Health Consultation

Evaluating Potential Public Health Implications of Drinking Water Contamination

Moorestown, Burlington County,
New Jersey

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Prepared by:

New Jersey Department of Health
Environmental and Occupational Health Surveillance Program

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Summary

Introduction	The New Jersey Department of Health (NJDOH) reviewed environmental data to evaluate the public health implications of drinking water contamination in Moorestown, Burlington County, New Jersey. This was done under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). The data reviewed in this health consultation includes data collected during the third cycle of the United States Environmental Protection Agency's (USEPA) Unregulated Contaminant Monitoring Rule (UCMR3) program. Data from the New Jersey Department of Environmental Protection's (NJDEP) Drinking Water Watch website and Mooretown Township's 2015 Annual Water Quality Report were also included. This data was reviewed at the request of the Moorestown Water Group. This community group formed due to concerns about unregulated contaminants discovered in the Moorestown drinking water supply during the UCMR3 program. The top priority of the NJDOH is to ensure that the community of Moorestown has the best information possible to safeguard its health. Copies of this Health Consultation will be provided to the Moorestown Water Community Group and to Moorestown Township. Questions about this Health Consultation should be directed to the NJDOH at (609) 826-4984.
Conclusions	Based on available information, the NJDOH has reached four conclusions for the Moorestown Drinking Water Contamination site.
Conclusion 1	*Current and future exposures to 1,2,3-Trichloropropane (TCP) in the Moorestown drinking water supply are not likely to harm people's health.*
Basis for Conclusion 1	Current and future exposures to TCP from the North Church Street plant have been interrupted through the installation of a Granular Activated Carbon (GAC) treatment system in February 2017. This system was installed specifically to remove TCP prior to the water being distributed for consumption.
Next Steps	The NJDOH recommends that the NJDEP work with Moorestown to ensure that the GAC treatment system at the North Church Street plant continues to remove TCP from the community drinking water supply.
Conclusion 2	*Current and future exposures to 1,4 dioxane in the Moorestown drinking water supply are not likely to harm people's health.*
Basis for Conclusion 2	The evaluation of 1,4-dioxane data collected between 2013 and 2018 indicates that health effects, including cancer, would not be expected.

Conclusion 3	*We cannot conclude whether current and future exposures to hexavalent chromium in the Moorestown drinking water supply will harm people's health.*
Basis for Conclusion 3	The NJDOH does not have current sampling results for hexavalent chromium in the Moorestown drinking water supply. If the hexavalent chromium levels have remained unchanged since the 2013-2015 UCMR3 sampling event, cancer risks would be low. Non-cancer health effects, such as anemia and gastrointestinal irritation, would not be expected based on the evaluation of the available data.
Next Steps	The NJDOH recommends that the NJDEP continue to work with Moorestown to ensure that contaminants not currently removed with the GAC system be monitored and treated using another technology if necessary. The NJDOH encourages the USEPA and/or the NJDEP to proceed with the development of maximum contaminant levels for hexavalent chromium.
Conclusion 4	*We cannot conclude whether past exposures to contaminated drinking water (prior to the installation of the GAC system in February 2017) harmed people's health.*
Basis for Conclusion 4	The NJDOH does not have meaningful data prior to the 2013-2015 UCMR3 program to determine what the actual levels of unregulated contaminants were in the past. Specifically, it is possible that levels of TCP prior to 2013 may have been higher or lower than the data used to evaluate the potential for health effects. Therefore, data collected between 2013 and 2016 was used to approximate historical concentrations. Based on the available data, non-cancer health effects are not expected from exposures to drinking water contaminants. Cancer risks were low for combined exposures to TCP, 1,4-Dioxane and hexavalent chromium for the majority of the population. There may have been an increased cancer risk for a small portion of the population near the North Church Street plant, as some individuals may have received the majority of contaminated water from this plant.

Statement of Issues

The New Jersey Department of Health (NJDOH) prepared this health consultation at the request of the Moorestown Water Group. This was done under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). The Moorestown Water Group represents community members concerned about contaminants found in the public drinking water supply in Moorestown, Burlington County, New Jersey.

