Minor Change to the Records of Decision
for the On-Post and Off-Post Operable Units
North Boundary Containment System, Northwest Boundary Containment System, and
Off-Post Groundwater Intercept and Treatment System,
Containment System Remediation Goals for 1,4-Dioxane and n-Nitrosodi-n-propylamine

Fact Sheet
April 8, 2020

Purpose

The purpose of this document is to finalize minor changes to the requirements of the *Record of Decision for the On-Post Operable Unit* (FWENC 1996) and the *Offpost Operable Unit Final Record of Decision* (HLA 1995) for the Rocky Mountain Arsenal (RMA) related to the Contaminant System Remediation Goals for the North Boundary Containment System (NBCS), Northwest Boundary Containment System (NWBCS) and the Off-Post Groundwater Intercept and Treatment System (OGITS). These treatment systems are designed to extract and treat contaminated alluvial groundwater and return treated water to the alluvial aquifer. The NBCS and NWBCS extract and treat contaminated groundwater at the site boundary before it migrates off site. The OGITS is a mass removal system designed to extract and treat contaminated groundwater north of RMA. The locations of the facilities described in this document are shown in Figure 1.

During the 2010 and 2015 Five-Year Reviews, 1,4-dioxane and n-Nitrosodi-n-propylamine (NDPA) were identified as potential new groundwater contaminants at RMA. Because no groundwater standards for 1,4-dioxane or NDPA existed when the On-Post and Off-Post Records of Decision (RODs) were completed, the RODs did not identify a Containment System Remediation Goal (CSRG) for either contaminant. Since completion of the RODs, new Colorado groundwater standards for 1,4-dioxane and NDPA were identified. This document confirms the addition of 1,4-dioxane to the CSRG lists for the NBCS and NWBCS, and the addition of NDPA to the CSRG lists for the NBCS, NWBCS and OGITS.

Remediation Framework

The Off-Post ROD was signed by the U.S. Army (Army), the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE) on December 19, 1995. The On-Post ROD was signed by the U.S. Army (Army), the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and

Environment (CDPHE) on June 10, 1996, with concurrence from the U.S. Fish and Wildlife Service and Shell Oil Company (Shell). The Army, serving as lead agency, and Shell are implementing the on-post and off-post remedies, which include treatment of contaminated groundwater at multiple systems, including the NBCS, NWBCS and OGITS.

Summary of Site History and Contamination Issues

The RMA is a federally owned facility located in Commerce City, Colorado, approximately 10 miles northeast of downtown Denver.

Following the attack on Pearl Harbor, the Army established RMA in 1942 to produce chemical warfare agents and incendiary munitions. Following the war and through the early 1980s, the Army continued to use these facilities. Beginning in 1946, some RMA facilities were leased to private companies to manufacture industrial and agricultural chemicals. Shell Oil Company purchased Julius Hyman and Co., the principal lessee, and continued to manufacture primarily pesticides at RMA from 1950 to 1982. Although the Army and Shell used accepted manufacturing and disposal practices of the time, contamination of soil, sediments, structures and groundwater occurred. The principal contaminants include organochlorine pesticides, heavy metals, chemical agent-degradation products and manufacturing by-products, and chlorinated and aromatic solvents.

In 1984, the Army began a systematic investigation of site contamination in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), and the site was placed on the National Priorities List (NPL) in 1987. The NPL is a list of the nation's most contaminated sites, also known as Superfund sites. As required by CERCLA, a Remedial Investigation (RI) was conducted to determine the nature and extent of contamination (Ebasco 1992). The RI identified contaminated soils and waste materials in manufacturing and disposal areas, including Basin A, Basin F, South Plants Central Processing Area, Shell Disposal Trenches and the Complex Army Disposal Trenches. The primary contaminants in these areas are pesticides, solvents, heavy metals and chemical agent by-products.

The RMA was divided into the On-Post OU and Off-Post OU. On-Post sites that posed potential immediate risks to human health and the environment were addressed through Interim Response Actions (IRAs). A Remedial Investigation/Feasibility Study (RI/FS) (Ebasco 1992, FWENC 1995) was conducted for the On-Post OU leading to the actions required by the On-Post ROD (FWENC 1996). Currently, the RMA On-Post OU site encompasses approximately 1.7 square miles and is on the EPA NPL for environmental cleanup as a result of contamination released during previous RMA operations.

