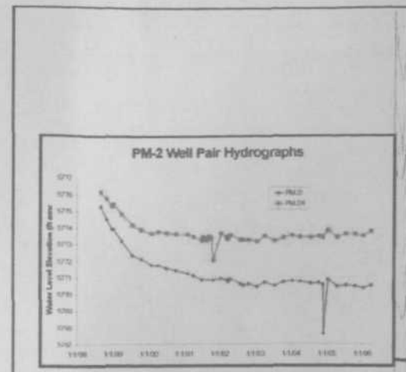

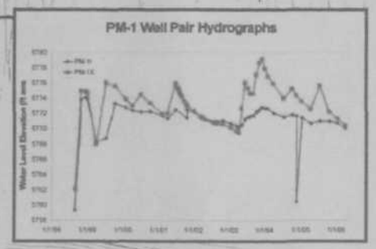

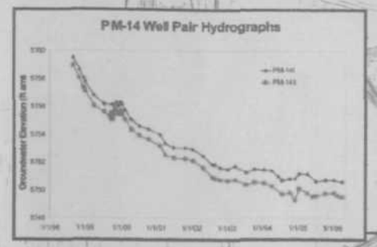

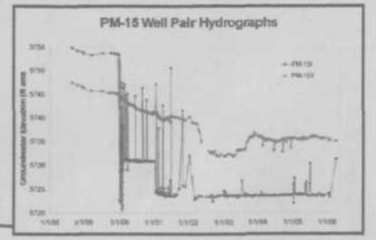

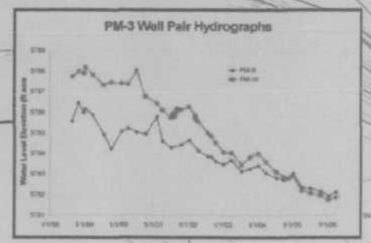

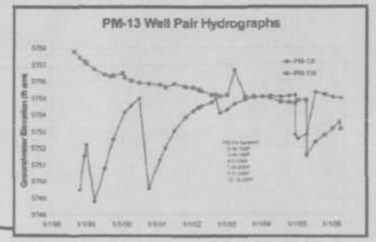

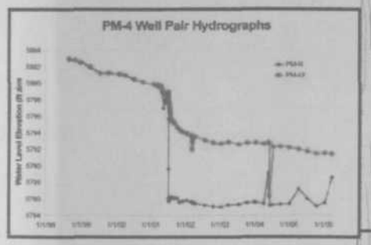

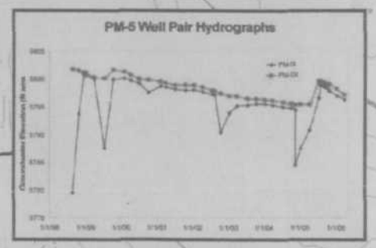

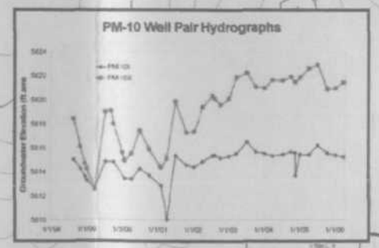

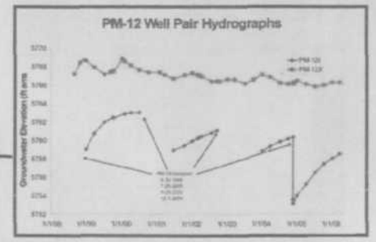

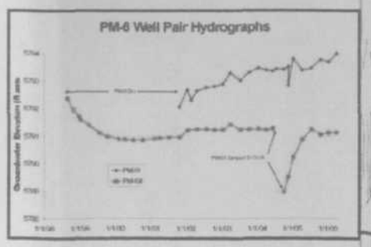

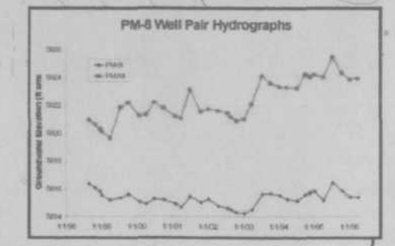

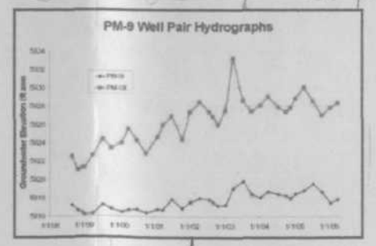

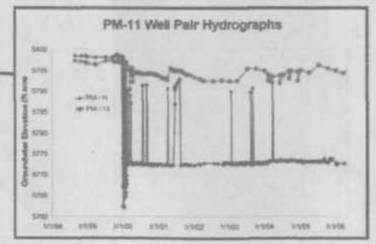

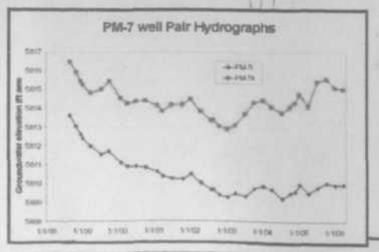

PM-1X PM-1I PM-2X PM-2I PM-3X PM-3I PM-4X PM-4I PM-5X PM-5I PM-6X PM-6I PM-7X PM-7I PM-8X PM-8I PM-9X PM-9I PM-10X PM-10I PM-11X PM-11I PM-12X PM-12I PM-13X PM-13I PM-14X PM-14I PM-15X PM-15I

SLURRY WALL

Legend

PM-14X Hydraulic gradient monitoring well

Exterior well hydrograph

Interior well hydrograph

0 200 400

FEET

N

Figure 11

Perimeter Slurry Wall
Well Pair Hydrographs

Lowry Landfill Superfund Site
Arapahoe County, Colorado

EMSI Engineering Management Support, Inc.

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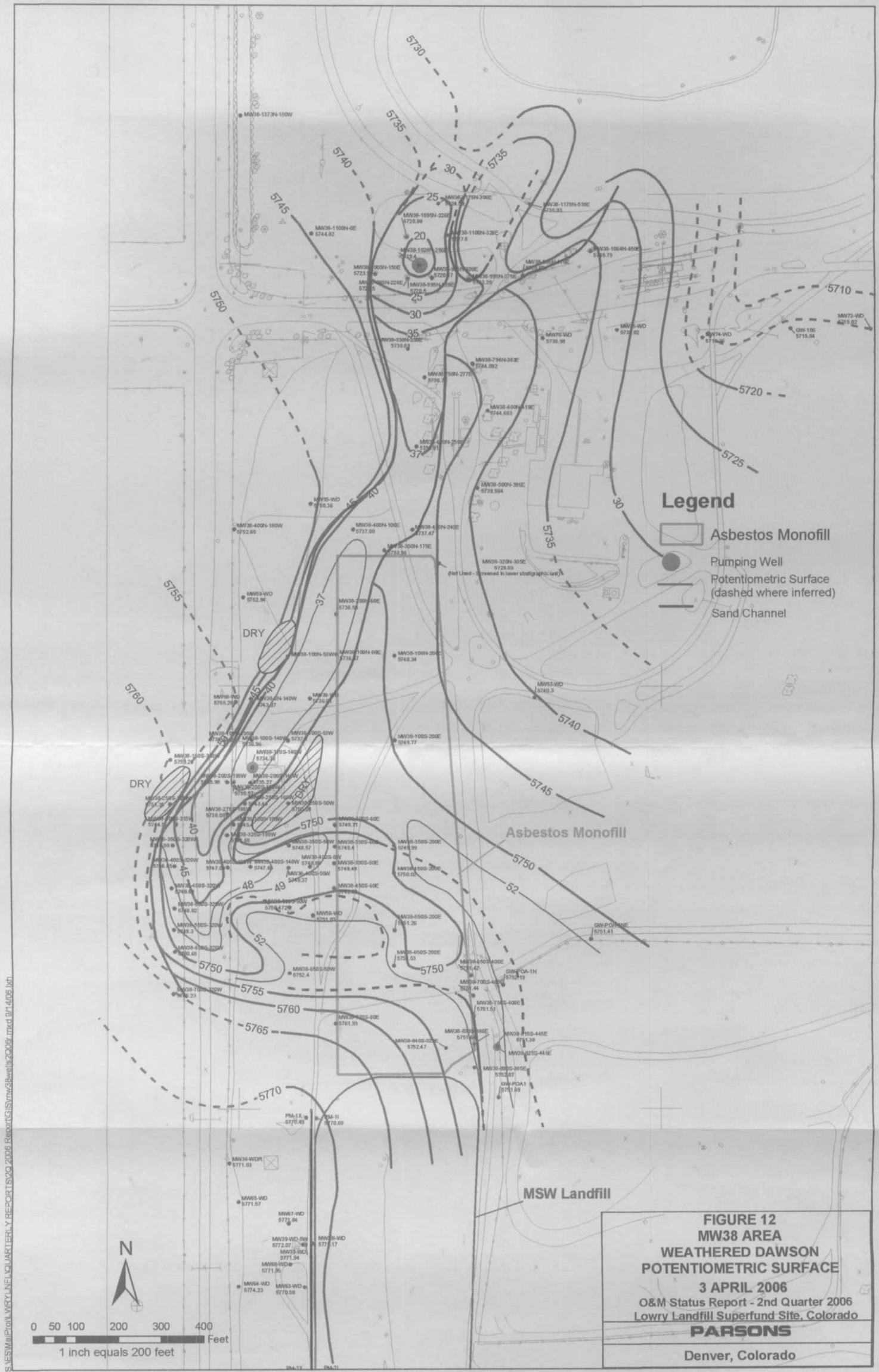

FIGURE 12
MW38 AREA
WEATHERED DAWSON
POTENTIOMETRIC SURFACE
3 APRIL 2006
O&M Status Report - 2nd Quarter 2006
Lowry Landfill Superfund Site, Colorado
PARSONS
Denver, Colorado

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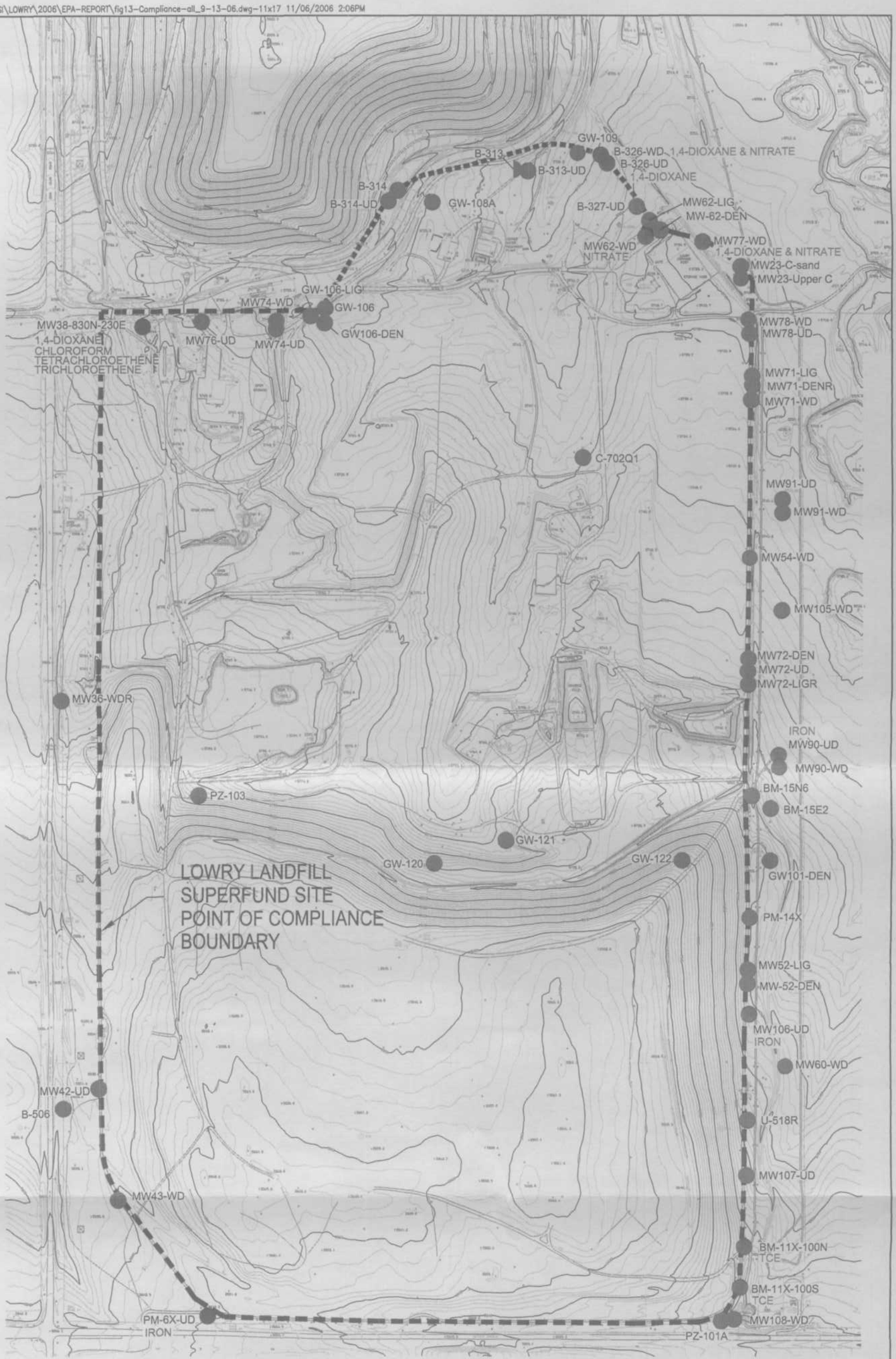

Legend

- In Compliance
- In Compliance except Insufficient Data to assess 1,4 Dioxane Compliance
- Out-of Compliance
- IRON Compounds Exceeding Performance Standards

N

0 250 500
FEET

Figure 13
Groundwater Compliance
With Performance Standards
2nd Quarter 2006
Lowry Landfill Superfund Site
Arapahoe County, Colorado

EMSI Engineering Management Support, Inc.

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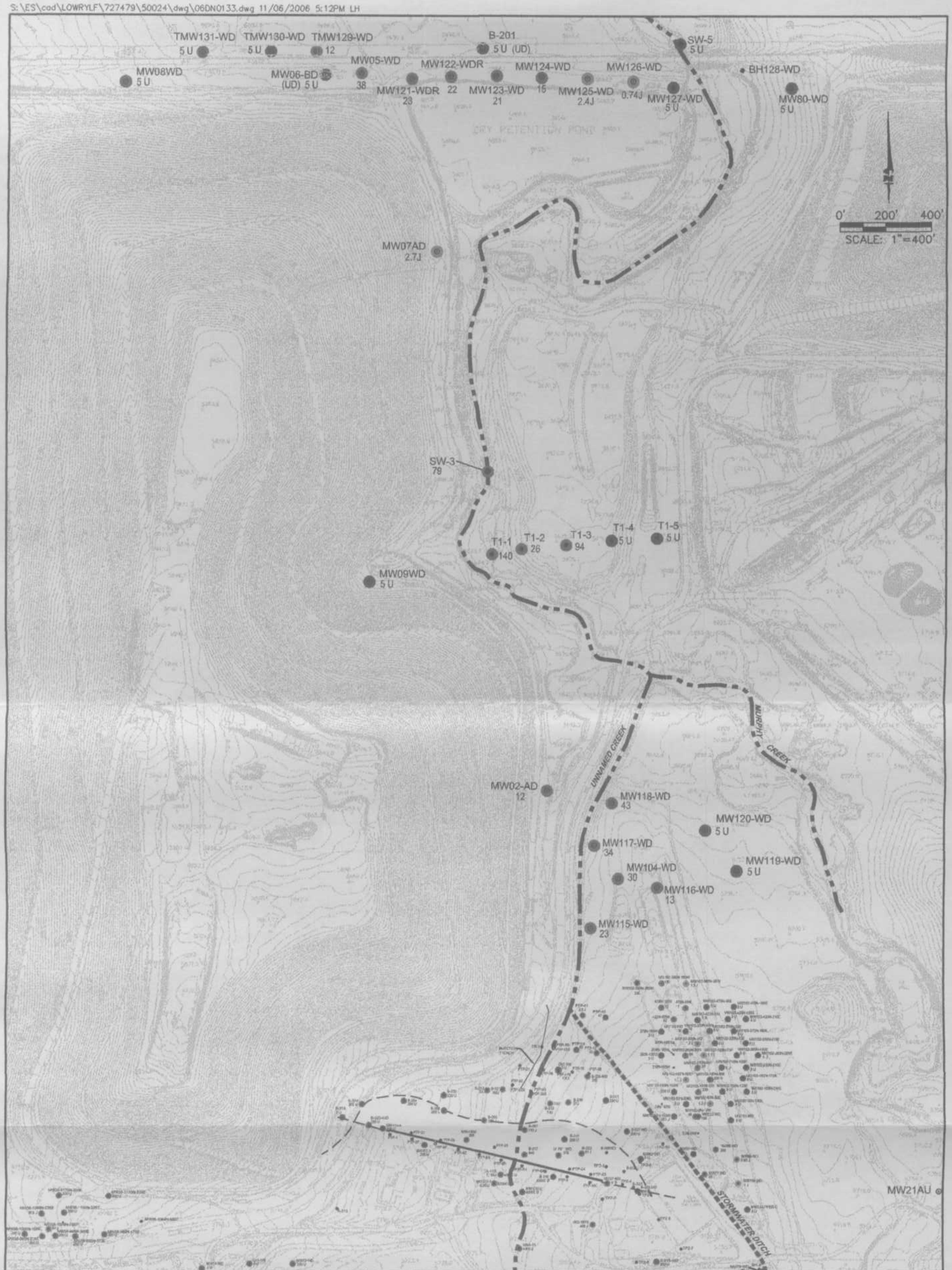

LEGEND

- ⊙ GROUNDWATER MONITORING WELL
- • DIRECT-PUSH GROUNDWATER SAMPLE LOCATION
- \+ ABANDONED PIEZOMETER
- (UD) = UNWEATHERED DAWSON
- ZONE OF CONTAINMENT