This document evaluates the public health implications of exposures to these drinking water contaminants. These contaminants were found during the United States Environmental Protection Agency's (USEPA) third Unregulated Contaminant Monitoring Rule (UCMR3) program. The UCMR3 drinking water monitoring program occurred between 2013 and 2015. In addition to the unregulated contaminants found in the UCMR3 data, some regulated contaminants with elevations above standards were also included in this health consultation.

Background

Geographic and Demographic Information

Moorestown Township is located in Burlington County, New Jersey (**See Figure 1**). According to the United States Census Bureau, the township has a total area of approximately 15 square miles.

The township is located in southwest Burlington County. Surrounding towns include Maple Shade, Cinnaminson, Delran, Willingboro, and Mount Laurel. Moorestown Township is approximately 10 miles east of Philadelphia, Pennsylvania.

According to the United States 2010 Census, there are 20,726 people living in Moorestown and 7,450 households. The median age is 43 years. **Table 1** summarizes the demographics of Moorestown:

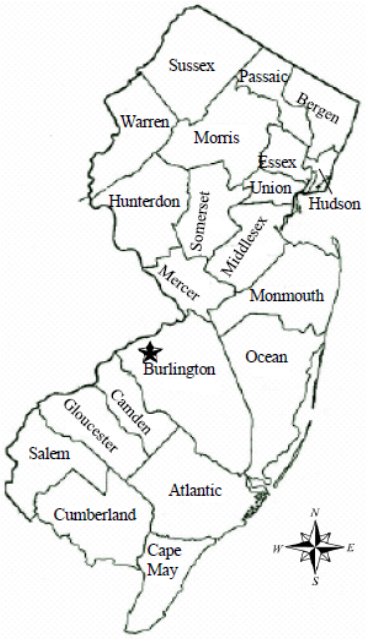

Figure 1: Moorestown Drinking Water Contamination

Table 1. Demographics of Moorestown, Burlington County, New Jersey

Race	Percentage of Population (%)
White	84.5
Black/African American	6.4
Native American	0.1
Asian	6.0
Pacific Islander	<0.1
Two or More Races	2.2
Other Races	0.8
Age Distribution	**Percentage of Population (%)**
Under 18 years of age	27.3
Ages 18-24 years	6.2
Ages 25-44	19.0
Ages 45-64	31.2
Ages 65 and older	16.2

Source: https://en.wikipedia.org/wiki/Moorestown,_New_Jersey

Moorestown Water Sources

The Moorestown Water Department obtains water from three Township water treatment plants and has purchased water from New Jersey American Water Company since 1993. There are seven public supply wells in the system that are served by the three township water treatment plants: North Church Street, Kings Highway, and Hartford Road. **Table 2** summarizes the treatment plants and the associated supply wells.

Table 2. Water Treatment Plants and Associated Supply Wells

Treatment Plant	Well Number	Year of Well Installation / Began Supplying Water to Moorestown
Kings Highway	3	Installed April 1942
Hartford Road	4	Installed May 1959
Kings Highway	5	Installed July 1964
Kings Highway	6	Installed November 1963
North Church Street	7	Became a public supply well in February 1969
Hartford Road	8	Installed July 1969
North Church Street	9	Installed November 2011/ Began supplying water in 2012

Moorestown Water Supply Contamination

The 1996 amendments to the Safe Drinking Water Act require the USEPA to issue a list of up to 30 unregulated contaminants once every five years for public water systems to monitor. The UCMR provides the USEPA with data on the occurrence of these unregulated contaminants in drinking water. These data serve as a primary source of occurrence and exposure information that the USEPA uses to make regulatory decisions [USEPA 2012]. The UCMR3 monitoring in Moorestown occurred between 2013-2015 and included sampling for 28 chemicals and two viruses.

