

## Revised Memorandum

Date: July 3, 2018  
To: Jill McKenzie, New Jersey Department of Environmental Protection  
Supinderjit Kaur, United States Environmental Protection Agency  
From: Jessica Yeager, Meghan Kilian, John Persico  
Subject: Development of Alternative Remediation Standards  
Rolling Knolls Landfill Superfund Site  
Chatham, New Jersey

---

On behalf of Chevron Environmental Management Company for itself and on behalf of Kewanee Industries, Nokia of America Corporation (f/k/a Alcatel-Lucent USA Inc.), and Novartis Pharmaceuticals Corporation (collectively, the “Group”), Geosyntec Consultants (Geosyntec) has prepared this revised memorandum describing the development of Alternative Remediation Standards (ARS) for soil at the Rolling Knolls Landfill Superfund Site located in the Township of Chatham, Morris County, New Jersey (the “Site”). The site-specific ARS presented herein were developed in consideration of site-specific conditions, primarily its inaccessibility and lack of use, and with input from the United States Environmental Protection Agency (USEPA) and New Jersey Department of Environmental Protection (NJDEP). Key documents and a meeting related to the development of the final ARS include:

- Geosyntec draft ARS Memorandum dated June 22, 2017;
- USEPA and NJDEP comment letter on the ARS dated August 22, 2017;
- Geosyntec revised ARS Memorandum dated November 29, 2017;
- USEPA and NJDEP comment letter on the ARS dated January 17, 2018;
- USEPA, Geosyntec, and Group representative discussion during a teleconference on February 21, 2018; and
- Geosyntec email to USEPA on March 7, 2018 and a subsequent letter from USEPA and NJDEP dated May 3, 2018.

Importantly, the ARS calculated herein are only applicable to the Rolling Knolls Landfill Superfund Site due to unique Site conditions; they should not be used at other sites.

## **ARS OVERVIEW**

The New Jersey Soil Remediation Standards (N.J.A.C. 7:26D; NJDEP, 2017) are based on either residential exposure, which assumes 350 days of exposure per year, or non-residential exposure, which assumes 225 days of exposure per year. Under NJDEP's regulations, an ARS for soil may be based on an alternative land use planned for the site (N.J.A.C. 7:26D-7.3(b)(3)). NJDEP specifically allows an ARS for "recreational uses" which are site-specific uses that do not reflect either a residential or non-residential land use scenario (N.J.A.C. 7:26D, Appendix 4). The landfill portion of the Site will remain vacant and dedicated to preservation/conservation purposes. This area is inaccessible because there is access only through one road (Britten Road) and much of the perimeter of the landfill is surrounded by the wilderness portions of the Great Swamp National Wildlife Refuge (GSNWR), which further limits access to the landfill. The only potential human receptors in the landfill portion of the Site may be trespassers. Accordingly, the exposure scenarios to develop the soil remediation standards for residential and non-residential uses set forth in N.J.A.C. 7:26D are not appropriate for the anticipated future use and potential exposures at this Site. In addition, to the extent an ARS is employed, institutional controls (deed notice or other means) and engineering controls (fence and signs) will be used to ensure that access to the landfill portion of the Site is restricted and remains dedicated to preservation/conservation purposes. The specific locations of the engineering controls will be developed during remedy design.

NJDEP regulation allows for development of site-specific ARS in the situations applicable here (NJDEP, 2012). The following sections describe the development of Site-specific ARS for soil for a trespasser exposure scenario on the landfilled portion of the Rolling Knolls Site. Additionally, based on NJDEP comments, Site-specific ARS for soil were calculated for the shooting range and baseball field using the child residential exposure scenario assumptions with an exposure frequency of 156 days per year (3 days per week).

## **BACKGROUND INFORMATION**

### **Site Features**

The Site features are shown on Figure 1. The Site is a former municipal landfill in use from the 1930s to 1968. It consists of approximately 140 acres of landfill, with an adjacent 30-acre area west of the landfill that has debris scattered on the surface, but no buried waste (known as the Surface Debris Area). Most of the landfill and the Surface Debris Area are privately owned. Approximately 35 acres of the landfill are on the GSNWR. The

remainder of the Site, as defined by USEPA for purposes of the Remedial Investigation (RI) and Feasibility Study (FS), is located on land owned by the Green Village Fire Department.

### **Current Uses**

Two landscaping companies rent areas on the landfill and the Surface Debris Area for equipment storage and maintenance. A small area, known as the laydown area, is located on the privately-owned portion of the Site. Chatham Disposal and South Orange Disposal, both of which are municipal waste hauling companies owned by members of the Miele family, use this area for equipment storage. A small building known as the Hunt Club is located on the Surface Debris Area and is used infrequently for social gatherings. Hunters formerly used the landfill from time to time but are no longer observed. A shooting range and baseball field are located north of the landfill on land owned by the Green Village Fire Department and are used infrequently for recreation.

### **Anticipated Future Use**

With the GSNWR located both on and adjacent to the Site, maintenance of the Site in an undeveloped condition provides a buffer between the developed areas of Chatham Township and the GSNWR. The presence of wetlands, the flood hazard area and habitat for state- and federally-listed endangered species severely limits Site use. Accordingly, the environmental characteristics and associated regulatory restrictions and other impediments to development (TRC, 2017) make open space/preservation the likely anticipated future use of the Site. The GSNWR is already preserved and the private landowner of the other portion of the landfill appears willing to institute engineering and institutional controls to restrict use of and access to the Site.

Based on the results of the RI, the baseball field and shooting range were found to be outside the landfill boundary and are not impacted by the waste materials. These areas may be used for recreational purposes in the future. The owner of the privately-owned portion of the Site may continue to allow use of a portion of the property that is outside the landfill boundary as a laydown area to the extent USEPA agrees that area is not part of the Site or otherwise allows this use.

## **Site Investigations**

Soil data were obtained during several sampling events at the Site since 2006. The results of this soil sampling are presented and compared to the Residential Direct Contact Soil Remediation Standards (RDSCRS) and Nonresidential Direct Contact Soil Remediation Standards (NRDCRS) in the *Remedial Investigation Report* (Geosyntec, 2017).