ANALYTICAL RESULTS FROM MOST RECENT SAMPLING EVENT

- NO 1,4-DIOXANE (14X) DETECTED
- DETECTED 14X < 6.1 µg/L PERFORMANCE STANDARD
- DETECTED 14X > 6.1 µg/L PERFORMANCE STANDARD
- J = ESTIMATED VALUE
- U = UNDETECTED

FIGURE 14

1,4-DIOXANE RESULTS MAY 1, 2006

No. End Investigation
Lowry Landfill Superfund Site, Colorado

PARSONS

Denver, Colorado

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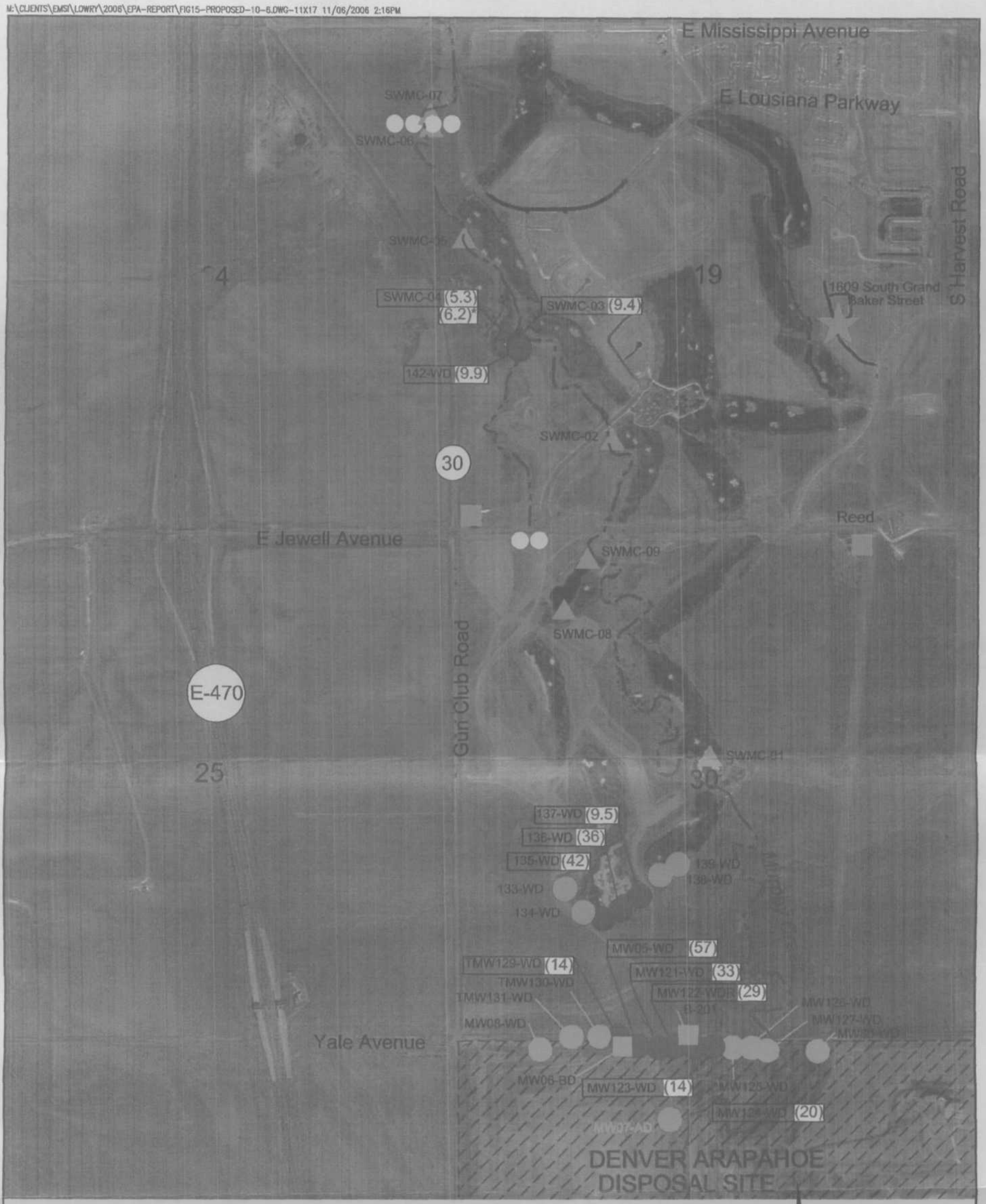

Preliminary

Legend

- ▲ Surface Water Samples With 1,4 Dioxane > 6.1 µg/L Standard (6.2)
- △ Surface Water Samples With 1,4 Dioxane < 6.1 µg/L Standard
- ● Shallow Groundwater With 1,4 Dioxane > 6.1 µg/L Standard (57)
- ○ Shallow Groundwater With 1,4 Dioxane < 6.1 µg/L Standard
- ■ Unweathered Dawson or Deeper Groundwater < 6.1 µg/L Standard
- ★ Private Residence Tap Water Samples < 6.1 µg/L Standard
- Proposed New Well (Subject to Access Acquisition)

* 6.2 µg/L value from sample collected on 3/30/06

N

1000 0 1000

SCALE IN FEET

Figure 15

Status of North End Investigation
October 6, 2006

Lowry Landfill Superfund Site

EMSI Engineering Management Support, Inc.

APPENDIX A

Lowry Landfill Superfund Site
Community Involvement Plan Update
Interview with CLLEAN March 23, 2006

Attendees:
Nancy Mueller/EPA
Angus Campbell/CDPHE
Marion Galant/CDPHE
Bonnie and Richard Rader/CLLEAN
Fred Mould/CLLEAN
Meeting notes by: Jane Koewing/CH2M HILL (consultant to EPA)

Nancy Mueller opened the discussion by noting that the purpose of the interview is to obtain feedback from the Citizens for Lowry Landfill Environmental Action Now (CLLEAN) for the Second Five-Year Review to be completed by September 30, 2006. The interview will also identify concerns for the Community Involvement Plan (CIP) Update. EPA updates the CIP periodically to identify changes and community concerns pertaining to the Lowry Site. Copies of the interview questions were distributed to the group and CLLEAN's responses to the questions are below.

Bonnie Rader noted that CLLEAN had recently hired a new technical consultant. (CLLEAN is the recipient of an EPA Technical Advisory Grant to review activities at the Lowry Site.) CLLEAN submitted his resume and contract information to Linda Armor at EPA for review.

CLLEAN distributed written comments summarizing their responses to the three questions that EPA and the State use during the Five-Year Review to determine protectiveness of the site remedy. The comments were compiled from discussions among CLLEAN members and represent a consensus among the group. CLLEAN's comments are attached to this summary. Bonnie Rader read the Five-Year Review questions and used the questions as a basis for further discussion during the meeting.

1. Is the remedy working as intended by the decision documents?
2. Are the exposure scenarios, toxicity data, cleanup levels and Remedial Action Objectives (RAOs) used at the time of the remedy still valid?
3. Has any new information come to light that could call into question the protectiveness of the remedy?

CLLEAN does not believe that the criteria used to select the remedy in the 1994 Record of Decision (ROD) and subsequent decision documents are still valid. They think there is a lot of new information as the result of new data. CLLEAN hopes that EPA will revisit the

remedy during the Second Five-Year Review. They would like EPA to review performance standards and ARARs and to evaluate whether the risk and exposure assumptions used in the ROD may have changed in light of exceedances of performance standards that have occurred since the last review. CDPHE said that EPA issued a ROD amendment in 2005 addressing changes to the Former Tire Pile Area waste pit remedy. CLLEAN would also like to see these remedial action objectives reviewed.

CLLEAN is concerned that containment may be failing at this Site and would like to see innovative technologies used for remediation. They believe that there are new technologies that may not have been available at the time decisions were made for the ROD, over ten years ago. CLLEAN would like EPA and CDPHE to revisit the ROD to determine whether the sitewide remedy (especially the containment components) is protective. CLLEAN is concerned about the potential for downward migration of contaminants to deeper aquifers used for drinking water.

Bonnie Rader expressed concerns about the detections of 1,4-dioxane and nitrates. CLLEAN is concerned about potential risks and exposure scenarios from elevated contaminants to the north of the site. They realize that the source of the contamination needs to be evaluated and verified but they believe that contamination outside of the Compliance Boundary represents the failure of the containment remedy. They are also concerned about detections of chlorinated solvents in deeper wells at the site.

CLLEAN is pleased that the City of Denver and Waste Management of Colorado, Inc.,(the Work Settling Defendants or WSDs) are testing two offsite wells in the neighborhood for contamination and that Tri-County Health Department is also collecting samples from those wells. CLLEAN commented that the WSDs agreed that if the wells show exceedances of 1,4- dioxane they will conduct additional tests for VOCs. CLLEAN asked to see the results of previous homeowner well samples (taken in 1995 at different offsite wells). Nancy said that EPA will try to locate those results and provide them to CLLEAN.

CLLEAN would like EPA to review the Site performance standards in conjunction with the Second Five-Year Review. Angus Campbell said that the standards and the Applicable or Relevant and Appropriate Requirements (ARARs) will be reviewed during the review. After the first Five-Year Review, EPA issued a minor-modification to the ROD to address changes to performance standards identified during the review, CLLEAN indicated that the nitrate standard is higher on the Lowry Site than at the Denver Arapahoe Disposal Site (DADS) , the active landfill to the north of the Site. CDPHE commented that the Lowry Site performance standard was based on the results from background wells. DADS used more conservative standards. CLLEAN would like the Site nitrate performance standards to be reevaluated in the Five-Year Review and to be revised to be consistent with the standards used at DAD.

CLLEAN noted that the area has changed from rural to urban. Aurora is surrounding the Site. People buying property in the area don't know the dangers of the Superfund Site. Developers do not inform potential buyers of potential impacts from the Site. CLLEAN remarked that the Lowry Sitewide remedy is containment, and is not really a cleanup. While they agree that the slurry walls have slowed down the migration of chemicals offsite, they believe that containment should not be considered a permanent remedy.

CLLEAN's answers to the interview questions distributed at the meeting are summarized below:

How long have you lived in the vicinity of the Lowry Landfill Superfund Site?

Fred Mould lives 3 miles north of the Site in Gun Club Estates. Richard and Bonnie Rader live about 4 miles to the north of the Site in Thunderbird Estates. Bonnie commented that Bob and Lora Atwood were unable to attend the meeting but had provided input into CLLEAN's written comments. Bonnie lived in the neighborhood from the early 70s through 1981. At that time, the chemicals from the pits carried in the air to their homes. They could taste the chemicals and their eyes would be covered with film because chemicals were so thick in the air. The people who lived closest to the Site were the most affected by the air quality. Some people had heart problems that were affected by air quality. Bonnie's son had bronchial pneumonia with no fever and severe asthma that abated when the pits were covered. Her family experienced severe nosebleeds, tingling hands and feet, headaches, and depression. The smell of chemicals from the waste pits was unique; therefore, they could distinguish between odors from the waste pit chemicals, the brine ponds, and the sewage sludge. Richard Rader has lived in the area for about 12 years.

Have you noticed any impacts to your neighborhood from Site operations?

CLLEAN is concerned about exceedances from the MW 38area and in the north area outside of the Point of Compliance They are also concerned about contaminants in deep wells such as B712 and are worried that the Site may act as a conduit for contaminants to migrate downward. They are worried about both the horizontal and vertical migration of contaminants from the Site.

Have you seen the Lowry Superfund Site signs and are you aware of Site access restrictions?

CLLEAN appreciates the signs and access restrictions and thinks it is important that the community be aware of the Superfund Site. CLLEAN would like the signs at the north of the Site to clearly indicate that it is a Superfund Site. They said that people moving into Murphy Creek and other subdivisions may not be aware that the Superfund Site is close to the developments.

Is there anything going on at the Lowry Site that worries you or have you heard about any concerns from your neighbors?

CLLEAN is concerned that developers do not inform new residents about the Superfund Site. CLLEAN is not often contacted by new community members but occasionally receives calls from concerned citizens. They think that homeowners in the area may become concerned about property values as a result of their proximity to the Superfund Site.

Some methods used in the past to keep the community informed about the Lowry Site include, mailings, newspaper notices, updates, fact sheets, public meetings, open houses, neighborhood presentations, or HOA meetings. What do you think are the best ways to keep you and the community informed about this Site?

Bonnie Rader suggested that EPA and CDPHE hold a public meeting in Murphy Creek and invite CLLEAN, neighborhood HOAs, and other agencies to disseminate information about the exceedances as soon as possible. CLLEAN would like to be involved at the meetings but thinks that EPA and CDPHE should take the lead on conducting the meetings. It would be good to show cooperation between the citizens' group and the agencies providing oversight at the Site.

They think it is important to have a public meeting to explain the results of the additional north end investigations currently being conducted by the PRPs and to explain the significance of exceedances of 1,4-dioxane and nitrates in the vicinity of the new development. It was suggested that names of people who buy homes in the neighborhood could be obtained from the county and added to the mailing list.

Have you attended any public meetings or open houses for the Lowry Site? If so, do you think they provided useful information and materials? Do you have any ideas to improve Site meetings or additional information you would like to see provided?

CLLEAN thinks that EPA's community involvement program and site meetings are informative. They would like to see more interest from the residents of new developments in the area and would like the mailing list to be expanded to include new residents.

Bonnie Rader noted that sometimes when new residents contact EPA or CDPHE, they comment that it is difficult to get routed to the correct parties to provide information about the Lowry Site. Calls can be misrouted by the switchboard or electronic messaging systems. In addition, there can be confusion because there are several projects with Lowry in the name such as the Lowry Bombing Range, the Former Lowry Air Force Base, the Lowry Redevelopment area etc. Nancy Mueller and Marion Galant said they would look into how calls are routed to see if the system can be improved and make sure that contact information is clearly provided on the project web site.

Do you have any ideas for meeting places in this area to hold meetings or open houses?

CLLEAN suggested the clubhouse in the Murphy Creek subdivision as well as the new elementary (K-8) school a few blocks north of Yale. Bonnie Rader said that simple community meetings or open houses similar to meetings held at the command post or neighborhood schools work well.

Would you like to have your name on the mailing list to receive mailings with information and updates about the Lowry Site? (Site mailing lists are confidential and not used for other purposes.)

CLLEAN is included on the mailing list. They would like to see the mailing list expanded to include residents of the new developments. Nancy Mueller said that the list has been expanded several times to include new residents and homeowner associations.

Do you have any other questions or comments about the Lowry Site and operations or activities there?

CLLEAN commented that it may take years to demonstrate that the containment remedy is failing. CLLEAN said that they are concerned that the agencies will wait until there is a documented problem rather than avoid problems with more aggressive remediation. If it takes twenty years to demonstrate that there are exceedances beyond the point of compliance, and that these exceedances are indicative of non-containment, the problem may be more difficult to address than if more proactive measures are taken to avoid problems. CLLEAN hopes that t the Five-Year Review may result in more proactive methods to assure protectiveness at this Site. CLLEAN does not believe that the remedy is protective and hopes this will be shown in the next Five-Year Review. They said that covering the wastes in the waste pits with a cap may be masking problems. While CLLEAN agrees that it was important to close the waste pits for safety and health issues, they hope that the agencies will use the Five-Year Review as an opportunity to revisit the protectiveness of the sitewide remedy to protect the aquifers beneath the site.

CLLEAN said that the air emissions are better than when the waste pits were open and it is good that people are monitoring the situation at the Site. However, they believe that if containment is failing, there are ramifications for the community. CLLEAN is also concerned that Denver and WMC continue to start new activities such as treating gas from DADS and the landfill cover using construction and demolition debris that allow the Site that serve to feed the activities of DADS Site into the Superfund Site. The agencies and communities find out about problems and activities after the fact. Bonnie Rader noted that the WMDs are collecting gas from Section 31. Their goal appears to be to make money from the Superfund Site and not to put back money into the Site for cleanup.

Have you heard of anyone else who would like to talk to EPA or who has questions about the Lowry Superfund Site?

CLLEAN suggested that it would be a good idea for EPA to contact the owners of the properties where the wells are being sampled and it might also be good to talk to the Murphy Creek homeowners association. It is important to tell the community about the detections of 1,4- dioxane at Yale and to discuss where it's coming from and how it is moving.

CITIZENS FOR LOWRY LANDFILL ENVIRONMENTAL ACTION NOW (CLLEAN)

2ND FIVE YEAR REVIEW COMMENT
March 23, 2006

The Lowry Landfill Superfund Site is now subject to the second Five-year Review because Federal agencies are responsible for ensuring the protection of human health and the environment as regards all remedial actions selected for the site under CERCLA.

A. Overall impression of the project.

The primary question is, "Are the remedies at the Lowry Landfill Superfund Site functioning as intended by the decision documents?"

Nothing on the Site is clear-cut, however, it is becoming increasingly clear to CLLEAN that there are many indications that the remedies are not working as they were intended:

a. Stable concentrations beyond the Point of Compliance,
b. Large, significant off-site plumes such as MW-38 and MW-77, no identified source, no clear indication of direction of movement or depth,
c. Evidence of deep migration in the Unweathered Dawson at B712 near the North Toe Extraction system, chlorinated solvents in deeper wells,
d. Unanswered questions regarding the lineament investigation.
e. Recent identification of 1-4 Dioxane in the groundwater north of the Superfund Site in Section 31 at Yale.

CLLEAN's overall impression of the Site is that the remedies were implemented because the Agencies were convinced that with these remedies, the chemicals could be contained on-site, within the Point of Compliance. Rather than containment in a secure structure, it appears to CLLEAN that the remedy is more akin to a colander. The bottom of the chemical pits are not separated from the groundwater and there are too many sand lenses and fractures in the shale layer to say that there is a tight bottom.

B. Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

CLLEAN does not believe the remedy selection is still valid.

a. New State standards for 1-4 Dioxane that may affect the ARARs.
b. If 1-4 Dioxane is verified in off-site water sources, the exposure assumptions will be changed dramatically.

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

Yes.

a. 1-4 Dioxane in groundwater in Section 31 at Yale.
b. MW-38 and MW-77 were not an issue in the first 5-Year Review, they are now.