The remedy selected in the On-Post ROD consisted primarily of on-site containment and groundwater treatment. Contaminated soils and sediments were excavated to a maximum depth of 10 feet and disposed in the on-site hazardous waste landfills or consolidated beneath soil covers. Contaminated structures were demolished and disposed in the landfills or Basin A. The groundwater remedy, which is ongoing, includes extraction of contaminated groundwater before it flows off post, treatment at on-site facilities including the NBCS and NWBCS, and reinjection of treated groundwater. All remedial actions required by the RODs have been completed (TtEC 2011a); however, treatment of groundwater and maintenance of caps and covers continue as part of long-term operations and maintenance.

The remedy selected in the Off-Post ROD consisted primarily of groundwater treatment and exposure control through provision of alternate water supply and institutional controls to prevent use of contaminated groundwater. The groundwater remedy, which is ongoing, includes extraction of contaminated groundwater that migrated off post prior to completion of the boundary containment systems, treatment at the OGITS, and reinjection of treated groundwater. Groundwater monitoring continues as part of long-term operations and maintenance.

Groundwater Treatment Systems

The NBCS and NWBCS were constructed as IRAs to extract and treat contaminated alluvial groundwater plumes migrating toward the RMA boundaries. The NBCS is located immediately south of the RMA north boundary in Sections 23 and 24 and is designed to contain contaminated groundwater flowing from Basin F and the North Plants area. It was originally installed as a pilot project in 1979 and extended to its current extent in 1981. The containment system consists of a soil bentonite barrier with alluvial extraction wells upgradient and recharge trenches downgradient of the barrier wall. A reverse hydraulic gradient is being maintained across the entire alluvial system to minimize contaminated groundwater flow across the boundary. A carbon adsorption system is used to remove organic compounds and ultraviolet (UV) oxidation is used to treat n-nitrosodimethylamine (NDMA) prior to recharge.

The NWBCS is located along the northwest boundary of RMA in Section 22 and is designed to contain contaminated groundwater flowing from South Plants and Basin A areas. The NWBCS includes three different components: the Original System, the NWBCS Northeast Extension, and the NWBCS Southwest Extension. The Original System, installed in 1984, consists of alluvial extraction wells, recharge wells, and a soil bentonite barrier extending across a portion of the system. The recharge wells are located downgradient of the extraction wells and barrier and the system creates a reverse hydraulic gradient to contain the contaminant plumes. The NWBCS Northeast Extension, which was added in 1990, included the installation of two extraction wells and an extension of the barrier. The NWBCS Southwest Extension was installed in 1991 to capture a separate contaminant plume that extended from South Plants to the Southwest Extension of the NWBCS. The Southwest Extension consists of four extraction wells and four recharge wells. Contaminated groundwater from the combined extraction systems is treated using a carbon adsorption system prior to reinjection to the aquifer.

The OGITS was originally constructed in 1993 as an IRA to extract and treat contaminated alluvial groundwater plumes that had migrated north of RMA prior to construction of the NBCS. The OGITS treats contaminated groundwater extracted from two systems, the First Creek System and the Northern Pathway System. Both extraction systems are located along Highway 2 north of RMA and the OGITS is located on Peoria Street between 96th Avenue and 104th Avenue. The First Creek System currently uses three extraction wells and four recharge trenches. The Northern Pathway System originally consisted of 12 extraction wells and 24 recharge wells. A modified system, which includes six new extraction wells and five recharge trenches, began operation in 2006. The modified system currently operates along with a portion of the original system.

Figure 1 shows the location of groundwater treatment facilities at RMA.