## **DEVELOPMENT OF ARS FOR SOIL ON THE LANDFILL**

Under NJDEP regulation, an ARS may be based on an alternative land use planned for the site (e.g., recreational purposes), which is defined as any site-specific use that does not reflect either a residential or non-residential land use scenario, and should incorporate the amount of time that people are likely to spend at a site given that site-specific use (N.J.A.C. 7:26D-7.3(b)(3) and Appendix 4). The plans for landfilled portions of the Site are to discontinue the current Site activities (landscaper storage areas, hunting to the extent it continues) and restrict use of the Site using both institutional controls (deed notice or other means) and engineering controls (fence and signs).

Despite fencing and signage, individuals may trespass at the Site and contact surficial soil; accordingly, for the purpose of calculating Site-specific ARS for the landfill, the exposure scenario is based upon an adolescent trespasser. The adolescent trespasser was selected as the target receptor based on the USEPA-approved Baseline Human Health Risk Assessment (BHHRA; CDM, 2014). The BHHRA evaluated adolescent trespassers, adult trespassers, adolescent hunters, and adult hunters exposed to soil at the landfill. The BHHRA concluded that there are no unacceptable cancer risks or lead exposure risks to trespassers or hunters and no unacceptable non-cancer hazards to hunters; however, the non-cancer hazard index (HI) exceeded the USEPA threshold value of 1 for adolescent trespassers (HI = 6) and adult trespassers (HI = 4). Given that the landfill receptor with the highest health hazard was the adolescent trespasser, ARS that are protective of this receptor will also be protective of other potential receptors (e.g., adult trespassers, adolescent hunters). Calculated risks, non-cancer hazards, and probabilities of elevated blood lead levels for landfill receptors are summarized in the in-text tables of Section 7 of the BHHRA.

At the request of NJDEP, ARS were calculated for those constituents identified at concentrations above the NJDEP NRDCRS in the shallow soil (0 to 2 feet bgs) at the landfill portion of the Site. With the exception of lead and arsenic, Geosyntec used Equations 3 and 4 in Appendix 2 and Equations 1, 2, 15, 17, and 18 in Appendix 3 of

N.J.A.C. 7:26D to calculate ARS associated with the inhalation, ingestion, and dermal absorption of carcinogenic and non-carcinogenic contaminants in soil for a trespasser exposure scenario.

As shown in Table 1, of the thirteen exposure factors used in these equations, the Group uses seven that are consistent with NJDEP default values, one (exposure frequency) that is Site-specific, and five (body weight, non-cancer averaging time, exposure duration, skin surface exposed and skin-soil adherence factor) that are receptor-specific values drawn from the USEPA-approved BHHRA (CDM, 2014). Table 1 presents the exposure factors used in these equations to calculate the Site-specific ARS for the landfill.

### **Exposure Frequency and Duration**

There is no established exposure frequency for trespassers on properties to be preserved and where access is restricted. Rather, ARS may be based on site-specific land use scenarios that affect the amount of time that people are likely to spend at a site. See N.J.A.C. 7:26D, Appendix 4. Accordingly, a reasonable and conservative exposure frequency for trespassers of 84 days per year was selected based on the following assumptions:

- During the summer months (June, July, and August), when school is not in session, it was assumed that trespassers would access the Site 3 days per week (13 days per month), for a total of 39 days.
- During the fall and spring months (i.e., September through November, April, and May), it was assumed that trespassers would access the Site 2 days per week (9 days per month), for a total of 45 days.
- During the winter months, defined as having an average high temperature less than approximately 50 degrees Fahrenheit (December through March; <https://www.usclimatedata.com/climate/new-jersey/united-states/3200>), it was assumed that trespassers would not access the Site.

We understand that this exposure frequency has been used to develop ARS for sites that will have passive recreational use (e.g., walking or hiking).<sup>1</sup> Additionally, the Site lacks

---

<sup>1</sup> See e.g., [https://www.epa.gov/sites/production/files/2017-01/documents/plks\\_cms\\_draftwkpl.pdf](https://www.epa.gov/sites/production/files/2017-01/documents/plks_cms_draftwkpl.pdf)

“attractive nuisances” and it is located in a relatively remote, sparsely populated area. Physical access to the majority of the landfill is limited by: a chained gate on Britten Road; wet areas and brooks along the eastern, western and southern boundaries; and the exclusion of visitors to the Wilderness Area section of the GSNWR located on a portion of the landfill and to the east and south. Given that access to the Site will be restricted and the planned institutional and engineering controls, the actual exposure frequency is likely to be less than 84 days and the use of this assumption here is especially conservative.

For exposure duration, the receptor is assumed to be 6 to 17 years of age (total of 12 years) as stated for an adolescent trespasser at the landfill in the BHHRA.

#### **Skin-Soil Adherence Factor**

The skin-soil adherence factor (0.07 mg/cm<sup>2</sup>-event) used to calculate the ARS was included in the BHHRA and is the USEPA’s recommended value for an adult resident. This value is based on the 50th percentile weighted adherence factor for gardeners, which is the activity determined by USEPA to represent a reasonable, high-end activity (USEPA, 2004). Again, this is a conservative value since gardening is not an activity that will occur on the landfill.

#### **Proposed Site-Specific ARS for the Landfill**

The proposed Site-specific ARS for those constituents that were identified in soil at concentrations above the NRDCSRS are provided in Table 2. These ARS were developed as described above, with the exception of lead and arsenic, as described below.

##### *Lead*

The ARS for lead was calculated using the USEPA (2017a) Adult Lead Model with an exposure frequency of 84 days per year and the geometric standard deviation for baseline blood lead concentration and baseline blood lead concentrations from the National Health and Nutrition Examination Survey (NHANES) (2009-2014) for a probability of fetal blood lead concentration exceeding the target blood lead concentration of 5 micrograms per deciliter of 5%.

*Arsenic*

The ARS for arsenic is set to the NJDEP direct contact soil remediation standard of 19 milligrams per kilogram, which is based on natural background. This is equivalent to the RDCSRS and the NRDCSRS.