Lowry Landfill Superfund Site Five-Year Review
Interview Record

Site Name: Lowry Landfill EPA ID No.: 0800186	Date: May 18, 2006
Name and Title: James L. Schrack, Environmental Program Supervisor	Organization: City of Aurora, Colorado
Telephone No: 303-739-7555 Fax No: 303-739-7268 E-Mail Address: jschrack@auroragov.org	Street Address: 15151 East Alameda Parkway City: Aurora State, Zip: Colorado 80012
Contact Made by :	

1. What is your overall impression of the remedial actions performed at this Superfund Site and their operations and maintenance?
The responsible parties (Denver and Waste Management) are acting very responsibly. Issues and problems identified in the extensive monitoring program are openly discussed and the responses are appropriate. The project managers are genuinely interested in performing their work in compliance with all requirements, including those of being transparent to stakeholders.

2. Are you aware of any community concerns regarding the Lowry Landfill Site or its operation and administration? If so, please give details.
People are concerned about the 1,4-dioxane issue. The CCLLEAN group is the primary party interested in this issue, but the topic has interest to Aurora as well. The well owners (Pingles and Reeds) are probably also concerned, but recent samples of their domestic well water did not indicate detectable quantities of 1,4-dioxane.

The Plains Conservation Center attends the Steering Committee meetings, however no specific concerns have been expressed to Aurora about the environmental aspects of the Superfund Site.

3. Are you aware of any events, incidents or activities at the Site that concern you (or your department)? If so, please detail.
The grading project soon to be visible from Quincy Avenue is a concern, primarily because it may trigger community questions and be disruptive aesthetically; but not from a remedy-effectiveness, technical basis.

The discharge from the on-site water treatment plant may not be being screened adequately for 1,4-dioxane before it is discharged. The plant effluent may enter the Sand Creek Water Reuse Facility with 1,4-dioxane levels that exceed the current standards.

Aurora has an ordinance that precludes drilling water wells within one-half mile and developing land within one-quarter mile of the Superfund Site boundary until the EPA issues a 5-year performance review concluding that the remedy is protective at the compliance boundary. These restrictions are temporary and not considered institutional controls. The results of the 5-year performance review will be an important consideration in the determination to grant requests for annexation, particularly in the northern portion of section 7, south of Quincy Avenue and adjacent to the Superfund Site.

4. Are you aware of any unusual events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities? If so, please give dates, details, and outcome(s) if known.
No unusual events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities are known.

(Form continued on next page)

Name and Title:
James L. Schrack, City of Aurora, Environmental Program Supervisor

5. Has your department had routine communications with representatives from the Site? Has your office conducted routine activities (Site visits, inspections, reporting activities, etc.) related to the Site? If so, please indicate purpose and provide results.
Aurora's Environmental Program Supervisor is a designated representative on the Steering Committee. Regular and routine communications with the Superfund Site representatives occur as a result of this participation on the Steering Committee. Part of this involvement includes receiving quarterly status reports pertaining to the site-monitoring program. These reports provide detailed information and analyses of the monitoring program, identify any problems or issues that were discovered, and address the resolution to these concerns.

In addition, the Superfund Site representatives provided a tour for the Steering Committee in the fall of 2005. The purpose was to orient Aurora's recently appointed representative and to update the Steering Committee about site developments.

6. Do you feel informed about the Site's activities and progress made in the last five years?
Yes, given the city's representation on the Steering Committee, we have been well informed.

7. Are you aware of any changes in current or future land use in areas surrounding the Site?
There is a subdivision planned in Arapahoe County to the southwest of the Superfund Site called Copperleaf. This is not in the City of Aurora, however, and the Arapahoe County Planning office is handling the development processing.

There is another subdivision planned by Cooper Development, Inc. in Section 29 a mile or more to the north and east of the Superfund Site.

Cherry Creek Schools is considering a bus parking and maintenance facility, middle school and high school site in the SW quarter of Section 8, approximately one mile south of Quincy Avenue and just east of Harvest Road, south of the racetrack.

8. Has your office encountered any problems or difficulties in implementing or enforcing institutional controls or deed restrictions? Do you feel you are adequately informed about the institutional controls that are part of the selected remedy for the Site?
There have been no difficulties in implementing the city ordinance prohibiting water well drilling and land development discussed in Question 3 above.

Aurora is not aware of any issues pertaining to institutional controls that are part of the selected remedy.

9. Do you have any other comments, suggestions, or recommendations regarding the Site's long-term management? If so, what types of future problems do you think either (1) could occur; or (2) would concern you at this Site?
The issue of the 1,4-dioxane contamination of the water possibly leaving the site on the north end is a concern to the city. We own and operate the nearby Murphy Creek Golf Course and the Murphy Creek Community is within our city boundaries. Although not necessarily solvable within the timeframe of this 5-year performance review, resolution of the 1,4-dioxane issue is an important concern that must be addressed by the responsible parties.

The Quincy Avenue right-of-way will likely be widened as a result of the Copperleaf development and other growth. Currently the northernmost boundary of the existing 70-foot wide right-of-way is located at the southern edge of the Superfund Site. To accommodate growth, a 144-feet wide right-of-way is needed. The Lowry Environmental Cleanup Trust Property is reportedly willing to offer the land needed to widen the right-of-way, and one of the principal persons involved in the needed land dedication from the Trust Cooperation also represents the Superfund Site. Cooperation from the Superfund Site may be needed to (1) facilitate the land transactions needed for the widening effort, and (2) possibly agreeing to a design configuration that is conducive to limiting potential encroachment onto the site (e.g., only building curb and gutter on the north side of Quincy Avenue to force foot and bicycle travel to the south side of the road).

Similarly, the city may need to locate water lines nearby the Superfund Site as part of a major supply system expansion project. There may be accommodations needed from the Superfund Site to facilitate this development.

The recent tightening of the standard for 1,4-dioxane (from 200 to 6.1 micrograms per liter) has highlighted the awareness that parameters used to determine the effectiveness of the remedy may have to be periodically adjusted to coincide with this and future regulatory changes. Although this is a requirement of the regulatory program and there is no indication that the Superfund Site managers have any inclination to balk at such modifications, it should be made clear to stakeholders that such adjustments may be a long-term possibility.

Recent proposals to the State Land Board for development of properties east of the project may result in increased traffic and the encroachment of residential areas from proposed annexation to the south and from Copperleaf may require increased security diligence, although security has not been a concern or issue to the city to date.

APPENDIX B

Table 1: Site-wide Groundwater Performance Standards

Parameter	Performance Standard based on *Minor Modification* (dated 9/30/02) to ROD (dated 3/10/94)	Most Current MCL	Most Current Colorado Basic Standard for GW (effective March 22, 2005)	Background	Laboratory Project Reporting Limit	Final Performance Standard	Comments
Inorganics (ug/L) (except where noted)							
Aluminum	5000	200 (2° DW)	5000		100	5000	agricultural std.
Antimony	6	6	6	770	10	770	
Arsenic	50	50	50	52.18	15	52.18	MCL - 10 ppb after 1/23/06
Asbestos (fibers/l)	30000	7000000	7000000			7000000	fibers/L, longer than 10 um
Barium	1000	2000	2000	200	10	2000	
Beryllium	5	4	4	2.89	5	5	
Boron	750		750	200	100	750	agricultural std.
Cadmium	5	5	5	5.48	5	5.48	
Chloride	250000	250000 (2° DW)	250000	1000000	3000	1000000	
Chromium (hexavalent)	50			83.47	10	83.47	
Chromium	50	100	100	11.04	10	100	
Cobalt	50			13.67	10	50	agricultural std.
Coliform (total)/ 100 ml	1	TT	1			1	TT - treatment technique, >5% of samples test positive
Color, color units	15	15 (2° DW)	15		5	15	
Copper	200	1300 (action level),	200	90.9	10	200	agricultural std
Corrosivity	non-corrosive	non-corrosive (2°	non-corrosive			non-corrosive	
Cyanide	200	200	200	7.39	10	200	free cyanide
Fluoride	2000	4000 (MCL), 2000	4000	50000	1000	50000	MCL - community water systems
Foaming Agents	500	500 (2° DW)	500		100	500	
Iron	300	300 (2° DW)	300	2060	100	2060.4	
Lead	15	15 (action level)	50	50	3	50	TT - treatment technique, >10% of samples exceeding action level
Manganese	50	50 (2° DW)	50	1620	10	1620	
Mercury	2	2	2		0.2	2	
Nickel	2		100	100	40	100	previous MCL deleted
Nitrogen, Nitrate plus Nitrite	10000	10000	10000	34000	100	34000	
Nitrogen, Nitrate	10000	10000	10000	29100	500	29100	
Nitrogen, Nitrite	1000	1000	1000		500	1000	
pH	6.5-8.5	6.5-8.5 (2° DW)	6.5-8.5			6.5-8.5	
Selenium	10	50	50	371.98	15	371.98	
Silver	50	100 (2° DW)	50		10	50	
Sulfate	250000	250000 (2° DW)	250000	2400000	5000	2400000	
Thallium	2	2	2		10	10	
Vanadium	100		100		10	100	agricultural standard
Zinc	2000	5000 (2° DW)	2000		20	5000	agricultural standard

Table 1: Site-wide Groundwater Performance Standards

Parameter	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	Most Current MCL	Most Current Colorado Basic Standard for GW (effective March 22, 2005)	Background	Laboratory Project Reporting Limit	Final Performance Standard	Comments
Organics (ug/L)							
1,1-Dichloroethane	990				1	990	
1,1-Dichloroethene	7	7	7		1	7	
1,1,1-Trichloroethane	200	200	200		1	200	
1,1,2-Trichloroethane	3	5	2.8-5[1/]		1	5	
1,1,2,2-Tetrachloroethane	0.055		0.18		1	1	
1,2-Dibromo-3-chloropropane	0.2	0.2	0.2		2	2	
1,2-Dichlorobenzene	600	600	600		10	600	
1,2-Dichloroethane	0.4	5	0.38-5[1/]		1	5	
cis-1,2-Dichloroethene	70	70	70		1	70	
trans-1,2-Dichloroethene	100	100	100		1	100	
1,2-Dichloropropane	0.56	5	0.52-5[1/]		1	5	
1,2 Diphenylhydrazine	0.05		0.044		10	10	
1,2,4-Trichlorobenzene	70	70	70		1 for 8260 10	70	
1,2,4,5-Tetrachlorobenzene	2		2.1		10	10	
1,3-Dichlorobenzene	620		94		1	94	
trans-1,3-Dichloropropene	87				1	87??	ARAR unknown
1,4-Dichlorobenzene	75	75	75		1	75	
1,4-Dioxane	8		6.1		200	200	
2-Butanone (MEK)	1904				5	1904	
2-Chlorophenol	0.1		35		10	35	
2-Hexanone					5		
2-Methylnaphthalene	0.0031				10	10	
2,3,7,8-Tetrachlorodibenzodioxin	0.00000022	0.00000003	0.00000022-0.00003[1/]		0.00001	0.00001	State says MCL is 0.00003 but is
2,4-D	70	70	70		4	70	
2,4-Dichlorophenol	21		21		10	21	
2,4-Dinitrophenol	14		14		50	50	
2,4,5-TP	50	50	50		1	50	
2,4,6-Trichlorophenol	2		3.2		10	10	
4-Methyl-2-pentanone (MIBK)	158				5	158	
Acetone	1600				10	1600	
Alachlor	2	2	2		0.1	2	
Aldicarb	3		7		0.1	7	MCL - removed
Aldicarb Sulfone	2		7		0.1	7	MCL - removed
Aldicarb Sulfoxide	4		7		0.1	7	MCL - removed
Aldrin	0.002		0.0021		0.05	0.05	
Atrazine	3	3	3		0.1	3	

Table 1: Site-wide Groundwater Performance Standards

Parameter	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	Most Current MCL	Most Current Colorado Basic Standard for GW (effective March 22, 2005)	Background	Laboratory Project Reporting Limit	Final Performance Standard	Comments
Organics (ug/L) (cont.)							
Benzene	5	5	5		1	5	
Benzidine	0.0002		0.00015		100	100	
Benzo(a)anthracene	0.1		0.0048		10	10	
Benzo(a)pyrene	0.01	0.2	0.0048-.2[1]		10	10	
Benzyl alcohol					10		
Bis(2-Chloroethyl)Ether	0.03		0.032		10	10	
bis(2-Ethylhexyl)phthalate	4.8	6	2.5-6[1]		10	10	
Bromodichloromethane	0.3		0.56		1	1 (BDCM) & 80	State Std for BDCM and THM [2]
Bromoform	4		4		1	4 (Bromoform) &	State Std for Bromoform and THM
Carbazole					10		
Carbofuran	36	40	35-40[1]		10	40	
Carbon Tetrachloride	0.3	5	0.27-5[1]		1	5	
Chlordane	0.03	2	0.1-2[1]		0.5	2	
Chlorobenzene	100	100	100		1	100	
Chloroethane					2		
Chloroform	6		3.5		1	3.5 (Chloroform)	State Std for Chloroform and THM
2-Chlorophenol	0.2		35/0.2 [4]		10	10	0.2 is drinking water std
Dalapon	200	200	200		2	200	
4,4'-DDT	0.1		0.1		0.05	0.1	
4,4'-DDE	0.1		0.1		0.05	0.1	
Di(2-ethylhexyl)adipate	400	400	400			400	
Dibenzofuran					10		
Dibromochloromethane	0.42		14		1	14 (DBCM) & 80	State Std for DBCM and THM [2]
Dieldrin	0.002		0.002		0.05	0.05	
Di-N-Octylphthalate					10		
Dinoseb	7	7	7		0.6	7	
Diquat	20	20	15-20[1]			20	
Endothall	100	100	100			100	
Endrin	0.2	2	2		0.05	2	
Endrin Aldehyde	0.2		2.1		0.05	2.1	
Ethylbenzene	680	700	700		1	700	
1,2-dibromoethane	0.05	0.05	0.00041-0.05		1	1	
Fluoranthene	188		280		10	280	
Glyphosate	700	700	700			700	
Heptachlor	0.008	0.4	0.008-0.4[1]		0.05	0.4	
Heptachlor Epoxide	0.004	0.2	0.004-0.2[1]		0.05	0.2	
Hexachlorobenzene	1	1	0.022-1.0[1]		10	10	

Table 1: Site-wide Groundwater Performance Standards

Parameter	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	Most Current MCL	Most Current Colorado Basic Standard for GW (effective March 22, 2005)	Background	Laboratory Project Reporting Limit	Final Performance Standard	Comments
Organics (ug/L) (cont.)							
Hexachlorobutadiene	1		0.45		1	1	
Alpha - BHC	0.006		0.0056		0.05	0.05	
Gamma - BHC	0.2	0.2	0.2		0.05	0.2	
Hexachlorocyclopentadiene	50	50	42-50[1]		50	50	
Isophorone	40		140		10	140	
Malathion	2500		140		1.2	140	
Methoxychlor	40	40	35-40[1/]		0.1	40	
Methylene chloride	5	5	4.7-5[1/]		5	5	
Monohydric Phenol	1						
Naphthalene	6.2		140		1 for 8260 10	140	See 3/
Nitrobenzene	3.5		3.5		10	10	
Oxamyl	200	200	175-200[1]		0.1	200	
Arochlor 1260 (Total PCBs)	0.005	0.5	0.0175-0.5[1]		1	1	
Pentachlorophenol	1	1	0.29-1.0[1/]		50	50	
Pentachlorobenzene	6		5.6		10	10	
Phenanthrene	0.0031				10	10	
Phenol	300		2100/300		10	300	300 is drinking water std
Picloram	500	500	490		0.1	500	
Simazine	4	4	4		0.1	4	
Styrene	100	100	100		1	100	
Tetrachloroethene	5	5	5		1	5	
Toluene	1000	1000	1000		1	1000	
Toxaphene	0.03	3	0.032-3[1/]		5	5	
Trichloroethene	5	5	5		1	5	
Vinyl chloride	2	2	0.023-2[1]		1	2	
Xylenes, Total	10000	10000	1400-10000[1]		2	10000	
Radionuclides (ug/L)							
Americium-241	0.46		0.15			0.15	
Beta, Gross	80	80		67		80	
Cesium-134	80		80			80	
Alpha, Gross	15	15		55.4		55.4	
Lead-210	0.037					0.037	
Plutonium-238	0.15					0.15	
Plutonium-239	0.15		0.15			0.15	
Plutonium-240	0.15		0.15			0.15	
Potassium-40	1.9					1.9	

Table 1: Site-wide Groundwater Performance Standards

Parameter	Performance Standard based on Minor Modification (dated 9/30/02) to ROD (dated 3/10/94)	Most Current MCL	Most Current Colorado Basic Standard for GW (effective March 22, 2005)	Background	Laboratory Project Reporting Limit	Final Performance Standard	Comments
Radionuclides (ug/L) (con.)							
Radium-226	5					5	
Radium-226/228	5	5	5			5	
Radium-228	5					5	
Strontium-90	8		8			8	
Thorium-228	0.16					0.16	
Thorium-232	60		60			60	
Thorium-230	60		60			60	
Thorium-230 + 232	60		60			60	
Tritium	20000		20000			20000	
Uranium-234	30	30				30	
Uranium-235	30	30				30	
Uranium-238	30	30				30	

1/ 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 SDWA has been determined to be an acceptable level of this chemical in public water supplies, taking treatability and laboratory detection limits into account. The Commission intends that control requirements for this chemical be implemented to attain a level of ambient water quality that is at least equal to the first number in the range except as follows

* Where groundwater quality exceeds the first number in the range due to release of contaminants that occurred prior to September 14, 2004. (regardless of the date of discovery or subsequent migration of such contaminants) clean-up levels for the entire contaminant plume shall be no more restrictive than the second number in the range or the groundwater quality resulting from such release, whichever is more protective.