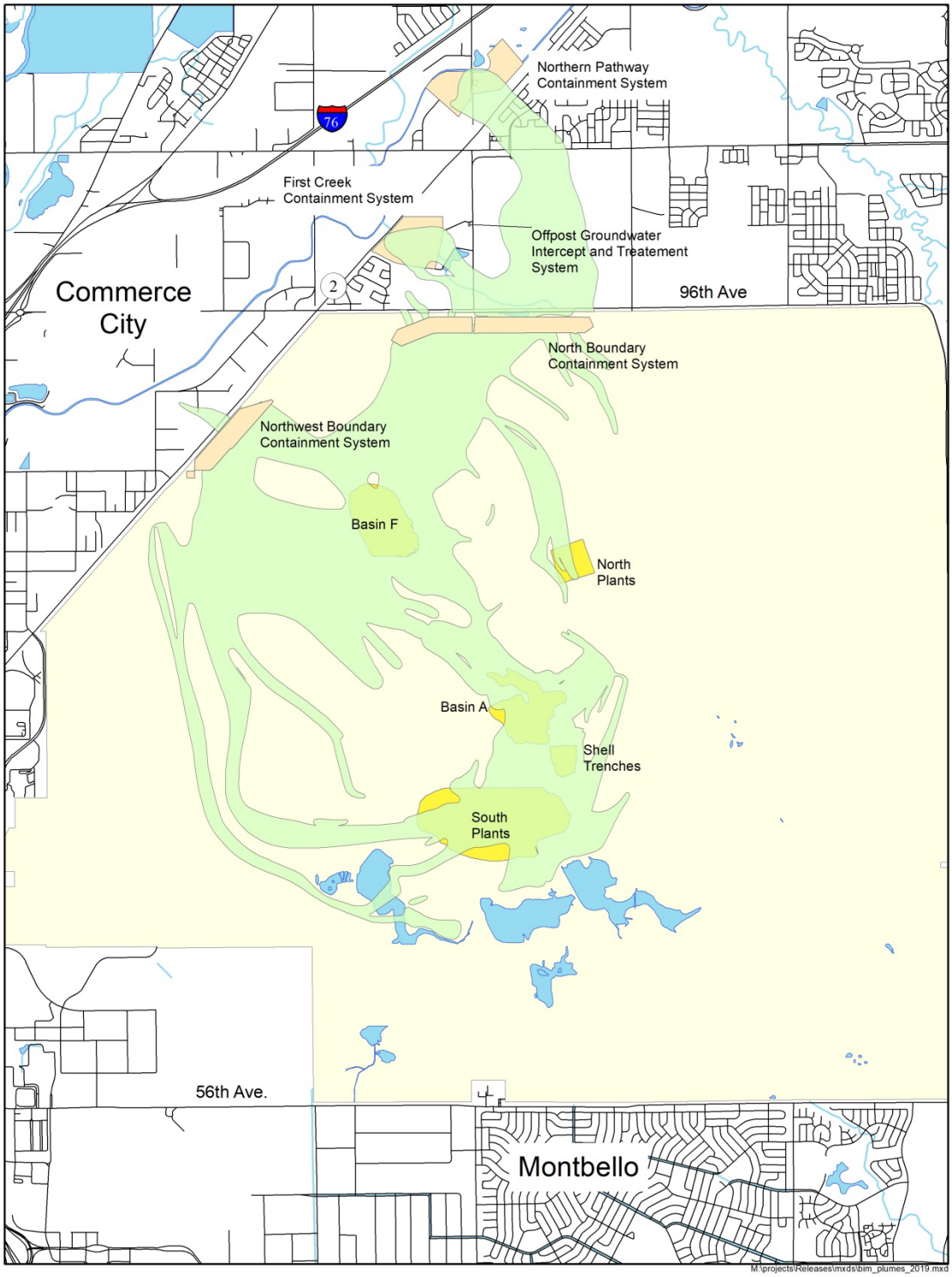

Figure 1. Location of RMA Groundwater Treatment Systems
(Green-shaded area represents 2019 groundwater contaminant plumes)

Chemicals present in groundwater and treated at the NBCS, NWBCS and OGITS include; volatile halogenated organics, volatile hydrocarbon compounds, volatile aromatic organics, organochlorine pesticides, diisopropylmethyl phosphonate (DIMP), phosphorous and sulfur-containing organic chemicals, semivolatile halogenated organics and arsenic.

Explanation of Minor Change to ROD Requirements

Both the On-Post and Off-Post RODs included Applicable or Relevant and Appropriate Requirements (ARARs) for each treatment system including NBCS, NWBCS and OGITS as well as To-Be-Considered Criteria (TBCs) for groundwater. The groundwater standards, or ARARs, designated in the ROD along with the TBCs are referred to as CSRGs. The compounds listed for each system were selected based on compounds present upgradient of the system and current or likely exceedances of applicable standards. Because there were no standards for 1,4-dioxane or NDPA when the RODs were completed, the RODs did not identify a CSRG for either compound.

During the 2010 Five-Year Review, 1,4-dioxane was identified as an emerging contaminant with the possibility that it might be present in RMA groundwater. In addition, the review identified a new Colorado Basic Standards for Groundwater (CBSG) for 1,4-dioxane of 6.1 µg/l that had been promulgated in 2004, which would drop to 3.2 µg/l after five years. As a result, the Five-Year Review Report (Army 2011) included a recommendation to review existing information and conduct additional groundwater monitoring to determine whether 1,4-dioxane should be added to the RMA list of ARARs. Groundwater monitoring was initiated in 2011 but was not completed by 2015 and the issue was identified again in the 2015 Five-Year Review Report (Army 2016). Also, a lower 1,4-dioxane groundwater standard of 0.35 microgram(s) per liter (µg/l) became effective January 31, 2013. The 2015 Five-Year Review Report included a recommendation to complete the data evaluation and prepare a technical evaluation report with risk evaluation to support the ARAR determination.