**DEVELOPMENT OF ARS FOR SOIL ON THE SHOOTING RANGE AND BASEBALL FIELD**

As discussed above, the RI has confirmed that the shooting range and ball field are not impacted by the landfill. Accordingly, while these areas remained part of the Site for purposes of the RI/FS, the Group will be discussing with USEPA a revised definition of the Site to remove these areas where impacts are not related to the landfilling activities and are consistent with background. Additionally, the USEPA-approved BHHRA (CDM, 2014) concluded that there was no unacceptable risk for an adult baseball player, adult shooting range user, or adolescent shooting range user. Calculated cancer risks and non-cancer hazards for these areas are summarized in the in-text tables of Section 7 of the BHHRA.

Nonetheless, at NJDEP's request we have calculated ARSs for the ballfield and shooting range. For the purpose of calculating Site-specific ARS for the baseball field and shooting range, the exposure scenario is based upon a child recreator. ARS were developed for those constituents identified at concentrations above the NJDEP RDCSRS in soil at the shooting range and baseball field portions of the Site. The only constituent that met this criterion was benzo(a)pyrene in both areas. Geosyntec used Equations 1 and 2 in Appendix 2 of N.J.A.C. 7:26D to calculate carcinogenic and non-carcinogenic ARS, respectively, based on ingestion and dermal absorption of benzo(a)pyrene in soil for a child recreator exposure scenario.

As shown in Tables 3 and 5, of the thirteen exposure factors used in these equations, the Group uses twelve that are consistent with NJDEP default values and one (exposure frequency) that is Site-specific. Tables 3 and 5 present the exposure factors used in these equations to calculate the Site-specific ARS for the shooting range and baseball field, respectively.

### **Exposure Frequency and Duration**

Based on NJDEP comments, an exposure frequency of 156 days per year (3 days per week) was used for a child recreator at the shooting range and baseball field.

### **Proposed Site-Specific ARS for the Shooting Range and Baseball Field**

The proposed Site-specific ARS for those constituents that were identified in soil at concentrations above the RDCSRS are provided in Tables 4 and 6. These ARS were developed as described above.

### **CHEMICAL-SPECIFIC TOXICITY VALUES**

The chemical-specific toxicity values used in developing the ARS are provided in Table 7. The sources for these values are the NJDEP Ingestion-Dermal Exposure Pathway Soil Remediation Standards, Basis and Background dated June 2008, the NJDEP Inhalation Exposure Pathway Soil Remediation Standards, Basis and Background dated June 2008, and the USEPA Regional Screening Levels - Generic Tables (last updated November 2017b).

### **CONCLUSIONS**

The ARS shown in Tables 2, 4 and 6 are proposed for soil at the landfill, shooting range, and baseball field portions of the Rolling Knolls Site, respectively. The ARS are Site-specific for the Rolling Knolls Landfill Superfund Site in Chatham, New Jersey only.

### **REFERENCES**

CDM Federal Programs Corporation, 2014. *Baseline Human Health Risk Assessment, Rolling Knolls Landfill Superfund Site, Chatham, New Jersey*. June.

Geosyntec Consultants, 2017. *Remedial Investigation Report, Rolling Knolls Landfill Superfund Site, Chatham, New Jersey*. April.

NJDEP, 2017. *N.J.A.C. 7:26D Remediation Standards*. Statutory authority N.J.S.A. 13:1D-1 et seq., 58:10-23.11a et seq., 58:10A-1 et seq. and 58:10B-1 et seq. September 18.

NJDEP, 2012. *Technical Guidance for the Attainment of Remediation Standards and Site-Specific Criteria*. September 24.

NJDEP, 2008a. *Development of Alternative Remediation Standards for the Ingestion-Dermal Pathway Guidance Document*. June.

NJDEP, 2008b. *Development of Alternative Remediation Standards for the Inhalation Pathway Guidance Document*. June.

NJDEP, 2008c. *Inhalation Exposure Pathway Alternative Remediation Standard Calculator*. [http://www.nj.gov/dep/srp/guidance/rs/inhalation\\_ars.xls](http://www.nj.gov/dep/srp/guidance/rs/inhalation_ars.xls). June.

TRC, 2017. *Reuse Assessment Report, Rolling Knolls Landfill Superfund Site, Chatham, New Jersey*. February.

United States Environmental Protection Agency, 2017a. *Update to the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters*. OLEM Directive 9285.6-56. Office of Land and Emergency Management, Washington, D.C., May.

United States Environmental Protection Agency, 2017b. *Regional Screening Levels for Chemical Contaminants at Superfund Sites*. <https://www.epa.gov/risk/regional-screening-levels-rsls>. November.