* Wherever the Commission has adopted alternative, site-specific standards for the chemical, the site-specific standards shall apply instead of these staewide standards

For sites for which the clean-up standards have been established prior to September 14,2004, the Commission does not intend the adoption of this range of standards to result in changes to the require

2/ For aquifer storage and recovery facilities that existed as of September 14, 2004, if the source of this chemical in groundwater is potable that met all applicable Federal Safe Drinking Water Act and corresponding State requirements at the time that it is utilized for aquifer storage and recovery, or artificial recharge, then the separate Total Trihalomethane standard shall apply to the groundwater in question, rather than the individual standards for bromodichloromethane, bromoform, chloroform, and/or dibromochloromethane.

3/ Naphthalene Colorado Basic Standard changed from 28 to 140 because the methodology for deriving the standard for Group C carcinogens changed.

4/ First value is listed in Table A (Groundwater Organic Chemical Standards), and second value is listed in Table 2 (Domestic Water Supply - Human Health Standards) in the Colorado Basic Standards for Groundwater

Table 3
Air Quality Performance Standards

Chemical/Element	ROD [a]		ESD [b]		New Changes Identified in Five-Year Review [c]			New Performance Standards		
	AAL	TEL	AAL	TEL	AAL	TEL	Risk-Based	AAL	TEL	Risk-Based
Organics										
1,1,1-Trichloroethane	1038.37	1038.37			1038.37	1038.37	–	1038.37	1038.37	–
1,1,2-Trichloroethane	0.06	14.84			0.06	14.84	–	0.06	14.84	–
1,1-Dichloroethane	–	–			–	–	521	–	–	521
1,1,2,2-Tetrachloroethane	0.02	18.67			0.02	18.67	–	0.02	18.67	–
1,2,4 Trichlorobenzene	–	–			–	–	11	–	–	11
1,2-Dichloroethylene (total)	107.81	215.62			107.81	215.62	–	107.81	215.62	–
1,1-Dichloroethylene (vinylidene chloride)*	–[d]	–[d]			0.02[d]	1.08[d]	0.049	0.02	1.08	0.049
1,2-Dichlorobenzene (ortho)	81.74	81.74			81.74	81.74	–	81.74	81.74	–
1,2-Dichloroethane	0.04	11.01			0.04	11.01	–	0.04	11.01	–
1,2-Dichloropropane	0.05	94.23			0.05	0.9	–	0.05	0.9	–
1,4-Dichlorobenzene	0.18	122.61			0.18	122.61	–	0.18	122.61	–
2,3,7,8-TCDD (dioxin equivalence)	–	–			–	–	–	–	–	–
2,4-Dichlorophenol	–	–			–	–	–	–	–	–
2,4-Dimethylphenol	–	–			–	–	–	–	–	–
2,4-Dinitrophenol	–	–			–	–	–	–	–	–
2-Butanone (methyl ethyl ketone)	32.07	32.07			10	200	–	10	200	–
2-Chlorophenol	–	–			–	–	–	–	–	–
2-Hexanone	10.88	10.88			10.88	10.88	–	10.88	10.88	–
2-Methylphenol	–	–			–	–	–	–	–	–
2-Methylnaphthalene [e]	14.25	14.25			14.25	14.25	–	14.25	14.25	–
4,4-DDT	–	–			–	–	0.0103	–	–	0.0103
4-Methylphenol	–	–			–	–	–	–	–	–
4-Methyl-2-pentanone	–	–			–	–	–	–	–	–
Acetone	160.54	160.54			160.54	160.54	–	160.54	160.54	–
Acrylonitrile	0.01	1.18			0.01	0.4	–	0.01	0.4	–
Aniline	0.14	2.07			0.1	0.2	–	0.1	0.2	–
Benzene	0.12	1.74			0.12	1.74	–	0.12	1.74	–
Benzo(a)anthracene	–	–			–	–	–	–	–	–
Benzyl alcohol	–	–			–	–	–	–	–	–
Bis(2-chloroethyl)ether	–	–			–	–	–	–	–	–
Bis(2-ethylhexyl)phthalate	–	–			–	–	–	–	–	–
Carbazole	–	–			–	–	–	–	–	–
Carbon disulfide	0.27	0.27	0.82	0.82	0.1	0.1	–	0.1	0.1	–
Carbon tetrachloride	0.07	85.52			0.07	85.52	–	0.07	85.52	–
Chlorobenzene	6.26	93.88			6.26	93.88	–	6.26	93.88	–

units are ug/m3 unless noted

Table 3
Air Quality Performance Standards

	ROD [a]		ESD [b]		New Changes Identified in Five-Year Review [c]			New Performance Standards		
Chemical/Element	AAL	TEL	AAL	TEL	AAL	TEL	Risk-Based	AAL	TEL	Risk-Based
Chloroethane	358.78	717.55			358.78	717.55	–	358.78	717.55	–
Chloroform	0.04	132.76			0.04	132.76	–	0.04	132.76	–
Chloromethane (methyl chloride)	–	–			–	–	0.56	–	–	0.56
Dibenzofuran	–	–			–	–	–	–	–	–
Dieldrin	–	–			–	–	0.000219	–	–	0.000219
Di-n-Octylphthalate	–	–			–	–	–	–	–	–
Ethylbenzene	118.04	118.04			300	300	–	–	–	–
Ethylenedibromide	–	–			–	–	–	–	–	–
Fluoranthene	–	–			–	–	–	–	–	–
Gamma BHC (lindane)	0.003	0.14			0.003	0.14	–	0.003	0.14	–
Heptachlor	0.001	0.14			0.001	0.14	–	0.001	0.14	
Methylene chloride	0.24	9.45			–	–	–	0.24	9.45	–
Naphthalene [e]	14.25	14.25			14.25	14.25	–	14.25	14.25	–
NDMA	–	–			–	–	0.0001	–	–	0.0001
PCBs	0.0005	0.003			0.0005	0.003	–	0.0005	0.003	–
Pentachlorophenol	0.01	0.01			0.01	0.01	–	0.01	0.01	–
Phenanthrene	–	–			–	–	–	–	–	–
Phenol	52.33	52.33			52.33	52.33	–	52.33	52.33	–
Styrene	1.75	115.81			2	200	–	2	200	–
Tetrachloroethylene	0.02	922.18			0.02	922.18	–	0.02	922.18	–
Toluene	10.24	10.24			20	80	–	20	80	–
trans-1,3-Dichloropropene	–	–			–	–	–	–	–	–
Trichloroethylene	0.61	36.52			0.61	36.52	–	0.61	36.52	–
Vinyl chloride [f]	3.47	0.38			0.38	3.47	–	0.38	3.47	–
Xylenes (total)	11.8	11.8			11.8	11.8	–	11.8	11.8	–
Inorganics										
Ammonia	4.73	4.73			100	100	–	100	100	–
Arsenic	–	–			0.0002	0.0005	0.0007	0.0002	0.0005	0.0007
Barium	–	–			–	–	0.5	–	–	0.5
Beryllium	0.0004	0.001			0.0004	0.001	–	0.0004	0.001	–
Cadmium	0.001	0.003			0.001	0.003	–	0.001	0.003	–
Chromium	–	–			0.68	1.36	0.000085	0.68	1.36	0.000085
Lead	0.07	0.14			0.07	0.14	–	0.07	0.14	–
Manganese	–	–			–	–	1	–	–	1
Mercury	–	–			0.01	0.14	0.3	0.01	0.14	0.3
Nickel	0.18	0.27			0.18	0.27	–	0.18	0.27	–
Selenium	0.54	0.54			0.54	0.54	–	0.54	0.54	–

units are ug/m3 unless noted

Table 3
Air Quality Performance Standards

	ROD [a]		ESD [b]		New Changes Identified in Five-Year Review [c]			New Performance Standards		
Chemical/Element	AAL	TEL	AAL	TEL	AAL	TEL	Risk-Based	AAL	TEL	Risk-Based
Vanadium	0.27	0.27			0.27	0.27	–	0.27	0.27	–
[a] Record of Decision, March 1994										
[b] Explanation of Significant Differences, August 1995										
[c] Commonwealth of Massachusetts Department of Environmental Protection TELs and AALs for Ambient Air, December 1995										
AAL - ambient; TEL threshold effects level										
[d] 1994 ROD did not list Massachusetts standards for 1,1-dichloroethene mistakenly omitted. Standard was listed under the chemical name vinylidene chloride and should have been included										
[e] Value is for total of 2-methylnapthalene and napthalene										
[f] Values for AAL and TEL were mistakenly reversed in the ROD										
* New risk data was released for 1,1-Dichloroethylene during the 1st Addendum to the Five-Year Review. The effect of this new data will be evaluated in the 2nd Addendum.										

units are ug/m3 unless noted

Table 4
Surface Water Standards

	Agricultural Standard (ROD)	Water Supply Segments (ROD)	Water Supply Segments (Five-Year Review)	Aquatic Life (ROD - Acute)	Aquatic Life (Five-Year Review - Acute)	Aquatic Life (ROD - Chronic)	Aquatic Life (Five-Year Review - Chronic)	Background Inorganics[b]	PQL[c]
Organics									
Acenaphthene	–		420*	1700*		520*			10
Acrolein	–		110*	68*		21*			10
Acrylonitrile	–		0.065*	7500*		2600*			20
Aldicarb	–	10	7*	–		–			
Aldrin	–	0.002	0.0021*	1.5		–			0.05
Benzene	–	1	1.2*	5300*		–			1
Benzidine	–	0.0002*		2500*		–			10
Beryllium	100 (30 day)	0.007*		–		–			–
BHC Hexachlorocyclohexane	–	–		100*		–			0.05
Bromodichlormethane (HM)	–	0.3	.56 (W&F)*		11000*	–			1
Bromoform (HM)	–	4	4.3 (W&F)*	–		–			1
Carbofuran	–	36	40*	–		–			–
Carbon Tetrachloride	–	0.3	0.27*	35200*		–			1
Chlorobenzene	–	100		–		–			1
Chlordane	–	0.03	0.1*	1.2*		0.0043*			1
Chloroethyl Ether (bis-2-)	–	0.03	0.032*	–		–			10
Chloroform (HM)	–	6	5.7 (W&F)*	28900*		1240*			1
4-Chloro 3-Methyl Phenol	–		210*	30*		–			50
2-Chlorophenol	–		35*	4380*		2000*			50
Chlorphyrifos	–		21*	0.083*		0.041*			0.1
DDT	–	0.1*		0.55*		0.001*			0.1
DDT Metabolite (DDE)	–	0.1*		1050*		–			0.1
DDT Metabolite (DDD)	–		0.15*	0.6*		–			0.1
Demeton	–	–		–		0.1			1
Dibromochloromethane (HM)	–	14*		–		–			1
1,2-Dichlorobenzene	–	620	600*	–		–			1
1,3-Dichlorobenzene	–	620	600*	–		–			1
1,4-Dichlorobenzene	–	75*		–		–			1
1,2-Dichloroethane	–	0.4	0.38*	118000*		20000*			1

units are ug/l unless noted

Table 4
Surface Water Standards

	Agricultural Standard (ROD)	Water Supply Segments (ROD)	Water Supply Segments (Five-Year Review)	Aquatic Life (ROD - Acute)	Aquatic Life (Five-Year Review - Acute)	Aquatic Life (ROD - Chronic)	Aquatic Life (Five-Year Review - Chronic)	Background Inorganics[b]	PQL[c]
1,1-Dichlorethylene[d]	–	7*		–		–			1
1,2-cis-Dichlorethylene	–	70*		–		–			1
1,2-trans-Dichlorethylene	–	100*		–		–			1
2,4-Dichlorophenol	–	21*		2020*		365*			50
Dichlorophenoxyacetic Acid (2,4-D)	–	70*		–		–			2.02
1,2-Dichloropropane	–	0.56	0.52*	23000*		5700*			1
1,3-Dichloropropylene	–	–		6060*		244*			1
Dieldrin	–	0.002*		1.3	2.4*	0.0019	0.056*		0.1
2,4-Dimethylphenol	–		140*	2120*		–			50
2,4-Dinitrophenol	–	14*		–		–			50
2,6-Dinitrotoluene	–	–		330*		230*			10
Dioxin (2,3,7,8-TCDD)	–	2.2 x 10-7*		0.01*		0.00001*			0.02
1,2-Diphenylhydrazine	–	0.05	0.044*	270*		–			1
Endosulfan	–		0.35*	0.22	0.11*	0.056*			0.1
Endrin	–	0.2	2*	0.09	0.086*	0.0023	0.036*		0.05
Endrin Aldehyde	–	0.2	2.1*	–		–			0.1
Ethylbenzene	–	680	700*	32000*		–			1
Fluoranthene (PAH)	–		280*	3980*		–			10
Guthion	–			–		0.01*			1.5
Heptachlor	–	0.008*		0.26	0.52*	0.0038*			0.05
Heptachlor Epoxide	–	0.09	0.004*	0.26	0.52*	0.0038*			0.05
Hexachlorobenzene	–	6	1*	–		–			10
Hexachlorobutadiene	–	1	14*	90*		9.3*			10
Hexachlorocyclohexane, Alpha	–	0.006	0.0056*	0.0039*	–	–			0.05
Hexachlorocyclohexane, Gamma (Lindane)	–	0.2*		1*		0.08*			0.05
Hexachloroethane	–		7*	980*		540*			10
Hexachlorocyclopentadiene	–		50*	7*		5*			10
Indeno(1,2,3-cd)pyrene (PAH)	–		0.048*	–		–			10

units are ug/l unless noted

Table 4 Surface Water Standards									
	Agricultural Standard (ROD)	Water Supply Segments (ROD)	Water Supply Segments (Five-Year Review)	Aquatic Life (ROD - Acute)	Aquatic Life (Five-Year Review - Acute)	Aquatic Life (ROD - Chronic)	Aquatic Life (Five-Year Review - Chronic)	Background Inorganics[b]	PQL[c]
Isophorone	–	1050	40*	117000*		–			10
Malathion	–		140*	–		0.1*			0.2
Methoxychlor	–	40*		–		0.03*			0.5
Mirex	–	–		–		0.001*			0.1
Naphthalene (PAH)	–		28*	2300*		620*			10
Nitrobenzene	–	3.5*		27000*		–			10
Parathion	–	–		0.065*		0.013*			
PCBs	–	0.005	0.0175*	2*		0.014*			1
Pentachlorobenzene	–	6	5.6*	–		–			10
Pentachlorophenol	–	200	1*	9	19*	5.7	15*		50
Phenol	–		4200*	10200*		2560*			50
1,2,4,5-Tetrachlorobenzene	–	2	2.1*	–		–			10
1,1,2,2-Tetrachlorethane	–		0.18*	–		2400*			1
Tetrachloroethylene	–	5*		5280*		840*			1
Toluene	–	1000*		17500*		–			1
Toxaphene	–	0.03	0.032*	0.73*		0.0002*			5
1,1,1-Trichlorethane	–	200*		–		–			1
1,1,2-Trichlorethane	–	3*		9400*		–			1
Trichlorethylene	–	5*		45000*		21900*			1
2,4,6-Trichlorophenol	–	2	3.2*	–		970*			10
Trichlorophenoxypropionic Acid (2,4,5-TP)	–	50*		–		–			0.5
Vinyl Chloride	–	2*		–		–			2
Inorganics and Miscellaneous									
Antimony	–	14	6*	–		–			
Aluminum	–	–		750*		87*		19	
Ammonia (un-ionized as N)	–	500*		site specific		60-100*			
Arsenic	100 (30 day)*	50*		360	340*	150*		1	
Asbestos, fibers/l	–	30,000	7000000*	–		–			
Barium	–	1000*		–		–		23	

units are ug/l unless noted

Table 4
Surface Water Standards[a]

	Agricultural Standard (ROD)	Water Supply Segments (ROD)	Water Supply Segments (Five-Year Review)	Aquatic Life (ROD - Acute)	Aquatic Life (Five-Year Review - Acute)	Aquatic Life (ROD - Chronic)	Aquatic Life (Five-Year Review - Chronic)	Background Inorganics[b]	PQL[c]
Boron	750 (30 day)*	–		–		–			–
Cadmium	10 (30 day)*	10 (1day)*	5 (1 day)*	–[d]		–[d]		1	–
Chloride	–	250000*		–		–			
Chromium (hexavalent)	100 (30 day)*	50 (1 day)*		16*		11*		5	
Chromium (trivalent)	100 (30 day)*	50 (1 day)*		–[d]		–[d]		5	
Copper	200 (30 day)*	1,000 (30 day)*		–[d]		–[d]		14	
Cyanide (free)	200 (1 day)*	200 (1 day)*			5		5	7*	10
Dissolved Oxygen	3000*	3,000	3000*	–		–			
e. coli	–	–	126/100 ml*	–					
Fecal Coliform	–	2,000/100 ml	200/100 ml*	–		–			
Fluoride	–	2000*		–		–			
Iron	–	300 (30 day)*		–		1,000 (tot rec)*			
Lead	100 (30 day)*	50 (1 day)*		–[d]		–[d]		0	
Manganese	200 (30 day)*	50 (dis)(30 day)*			–[d]	1000*	–[d]	26	
Mercury	–	2.0 (1 day)*		2.4*		0.1	0.77	2*	
Nickel	200 (30 day)*		100 (30 day)*	–[d]		–[d]		2	
Nitrate as N	100000*	10,000 (1 day)*		–		–			
Nitrite as N (NO_2-N)	10000*	1,000 (1 day)*		–		–			
pH	–	5.0 - 9.0	6.5 - 9.0*	–		–			
Selenium	20 (30 day)*	10 (1 day)	50 (30 day)*	135	18.4*	17	4.6*		
Silver	–	50	100 (1 day)*	–[d]		–[d]		1	
Sulfide as H2S	–	50*			2*		2*		
Sulfate	–	250000*		–					
Thallium	–		0.5*	–		15	15*		
Uranium	–	–		–[d]		–[d]			
Zinc	2,000 (30 day)*	5,000 (30 day)*		–[d]		–[d]		26	
Radionuclides									
Cesium 134, pCi/l	–	80h*		–		–			–
Plutonium 238,239, and 240, pCi/l	–	15h	0.15*	–		–			

units are ug/l unless noted

Table 4
Surface Water Standards

	Agricultural Standard (ROD)	Water Supply Segments (ROD)	Water Supply Segments (Five-Year Review)	Aquatic Life (ROD - Acute)	Aquatic Life (Five-Year Review - Acute)	Aquatic Life (ROD - Chronic)	Aquatic Life (Five-Year Review - Chronic)	Background Inorganics[b]	PQL[c]
Radium 226 and 228, pCi/l	--	5[a]		--		--			
Strontium 90, pCi/l	--	8[a]		--		--			
Thorium 230 and 232 pCi/l	--	60[a]		--		--			
Tritium, pCi/l	--	20000[a]		--		--			