Groundwater monitoring was conducted in several phases between 2011 and 2018. The objective of the sampling program was to characterize the horizontal and vertical extent of 1,4-dioxane in groundwater at the RMA and assess the concentrations in the influent and effluent at the treatment plants. Investigative samples were collected from both on-post and off-post groundwater monitoring wells. 1,4-Dioxane was detected in the majority of monitoring wells within and downgradient of RMA source areas (Navarro 2017, 2019a). The 1,4-dioxane concentration was above the CBSG in the Basin A, South Plants, Complex Army Trenches, and Basin F source areas with contaminant plumes extending to the NBCS and NWBCS. Several wells off post in the First Creek and Northern Pathway areas also exceeded the CBSG.

The Army completed a Focused Feasibility Study (FS) in 2019 to determine the appropriateness of the 1,4-dioxane CBSG for each system and evaluate the need for remediation of 1,4-dioxane in groundwater at RMA. Recommendations in the FS included adding the 1,4-dioxane CBSG to the CSRG lists for NBCS and NWBCS (Navarro 2019b). Review of the analytical method has determined that the CBSG of 0.35 µg/L can be used as the CSRG.

During the 2015 Five-Year Review, NDPA was identified in groundwater above the CBSG of 0.005 µg/L; however, because NDPA was not part of the standard analytical reporting, further evaluation

was required. The CBSG for NDPA was promulgated after the On-Post and Off-Post RODs were completed and no CSRG for NDPA was identified in the RODs. Groundwater and treatment plant sampling were conducted in 2017/2018 to determine whether NDPA should be added to the treatment plants CSRG lists.

NDPA was detected in multiple monitoring wells within and downgradient of RMA source areas. The NDPA concentration was above the CBSG in the Basin A, South Plants, Complex Army Trenches, and Basin F source areas with contaminant plumes extending to the NBCS and NWBCS, indicating that RMA is a source of NDPA contamination in groundwater (Navarro 2019a). The NDPA concentration was also above the CBSG upgradient of the First Creek System and Northern Pathway System and in some Northern Pathway System extraction wells. Review of treatment plant data shows that NDPA is present above the CBSG in all plant influents at concentrations above the CBSG. Effluent concentrations at all plants are below the CBSG, indicating effective treatment from the existing systems. Based on the monitoring data collected, NDPA is being added to the CSRG list for NBCS, NWBCS and OGITS. Review of the analytical method has determined that the CBSG of 0.005 µg/L can be used as the CSRG.

Tables 1, 2 and 3 present the revised chemical-specific ARARs and TBCs, or CSRGs, for the NWBCS, NBCS and OGITS respectively. For NWBCS and NBCS, 1,4-dioxane has been added to the CSRG lists as recommended in the FS. NDPA has been added to the CSRG list for all three systems.

Table 1 Chemical-Specific ARARs and TBCs - CSRGs for NWBCS

Chemical Group/Compound	ROD Containment System Remediation Goals (µg/l)[1]	Revised Containment System Remediation Goals (µg/l)[1]
Volatile Halogenated Organics		
Chloroform	6	6
Trichloroethylene	3[2]	3[2]
Organophosphorus Compounds; GB Agent Related		
Diisopropylmethyl phosphonate (DIMP)	8	8
Organochlorine Pesticides		
Dieldrin	0.002 (0.05[3])	0.002 (0.013[3])
Endrin	0.2	2[5]
Isodrin	0.06[2]	0.06[2]
Other Organics		
n-Nitrosodimethylamine	0.007[4] (0.033[3])	0.00069[1] (0.009[3])
1,4-Dioxane	--	0.35[6]
n-Nitrosodi-n-propylamine	--	0.005[6]
Arsenic	2.35[2]	2.35[2]

[1] Colorado Basic Standards for Groundwater unless otherwise noted, 5 Code of Colorado Regulations 1002-8, Section 3.11 (1996).
[2] Health-based value from the ROD for the Off-Post Operable Unit (HLA 1995).
[3] The CSRG represents the current practical quantitation limit.
[4] Risk-based level from the Integrated Risk Information System (EPA 1995).
[5] The ARAR for endrin was revised in 2001 based on revision to the CBSG (Army 2001).
[6] Colorado promulgated this standard subsequent to the ROD. No ROD CSRG was identified. Colorado Basic Standards for Groundwater, 5 Code of Colorado Regulations 1002-41 (2016).