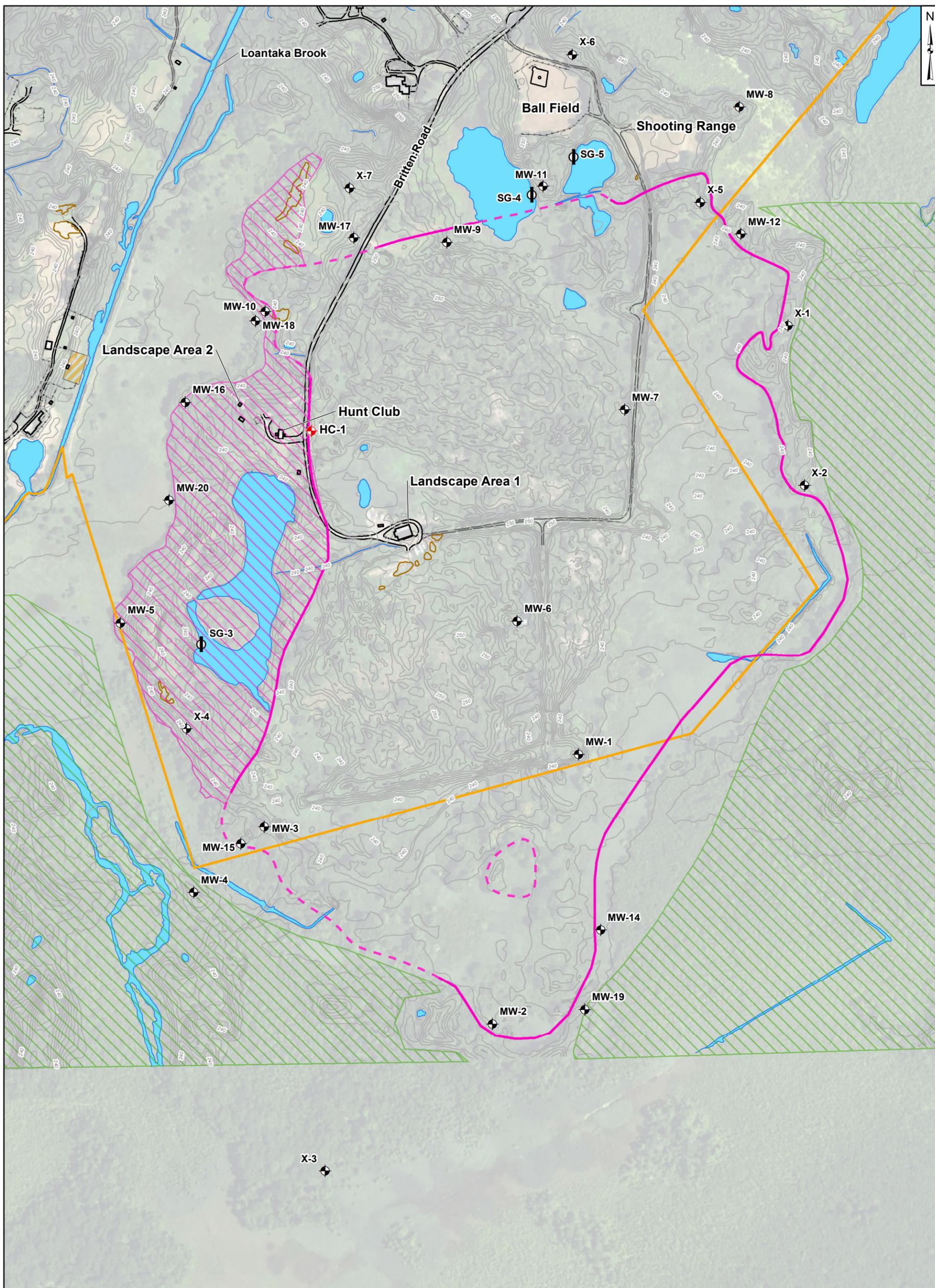
United States Environmental Protection Agency, 2016. *Updated Scientific Considerations for Lead in Soil Cleanups*. OLEM Directive 9200.2-167. Office of Land and Emergency Management, Washington, D.C., December.

United States Environmental Protection Agency, 2004. *Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment*. EPA/540/R-99/005. Office of Superfund Remediation and Technology Innovation, Washington, D.C., July, 181 pp.

United States Environmental Protection Agency, 2003. *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*, EPA-540-R-03-001. Technical Review Workgroup for Lead, December 1996 (Revised January 2003), 62 pp.

Development of Alternative Remediation Standards  
Rolling Knolls Landfill Superfund Site  
July 3, 2018  
Page 10

\* \* \* \* \*



Site Plan created from Arcadis CAD drawings received December 2015.  
 Aerial imagery accessed via ArcGIS Online and provided by the United States Department of Agriculture on 9 December 2016.  
 Image is dated 31 July 2015.

400 200 0 400 Feet



**Legend**

- Monitoring Well Location
- Staff Gauge Location
- Non-Potable Supply Well
- Edge of landfilled wastes (dashed where approximate)
- Great Swamp National Wildlife Refuge property boundary
- Areas where surface water flow does not exhibit typical bed and bank morphology
- Waste and debris observed on ground surface but not observed or anticipated below ground surface
- Off-site shooting range
- Open water

**Site Plan**  
 ROLLING KNOLLS LANDFILL SUPERFUND SITE  
 CHATHAM, NEW JERSEY

**Geosyntec**  
 consultants

Princeton, NJ

June 2017

Figure  
 1

**TABLE 1**  
**Exposure Assumptions for Landfill Area Evaluation**  
Rolling Knolls Landfill Superfund Site  
Chatham, New Jersey

Exposure Assumptions	NJDEP Abbreviation	NJDEP Non-Residential Exposure Scenario	Site-Specific Trespasser Exposure Scenario	Units
Target Cancer Risk	TR	1E-06	1E-06	unitless
Target Hazard Quotient	THQ	1	1	unitless
Body Weight	BW	70	48	kg
Averaging Time (cancer)	AT	70	70	yr
Averaging Time (non-cancer)	AT	25	12	yr
Exposure Frequency	EF	225	84	days/yr
Soil Ingestion Rate	IR	100	100	mg/day
Skin-Soil Adherence Factor	AF	0.2	0.07	mg/cm <sup>2</sup> -event
Skin Surface Exposed	SA	3300	4373	cm <sup>2</sup>
Exposure Duration	ED	25	12	yr
Event Frequency	EV	1	1	event/day
Daily inhalation rate	DIR	20	20	m <sup>3</sup> /day
Particulate emission factor from site activity	PEF <sub>s</sub>	1.39E-02	1.39E-02	mg/m <sup>3</sup>
Soil-to-air volatilization factor <small>Chloroform</small>	VF	8.86E+03	8.86E+03	cm <sup>2</sup> /s
Soil-to-air volatilization factor <small>Mercury</small>	VF	1.35E+05	1.35E+05	cm <sup>2</sup> /s
Soil-to-air volatilization factor <small>Acetophenone</small>	VF	1.54E+05	1.54E+05	cm <sup>2</sup> /s