[a] Value is dependent on hardness of water
[b] From Summary Statistics for Surface Water 1996
[c] Practical Quantitation Limit (PQL) Annual Update (EPA 2002; Parsons 2001)

units are ug/l unless noted

Table 5
Landfill Gas Compliance Boundary Standards

Chemical	ROD Standard [a]	Soil Vapor Action Levels [b]	New Performance Standards
Acetone		1,648	1,648
Benzene	0.12	605	605
Bromodichloromethane		16,900	16,900
Bromoform		96	96
Bromomethane		2,550	2,550
2-Butanone	700	1,549	1,549
Carbon disulfide	0.27	1,250,000	1,250,000
Carbon tetrachloride		1,240	1,240
Chlorobenzene		15,300	15,300
Chloroethane		756	756
Chloroform	0.04	212	212
Chloromethane	1.5	570	570
1,2-Dibromo-3-chloropropane		13	13
Dibromochloromethane		452	452
Dichlorodifluoromethane	274	428,548	428,548
1,2-Dichlorobenzene		48,000	48,000
1,1-Dichloroethane	400	10,751	10,751
1,1-Dichloroethene *	0.033	98	98
1,2-Dichloroethane	0.04	20	20
cis-1,2-Dichloroethene		92,400	92,400
trans-1,2-Dichloroethene		21,900	21,900
1,2-Dichloropropane		200	200
trans-1,2-Dichloropropene		60,900	60,900
1,4-Dioxane		1	10[c]
Ethylbenzene	118.04	219,640	219,640
Ethylene dibromide		29	29
2-Hexanone		69,300,000	69,300,000
Ethylene dibromide		13,416	13,416
2-Hexanone		10,800	10,800
Methane	5% LEL	5% LEL	5% LEL
Methylene chloride	0.24	450	450
4-Methyl-1,2-pentanone		13,416	13,416

units are ug/m3 unless noted

Table 5
Landfill Gas Compliance Boundary Standards

Chemical	ROD Standard [a]	Soil Vapor Action Levels [b]	New Performance Standards
Styrene		10,800	10,800
1,1,2,2-Tetrachloroethane		83	83
Tetrachloroethene		3,795	3,795
Toluene	10.24	272,000	272,000
Trichlorofluoromethane	961	1,493,000	1,493,000
1,1,1-Trichloroethane	700	100,400	100,400
1,1,2-Trichloroethane		92	92
1,1,2-Trichloro-1,2,2-Trifluoroethane	41,300	69,150,000	69,150,000
Trichloroethene		2,070	2,070
Vinyl chloride	0.02	56	56
Xylenes (total)	11.8	2,760,000	2,760,000
[a] Record of Decision, March 1994			
[b] Letter dated February 16, 2000 regarding *Responses to EPA Comments (dated December 16, 1999) on the Response to Comments and 2nd Edition of the Development of Action Levels for Soil Vapors in Lowry Landfill Offsite Areas, dated October 1999*; and letter dated November 13, 2000 regarding *Response to EPA Comments (dated October 17, 2000) on Response to EPA Comments (dated December 16, 2000) and 2nd Edition of the Development of Action Levels for Soil Vapors in Lowry Landfill Offsite Areas (dated February 16, 2000)*			
[c] Practical Quantitation Limit of 10 ug/m^3			
* New risk data was released for 1,1-Dichloroethylene during the 1st Addendum to the Five-Year Review. The effect of this new data will be evaluated in the 2nd Addendum.			

units are ug/m3 unless noted

APPENDIX C

`Screening-level Human Health Risk Assessment,
1,4-Dioxane in Surface Water Samples Collected from Murphy Creek,
North of the Lowry Landfill Superfund Site

1. SCOPE

This screening-level risk assessment considers the health risk associated with potential exposure of residents and recreational users in the Murphy Creek development to the chemical 1,4-dioxane, detected in surface water samples collected from Murphy Creek at locations up to 2 ½ miles downgradient (north) of the Lowry Landfill Superfund Site.

2. BACKGROUND

In accordance with the EPA-approved *"Addendum No. 1 to Work Plan for North End Investigation, Lowry Landfill Superfund Site" (March 2006),* the Work Settling Defendants collected surface water samples from Murphy Creek at seven locations north of the Lowry Landfill Superfund Site(the Site) boundary in March 2006. The objective of the sampling was to obtain screening level information on the chemistry of shallow groundwater where it discharges into Murphy Creek north of the Site. To achieve this objective, surface water sample locations were chosen at the most likely areas of possible shallow groundwater discharge into Murphy Creek, based on observations made during a field reconnaissance of the Murphy Creek drainage.

Sample collection, analysis, and quality assurance were performed in accordance with procedures described in the EPA-approved "*Work Plan for North End Investigation, Lowry Landfill Superfund Site" (January 2006).* The surface water sampling locations are illustrated on Figure 15. Table C-1 presents a description of each sampling location and a summary of the concentration of 1,4-dioxane detected in the surface water sample collected at each location.

Table C-1: Summary of Surface Water Sampling Results

SAMPLE LOCATION	DESCRIPTION	ANALYTICAL METHOD	1,4-DIOXANE PRACTICAL QUANTITATION LIMIT	1,4 DIOXANE RESULT
SWMC-01	Standing water in a small depression near the barn in Section 30, Township 4 South, Range 65 West	Modified SW-846 Method 8270M	5 micrograms per liter (ug/L)	Not detected
SWMC-02	Immediately upstream of the box culvert beneath Old Tom Morris Road (entrance road to golf course) immediately north of East Jewell Avenue	Modified SW-846 Method 8270M	5 ug/L	Not detected

SAMPLE LOCATION	DESCRIPTION	ANALYTICAL METHOD	1,4-DIOXANE PRACTICAL QUANTITATION LIMIT	1,4 DIOXANE RESULT
SWMC-03	Adjacent to the 11th fairway of the Murphy Creek Golf Course where the western drainage merges with the main stem of Murphy Creek Sample was collected from the main stem of Murphy Creek at this location.	Modified SW-846 Method 8270M	5 ug/L	10 ug/L
SWMC-04	Adjacent to the 11th fairway of the Murphy Creek Golf Course where the western drainage merges with the main stem of Murphy Creek. Sample was collected from the western branch of Murphy Creek at this location.	Modified SW-846 Method 8270M	5 ug/L	6.2 ug/L
SWMC-05	Upstream of the weir structure located near the 12th green of the Murphy Creek Golf Course	Modified SW-846 Method 8270M	5 ug/L	0.51 J ug/L
SWMC-06	Near the new location of Gun Club Road and East Louisiana Parkway, there is a new bridge (yet unpaved) crossing Murphy Creek. Murphy Creek is ponded upstream of the bridge. There is also a plastic pipe (appears to be a utility underdrain) that has a flowing discharge on the eastern edge of the upstream abutment. Sample was collected from Murphy Creek upstream of the discharge.	Modified SW-846 Method 8270M	5 ug/L	0.99 J ug/L
SWMC-07	Same location as SWMC-06 Sample was collected from the pipe discharge.	Modified SW-846 Method 8270M	5 ug/L	4.9 ug/L

"J" qualifier indicates analytical result is an estimated value; chemical was detected at a concentration above the method detection limit and below the practical quantitation limit

3. TOXICITY ASSESSMENT

The chemical of concern in Murphy Creek surface water is 1,4-dioxane. EPA's Integrated Risk Information System (IRIS), a database containing information about human health effects that may result from exposure to various chemicals in the environment, contains information on the health effects of exposure to 1,4-dioxane. Health assessment information on a chemical substance is included in IRIS only after a comprehensive review of toxicity data by EPA health scientists from several EPA Program Offices, Regional Offices, and the Office of Research and Development. For carcinogens, IRIS provides information on three aspects of the carcinogenic assessment; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure.

The weight of evidence discussion in IRIS for 1,4-dioxane indicates that human carcinogenicity data are inadequate and animal carcinogenicity data are sufficient. Therefore, IRIS characterizes 1,4-dioxane as a probable human carcinogen.

The quantitative estimate of carcinogenic risk for oral exposure to 1,4-dioxane is provided in IRIS three ways:

1. Oral slope factor: 1.1×10^{-2} per milligram/kilogram-day (mg/kg-day)
2. Drinking water unit risk: 3.1×10^{-7} per microgram per liter (ug/L)
3. Dinking water concentrations at specified risk levels:
    a. Risk level of 10^{-4} is associated with exposure to a drinking water concentration of 300 ug/L
    b. Risk level of 10^{-5} is associated with exposure to a drinking water concentration of 30 ug/L
    c. Risk level of 10^{-6} is associated with exposure to a drinking water concentration of 3 ug/L

IRIS does not contain a quantitative estimate of carcinogenic risk for inhalation exposure or a chronic health hazard assessment for noncarcinogenic effects.

4. EXPOSURE ASSESSMENT

Land Use and Exposed Population

Land use surrounding the segment of Murphy Creek where 1,4-dioxane has been detected in surface water is currently a mix of residential and recreational uses. The Murphy Creek Golf Course extends along Murphy Creek from Section 30, Township 4 South, Range 65 West north into Section 19, Township 4 South, Range 65 West. Residential properties, including single family homes and apartment buildings, currently exist in Section 19 and additional residential development is underway in Section 30. Murphy Creek is not currently used as a drinking water supply and it is not reasonably anticipated that it will be used as such in the future.

Exposure to surface water within Murphy Creek is possible for adults who golf at the Murphy Creek Golf Course and for adults and children who reside in the nearby development. For recreational golfers, the potentially complete exposure pathways are dermal contact and incidental ingestion of surface water while retrieving golf balls. Likewise, for children and adult residents, the potentially complete exposure pathways are dermal contact and incidental ingestion while wading or playing within Murphy Creek.

Dermal Contact

The EPA guidance document *"Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)" (July 2004)* recommends the use of a screening procedure to analyze whether or not the dermal exposure route is likely to be significant compared to other routes of exposure. The screening procedure compares the exposure associated with dermal contact with water during showering or bathing in a residential exposure scenario to the exposure associated with ingestion of water as a drinking water source in a residential exposure scenario. According to the guidance document, the dermal exposure route is significant for a given chemical if it contributes at least 10% of the exposure derived from the oral route. The guidance recommends that the dermal exposure pathway be evaluated for such chemicals.

Table C-2 summarizes the exposure parameters used in the screening procedure to estimate the dermally absorbed dose.

Table C-2: Exposure Parameters for Estimating Dermally Absorbed Dose Using Screening Procedure

EXPOSURE PARAMETER	ABBREVIATION	UNITS	VALUE
Concentration of Chemical in Water	C	Micrograms per liter (ug/L)	1000
Body Surface Area Exposed	SA	Square centimeters (cm^2)	18,000
Event Time	t_{event}	Hours (hr)/event	0.58 hr (35minutes)
Event Frequency	EV	Events/day	1
Exposure Frequency	EF	Days/year	350
Exposure Duration	ED	Years	30
Body Weight	BW	Kilograms(kg)	70
Averaging Time	AT	Years	70
Skin Thickness		Centimeters (cm)	10^{-3}
Time to Reach Steady State	t^*	Hrs	0.8 (Chemical-specific)

EXPOSURE PARAMETER	ABBREVIATION	UNITS	VALUE
Fraction Absorbed	FA	Unitless	1.0 (Chemical-specific)
Dermal Permeability Coefficient	K_p	Cm/hr	3.3×10^{-4} (Chemical-specific)

Table C-3 summarizes the exposure parameters used in the screening procedure to estimate the oral dose.

Table C-3: Exposure Parameters for Estimating Oral Dose Using Screening Procedure

EXPOSURE PARAMETER	ABBREVIATION	UNITS	VALUE
Concentration of Chemical in Water	C	ug/L	1000
Ingestion Rate	IR	L/day	2
Exposure Frequency	EF	Days/year	350
Exposure Duration	ED	Years	30
Body Weight	BW	Kg	70
Averaging Time	AT	Years	70
Absorption Fraction in GI Tract	ABS_{GI}	Unitless	1.0

Exhibit B-3 in Appendix B of the EPA guidance document provides the results of the screening procedure. For the chemical 1,4-dioxane in water, the guidance recommends that the dermal exposure pathway not be quantified since the ratio of the dermally absorbed dose to the oral dose is 0%, indicating that 1,4-dioxane does not contribute significantly to the exposure via the dermal exposure route.

Incidental Ingestion

Although ingestion of surface water from Murphy Creek by recreational users is limited to incidental ingestion while retrieving golf balls or wading, as a conservative screening-level assessment, exposure to 1,4-dioxane in surface water via the drinking water pathway under a residential exposure scenario was estimated. Table C-4 summarizes the exposure parameters used to estimate the dose under this scenario. The highest concentration of 1,4-dioxane detected in the surface water samples from Murphy Creek was used to characterize the exposure point concentration.

Table C-4: Exposure Parameters for Estimating Dose from Ingestion of Water

EXPOSURE PARAMETER	ABBREVIATION	UNITS	CHILD	ADULT
Concentration of Chemical in Water	C	Milligram /liter (mg/L)	0.01	0.01
Ingestion Rate	IR	L/day	1.0	2.0
Body Weight	BW	Kg	15	70
Exposure Frequency	EF	Days/year	350	350
Exposure Duration	ED	Years	6	24
Averaging Time	AT	Years	-	70

The basic equation for evaluation of exposure from ingestion of surface water as a drinking water source is:

Average Daily Intake = C x (IR / BW) x (EF x ED)/ AT

Using the exposure parameters from Table C-4, the average daily intake of 1,4-dioxane is calculated to be 0.0002 mg/kg-day

5. RISK CHARACTERIZATION

The estimated excess cancer risk from exposure to 1,4-dioxance associated with ingestion of surface water from Murphy Creek under a residential drinking water scenario is determined by multiplying the average daily intake calculated in Section 4 above by the oral slope factor, 1.1×10^{-2} / mg/kg-day.

Risk = (0.0002 mg/kg-day) x (1.1×10^{-2} / mg/kg-day) = 2.2×10^{-6}

6. UNCERTAINTY

This screening-level risk assessment overestimates the true risk by assuming that exposures will occur under a residential drinking water scenario. The actual exposures will be associated with incidental exposures during recreational activities and will be much less than predicted in this screening-level assessment since Murphy Creek is not currently nor is it reasonable to assume it will ever be a source of drinking water.

ATTACHMENT 1

List of Documents

March 1994	Record of Decision
August 1995	Explanation of Significant Differences
August 1995	Minor Modification to the ROD
February 1996	Final Interim Compliance Monitoring Plan
March 1996	Minor Modification to the ROD
October 1997	Second Explanation of Significant Differences
November 1997	Final Compliance Monitoring Plan Landfill Gas Remedy
January 1998	Final Operations and Maintenance Manual Landfill Gas Remedy
June 1999	Final Operations and Maintenance Plan Landfill Solids, Soils, and Sediments
September 2001	First 5 yr Review
May 2001	Minor Modification to the ROD
September 2002	Amendment to the First 5 yr review
September 2002	Final Institutional Controls Plan
September 2002	Minor Modification to the ROD
October 2003	Addendum 2 to Final Operations and Maintenance Manual Landfill Gas Remedy
August 2004	Industrial Wastewater Discharge Permit No. I-218
September 2005	Final Consent Decree
February 2005	Groundwater Monitoring Plan
July 2005	Final Operations and Maintenance Manual Water Treatment Plant
August 2005	Groundwater Monitoring Plan Addendum No. 1
August 2005	Amendment to the Record of Decision
September 2005	Remedial Action and Operation and Maintenance Status Report 2nd Quarter 2005 (Excluding Appendices F-2 and G)
October 2005	Draft Operations and Maintinance Manual GW Extraction
October 2005	Remedial Action and Operation and Maintenance Status Report 3rd Quarter 2005 (Excluding Appendices F-2 and G)
October 2005	Denver Arapahoe Disposal Site Section 6 Engineering Design and Operations Plan
January 2006	Work Plan for North End Investigation Lowery Landfill Superfund Site
January 2006	Addendum 1 to Final Operations and Maintenance Manual Water Treatment Plant
February 2006	Industrial Wastewater Discharge Permit No. I-218
March 2006	Remedial Action and Operation and Maintenance Status Report 4th Quarter 2005 (Excluding Appendices F-2 and G)
May 2006	Final Remedial Action Work Plan Former Tire Pile Area Waste Pit Remedy
June 2006	Addendum No. 1 to Remedial Action Work Plan Former Tire Pile Area Waste Pit Remedy

ATTACHMENT 2

Five-Year Review Site Inspection Checklist

I. SITE INFORMATION	
Site name: Lowry Landfill	**Date of inspection: May 31 & June 1, 2006**
Location and Region: Colorado/ Region 8	**EPA ID: COD 980499248**
Agency, office, or company leading the five-year review: U.S. Army Corps of Engineers	**Weather/temperature: May 31 (75°F & cloudy/rain occasionally) June 1 (80°F & sunny)**

Remedy Includes: (Check all that apply)

- ☑ Landfill cover/containment
- ☑ Access controls
- ☑ Institutional controls
- ☑ Groundwater pump and treatment
- ☐ Surface water collection and treatment
- ☐ Other _____
- ☐ Monitored natural attenuation
- ☑ Groundwater containment
- ☑ Vertical barrier walls

Attachments: ☐ Inspection team roster attached ☐ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Tim Shangraw (Name) | Principal Engineer (Title) | May 31, 2006 (Date)
   Interviewed ☑ at site ☐ at office ☐ by phone Phone no. (303) 619-5179 (cell)
   Problems, suggestions; ☐ Report attached _____
   Tim Shangraw accompanied Kim Witt (USACE) and Ted Streckfuss (USACE) to inspect treatment plant.