Table 2 Chemical-Specific ARARs and TBCs - CSRGs for NBCS

Chemical Group/Compound	ROD Containment System Remediation Goals (µg/l)[1]	Revised Containment System Remediation Goals (µg/l)[1]
Volatile Halogenated Organics		
1,2-Dichloroethane	0.4	0.4
1,2-Dichloroethylene	70	70
Carbon tetrachloride	0.3	0.3
Chloroform	6	6
Methylene Chloride	5	5
Tetrachloroethylene	5	5
Trichloroethylene	3[2]	3[2]
Volatile Hydrocarbon Compounds		
Dicyclopentadiene	46[2]	46[2]
Volatile Aromatic Organics		
Benzene	3[2]	3[2]
Xylenes	1,000[2]	1,000[2]
Toluene	1,000	1,000
Organosulfur Compounds; Mustard Agent Related		
1,4-Oxathiane	160[2]	160[2]
Dithiane	18[2]	18[2]
Organosulfur Compounds; Herbicide Related		
Chlorophenylmethylsulfide	30[3]	30[3]
Chlorophenylmethylsulfone	36[3]	36[3]
Chlorophenylmethylsulfoxide	36[3]	36[3]
Organophosphorus Compounds; GB Agent Related		
Diisopropylmethyl phosphonate (DIMP)	8	8
Organophosphorus Compounds; Pesticide Related		
Atrazine	3	3
Malathion	100[2]	100[2]
Organochlorine Pesticides		
Aldrin	0.002 (0.05[3])	0.002 (0.014[4])
Dieldrin	0.002 (0.05[3])	0.002 (0.013[4])
Endrin	0.2	2[6]
Isodrin	0.06[2]	0.06[2]
Other Organics		
Dibromochloropropane	0.2	0.2
n-Nitrosodimethylamine	0.007[5] (0.033[3])	0.00069[1] (0.009[4])
1,4-Dioxane	--	0.35[7]
n-Nitrosodi-n-propylamine	--	0.005[7]
Arsenic	2.35[2]	2.35[2]
Anions		
Fluoride	2,000	2,000
Chloride	250,000	250,000
Sulfate	540,000[8]	540,000[8]

[1] Colorado Basic Standards for Groundwater unless otherwise noted, 5 Code of Colorado Regulations 1002-8, Section 3.11 (1996).
[2] Health-based value from the ROD for the Off-Post Operable Unit (HLA 1995).
[3] EPA Region VIII Health Advisory value.
[4] The CSRG represents the current practical quantitation limit.
[5] Risk-based value from the Integrated Risk Information System (EPA 1995).
[6] The ARAR for endrin was revised in 2001 based on revision to the CBSG (Army 2001).
[7] Colorado promulgated this standard subsequent to the ROD. No ROD CSRG was identified. Colorado Basic Standards for Groundwater, 5 Code of Colorado Regulations 1002-41 (2016).
[8] Inorganic CSRG for sulfate may be natural background concentration.

Table 3 Chemical-Specific ARARs and TBCs - CSRGs for OGITS

Chemical Group/Compound	ROD Containment System Remediation Goals (µg/l)[1]	Revised Containment System Remediation Goals (µg/l)[1]
Volatile Halogenated Organics		
1,2-Dichloroethane	0.4	0.4
1,3-Dichlorobenzene	6.5[2]	6.5[2]
Carbon tetrachloride	0.3	0.3
Chlorobenzene	25[2]	25[2]
Chloroform	6	6
Ethylbenzene	200[2]	200[2]
Tetrachloroethylene	5	5
Trichloroethylene	3[2]	3[2]
Volatile Hydrocarbon Compounds		
Dicyclopentadiene	46[2]	46[2]
Volatile Aromatic Organics		
Benzene	3[2]	3[2]
Xylenes	1,000[2]	1,000[2]
Toluene	1,000	1,000
Organosulfur Compounds; Mustard Agent Related		
1,4-Oxathiane	160[2]	160[2]
Dithiane	18[2]	18[2]
Organosulfur Compounds; Herbicide Related		
Chlorophenylmethylsulfide	30[2]	30[2]
Chlorophenylmethylsulfone	36[2]	36[2]
Chlorophenylmethylsulfoxide	36[2]	36[2]
Organophosphorus Compounds; GB Agent Related		
Diisopropylmethyl phosphonate (DIMP)	8	8
Organophosphorus Compounds; Pesticide Related		
Atrazine	3	3
Malathion	100[2]	100[2]