## Notes:

1. The New Jersey Department of Environmental Protection (NJDEP) Exposure Scenario assumptions are from the tables for Equations 3 and 4 from Appendix 2 and Equation 18 from Appendix 3 of the New Jersey Administrative Code (N.J.A.C) 7:26D, Last amended September 18, 2017. The particulate emission factor (PEF) from site-specific activity is the NJDEP default value, which was calculated using Equation 19 of Appendix 3 of the N.J.A.C. 7:26D. ([http://www.nj.gov/dep/rules/rules/njac7\\_26d.pdf](http://www.nj.gov/dep/rules/rules/njac7_26d.pdf))
2. The exposure frequency for the Site-specific exposure scenario assumes a trespasser may visit the Site 84 days a year.
3. The Site-specific exposure scenario assumptions (other than exposure frequency) are from Table 4.1 Reasonable Maximum Exposure for an adolescent trespasser at the landfill in the Revised Baseline Human Health Risk Assessment prepared by CDM Smith dated June 2014.
4. yr = year, mg = milligram, cm<sup>2</sup> = square centimeter, kg = kilogram, m<sup>3</sup> = cubic meter, s = second.
5. The soil-to-air volatilization factors of chloroform, acetophenone, and mercury are from the NJDEP Inhalation Exposure Pathway Alternative Remediation Standards Calculation Spreadsheet. ([http://www.nj.gov/dep/srp/guidance/rs/inhalation\\_ars.xls](http://www.nj.gov/dep/srp/guidance/rs/inhalation_ars.xls))

**TABLE 2**  
**Comparison of Maximum Soil Concentrations to New Jersey Non-Residential Soil Remediation Standards and Proposed Alternative Remediation Standards**  
 Rolling Knolls Landfill Superfund Site  
 Chatham, New Jersey

Constituent of Potential Concern Based on Comparison to NRDCSRS	Maximum Concentration in 0-2-foot Samples from the Site <sup>1</sup>	Nonresidential Direct Contact Soil Remediation Standards (NRDCSRS) <sup>2</sup>	Inhalation Health Based Criterion <sup>2</sup>	Site-Specific Inhalation (Trespasser) Carcinogen Concentration <sup>3</sup>	Site-Specific Inhalation (Trespasser) Non-Carcinogen Concentration <sup>3,4</sup>	Ingestion-Dermal Health Based Criterion <sup>2</sup>	Site-Specific Ingestion-Dermal (Trespasser) Carcinogen Concentration <sup>5</sup>	Site-Specific Ingestion-Dermal (Trespasser) Non-Carcinogen Concentration <sup>5</sup>	Proposed Alternative Remediation Standard (ARS) <sup>7,8,9</sup>	Does Maximum Concentration exceed Proposed ARS?
<i>Volatile Organic Compounds</i>										
Chloroform	1,900	2	2	10	11,550	11,000	NC	20,857	10	Y
<i>Semi-Volatile Organic Compounds</i>										
Acetophenone	18	5	5	NC	13	68,000	NC	159,689	13	Y
Bis(2-ethylhexyl)phthalate	19,000	140	140,000	NC	NC	140	665	31,938	670	Y
Benzo(a)anthracene	66	17	5,500	NC	NC	17	87	NC	87	N
Benzo(a)pyrene	51	2	230	NC	NC	2	8.7	448	9	Y
Benzo(b)fluoranthene	49	17	5,500	NC	NC	17	87	NC	87	N
Dibenz(a,h)anthracene	5	2	270	NC	NC	2	8.7	NC	9	N
<i>Pesticides</i>										
Aldrin	0.27	0.2	14	NC	NC	0.2	0.7	63	0.7	N
alpha-Chlordane	2.5	1	3,300	NC	NC	1	5	929	5	N
gamma-Chlordane	2.3	1	3,300	NC	NC	1	5	929	5	N
Dieldrin	0.3	0.2	3	NC	NC	0.2	0.8	104	0.8	N
Heptachlor	1.1	0.7	18	NC	NC	0.7	3	1,043	3	N
<i>Polychlorinated Biphenyls (PCBs)</i>										
Total PCBs (Sum of Aroclors)	126	1	57	NC	NC	1	5	NC	5	Y
<i>Inorganics</i>										
Antimony	1,960	450	23,000	NC	NC	450	NC	834	830	Y
Arsenic	529	19	76	NC	NC	2	7	573	19	Y
Copper	49,900	45,000	280,000	NC	NC	45,000	NC	83,429	83,000	N
Lead	16,500	800	12,000	NC	NC	800	NC	NC	2,700	Y
Manganese	13,600	5,900	5,900	NC	15,630	160,000	NC	292,000	16,000	N
Mercury	85.1	65	65	NC	176	340	NC	626	180	N
Vanadium	6,140	1,100	470,000	NC	NC	1,100	NC	2,086	2,100	Y

Notes:

- The maximum concentration of bis(2-ethylhexyl)phthalate was found in a sample of potential industrial waste in the landfill, not in soil.
- The New Jersey Department of Environmental Protection (NJDEP) NRDCSRS, Inhalation Health Based, and Ingestion-Dermal Health Based Criteria are from Table 1B in the New Jersey Administrative Code (N.J.A.C.) 7:26D - Remediation Standards, Last amended September 18, 2017. A Proposed Alternative Remediation Standard (ARS) was calculated for those compounds that exceed a specific NJDEP criterion.
- Site-specific carcinogenic and non-carcinogenic concentrations for inhalation exposure pathway for chloroform, acetophenone, and mercury were calculated using the exposure assumptions presented in Table 1 and the following equations from the N.J.A.C. 7:26D, Last amended September 18, 2017: Appendix 3, Equations 1 and 2.  
 Equation 1:  $InhvSRSc = (TR \cdot AT \cdot 365) / (URF \cdot 1000 \cdot EF \cdot (ED / VF))$  where  $InhvSRSc$  = Inhalation soil remediation standard for volatile carcinogens,  $TR$  = Target cancer risk,  $AT$  = Averaging time,  $URF$  = Inhalation unit risk factor,  $EF$  = Exposure frequency,  $ED$  = Exposure duration, and  $VF$  = Soil-to-air volatilization factor.  
 Equation 2:  $InhvSRSn = (THQ \cdot AT \cdot 365) / ((EF \cdot ED) / (RfC \cdot VF))$  where  $InhvSRSn$  = Inhalation soil remediation standard for volatile noncarcinogens,  $THQ$  = target hazard quotient, and  $RfC$  = inhalation reference concentration.
- A site-specific non-carcinogenic concentration for inhalation exposure pathway for manganese was calculated using the exposure assumptions presented in Table 1 and the following equations from the N.J.A.C. 7:26D, Last amended September 18, 2017: Appendix 3, Equations 15, 17, and 18.  
 Equation 15:  $InhpSRSn = (10^6 \text{ mg/kg}) / (DOSE / RfDi)$  where  $InhpSRSn$  = Inhalation soil remediation standard for particulate noncarcinogens,  $DOSE$  = exposure dose calculation, and  $RfDi$  = inhalation reference dose.  
 Equation 17:  $RfDi = RfC \cdot DIR / BW / 10^3 \text{ } \mu\text{g/mg}$  where  $BW$  = body weight and  $DIR$  = daily inhalation rate.  
 Equation 18:  $DOSE = PEFs \cdot DIR \cdot EF \cdot ED / (BW \cdot AT \cdot 365 \text{ d/yr})$  where  $PEFs$  = particulate emission factor from site activity.
- Site-specific carcinogenic and non-carcinogenic concentrations for the ingestion-dermal exposure pathway were calculated using the exposure assumptions presented in Table 1 and the following equations from Appendix 2 of the N.J.A.C. 7:26D, Last amended September 18, 2017: Equation 3 and Equation 4.  
 Equation 3: Remediation Standard =  $(TR \cdot BW \cdot AT \cdot 365 \text{ d/yr}) / ((EF \cdot ED \cdot 0.000001 \text{ kg/mg}) \cdot ((SfO \cdot IR) + (SFabs \cdot AF \cdot ABSd \cdot SA \cdot EV)))$ , where  $SfO$  = oral cancer slope factor,  $IR$  = soil ingestion rate,  $SFabs$  = dermally adjusted cancer slope factor,  $AF$  = skin-soil adherence factor,  $ABSd$  = dermal absorption fraction,  $SA$  = skin surface exposed, and  $EV$  = event frequency.  
 Equation 4: Remediation Standard =  $(THQ \cdot BW \cdot AT \cdot 365 \text{ d/yr}) / ((EF \cdot ED \cdot 0.000001 \text{ kg/mg}) \cdot ((1 / RfDo \cdot IR) + (1 / RfDabs \cdot AF \cdot ABSd \cdot SA \cdot EV)))$ , where  $RfDo$  = oral reference dose and  $RfDabs$  = dermally adjusted reference dose.
- Chemical-specific toxicity values used in the equations referenced in notes 3, 4, and 5 are shown in Table 7.
- Proposed ARS are the lower of the carcinogenic and non-carcinogenic values for the inhalation and ingestion-dermal exposure pathways rounded to two significant figures or one significant figure if the value is less than 10, except for lead and arsenic.
- The Proposed ARS for lead in soil was developed using the adult lead model (ALM) with default baseline blood lead concentration and geometric standard deviation (GSD) parameters derived from the National Health and Nutritional Examination Survey (NHANES) (2009-2014) data set and a target blood lead level (BLL) concentration recommended by the Centers for Disease Control of 5 micrograms per deciliter ( $\mu\text{g/L}$ ). In May of 2017, the Office of Land and Emergency Management (OLEM) Directive 9285.6-56 was released and updated the values for the baseline blood concentration and GSD parameters to 0.6  $\mu\text{g/dL}$  and 1.8, respectively, using more recent NHANES 2009-2014 data. In addition, a December 2016 memorandum from OLEM to USEPA acknowledges that current science shows that there is no safe exposure level to lead and that several studies have observed "clear evidence of cognitive function decrements with mean or group blood lead levels between 2 and 8  $\mu\text{g/dL}$ ."
- The Proposed ARS for arsenic is set to the NJDEP direct contact soil remediation standard of 19 mg/kg, which is based on natural background.
- All concentrations are in milligram per kilogram (mg/kg).
- Y = yes, N = no, NC = not calculated.

**TABLE 3**  
**Exposure Assumptions for Shooting Range Evaluation**  
 Rolling Knolls Landfill Superfund Site  
 Chatham, New Jersey

Exposure Assumptions	NJDEP Abbreviation	NJDEP Residential Exposure Scenario	Site-Specific Recreator Exposure Scenario	Units
Target Cancer Risk	TR	1E-06	1E-06	unitless
Target Hazard Quotient	THQ	1	1	unitless
Body Weight	BW	15	15	kg
Averaging Time (cancer)	AT	70	70	yr
Averaging Time (non-cancer)	AT	6	6	yr
Exposure Frequency	EF	350	156	days/yr
Soil Ingestion Rate	IR	200	200	mg/day
Age-adjusted dermal factor	SFS	360	360	mg-yr/kg-event
Age-adjusted soil ingestion factor	IF	114	114	mg-yr/kg-event
Skin-Soil Adherence Factor	AF	0.2	0.2	mg/cm <sup>2</sup> -event
Skin Surface Exposed	SA	2800	2800	cm <sup>2</sup>
Event Frequency	EV	1	1	event/day
Exposure Duration	ED	6	6	yr

## Notes:

1. The New Jersey Department of Environmental Protection (NJDEP) Exposure Scenario assumptions are from the tables for Equation 1 and Equation 2 from Appendix 2 of the New Jersey Administrative Code (N.J.A.C) 7:26D, Last amended September 18, 2017. ([http://www.nj.gov/dep/rules/rules/njac7\\_26d.pdf](http://www.nj.gov/dep/rules/rules/njac7_26d.pdf))
2. The exposure frequency for the Site-specific exposure scenario assumes a recreator (child) may visit the Site three (3) days per week.
3. yr = year, mg = milligram, cm<sup>2</sup> = square centimeter, kg = kilogram.