2. **O&M staff** Chris Carlson (Name) | _____ (Title) | May 31, 2006 (Date)
   Interviewed ☑ at site ☐ at office ☐ by phone Phone no. _____
   Problems, suggestions; ☐ Report attached _____

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency Tri-County Health Department
Contact Lynn Wagner (Name) Field Supervisor (Title) May 31 & June 1, 2006 (Date) (303)-288-6816 (Phone no.)
Problems; suggestions; ☐ Report attached _____

Agency Colorado Department of Public Health and Environment
Contact Lee Pivonka (Name) Hydrogeologist (Title) May 31 & June 1, 2006 (Date) (303) 692-3453 (Phone no.)
Problems; suggestions; ☐ Report attached _____

4. On May 31, Don Moses, Dave Kachek, Bonnie Lavelle (USEPA), Lynn Wagner and Lee Pivonka inspected surface features of the ground water barrier wall and extraction system, the North Boundary Barrier wall, the North Toe Extraction System, the Landfill Gas Flare, the Unnamed Creek Surface Water Separation System, and the Former Tire Pits. The Landfill Cover and Wetlands were inspected on June 1.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. **O&M Documents**
   - ☑ O&M manual — ☑ Readily available — ☑ Up to date — ☐ N/A
   - ☐ As-built drawings — ☐ Readily available — ☐ Up to date — ☐ N/A
   - ☑ Maintenance logs — ☑ Readily available — ☑ Up to date — ☐ N/A

   Remarks O&M Manuals – GW Extraction, December 28, 2005; Landfill Gas Remedy and Addendum, January 30, 1998 & October 10, 2005; Landfill Solids June 18, 1992; and Water Treatment July 21, 2005 and January 26, 2006.

2. **Site-Specific Health and Safety Plan** — ☐ Readily available — ☐ Up to date — ☐ N/A
   - ☐ Contingency plan/emergency response plan — ☐ Readily available — ☐ Up to date — ☐ N/A

   Remarks _____

3. **O&M and OSHA Training Records** — ☐ Readily available — ☐ Up to date — ☐ N/A
   Remarks _____

4. **Permits and Service Agreements**
   - ☐ Air discharge permit — ☐ Readily available — ☐ Up to date — ☐ N/A
   - ☑ Effluent discharge (WTP) — ☑ Readily available — ☑ Up to date — ☐ N/A
   - ☐ Waste disposal, POTW — ☐ Readily available — ☐ Up to date — ☐ N/A
   - ☐ Other permits _____ — ☐ Readily available — ☐ Up to date — ☐ N/A

   Remarks Industrial Discharge Permit No. 1-218 issued by Metro Wastewater Reclamation District and City of Aurora.

5. **Gas Generation Records** ☑ Readily available ☑ Up to date ☐ N/A
Remarks

6. **Groundwater Monitoring Records** ☑ Readily available ☑ Up to date ☐ N/A
Remarks

7. **Leachate Extraction Records** ☑ Readily available ☑ Up to date ☐ N/A
Remarks

8. **Discharge Compliance Records**
☐ Air ☐ Readily available ☐ Up to date ☐ N/A
☑ Water (effluent) ☐ Readily available ☐ Up to date ☐ N/A
Remarks See line 4 above.

9. **Daily Access/Security Logs** ☑ Readily available ☑ Up to date ☐ N/A
Remarks Sign in Sheet

IV. O&M COSTS

1. **O&M Oranization**
☐ State in-house ☐ Contractor for State
☐ PRP in-house ☑ Contractor for PRP
☐ Federal Facility in-house ☐ Contractor for Federal Facility
☐ Other

2. **O&M Cost Records**
☐ Readily available ☐ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate ☐ Breakdown attached

Total annual cost by year for review period if available

From Date To Date Total cost ☐ Breakdown attached
From Date To Date Total cost ☐ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs During Review Period**
Describe costs and reasons:

V. ACCESS AND INSTITUTIONAL CONTROLS ☐ Applicable ☐ N/A

A. Fencing damaged ☐ Location shown on site map ☐ Gates secured ☐ N/A
Remarks Perimeter fencing is well maintained and is in good condition. Photos taken.

B. Signs and other security measures ☐ Location shown on site map ☐ N/A
Remarks

C. Institutional Controls (ICs)

1. **Implementation and enforcement**
Site conditions imply ICs not properly implemented ☐ Yes ☑ No ☐ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ☑ No ☐ N/A

Type of monitoring (*e.g.*, self-reporting, drive by)
Frequency
Responsible party/agency
Contact
Name Title Date Phone no.

Reporting is up-to-date ☐ Yes ☐ No ☐ N/A
Reports are verified by the lead agency ☐ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ☐ Yes ☐ No ☐ N/A
Violations have been reported ☐ Yes ☐ No ☐ N/A
Other problems or suggestions: ☐ Report attached
There is a one half mile wide PRP owned buffer around the site with an exception on the southwest corner of the site.

2. **Adequacy** ☑ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks See Comment Above

D. General

1. **Vandalism/trespassing** ☐ Location shown on site map ☑ No vandalism evident
Remarks

2. **Land use changes on site** ☐ N/A
Remarks PRP plans to use the site for the disposal of construction debris in the future.

3. **Land use changes off site** ☐ N/A
Remarks Urban sprawl continues to occur, ie. New Fairgrounds to the east.

VI. GENERAL SITE CONDITIONS

A. **Roads** ☐ Roads damaged ☐ Location shown on site map ☑ Roads adequate ☐ N/A

Remarks _____

_____

B. **Other Site Conditions**

Remarks _____

_____

VII. LANDFILL COVER AND GAS COLLECTION AND TREATMENT

A. **Landfill Surface**

1. **Settlement** (Low spots) ☐ Location shown on site map ☑ Settlement not evident
   Areal extent_____ Depth_____
   Remarks Settlement markers were noted durring the inspection._____

2. **Cracks** ☐ Location shown on site map ☑ Cracking not evident
   Lengths_____ Widths_____ Depths_____
   Remarks _____

3. **Erosion** ☐ Location shown on site map ☑ Erosion not evident
   Areal extent_____ Depth_____
   Remarks _____

4. **Holes** ☐ Location shown on site map ☑ Holes not evident
   Areal extent_____ Depth_____
   Remarks _____

5. **Vegetative Cover** ☑ Grass ☑ Cover properly established ☑ No signs of stress
   G Trees/Shrubs (indicate size and locations on a diagram)
   Remarks _____

6. **Bulges** ☐ Location shown on site map ☑ Bulges not evident
   Areal extent_____ Height_____
   Remarks _____

7. **Wet Areas/Water Damage** ☑ Wet areas/water damage not evident
- ☐ Wet areas ☐ Location shown on site map Areal extent_____
- ☐ Ponding ☐ Location shown on site map Areal extent_____
- ☐ Seeps ☐ Location shown on site map Areal extent_____
- ☐ Soft subgrade G Location shown on site map Areal extent_____

Remarks_____

8. **Slope Instability** ☐ Slides ☐ Location shown on site map ☑ No evidence of slope instability
Areal extent_____
Remarks_____

B. Cover Penetrations

1. **Gas Vents** ☑ Active ☐ Passive
☑ Properly secured/locked ☑ Functioning ☑ Routinely sampled ☑ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance
☐ N/A
Remarks_____

2. **Gas Monitoring Probes**
☑ Properly secured/locked ☑ Functioning ☑ Routinely sampled ☑ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks_____

3. **Monitoring Wells** (within surface area of landfill)
☐ Properly secured/locked ☐Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks_____

C. Gas Collection and Treatment

1. **Gas Treatment Facilities**
☑ Flaring ☑ Thermal destruction ☐ Collection for reuse
☑ Good condition ☐ Needs Maintenance
Remarks_____

2. **Gas Collection Wells, Manifolds and Piping**
☑ Good condition ☐ Needs Maintenance
Remarks_____

D. Perimeter Ditches/Off-Site Discharge

1. **Siltation** ☐ Location shown on site map ☑ Siltation not evident
   Areal extent_____ Depth_____
   Remarks_____

2. **Vegetative Growth** ☐ Location shown on site map ☐ N/A
   ☑ Vegetation does not impede flow
   Areal extent_____ Type_____
   Remarks_____

3. **Erosion** ☐ Location shown on site map ☑ Erosion not evident
   Areal extent_____ Depth_____
   Remarks PRP's have placed rip rap in areas to control erosion

4. **Discharge Structure** ☐ Functioning ☐ N/A
   Remarks_____

VIII. NORTH BOUNDARY GROUNDWATER BARRIER WALL, EXTRACTION AND INJECTION SYSTEM

A. Vertical Barrier Wall Groundwater

1. **Settlement** ☐ Location shown on site map ☑ Settlement not evident
   Areal extent_____ Depth_____
   Remarks Exterior features look good.

2. **Effectiveness Monitoring** Type of monitoring Head Differential
   ☐ Performance not monitored
   Frequency Quarterly ☐ Evidence of breaching
   Head differential_____
   Remarks Refer to quarterly O &M Status Reports for head differential and chemical data-GW mound in place

3. **Compliance Monitoring** Type of monitoring Chemical
   ☐ Performance not monitored
   Frequency Quarterly
   Remarks Refer to Quarterly O&M Status Reports to data, 1,4-Dioxane migrating off site

B. Groundwater Extraction Wells, Pumps, and Pipelines

1. **Pumps, Wellhead Plumbing, and Electrical**
☐ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks Above ground features in good condition.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☐ Good condition ☐ Needs Maintenance
Remarks Above ground features in good condition.

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks State noted that injection rates are above augmentation requirements a process dilutes contaminates.

C. Potable Water Injection Pipeline and Trench

1. **Settlement** ☐ Location shown on site map ☑ Settlement not evident
Areal extent_____ Depth_____
Remarks_____

2. **Pumps, Wellhead Plumbing, and Electrical**
☐ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks_____

IX. NORTH TOE EXTRACTION SYSTEM

1. **Extraction Trench Settlement** ☐ Location shown on site map ☑ Settlement not evident
Areal extent_____ Depth_____
Remarks Exterior above ground features look good.

2. **Effectiveness Monitoring** Type of monitoring Purging Rates and Water Levels
☐ Performance not monitored
Frequency Quarterly
Remarks Pumping rates from the sump have stabilized water levels have also stabilized.

3. **Compliance Monitoring** Type of monitoring_____
☐ Performance not monitored
Frequency_____
Remarks_____

4. **Pumps, Wellhead Plumbing, and Electrical**
☑ Good condition ☐ All required wells properly operating . ☐ Needs Maintenance ☐ N/A
Remarks

5. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☑ Good condition ☐ Needs Maintenance
Remarks

6. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks

X. EAST/SOUTH/WEST GROUNDWATER BARRIER WALL AND VOLUNTARY INTERIOR GROUNDWATER EXTRACTION SYSTEMS

A. Vertical Barrier Wall Groundwater

1. **Settlement** ☐ Location shown on site map ☑ Settlement not evident
Areal extent _____ Depth _____
Remarks

2. **Effectiveness Monitoring** Type of monitoring _____
☐ Performance not monitored
Frequency Quarterly ☐ Evidence of breaching
Head differential Varies – See Quarterly O&M Reports
Remarks

3. **Compliance Monitoring** Type of monitoring _____
☐ Performance not monitored
Frequency Quarterly
Remarks See Quarterly O&M Reports

B. Voluntary Interior Groundwater Extraction Systems

1. PM-4 Area Extraction and Transfer to WTP from BM-4I-10S
☑ Good condition ☑ Well properly operating ☐ Needs Maintenance ☐ N/A
Remarks Inward gradient of about 6 feet (with pumping) state noted that PM-4 area is located in channel sands opposite MW 51 area

2. PM-11 Area Extraction and Transfer to WTP from PM-11I and BM-11I-100N
☑ Good condition ☑ Wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks Inward gradient of about 20 feet (with pumping) state noted area is in a sand seam. TCE is located outward from the wall.

3. MW51-WD Area Extraction from interior wells MW51I-WD-15N, MW51I-WD &MW51I-WD-35S And air sparging from MW70-WD
☑ Good condition ☑ Wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks State noted that MW 51 area is located in channel sands extending to PM4 area.

3. PM-15 Area Extraction from interior wells PM-15I, BM-15I-25S, BM-15I-50S, BM-15I-100S & BM-15I-150S and air sparging from one
☑ Good condition ☑ Wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks With pumping, an inward gradient of about 12 feet exists.

4. MW38 Area New extraction well has been recently installed.
☐ Good condition ☐ Wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks

XI. UNNAMED CREEK SURFACE WATER SEPARATOR BARRIER

1. **Observe Flow in Channel**
☑ No flow ☐ Flow
Remarks

2. **Inspection Channel Bottom Clay Barrier Layer**
☐ No erosion ☑ Erosion or other damage observed
Remarks Erosion runnels were noted along the unnamed creek approximately 1 foot deep. Runnels need to be filled with top soil and vegetation.

XII. ONSITE WATER TREATMENT PLANT

1. **Treatment Train** (Check components that apply)
   - ☐ Metals removal ☐ Oil/water separation ☑ Bioremediation
   - ☐ Air stripping ☑ Carbon adsorbers
   - ☑ UV/OX only runs when NTES is not being pumped into the plant
   - ☐ Filters
   - ☐ Additive (*e.g.*, chelation agent, flocculent)
   - ☐ Others
   - ☑ Good condition ☐ Needs Maintenance
   - ☑ Sampling ports properly marked and functional
   - ☑ Sampling/maintenance log displayed and up to date
   - ☑ Equipment properly identified
   - ☐ Quantity of groundwater treated annually 10 gpm * 1500 minutes/day* 365 days/year ≈ 5.5 mil gal/yr
   - ☐ Quantity of surface water treated annually NA
   - Remarks Need carbon to polish the potable water being injected into the trench of the NBBW.

2. **Electrical Enclosures and Panels** (properly rated and functional)
   - ☐ N/A ☑ Good condition ☐ Needs Maintenance
   - Remarks

3. ***Tanks, Vaults, Storage Vessels***
   - ☐ N/A ☑ Good condition ☑ Proper secondary containment ☐ Needs Maintenance
   - Remarks

4. **Discharge Structure and Appurtenances**
   - ☐ N/A ☑ Good condition ☐ Needs Maintenance
   - Remarks

5. **Treatment Building(s)**
   - ☐ N/A ☑ Good condition (esp. roof and doorways) ☐ Needs repair
   - ☐ Chemicals and equipment properly stored
   - Remarks

6. **Monitoring Wells** (pump and treatment remedy)
   - ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
   - ☐ All required wells located ☐ Needs Maintenance ☐ N/A
   - Remarks

XIII. FORMER TIRE PILE AREA WASTE PITS

A. North Pit (Cover consist of 6" erosion layer; 24" compacted clay, grade fill, 12" gravel wrapped in 6 ounce geotextile and underlying layer of 20-guage wire mesh)

1. **Settlement** (Low spots) ☐ Location shown on site map ☑ Settlement not evident
   Areal extent_____ Depth_____
   Remarks_____

2. **Cracks** ☐ Location shown on site map ☑ Cracking not evident
   Lengths_____ Widths_____ Depths_____
   Remarks_____

3. **Erosion** ☐ Location shown on site map ☑ Erosion not evident
   Areal extent_____ Depth_____
   Remarks_____

4. **Holes** ☐ Location shown on site map ☑ Holes not evident
   Areal extent_____ Depth_____
   Remarks_____

5. **Vegetative Cover** ☐ Grass ☑ Cover properly established ☐ No signs of stress
   ☐ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks

6. **Wet Areas/Water Damage** ☑ Wet areas/water damage not evident
   ☐ Wet areas ☐ Location shown on site map Areal extent_____
   ☐ Ponding ☐ Location shown on site map Areal extent_____
   ☐ Seeps ☐ Location shown on site map Areal extent_____
   ☐ Soft subgrade ☐ Location shown on site map Areal extent_____
   Remarks_____

7. **Slope Instability** ☐ Slides ☐ Location shown on site map ☑ No evidence of slope instability
   Areal extent_____
   Remarks_____

8. **Perimeter Ditches/Off-Site Discharge** ☐ Erosion evident ☐ Siltation evident
   Remarks Unnamed Creek located to the west.

9. **NAPL Extraction from Existing Wells**
   Remarks

10. **Groundwater Monitoring Downgradient from FTPA.**
    Remarks

Note: EPA noted that they were currently reviewing work plan for demobilizing incinerator, disassembling pilot plant and moving treatment cell.

B. South Pit (Cover consist of 6" erosion layer; 24" compacted clay, grade fill, 12" gravel wrapped in 6 ounce geotextile and underlying layer of 20-guage wire mesh)

1. **Settlement** (Low spots) ☐ Location shown on site map ☑ Settlement not evident
   Areal extent_____ Depth_____
   Remarks_____

2. **Cracks** ☐ Location shown on site map ☑ Cracking not evident
   Lengths_____ Widths_____ Depths_____
   Remarks_____

3. **Erosion** ☐ Location shown on site map ☑ Erosion not evident
   Areal extent_____ Depth_____
   Remarks_____

4. **Holes** ☐ Location shown on site map ☑ Holes not evident
   Areal extent_____ Depth_____
   Remarks_____

5. **Vegetative Cover** ☐ Grass ☐ Cover properly established ☐ No signs of stress
   ☐ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks Grass is growing in planting strips._____

6. **Wet Areas/Water Damage** ☑ Wet areas/water damage not evident
   ☐ Wet areas ☐ Location shown on site map Areal extent_____
   ☐ Ponding ☐ Location shown on site map Areal extent_____
   ☐ Seeps ☐ Location shown on site map Areal extent_____
   ☐ Soft subgrade ☐ Location shown on site map Areal extent_____
   Remarks_____

7. **Slope Instability** ☐ Slides ☐ Location shown on site map ☑ No evidence of slope instability
   Areal extent_____
   Remarks_____

8. **Perimeter Ditches/Off-Site Discharge** ☑ Erosion evident ☐ Siltation evident
   Remarks Erosion was noted along the toe of the cap at the edge of unnamed creek.

9. **NAPL Extraction from Existing Wells**
   Remarks LNAPL is extracted and disposed of off site (No DNAPL).