The UCMR3 monitoring in Moorestown detected elevated concentrations of 1,2,3-Trichloropropane (TCP) between March 2013 and September 2013. The NJDEP's Synthetic Organic Compounds report also detected TCP in July 2013. In October 2014, the North Church Street water treatment plant was shut down due to the presence of TCP at the request of the New Jersey Department of Environmental Protection (NJDEP). The plant was re-opened in June 2015 using only well 7 as this well had had lower TCP levels than Well 9. Continued monthly sampling by the Township showed Well 7 continued to have detections of TCP. The plant was shut down again in February of 2016. In February 2017, a Granular Activated Carbon (GAC) system was installed at the North Church Street plant to remove TCP from the water supply. A more permanent system will be installed in the future [Moorestown 2016].

Based on information obtained from the UCMR3 program, NJDEP's Drinking Water Watch, and the 2015 Moorestown Water Quality Report TCP was not detected in the other two treatment plants or from the purchased water. Besides TCP, other unregulated contaminants were found during the UCMR3 program including hexavalent chromium, 1,4-Dioxane, and some metals and minerals. **Table 3** summarizes the UCMR3 contaminants and the treatment plants where they were found.

Table 3. Unregulated Contaminants in Treatment Plants

Unregulated Contaminant	Treatment Plant Location				
	North Church Street	Kings Highway	Hartford Road *	Distribution System	NJ American Water Co.
TCP	**X**	Not Detected	Not Detected	Not Detected	Not Detected
Hexavalent chromium	**X**	Not Detected	No Data	**X**	**X**
1,4-Dioxane	**X**	Not Detected	No Data	No Data	Not Detected
1,1-Dichloroethane**	**X**	Not Detected	Not Detected	Not Detected	Not Detected
Chlorate	**X**	Not Detected	No Data	**X**	Not Detected
Vanadium	**X**	Not Detected	No Data	**X**	Not Detected
Strontium	**X**	**X**	No Data	**X**	**X**
Cobalt	**X**	Not Detected	No Data	Not Detected	Not Detected
Molybdenum	Not Detected	Not Detected	No Data	**X**	**X**

* Since the 1990's, the Hartford Road plant is for emergency use only; ** Although not Federally regulated, 1,1-Dichloroethane is regulated by the NJDEP; "**X**" represents location where contaminant was detected

Moorestown Water Usage

The water distribution is an open system in which the treatment plants and purchased water typically serve properties closest to the distribution points. However there have been instances when one treatment plant or purchased water served as the primary source of water for the entire community for several months [Personal communication, Thomas Merchel, August 2, 2017]. The annual overall contribution from each water source is presented in Table 4. Based on water usage information received from the NJDEP, Well 7 contributed an average of 48% of the water to the community water supply between 1981 and 2016. Well 9 was installed in 2011 and contributed approximately 3% of the water supply between 2012 and 2017. Therefore, the total average water usage contribution from both wells was 51% (as shown in **Table 5**).

Table 4. Moorestown Water Usage

Year	Treatment Plant/Water Source	Wells	Annual Water Use Percentage (%)
1981	North Church Street	Well 7	28
	Kings Highway	Wells 3, 5 & 6	34
	Hartford Road	Wells 4 & 8	38
1982	Kings Highway	Wells 3, 5 & 6	39
	Hartford Road	Wells 4 & 8	24
	North Church Street	Well 7	37
1983	Kings Highway	Well 3	45
	Hartford Road	Well 4	25
	North Church Street	Well 7	30
1984	Kings Highway	Wells 3, 5 & 6	39
	Hartford Road	Wells 4 & 8	28
	North Church Street	Well 7	33
1985	North Church Street	Well 7	39
	Kings Highway	Wells 3, 5 & 6	35
	Hartford Road	Wells 4 & 8	26
1986	All Three Plants	Wells 7, 3, 5, 6, 4, & 8	17% from each well
1987	Kings Highway	Wells 3, 5 & 6	28
	Hartford Road	Wells 4 & 8	32
	North Church Street	Well 7	40
1988	Kings Highway	Wells 3, 5 & 6	22
	Hartford Road	Wells 4 & 8	38
	North Church Street	Well 7	40
1989	Hartford Road	Wells 4 & 8	25
	North Church Street	Well 7	42
	Kings Highway	Wells 3, 5 & 6	33
1990	Hartford Road	Wells 4 & 8	23
	North Church Street	Well 7	48
	Kings Highway	Wells 3, 5 & 6	29