**TABLE 4**  
**Comparison of Shooting Range Soil Maximum Concentrations to NJDEP Residential Standards and Proposed Alternative Remediation Standards**  
Rolling Knolls Landfill Superfund Site  
Chatham, New Jersey

Constituent of Potential Concern Based on Comparison to RDCSRS	Maximum Concentration in Samples from Shooting Range Exposure Area	Residential Direct Contact Soil Remediation Standards (RDCSRS) <sup>1</sup>	Inhalation Health Based Criterion <sup>1</sup>	Ingestion-Dermal Health Based Criterion <sup>1</sup>	Site-Specific Ingestion-Dermal (Child Resident) Carcinogen Concentration <sup>2</sup>	Proposed Alternative Remediation Standard (ARS) <sup>3</sup>	Does Maximum Concentration exceed Proposed ARS?
<i>Semi-Volatile Organic Compounds</i>							
Benzo(a)pyrene	0.77	0.5	3,600	0.5	1	1	N

Notes:

1. The New Jersey Department of Environmental Protection (NJDEP) RDCSRS, Inhalation Health Based, and Ingestion-Dermal Health Based Criteria are from Table 1A in the New Jersey Administrative Code (N.J.A.C.) 7:26D - Remediation Standards, Last amended September 18, 2017. A Proposed Alternative Remediation Standard (ARS) was calculated for those
2. The site-specific carcinogen concentration was calculated using the exposure assumptions presented in Table 1 and the following equations from Appendix 2 of the N.J.A.C. 7:26D, Last Amended September 18, 2017: Equation 1.

Equation 1: Remediation Standard =  $(TR \cdot AT \cdot 365 \text{ d/yr}) / ((EF \cdot 0.000001 \text{ kg/mg}) \cdot ((SFO \cdot IF) + (SFabs \cdot SFS \cdot ABSd \cdot EV)))$ , where TR = target cancer risk, AT = averaging time, EF = exposure frequency, SFO = oral slope factor, IF = age-adjusted soil ingestion factor, ABSd = dermal absorption fraction,; SFS = age-adjusted dermal factor, and EV = event frequency. SFAabs = SFO / ABSGI, where SFabs = dermally adjusted slope factor and ABSGI = gastrointestinal absorption factor.

3. Proposed ARS is the carcinogen concentration rounded to one significant figure because the value is less than 10.
4. N = no.
5. All units are in milligram per kilogram (mg/kg).

**TABLE 5**  
**Exposure Assumptions for Baseball Field Evaluation**  
 Rolling Knolls Landfill Superfund Site  
 Chatham, New Jersey

Exposure Assumptions	NJDEP Abbreviation	NJDEP Residential Exposure Scenario	Site-Specific Recreator Exposure Scenario	Units
Target Cancer Risk	TR	1E-06	1E-06	unitless
Target Hazard Quotient	THQ	1	1	unitless
Body Weight	BW	15	15	kg
Averaging Time (cancer)	AT	70	70	yr
Averaging Time (non-cancer)	AT	6	6	yr
Exposure Frequency	EF	350	156	days/yr
Soil Ingestion Rate	IR	200	200	mg/day
Age-adjusted dermal factor	SFS	360	360	mg-yr/kg-event
Age-adjusted soil ingestion factor	IF	114	114	mg-yr/kg-event
Skin-Soil Adherence Factor	AF	0.2	0.2	mg/cm <sup>2</sup> -event
Skin Surface Exposed	SA	2800	2800	cm <sup>2</sup>
Event Frequency	EV	1	1	event/day
Exposure Duration	ED	6	6	yr

## Notes:

1. The New Jersey Department of Environmental Protection (NJDEP) Exposure Scenario assumptions are from the tables for Equation 1 and Equation 2 from Appendix 2 of the New Jersey Administrative Code (N.J.A.C) 7:26D, Last amended September 18, 2017. ([http://www.nj.gov/dep/rules/rules/njac7\\_26d.pdf](http://www.nj.gov/dep/rules/rules/njac7_26d.pdf))
2. The exposure frequency for the Site-specific exposure scenario assumes a recreator (child) may visit the Site three (3) days per week.
3. yr = year, mg = milligram, cm<sup>2</sup> = square centimeter, kg = kilogram.

**TABLE 6**  
**Comparison of Baseball Field Soil Maximum Concentrations to NJDEP Residential Standards and Proposed Alternative Remediation Standards**  
Rolling Knolls Landfill Superfund Site  
Chatham, New Jersey

Constituent of Potential Concern Based on Comparison to RDCSRS	Maximum Concentration in Samples from Baseball Field Area	Residential Direct Contact Soil Remediation Standards (RDCSRS) <sup>1</sup>	Inhalation Health Based Criterion <sup>1</sup>	Ingestion-Dermal Health Based Criterion <sup>1</sup>	Site-Specific Ingestion-Dermal (Child Resident) Carcinogen Concentration <sup>2</sup>	Proposed Alternative Remediation Standard (ARS) <sup>3</sup>	Does Maximum Concentration exceed Proposed ARS?
<i>Semi-Volatile Organic Compounds</i>							
Benzo(a)pyrene	1	0.5	3,600	0.5	1	1	N

Notes:

- The New Jersey Department of Environmental Protection (NJDEP) RDCSRS, Inhalation Health Based, and Ingestion-Dermal Health Based Criteria are from Table 1A in the New Jersey Administrative Code (N.J.A.C.) 7:26D - Remediation Standards, Last amended September 18, 2017. A Proposed Alternative Remediation Standard (ARS) was calculated for those compounds that exceed a specific NJDEP criterion.
- The site-specific carcinogen concentration was calculated using the exposure assumptions presented in Table 1 and the following equations from Appendix 2 of the N.J.A.C. 7:26D, Last Amended September 18, 2017: Equation 1.  
Equation 1: Remediation Standard =  $(TR \cdot AT \cdot 365 \text{ d/yr}) / ((EF \cdot 0.000001 \text{ kg/mg}) \cdot ((SF_o \cdot IF) + (SF_{abs} \cdot SFS \cdot ABS_d \cdot EV)))$ , where TR = target cancer risk, AT = averaging time, EF = exposure frequency, SF<sub>o</sub> = oral slope factor, IF = age-adjusted soil ingestion factor, ABS<sub>d</sub> = dermal absorption fraction, SFS = age-adjusted dermal factor, and EV = event frequency. SFA<sub>abs</sub> = SF<sub>o</sub> / ABS<sub>GI</sub>, where SF<sub>abs</sub> = dermally adjusted slope factor and ABS<sub>GI</sub> = gastrointestinal absorption factor.
- Proposed ARS is the carcinogen concentration rounded to one significant figure because the value is less than 10.
- N = no.
- All units are in milligram per kilogram (mg/kg).