Organochlorine Pesticides		
Aldrin	0.002 (0.05[3])	0.002 (0.014[3])
Chlordane	0.03	0.03
DDE (Dichlorodiphenyltrichloroethane)	0.1	0.1
DDT (Dichlorodiphenyltrichloroethane)	0.1	0.1
Dieldrin	0.002 (0.05[3])	0.002 (0.013[3])
Endrin	0.2	2[4]
Hexachlorocyclopentadiene	0.23[2]	0.23[2]
Isodrin	0.06[2]	0.06[2]
Other Organics		
Dibromochloropropane	0.2	0.2
n-Nitrosodimethylamine	0.007[5] (0.033[3])	0.00069[1] (0.009[3])
n-Nitrosodi-n-propylamine	--	0.005[6]
Arsenic	2.35[2]	2.35[2]
Anions		
Fluoride	2,000	2,000
Chloride	250,000	250,000
Sulfate	250,000	540,000[7]

[1] Colorado Basic Standards for Groundwater unless otherwise noted, 5 Code of Colorado Regulations 1002-8, Section 3.11 (1996).
[2] Health-based value from the ROD for the Off-Post Operable Unit (HLA 1995).
[3] The CSRG represents the current practical quantitation limit.
[4] The ARAR for endrin was revised in 2001 based on revision to the CBSG (Army 2001).
[5] Risk-based level from the Integrated Risk Information System (EPA 1995).
[6] Colorado promulgated this standard subsequent to the ROD. No ROD CSRG was identified. Colorado Basic Standards for Groundwater, 5 Code of Colorado Regulations 1002-41 (2016).
[7] Inorganic CSRG for sulfate may be the natural background concentration.

Cost

The addition of 1,4-dioxane will increase long-term monitoring costs because a separate laboratory analysis is required to provide 1,4-dioxane data. Costs include quarterly analysis of samples from the treatment plants, annual groundwater performance monitoring associated with NBCS and NWBCS, and both on-post and off-post water quality monitoring networks. Estimated impact to the long-term monitoring program is approximately $70,000 annually, representing an approximate eight percent increase in monitoring costs.

Operating costs are expected to increase for NBCS upon implementation of treatment for 1,4-dioxane. However, additional treatability study and system design are required prior to implementation of treatment. Therefore, added costs for operations are not considered here and will be estimated following determination of treatment requirements.

The addition of NDPA is not expected to impact the operating cost for the treatment systems or the annual groundwater monitoring costs. The current treatment systems are capable of removing NDPA with no modifications. Monitoring for NDPA will be accomplished as part of the analyses already being performed for other analytes.

Public Participation

The documents that support the change described here are part of the Administrative Record and are available at the Joint Administrative Record and Document Facility (JARDF). This includes the 2015 Five-Year Review Report, which discussed these contaminants and recommended groundwater investigations and determinations for inclusion on the RMA treatment system CSRG lists. The 2015 Five-Year Review Report was provided for public comment between July 11 and August 26, 2016. Please call 303-289-0300 to schedule an appointment to visit the JARDF. Site information is also available at the EPA Region 8 Superfund Records Center, which can be reached at 303-312-7226. Hours of operation are Monday through Friday from 8:00 a.m. to 4:00 p.m.

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Document Location

- Joint Administrative Record and Document Facility (JARDF)
  Rocky Mountain Arsenal, 6550 Gateway Road, Building 129
  Commerce City, Colorado 80022
  Please call (303) 289-0300 to schedule an appointment.

Electronic Document Availability

- Rocky Mountain Arsenal Web site - www.rma.army.mil
- EPA Region 8 Superfund Records Center Website – www.epa.gov

References

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1995 *Integrated Risk Information System. Chemical Assessment Summary: N-Nitrosodimethylamine.* url=https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0045_summary.pdf

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2019a (Jan. 8) *Emerging Contaminants Data Summary Report*. Revision 0.

2019b (Nov. 21) *Focused Feasibility Study for 1,4-Dioxane in Groundwater*. Revision 0.

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TtEC (Tetra Tech EC, Inc.)

2011a (Sept.) *Remedial Action Summary Report for the Rocky Mountain Arsenal*. Revision 0.

URS (URS Corporation)

2012 (Mar. 5) *1,4-Dioxane Investigation*. Revision 0.