Year	Treatment Plant/ Water Source	Wells	Water Use Percentage (%)
1991	Hartford Road	Wells 4 & 8	39
	North Church Street	Well 7	47
	Kings Highway	Wells 3, 5 & 6	13
1992	Hartford Road	Wells 4 & 8	22
	North Church Street	Well 7	44
	Kings Highway	Wells 3, 5 & 6	34
1993	Kings Highway	Wells 3, 5 & 6	35
	North Church Street	Well 7	38
	Hartford Road	Wells 4 & 8	27
	NJ American Water Co.	NJ American Water Co.	1
1994	Kings Highway	Well 5	17
	Hartford Road	Well 8	3
	Kings Highway	Well 3	3
	Hartford Road	Well 4	12
	Kings Highway	Well 6	17
	North Church Street	Well 7	47
	NJ American Water Co.	NJ American Water Co.	1
1995	Hartford Road	Well 8	6
	North Church Street	Well 7	47
	Kings Highway	Well 6	11
	Kings Highway	Well 5	15
	Hartford Road	Well 4	9
	Kings Highway	Well 3	9
	NJ American Water Co.	NJ American Water Co.	3
1996	North Church Street	Well 7	54
	Hartford Road	Wells 4 & 8	3
	Kings Highway	Wells 3, 5 & 6	37
	NJ American Water Co.	NJ American Water Co.	6
1997	North Church Street	Well 7	48
	Hartford Road	Wells 4 & 8	4
	Kings Highway	Wells 3, 5 & 6	33
	NJ American Water Co.	NJ American Water Co.	15
1998	Kings Highway	Wells 3, 5 & 6	17
	North Church Street	Well 7	69
	NJ American Water Co.	NJ American Water Co.	14
1999	North Church Street	Well 7	82
	NJ American Water Co.	NJ American Water Co.	18
2000	Kings Highway	Wells 3, 5 & 6	18
	North Church Street	Well 7	71
	NJ American Water Co.	NJ American Water Co.	12

Year	Treatment Plant/Water Source	Wells	Water Use Percentage (%)
2001	North Church Street	Well 7	58
	Kings Highway	Well 6	2
	Kings Highway	Well 5	13
	NJ American Water Co.	NJ American Water Co.	27
2002	North Church Street	Well 7	67
	Kings Highway	Well 3	17
	NJ American Water Co.	NJ American Water Co.	16
2003	Kings Highway	Well 3	7
	Kings Highway	Well 5	7
	North Church Street	Well 7	73
	NJ American Water Co.	NJ American Water Co.	13
2004	Kings Highway	Well 3	13
	Kings Highway	Well 5	15
	Kings Highway	Well 6	1
	North Church Street	Well 7	45
	NJ American Water Co.	NJ American Water Co.	26
2005	Kings Highway	Well 3	4
	Hartford Road	Well 4	7
	Kings Highway	Well 5	5
	North Church Street	Well 7	64
	Hartford Road	Well 8	1
	NJ American Water Co.	NJ American Water Co.	19
2006	Kings Highway	Well 3	2
	Kings Highway	Well 5	5
	North Church Street	Well 7	76
	NJ American Water Co.	NJ American Water Co.	16
2007	Kings Highway	Well 5	7
	North Church Street	Well 7	68
	NJ American Water Co.	NJ American Water Co.	25
2008	Kings Highway	Well 6	7
	North Church Street	Well 7	69
	NJ American Water Co.	NJ American Water Co.	24
2009	Kings Highway	Well 6	3
	North Church Street	Well 7	63
	NJ American Water Co.	NJ American Water Co.	34
2010	Kings Highway	Well 5	13
	North Church Street	Well 7	57
	NJ American Water Co.	NJ American Water Co.	30
2011	Kings Highway	Well 6	12
	North Church Street	Well 7	61
	NJ American Water Co.	NJ American Water Co.	28