10. **Groundwater Monitoring Downgradient from FTPA.**
    Remarks_____

C. Middle Pit (Excavation of the middle pit was completed in 1999)

1. **Settlement** (Low spots) ☐ Location shown on site map ☑ Settlement not evident
   Areal extent_____ Depth_____
   Remarks_____

2. **Cracks** ☐ Location shown on site map ☑ Cracking not evident
   Lengths_____ Widths_____ Depths_____
   Remarks_____

3. **Erosion** ☐ Location shown on site map ☑ Erosion not evident
   Areal extent_____ Depth_____
   Remarks_____

4. **Holes** ☐ Location shown on site map ☑ Holes not evident
   Areal extent_____ Depth_____
   Remarks_____

5. **Vegetative Cover** ☑ Grass ☐ Cover properly established ☐ No signs of stress
   ☐ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks_____

6. **Wet Areas/Water Damage** ☑ Wet areas/water damage not evident
   ☐ Wet areas ☐ Location shown on site map Areal extent_____
   ☐ Ponding ☐ Location shown on site map Areal extent_____
   ☐ Seeps ☐ Location shown on site map Areal extent_____
   ☐ Soft subgrade G Location shown on site map Areal extent_____
   Remarks_____

7. **Slope Instability** ☐ Slides ☐ Location shown on site map ☑ No evidence of slope instability
   Areal extent_____
   Remarks_____

8. **Perimeter Ditches/Off-Site Discharge** ☐ Erosion evident ☐ Siltation evident
   Remarks_____

Note: The middle pit was difficult to locate because the reclaimed area was well vegetated.

D. Treatment Cell. Contaminated materials were excavated from the middle and placed on a geomembrane lined treatment cell. Active vapor extraction was used in attempt to treat the contaminated material. Work on a draft FTPA Work Plan has been suspended pending resolution of regulatory issues associated with closure of the FTPA treatment cell. WSDs have requested agency approval to consolidate the FTPA treatment cell material into the Section 6 landfill. EPA recently approved relocation of materials currently contained in the treatment cell to a CAMU which is to be located on the Section 6 landfill.

1. **Settlement** (Low spots) ☐ Location shown on site map ☑ Settlement not evident
   Areal extent_____ Depth_____
   Remarks_____

2. **Tears/Punctures** ☐ Location shown on site map ☑ Damage not evident
   Lengths_____ Widths_____ Depths_____
   Remarks_____

3. **Erosion around base** ☐ Location shown on site map ☑ Erosion not evident
   Areal extent_____ Depth_____
   Remarks_____

4. **Slope Instability** ☐ Slides ☐ Location shown on site map ☑ No evidence of slope instability
   Areal extent_____
   Remarks_____

E. Tire Shreds Monofill.

Remarks Chips are nearly gone – Remainder may go_____

XIV. WETLANDS MITIGATION

1. **Vegetative Cover** ☑ Good growth diversity and density ☐ Stressed vegetation
   Remarks_____

2. **Erosion** ☐ Areal Extent ☑ Erosion not evident
   Lengths_____ Widths_____ Depths_____
   Remarks_____

3. **Siltation** ☐ Areal extent ☐ Depth
   Remarks_____

4. **Slope Instability** ☐ Slides ☑ No evidence of slope instability
   Remarks_____

ATTACHMENT 3

EPA Response to Comments from the Colorado Department of Public Health and Environment (CDPHE) on the November 3, 2006 Draft Second Five-Year Review Report Lowry Landfill Superfund Site

CDPHE Comment:

The Colorado Department of Public Health and Environment (CDPHE) concurs with the Environmental Protection Agency's (EPA's) Five Year Review determination that the selected remedies for landfill solids, landfill gas, and soils are protective in the short- and long-term, with ongoing appropriate operation and maintenance. Further, the CDPHE believes the remedies for shallow groundwater, subsurface liquids, deep groundwater, and surface water and sediment are protective in the short-term because there is no immediate public health threat. However, based upon our review of EPA's Five Year Review guidance (2001) and the draft Lowry Landfill review, the CDPHE believes that the long-term protectiveness finding for these components and therefore, the overall Site remedy, should be "actions need to be taken to ensure long-term protectiveness." The CDPHE recommends specific follow-up actions to supplement those identified in Table 19.

While we appreciate that EPA views the off-site 1,4 dioxane groundwater and surface water contaminant characterization and remediation activities currently underway as a Record of Decision (ROD) contingency measure and part of site operations and maintenance, we believe this contamination and associated response actions should be identified as new information since the last Five Year Review and an indication that Remedial Action Objectives (RAOs) are not being achieved.

EPA Response:

The data reviewed for this five-year review indicate that the engineered containment features of the remedy are providing effective containment and are operating as intended by the decision documents. The preponderance of evidence indicates that the levels of 1,4-dioxane detected in off-Site groundwater and surface water is the result of re-injection, down gradient of the NBBW, of water from the WTP during the years 1984 until 2000 when the treatment process did not treat 1,4 dioxane and the effluent contained elevated levels of the chemical. The remedy is currently not operating under those conditions. So, while a few compliance wells along the northern point of compliance do not meet the performance standard for 1,4-dioxane, this is likely due to past Site operations, not due to failure of the remedy to provide effective containment.

The Sitewide Groundwater Monitoring Plan (GWMP) is also part of the selected remedy. Response actions are required by the GWMP under Case 3 conditions, that is, whenever a compliance well is out of compliance and it's likely that contaminated groundwater will migrate off-Site. Those required response actions are underway in the northern off-Site areas. The containment provided by the engineered containment features coupled with the response actions required by the GWMP ensure that performance standards will be achieved by the remedy. EPA's Comprehensive Five-Year Review Guidance indicates that the evaluation of remedial action objectives should consider whether the remedy is

meeting or will meet the remedial action objectives. EPA's evaluation of the selected remedy for the Site, including the GWMP and its required response actions, is that it will meet the remedial action objectives.

In addition, the levels of 1,4-dioxane detected in off-Site groundwater and surface water are within EPA's acceptable risk range, even assuming exposure by ingestion under a residential exposure scenario. The highest concentration of 1,4 dioxane detected in groundwater in areas where there are no institutional controls (at a well located along Yale Avenue) is 57 ug/L (please see figure 15 in the second five-year review report). Information from EPA's Integrated Risk Information System database indicates that the drinking water unit risk for 1,4 dioxane is $3.1x\ 10^{-7}$ per ug/L. Therefore, a concentration of 57 ug/L represents a $2.1x\ 10^{-5}$ cancer risk, assuming chronic exposure via the drinking water pathway under a residential exposure scenario. Effective containment provided by the engineered components of the remedy along with the response actions required by the GWMP ensure that concentrations of 1,4 dioxane in the off-Site areas will not increase in the future. Thus, the appropriate conclusion is that the remedy, including the containment features and associated monitoring plans, is protective.

CDPHE Comment:
We support the actions being taken to characterize and respond to the off-site groundwater plume, but because plume containment has not been achieved, we disagree with the overall site protectiveness finding at this time. If EPA opts to find the overall remedy protective, we suggest that the Five-Year Review be modified to include a discussion of how the ROD contingency measures (ROD, Section 11.2.1.2) could include the off-site characterization and installation of additional extraction wells or other remedial alternatives identified from the additional characterization work being conducted. This rationale is currently not explained in the Five Year Review and its addition may enhance public understanding.

EPA Response:
In response to CDPHE's concern, we have summarized the decision rules for compliance groundwater monitoring in the five-year review to enhance public understanding that the selected remedy requires that actions be taken as necessary to limit migration and to lower the concentrations of contaminants in groundwater in the case of an out-of-compliance condition coupled with evidence of a potential for off-Site migration of groundwater containing chemicals above performance standards. We have also described in the "Issues" section that response actions required by the GWMP component of the selected remedy are underway.

CDPHE GENERAL COMMENTS

CDPHE General Comment 1: CDPHE believes the answers to Five Year Review Questions A, B, and C may be No, No, and Yes, respectively. The answers to all three questions raise concerns regarding an overall protectiveness determination related to

shallow groundwater, subsurface liquids, deep groundwater, and surface water and sediment.

The answer to Question A (Is the remedy functioning as intended by the decision documents?) may be No for the following reasons:

- Groundwater remedy has been completed and operating for years. However, since the last Five Year Review, it was discovered that compliance monitoring data are not within performance standards or ARARs. Therefore, RAOs for groundwater (and surface water) are not being met.

EPA Response:
The data reviewed for this five-year review indicate that the engineered containment features of the remedy are providing effective containment, thus functioning as intended by the decision documents. Groundwater is out of compliance at a few compliance monitoring locations, however this is likely due to past Site activities, not due to ineffective functioning of the remedy as currently built and operated. Regardless of the reason for the out-of-compliance conditions, the GWMP requires responses to be implemented to limit migration of groundwater containing chemicals above performance standards and to lower concentrations. Finally, the concentrations of chemicals in groundwater do not present an unacceptable health risk even under a residential exposure scenario. Thus, we believe the appropriate conclusion is that the remedy, including the containment features and associated monitoring plans, is protective.

The preponderance of evidence indicates that the levels of 1,4 dioxane detected in off-Site groundwater and surface water is the result of re-injection, down gradient of the NBBW, of water from the WTP during the years 1984 until 2000 when the treatment process did not treat 1,4 dioxane and the effluent contained elevated levels of the chemical. We believe the RAOs are currently being met by the remedy as constructed and operated. Groundwater and surface water are out of compliance with the performance standards for two chemicals in an area north of the Site for reasons other than the construction and operation of the selected remedy. Implementation of the GWMP and associated requirements will ensure that performance standards will be met.

CDPHE Comment:

- Plume containment has not been demonstrated at the Point of Compliance (POC) in the vicinity of the NBBW.

EPA Response:
The data reviewed for this five-year review indicate that the NBBW is providing effective containment, thus functioning as intended by the decision documents.

CDPHE Comment:

- Deep (below weathered Dawson) and off-site groundwater contamination (continuous 2.5 mile long plume) may be early indicators of potential remedy problems that should be systematically evaluated (i.e., testing of both residual and active migration hypotheses). This hypothesis evaluation, while underway, has not been concluded, making it difficult to conclusively respond to Question A.

EPA Response:
The effectiveness of the engineered components of the selected remedy is evaluated using the decision rules developed in the GWMP. The data evaluated for this five-year review using those GWMP decision rules indicates that the remedy is effective and does not indicate problems with containment. The off-Site groundwater contamination is being effectively addressed by the investigation and response actions required by the GWMP component of the remedy. It is possible that, rather than an early indicator of potential remedy problems, the data indicates that past re-injection of WTP effluent containing elevated concentrations of 1,4 dioxane and nitrate has impacted groundwater and surface water down gradient of the Site. Another likely source of the elevated nitrate concentrations on and north of the Site is past landfarming of sewage sludge. The selected remedy was not designed to address this regional source of nitrates. Nonetheless, we believe it's important to recognize that the GWMP component of the remedy successfully detected dioxane and nitrate contamination and provided the mechanism for an extensive investigation of the problem and the implementation of a response. Our conclusion is that the GWMP component of the remedy is functioning as intended.

CDPHE Comment:

- The vertical extent of the 1,4-dioxane plume is incompletely defined in the vicinity of the NBBW, and;

EPA Response:
The North End Investigation is on-going. This is evidence that the GWMP is functioning as intended by the decision documents.

CDPHE Comment:

- The role of lineaments in lateral and vertical groundwater contaminant migration needs further evaluation.

EPA Response:
The "Work Plan for Additional Geologic Characterization of Potential Lineaments" has been successfully and completely implemented. This work plan was developed in response to consensus recommendations of the technical working group formed in 2004 to specifically consider the evidence that lineaments may be present in the subsurface beneath the Site. The consensus of the technical working group was that it is not

necessary to definitively prove or disprove the presence of lineaments but to determine if and where additional wells need to be installed to ensure that the existing groundwater compliance monitoring network for the Site is sufficient to address possible preferential groundwater flow. The technical working group reached consensus on a plan for investigating the most prominent depressions in the structure contour of the interface between the weathered and unweathered Dawson Formation in order to generate information to support decisions about whether to add new groundwater monitoring wells to the existing groundwater compliance monitoring network. That work has been completed and did not include further evaluation beyond determining whether and where to add new compliance wells.

CDPHE Comment:
It should be noted that CDPHE agrees with most of the decision rules contained in the GWMP decision document and believes this document is generally acceptable for the purpose of directing long-term effectiveness and compliance monitoring at the Site. While we support the use of hydraulics for evaluating the effectiveness of groundwater remedy components at Lowry Landfill and other sites in the state, when water quality and other data present contradicting conclusions, the evaluation should not be limited to the analysis of hydraulic data.

EPA Response:
The GWMP contains the following decision rule for determining effectiveness of containment provided by the NBBW: "If an inward gradient cannot be identified from the potentiometric maps or if the water level data are otherwise inconclusive, the water quality data obtained from down gradient monitoring wells will be used to assess the effectiveness of the NBBW." Given that decision rule, it is EPA's view that if the water level data conclusively demonstrates effective containment and water quality data indicate contamination beyond the containment feature, this is evidence of a problem unrelated to the constructed remedy. The value of the GWMP is that if groundwater is out of compliance with performance standards, additional investigation and response is required even if data indicate that containment is effective.

CDPHE General Comment 2:
The answer to Question B (Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?) may be No because:

- All groundwater and surface water RAOs are not achieved even though the groundwater remedy has been complete and operating for years.

- A new, potentially complete exposure pathway was discovered since the last Five-Year Review (i.e., off-site migration of 1,4 dioxane in surface water). Off-site groundwater contamination was also discovered.

- As indicated in Tables 18 and 19, a background concentration reevaluation of inorganic compounds and metals is needed. This suggests one or more cleanup

levels used at the time of remedy selection may be reduced (i.e., made more stringent) in the future.

EPA Response:
Please note that the determination of whether or not performance standards are achieved is separate from the determination of whether they are still valid.

Regarding exposure assumptions, the institutional controls that have been implemented since the ROD place restrictions on land and water use on-Site and in certain off-Site areas. These are described in detail in the "Final Institutional Controls Plan" (September 19, 2002 and amended February 28, 2005). The restrictions currently in place indicate that the exposure assumptions used at the time of the ROD for the on-Site areas and certain off-Site areas are no longer valid and were very conservative. Today, exposure on-Site is limited to pathways and receptors associated with landfilling, monitoring, and remediation activities only. Within off-Site properties owned by Denver and the Trust, land use is restricted to landfilling, monitoring or remediation activities, industrial, commercial, agricultural, transportation, utilities, open space, or recreation uses. Groundwater use is also restricted in these areas. The baseline risk assessment, summarized in the ROD, assumed future residential use of both the on-Site and off-Site areas. Therefore, the exposure assumptions used at the time of the remedy selection do not represent the reasonably anticipated future land use for all on-Site and off-Site areas under current conditions and are very conservative. The exposure assumptions used at the time of the remedy selection do represent the reasonably anticipated future land use for off-Site areas not owned by Denver or the Trust. The performance standards are based on these same assumptions. Although the exposure assumptions used at the time of the remedy selection may no longer be valid, they are considered to be conservative and protective. Also, although the performance standards for inorganics need to be re-evaluated, the basis for these standards (background) is still considered to be valid.

CDPHE General Comment 3:
Question C asks "Has any other information come to light that could call into question the protectiveness of the remedy (e.g., land use changes)?" Development pressures adjacent to the Site are strong and an EPA determination that the site remedy is protective will automatically result in expiration of Aurora development and well drilling restrictions adjacent to the Site. It should be demonstrated that effective action has been taken to prevent the use of groundwater for drinking water until such time as organic (1,4 dioxane) and inorganic (e.g., arsenic and nitrate) meet performance standards. CDPHE also recommends that coordination with developers be heightened to promote voluntary efforts to communicate the proximity of the Superfund site to nearby prospective property owners.

EPA Response:
The existing City of Aurora ordinance that restricts land and groundwater use in certain off-Site areas is only one of many institutional controls that have been implemented in off-Site areas to control the use of land and groundwater. Section II of the second five-year review report includes a description of all the off-Site institutional controls. The

"Final Institutional Controls Plan" (September 2002, amended February 2005) contains more detailed descriptions as well as information on enforcement of the institutional controls. EPA's analysis in the second five-year review report concludes that the on- and off-Site institutional controls are effective and functioning as intended by decision documents.

Regarding the second part of CDPHE's comment, EPA concurs with CDPHE's recommendation regarding coordination with developers. The existing Lowry Landfill Steering Committee, facilitated by the Tri-County Health Department, provides an effective forum for sharing information on local development plans. The Communications Subcommittee of the Steering Committee routinely creates informational materials for distribution to the public, including developers, that is reviewed by EPA and CDPHE. These existing forums offer opportunities to promote voluntary efforts to communicate Site-related information to nearby prospective property owners.

CDPHE SPECIFIC COMMENTS

The following are specific comments on the Five-Year Review for your consideration.

CDPHE Comment:

1. Pages 15 and 48 discuss historic partially treated Water Treatment Plant (WTP) effluent and ongoing potable water recharge operations at TR-1. As mentioned earlier, the evidence that the 1-4 dioxane contamination is residual is not conclusive in our opinion. The presence of the deeper contamination in B-326-UD and MW113-UD suggests that there may be potential migration paths not associated with the reinjection of not-fully-treated-effluent theory. It should be noted that in addition to 1,4-dioxane, the partially treated effluent likely contained nitrate, among other inorganic compounds, and metals that would not have been removed by the earlier WTP processes. On page 48, the document states: "it is unlikely that if dilution were occurring, the 1,4-dioxane and nitrate would still be present." Given that 1,4-dioxane and nitrate concentrations in groundwater immediately north of the NBBW, resulting from impacted effluent recharge operations and/or active migration across the POC, are expected to be higher than the volatile organic compounds (VOCs), it is also possible that the lower concentration VOCs (as seen in the recent MW113 nested pair) could be diluted to below performance standards while 1,4-dioxane and nitrate could (also diluted) remain above performance standards. CDPHE believes that this potential path needs to be addressed with certainty prior to a determination of effectiveness is made.