**TABLE 7**  
**Chemical-Specific Toxicity Values**  
Rolling Knolls Landfill Superfund Site  
Chatham, New Jersey

Constituent of Potential Concern	Oral Cancer Slope Factor (SFo) (mg/kg-day) <sup>-1</sup>	Dermally Adjusted Cancer Slope Factor (SFabs) (mg/kg-day) <sup>-1</sup>	Dermal Absorption Fraction (ABSd)	Gastrointestinal Absorption Fraction (ABSGI)	Oral Reference Dose (RfDo) (mg/kg-day)	Dermally Adjusted Reference Dose (RfDabs) (mg/kg-day)	Inhalation Unit Risk Factor (URF) (mg/kg-day) <sup>-1</sup>	Inhalation Reference Concentration (RfC) (µg/m <sup>3</sup> )
<i>Volatile Organic Compounds</i>								
Chloroform	3.1E-02	--	--	--	1.0E-02	1.0E-02	2.3E-05	3.0E+02
<i>Semi-Volatile Organic Compounds</i>								
Acetophenone	--	--	1.0E-01	1	1.0E-01	1.0E-01	--	2.0E-02
Bis(2-ethylhexyl)phthalate	1.4E-02	1.4E-02	1.0E-01	1	2.0E-02	2.0E-02		
Benzo(a)anthracene	1.0E-01	1.0E-01	1.3E-01	1	--	--		
Benzo(a)pyrene	1.0E+00	1.0E+00	1.3E-01	1	3.0E-04	3.0E-04		
Benzo(b)fluoranthene	1.0E-01	1.0E-01	1.3E-01	1	--	--		
Dibenz(a,h)anthracene	1.0E+00	1.0E+00	1.3E-01	1	--	--		
<i>Pesticides</i>								
Aldrin	1.7E+01	1.7E+01	--	1	3.0E-05	3.0E-05		
alpha-Chlordane	2.3E+00	2.3E+00	4.0E-02	1	5.0E-04	5.0E-04		
gamma-Chlordane	2.3E+00	2.3E+00	4.0E-02	1	5.0E-04	5.0E-04		
Dieldrin	1.6E+01	1.6E+01	--	--	5.0E-05	5.0E-05		
Heptachlor	4.5E+00	4.5E+00	--	--	5.0E-04	5.0E-04		
<i>Polychlorinated Biphenyls (PCBs)</i>								
Total PCBs (Sum of Aroclors)	2.0E+00	2.0E+00	1.0E-01	1	--	--		
<i>Inorganics</i>								
Antimony	--	--	--	--	4.0E-04	4.0E-04		
Arsenic	1.5E+00	1.5E+00	3.0E-02	1	3.0E-04	3.0E-04		
Copper	--	--	--	--	4.0E-02	4.0E-02		
Manganese	--	--	--	--	1.4E-01	1.4E-01	--	5.0E-02
Mercury	--	--	--	--	3.0E-04	3.0E-04	--	3.0E-01
Vanadium	--	--	--	--	1.0E-03	1.0E-03		

Notes:

- Generally, the Oral Cancer Slope Factors (SFo) and Oral Reference Doses (RfDo) are from Table A-4 of New Jersey Department of Environmental Protection (NJDEP) Ingestion-Dermal Exposure Pathway Soil Remediation Standards, Basis and Background dated June 2008. ([http://www.nj.gov/dep/srp/regs/rs/bb\\_ingest\\_dermal.pdf](http://www.nj.gov/dep/srp/regs/rs/bb_ingest_dermal.pdf)) See note 2 for exceptions.
- The SFo and RfDo for chloroform, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were obtained from the United States Environmental Protection Agency (USEPA) Regional Screening Levels - Generic Tables with a target cancer risk of 1E-6 and a target hazard quotient of 1 (last updated November 2017). (<https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-november-2017>)
- Generally, the Dermally Adjusted Cancer Slope Factors (SFabs), Dermal Absorption Fractions (ABSd), Gastrointestinal Absorption Fractions (ABSGI), and Dermally Adjusted Reference Doses (RfDabs) are from Table A-3 of NJDEP Ingestion-Dermal Exposure Pathway Soil Remediation Standards, Basis and Background dated June 2008. ([http://www.nj.gov/dep/srp/regs/rs/bb\\_ingest\\_dermal.pdf](http://www.nj.gov/dep/srp/regs/rs/bb_ingest_dermal.pdf)) See note 4 for exceptions.
- The SFabs and RfDabs for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were calculated using the following equations from the NJDEP Ingestion-Dermal Exposure Pathway Soil Remediation Standards, Basis and Background dated June 2008: Equations 1 and 2.  
Equation 1: SFabs = SFo / ABSGI.  
Equation 2: RfDabs = RfDo / ABSGI.
- The Inhalation Reference Concentrations (RfC) and Inhalation Unit Risk Factors (URF) for chloroform, acetophenone, manganese, and mercury are from Appendix A of the NJDEP Inhalation Exposure Pathway Soil Remediation Standards, Basis and Background dated June 2008. ([http://www.nj.gov/dep/srp/regs/rs/bb\\_inhalation.pdf](http://www.nj.gov/dep/srp/regs/rs/bb_inhalation.pdf)) No other RfCs or URFs were used in the Alternative Remediation Standard calculations; therefore, no other RfCs or URFs are presented.
- mg = milligram, m<sup>3</sup> = cubic meter, kg = kilogram, µg = microgram, -- = not available.