Year	Treatment Plant/Water Source	Wells	Water Use Percentage (%)
2012	Kings Highway	Well 5	5
	North Church Street	Well 7	29
	North Church Street	Well 9	37
	NJ American Water Co.	NJ American Water Co.	29
2013	Kings Highway	Well 5	3
	Kings Highway	Well 6	1
	North Church Street	Well 7	32
	North Church Street	Well 9	33
	NJ American Water Co.	NJ American Water Co.	32
2014	Kings Highway	Well 5	2
	Kings Highway	Well 6	5
	North Church Street	Well 7	1
	North Church Street	Well 9	51
	NJ American Water Co.	NJ American Water Co.	42
2015	Kings Highway	Well 5	8
	North Church Street	Well 7	42
	North Church Street	Well 9	0
	NJ American Water Co.	NJ American Water Co.	50
2016	Kings Highway	Well 5	8
	Kings Highway	Well 6	5
	North Church Street	Well 7	10
	North Church Street	Well 9	0
	NJ American Water Co.	NJ American Water Co.	76
2017 (GAC installed)	Kings Highway	Well 6	23
	North Church Street	Well 9	49
	NJ American Water Co.	NJ American Water Co.	28

Table 5. Water Contribution for North Church Street Wells 7 and 9

Year	Percent Contribution Well 7 (%)	Percent Contribution Well 9 (%)	Total Contribution (%)
1981	28	0	28
1982	37	0	37
1983	30	0	30
1984	33	0	33
1985	39	0	39
1986	17	0	17
1987	40	0	40
1988	40	0	40
1989	42	0	42
1990	48	0	48
1991	47	0	47
1992	44	0	44
1993	38	0	38
1994	47	0	47
1995	47	0	47
1996	54	0	54
1997	48	0	48
1998	69	0	69
1999	82	0	82
2000	71	0	71
2001	58	0	58
2002	67	0	67
2003	73	0	73
2004	45	0	45
2005	64	0	64
2006	76	0	76
2007	68	0	68
2008	69	0	69
2009	63	0	63
2010	57	0	57
2011	61	0	61
2012	29	37	66
2013	32	33	65
2014	1	51	52
2015	42	0 *	42
2016	10	0	10
Average Water Usage	**48%**	**3%**	**51%**

Notes: * In 2015, Well 9 operated only in the month of June, contributing 0.015 million gallons which is an insignificant contribution to the yearly percentage, making the yearly % equal to zero. This table represents water usage for pre-GAC treatment on the North Church Street plant.

Community Concerns

The Moorestown Water Group expressed concerns over potential health impacts from exposures to drinking water contaminants found during the UCMR3 program. These concerns were based on Moorestown Township's 2015 Annual Water Quality Report which included the UCMR3 findings. Specific concerns were raised regarding exposures to the following unregulated contaminants:

- *TCP*
- *1,4-Dioxane*
- *1,1-Dichloroethane (this contaminant is regulated by NJDEP, but not by EPA)*
- *Hexavalent chromium (also known as chromium (VI))*
- *Cobalt*
- *Molybdenum*
- *Strontium*
- *Vanadium*
- *Chlorate*

Concerns were also raised regarding elevated levels of two regulated contaminants:

- *Trichloroethylene (TCE) and*
- *Gross Alpha*.

TCE is a chlorinated volatile organic compound and gross alpha is a measure of radioactivity in drinking water.

These contaminants were primarily found in the North Church Street plant and distribution system. Hexavalent chromium, molybdenum and strontium were also found in the water purchased from New Jersey American Water Company. Strontium was the only UCMR3 contaminant detected in the Kings Highway treatment plant.