EPA Response:
The effectiveness of the engineered containment components of the selected remedy is evaluated using the criteria established in the GWMP. Even in situations where the containment components are determined to be effective based on Site data, if monitoring

data indicate that groundwater performance standards are not achieved at the groundwater point of compliance and contaminated groundwater is likely to migrate off-Site, the GWMP requires additional actions as necessary to limit migration and reduce concentrations. EPA has determined that the combination of effective containment along with an enforceable requirement for additional responses provide an effective remedy for OUs 1 and 6.

CDPHE Comment:

2. With respect to anticipated landfill cover re-grading operations discussed on Page 19, please correct the EDOP as being dated October 2005.

EPA Response:
The requested revision has been made.

CDPHE Comment:

3. Regarding Table 5 on Page 24, EPA prepared a lineament work plan addendum in May 2005. Please add this milestone to the table.

EPA Response:
The requested revision has been made.

CDPHE Comment:

4. Regarding Table 12 on Page 31, Addendum 1 to the Institutional Control Plan was completed in February 2005. This should be added to the table for the purpose of completeness.

EPA Response:
The requested revision has been made.

CDPHE Comment:

5. Page 33 and the bottom of Page 38 describe the interior vertical migration assessment. While concentrations of anthropogenic organic compounds in the four interior vertical migration assessment wells are below performance standards, without an increasing trend and therefore in compliance with the GWMP decision rule, it is worrisome that there is contamination above performance standards in deep wells B-326-UD and MW113-UD. While these wells are not currently part of the vertical migration assessment network, they are closer to the Point of Compliance. Please consider an adjustment to the vertical migration assessment in the GWMP to include the other deep compliance monitoring wells.

EPA Response:
Well B326-UD is currently in the compliance monitoring network. Well MW113-UD is being evaluated for possible inclusion in the compliance monitoring network. One of these wells will be the long term compliance monitoring well. The vertical migration assessment wells are necessarily located up gradient of the point of compliance. Data from these wells are used to evaluate whether adjustments need to be made to the compliance monitoring network. It would not be in keeping with the logic developed for the vertical migration assessment to use a well on the point of compliance for this purpose.

CDPHE Comment:

6. Page 37 has a discussion regarding the direction of the lateral hydraulic gradient at the PM-3 well pair. The Second Quarter 2006 O&M status report indicates the gradient is outward, not "converging where the gradient is near level." Please correct this statement in the Five Year Review.

EPA Response:
The requested revision has been made.

CDPHE Comment:

7. On Page 38, the data presented in the second quarter 2006 O&M status report are summarized. As indicated during the October 19, 2006 quarterly status meeting, please add a bullet noting that two of the compliance wells, B-313 and GW-109, currently have insufficient data to assess compliance with respect to 1,4-dioxane.

EPA Response:
We believe the report should focus on compliance monitoring locations where it has been concluded with sufficient confidence that performance standards are not being met.

CDPHE Comment:

8. Page 40 (first full paragraph) discusses the EPA-approved work plan to address Case 3 conditions at the four wells identified on Page 39. Does this approved work plan address the source(s) of and pathways to these four wells? If not, what will be done to complete our understanding of source(s) and pathways to these wells? It may be necessary for work to be performed inside the POC to resolve questions related to the sources for contamination in these wells. How can the Response Action work plan discussed at the top of Page 40 allow for the attainment of all groundwater RAOs at the POC?

EPA Response:
Extraction and treatment of contaminated water downgradient of containment features coupled with effective containment will result in performance standards eventually being met at the compliance monitoring wells.

CDPHE Comment:

9. Page 41, fourth bullet discusses groundwater data in the northeastern portion of Section 24, not the northwest corner of Section 19. Please correct the reference.

EPA Response:
The text has been corrected. Wells have been installed in both Section 19 and Section 24.

CDPHE Comment:

10. Regarding Page 41 first full, non-bulletized paragraph and Page 49 (2 of 2) technical assessment regarding NBBW: Paired well water quality monitoring results from the October and November 2006 sampling events indicate that "upper unweathered Dawson"(wells B-326-UD and MW113-UD) are in exceedance of performance standards for 1-4 dioxane but not nitrate. CDPHE recommends these exceedances be fully evaluated prior to any effectiveness statement is made. One of our concerns is what is the maximum estimated depth of NBBW effective containment in the upper Unweathered Dawson?

EPA Response:
As discussed in the second five-year review report, well B-326-UD is out of compliance with the performance standard for 1,4 dioxane and this represents a Case 3 condition. The ongoing North End Investigation is the required response. Please note that MW113-UD is not currently part of the compliance monitoring network.

CDPHE Comment:

11. Regarding the fourth bullet on Page 42, CDPHE thought the hypothesis that the landfill condensate leak had possibly caused groundwater contamination at MW77-WD had been recently eliminated from further consideration. Please clarify if it has or has not been eliminated. Depending on the answer to this question, it may be necessary to supplement Tables 18 and19.

EPA Response:
The text has been corrected.

CDPHE Comment:

12. Page 42 regarding compliance wells adjacent to the slurry wall: How can MW106-UD, BM-11X-100N, BM-11X-100S, and PM-6X-UD be Case 2

conditions if there is currently an insufficient number of sampling results to assess the time trends? Please clarify.

EPA Response:
As stated in the second five-year review report, it is unlikely that contaminated groundwater will migrate off-Site at these locations.

CDPHE Comment:

13. Last full sentence at top of Page 44 states analytical results from influent sources showed consistent water chemistry over time. Are the visually increasing concentrations of toluene, ethylbenzene, and xylenes observed in NTES WTP influent during 2005 and 2006 consistent with this statement?

EPA Response:
The statement is based on analytical data on the water quality of the influent to the WTP, not on visual observations at the NTES sump. Also, as stated in the second five-year review report, approximately 10 feet of groundwater is maintained vertically between the NTES sump pump intake and the LNAPL layer and the LNAPL layer is phase-separated above the groundwater.

CDPHE Comment:

14. Page 46, Surface Water Monitoring: This section should acknowledge the discovery since the last Five Year Review of off-site 1,4 dioxane contamination in excess of the Site's performance standards and Colorado surface water standard (ARARs). Also, the statement that the SWRA ensures that surface water is not contaminated from subsurface liquids and that the only other source of contamination is from soil erosion does not appear to be supported by this off site discovery. Please revise and indicate whether the long-term compliance monitoring program for surface water will include additional off-site locations to measure the effect of any additional remedial effort installed to control the release of the 1-4 dioxane from off-site ground water to off-site surface water.

EPA Response:
This section of the second five-year review report summarizes the basis for the current surface water monitoring program. EPA is recommending that the surface water compliance monitoring program be re-evaluated and modified as necessary. We expect that a discussion of all available surface water sampling results will be part of the effort of establishing data quality objectives for a new surface water compliance monitoring program. However, sample collection to evaluate the effectiveness of off-Site response actions may be part of the response action. If this monitoring is determined to be a necessary part of the off-Site response action, it would likely be short-term. The surface water compliance monitoring program is intended to be a long term monitoring program.

CDPHE Comment:

15. Page 49 (page 1 of 2): Are the EPA interviews available for CDPHE review?

EPA Response:
Summaries of the interviews have been included in the second five-year review report and were provided to CDPHE prior to release of the second five-year review report.

CDPHE Comment:

16. Question B, Exposure Assumptions: a) Please revise this section to include a discussion of a new, potentially complete exposure pathway discovered since the last Five-Year Review (i.e., off-site migration of 1,4 dioxane in surface water). The EPA Five-Year Review Guidance (2001), Exhibit 4-2, lists an example question as "Have any human health or ecological routes of exposure or receptors changes or been newly identified (e.g., dermal contact where none previously existed...)." While the surface water exposure issue is not introduced in Section VII, a protectiveness conclusion of "no public health threat" is provided in Section VIII, Table 18. Section VII should explain how this protectiveness conclusion was developed (e.g., EPA risk reevaluation?).

EPA Response:
Please see the screening level risk assessment in Appendix C of the second five-year review report.

CDPHE Comment:

b) Toxicity Data: Since the last Five Year Review, there have been changes to standard EPA risk assessment methods (i.e., RAGS Part E, July 2004) and toxicity values other than acetone (i.e., chloroform, Oct. 2001; 1,1-DCE, August 2002; Benzene, April 2003; Toluene, Sept. 2005; Vinyl Chloride, Aug. 2000). With the exception of acetone, these changes are not identified nor is the potential effect on protectiveness of the remedy discussed. EPA Five-Year Review Guidance (2001), Appendix G, provides some examples for evaluating changes in toxicity values and standards.

EPA Response:
EPA acknowledges that EPA has updated the toxicity values for chloroform, 1,1-DCE, benzene, and toluene since the last five-year review. The toxicity values for vinyl chloride have not been updated since August 2000. Since the performance standards for these chemicals are based on applicable or relevant and appropriate requirements and are not risk-based, there is no requirement to check the impact of the changes in toxicity values. This is consistent with Section 4.2.3 of EPA's "Comprehensive Five-Year Review

Guidance" (June 2001). There is no requirement to assess the impact of changes to standard EPA risk assessment methods in a five-year review.

CDPHE Comment:

c) It would be helpful to add some narrative to the "Cleanup Levels" section more clearly pointing out the change in the 1,4 dioxane groundwater and surface water standard since the last review. The surface water standard change is not currently mentioned.

EPA Response:
The suggested additional text regarding the newly promulgated State groundwater standard for 1,4-dioxane has been added to the "Cleanup Levels" section. There is not currently a surface water performance standard for 1,4-dioxane at the Site. The determination of whether 1,4-dioxane should be included as a long-term surface water compliance monitoring parameter will be made during the development of the long-term compliance monitoring plan for surface water, a recommendation of the second five-year review. 1,4-dioxane is currently a surface water analyte for the North End Investigation.

CDPHE Comment:

d) Also, Section IX, Table 19, indicates inorganic background concentrations may be recalculated. Please indicate how any revised inorganic performance standards will be evaluated in the context of Question B.

EPA Response:
Any modifications to the inorganic groundwater performance standards determined to be necessary by EPA will be incorporated into the GWMP upon approval by EPA.

CDPHE Comment:

17. Please revise the footnote as noted by "**" at the bottom of Page 51. The 6.1 ug/L 1,4 dioxane standard, promulgated by Colorado since the publication of the GWMP, is currently effective.

EPA Response:
The text has been corrected.

CDPHE Comment:

18. CDPHE appreciates EPA's acknowledgement of the issues associated with inorganic compounds and metals performance standards in Tables 18 and 19 that are related to contaminated Well MW05-WD being included in the background study. Until this can be completed, the second column should be changed from N to Y. The second row, the last column of this row ("Affects Protectiveness?") should be changed from "N" to "Y", to indicate the potential to affect long-term/future effectiveness of the remedy because the offsite plume is still being

evaluated and that the nitrate and metals levels have not been fully evaluated in terms of Question B.

EPA Response:
This issue does not affect protectiveness since there are no complete exposure pathways to shallow groundwater in the off-Site area and the recommendation does not change the basis for the performance standards for inorganics. The performance standards for inorganics are currently based on background.

CDPHE Comment:

19. Please modif y Table 18 to reflect that 1,.4 dioxane is above performance standards for surface water and that actions need to be taken to ensure long-term protectiveness. The last column of this row should be changed from "N" to "Y", to indicate that off-site evaluation is underway in response to performance standards not being met (North End Investigation and response action). Section VII, Question B, should explain how the short-term protectiveness determination was made. As discussed previously with EPA, the CDPHE from a qualitative perspective concurs that there is no public health threat from intermittent exposure to off-site surface water based on currently available information. We recommend, however, that EPA complete a risk evaluation to support the statement, once the nature and extent of contamination is known.

EPA Response:
The nature and extent of off-Site contamination has been determined. Please see EPA's response to CDPHE first general comment above.

CDPHE Comment:

20. We recommend the following changes to Table 19 (Recommendations and Follow-up Actions):

    - Include an additional row to address the issue identified in Table 18, (chemicals detected at levels above performance standards in wells north of the site and 1,4-dioxane in surface water). While the narrative should acknowledge the significant work that has already been accomplished in response to this discovery, this addition should identify key work plans or actions that have yet to be developed as part of the North End Investigation. The last sentence in the third row of Table 18 ("...Response actions to stop migration are required by the GWMP and are ongoing") could easily be moved to Table 19 to partially address this issue. (This addition would carry this issue over from Table 18, consistent with the treatment of surface water monitoring and Well MW05-WD in Tables 18 and 19.) Table 19 should also include recommendations for determining potential risk associated with 1,4-dioxane in Murphy Creek, as discussed above in comment 19, if this has not already been quantified.

EPA Response:
The North End Investigation is ongoing and is considered by EPA to be part of the selected remedy since it is a requirement of the GWMP. Recommendations that result from a five-year review are intended to be actions that are currently not planned or underway. The North End Investigation is not in this category. EPA believes the issues and recommendations tables are correct as written in the second five-year review.

CDPHE Comment:

Additionally, identify work plans that are focused on resolving the following issues:

- Testing of all reasonable working hypotheses related to whether or not off-Site and deep groundwater contamination is residual or actively migrating past the POC. This is necessary because assuming the NBBW is effective, 1,4-dioxane and nitrate concentrations in weathered Dawson groundwater have not decreased at the expected rates, even with ongoing and accelerated dilution related to TR-1 recharge operations. These work plans should not be limited to the area along or beyond the POC, as this makes the technical assessment difficult with respect to source and pathway identification. Based on the results of hypothesis testing, it may be necessary to consider the contingency of pulse pumping/recharging at NBBW/TR-1.

EPA Response:
The North End Investigation is ongoing and is considered by EPA to be part of the selected remedy since it is a requirement of the GWMP. If testing working hypotheses as described in CDPHE's comment is determined by EPA to be necessary to achieve the objectives of the North End Investigation (i.e., to limit migration and reduce the concentrations of contaminants in groundwater), it will be incorporated into the scope of the North End Investigation.

- The extent of deep 1,4-dioxane contamination in the vicinity of the NBBW should be determined as evidenced by B-326-UD and MW113-UD. (see suggestion in Specific Comment #5)

EPA Response:
The North End Investigation is ongoing and is considered by EPA to be part of the selected remedy since it is a requirement of the GWMP. If the work described in CDPHE's comment is determined by EPA to be necessary to achieve the objectives of the North End Investigation (i.e., to limit migration and reduce the concentrations of contaminants in groundwater), it will be incorporated into the scope of the North End Investigation.

- The significance of recent monitoring results for shallow and deep wells along lineaments should be evaluated by the technical working group and follow up actions, as appropriate, developed.

EPA Response:
The North End Investigation is ongoing and is considered by EPA to be part of the selected remedy since it is a requirement of the GWMP. If the work described in CDPHE's comment is determined by EPA to be necessary to achieve the objectives of the North End Investigation (i.e., to limit migration and reduce the concentrations of contaminants in groundwater), it will be incorporated into the scope of the North End Investigation.

- "Potential for off-site migration evaluations," required by the GWMP, when exceedances of performance standards at compliance wells need to be addressed and a work plan listed in Table 19. Please refer to our comment letter regarding PM-11 dated June 16, 2006.

EPA Response:
Each instance where a compliance monitoring well has been determined to be out of compliance with groundwater performance standards has been addressed as required by the GWMP. Only Case 3 conditions require the submittal of a work plan. Please see the summary of compliance monitoring in Section VI of the second five-year review report. Regarding the PM-11 area, the data indicate the following:

> *Wells BM-11X-100N and BM-11X-100S, located along the eastern point of compliance adjacent to the southeast end of the perimeter slurry wall, are out of compliance with the performance standard for TCE (average concentration is 5.7 ug/L at both wells compared to the performance standard of 5 ug/L). Similar to well MW106-UD, there is currently an insufficient number of sampling results to assess the time trend in concentration at these wells. This represents a Case 2 condition.*

- Revisions to the Early Warning Monitoring Plan. (This plan is currently under review.)

EPA Response:
Since this work is underway, EPA does not agree it should be identified as a recommendation in the second five-year review. Secondly, this plan is not related to the issues identified during the five-year review.

- Given the potential for deep migration and the undefined vertical extent of deep groundwater contamination, it may be necessary to further characterize and monitor the B-Sand. The latest known depiction of the B-Sand is provided in Figure 1.6 of the FTPA Waste Pit Feasibility Study document (Parsons, December 30, 2004). This depiction appears illogical with respect to the anticipated geological depositional environment of the

Upper Denver Aquifer and our understanding of the morphology of other channel sand sequences beneath the Site.

EPA Response:
The North End Investigation is ongoing and is considered by EPA to be part of the selected remedy since it is a requirement of the GWMP. If the work described in CDPHE's comment is determined by EPA to be necessary to achieve the objectives of the North End Investigation (i.e., to limit migration and reduce the concentrations of contaminants in groundwater), it will be incorporated into the scope of the North End Investigation.

- The known channel sand at RDSB-334 near Well MW110-WD should be monitored with a new compliance well, given the outward gradients in the vicinity of the PM-3 well pair.

EPA Response:
The response to the outward gradient at the location of well pair PM-3 is consistent with the requirements of the GWMP. That is, the graph of water levels over time at well pair PM-3 indicates that the groundwater levels in exterior and interior wells have been declining and now the hydraulic gradient is outward at this well pair. Since there is now an outward gradient at these locations, water quality data was used to assess the effectiveness of the slurry wall. Groundwater samples were collected from well PM-3X during the second quarter of 2006. The sample results indicated 1 ug/L of PCE and trace levels of the other three indicator chemicals. The data collected for all compounds are below their respective performance standards, indicating that the wall is achieving the RAOs for OUs 1 and 6 and providing effective containment.

- Work plans need to be developed to address exceedance of performance standards for five weathered and four unweathered Dawson compliance wells that are out of compliance (2nd Quarter 2006 O&M Status Report). The work plans need to evaluate contaminant sources, pathways to, and interwell extent (lateral and vertical) in these wells.

EPA Response:
Each instance where a compliance monitoring well has been determined to be out of compliance with groundwater performance standards has been addressed as required by the GWMP. Only Case 3 conditions require the submittal of a work plan. Please see the summary of compliance monitoring in Section VI of the second five-year review report.