Environmental Contamination

An evaluation of site-related environmental contamination follows a two-tiered approach:

1) a screening analysis and
2) an in-depth analysis to determine public health implications of site-specific exposures.

First, maximum concentrations of detected substances are compared to environmental media-specific health-based guideline comparison values. If contaminant concentrations exceed the environmental comparison value, these substances are selected for further evaluation. These are considered contaminants of concern. Contaminant levels above environmental comparison values do not mean that harmful health effects are likely, but that further evaluation is necessary. Once exposure doses are estimated, they are further evaluated to determine the likelihood of harmful health effects.

Environmental Comparison Value Guidelines

A number of environmental comparison values are available to screen contaminants to identify contaminants of concern. These include ATSDR Environmental Media Evaluation Guides (EMEGs) and Reference Media Evaluation Guides (RMEGs). EMEGs are estimated contaminant concentrations that are not expected to result in adverse non-cancer health effects. RMEGs represent the concentration in water or soil at which daily human exposure is unlikely to result in harmful non-cancer health effects. If the substance is a known or a probable carcinogen, ATSDR's Cancer Risk Evaluation Guides (CREGs) are also considered as comparison values. CREGs are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed over their lifetime (78 years).

If an ATSDR environmental comparison value is not available, other comparison values may be used. These include the USEPA Human Health Media-Specific Screening Levels (SLs) and the USEPA maximum contaminant levels (MCLs). These health-based benchmarks are derived from the evaluation of cancer and non-cancer effects using current toxicity criteria. Contaminants without environmental comparison values are selected for further evaluation.

The NJDOH reviewed all available public supply drinking water data for Moorestown for the following UCMR3 contaminants: TCP, 1,4-Dioxane, 1,1-Dichloroethane, hexavalent chromium, total chromium, cobalt, molybdenum, strontium, vanadium, and chlorate. Regulated contaminants TCE and gross alpha were also included since these were mentioned as concerns by the community. Although 1,1-Dichloroethane is not regulated by the USEPA, it is regulated by the NJDEP.

The primary source of data was the NJDEP New Jersey Drinking Water Watch through the Bureau of Safe Drinking Water. Data for contaminants not provided on the Drinking Water Watch website was obtained from the NJDEP Bureau of Safe Drinking Water. Data was also obtained from Mooretown Township's 2015 Annual Water Quality Report [Moorestown 2016]. The data evaluated includes samples taken from each of the treatment plants, the distribution system, and the purchased water from New Jersey American Water Company. A summary of contaminants detected in the Moorestown drinking water supply compared with the most conservative comparison values is shown in **Table 6**.

Table 6. Contaminants Detected in Moorestown Public Drinking Water Supply

Contaminant	Number of Samples	Number of Detections	Sample Dates	Minimum Concentration (µg/L)	Maximum Concentration (µg/L)	Comparison Value (µg/L)	Contaminant of Concern
TCP	74	13	July 1988 – Feb. 2016	ND	0.09	0.00040 [a]	**Yes**
TCE *	59	26	April 1993 – Feb. 2016	ND	1.23	0.43 [a]	**Yes**
1,4-Dioxane	22	17	March 2013 – April 2018	ND	0.68	0.24 [a]	**Yes**
1,1-Dichloroethane	70	5	July 1988 – Feb. 2018	ND	0.07	2.8 [b]	No
Chlorate	11	2	March 2013– June 2014	ND	90.4	Not Available	**Yes**
Hexavalent Chromium	11	9	March 2013– June 2014	ND	1.5	0.035 [b]	**Yes**
Cobalt	11	2	March 2013– June 2014	ND	6.4	6 [b]	**Yes**
Molybdenum	11	4	March 2013– June 2014	ND	2.1	35 [c]	No
Strontium	11	11	March 2013– June 2014	79.1	431.9	4,200 [c]	No
Vanadium	11	3	March 2013– June 2014	ND	0.31	70 [d]	No
Gross Alpha *	42	17	March 2005 – May 2018	ND	16.9 pCi/L	15 [e] pCi/L	**Yes**

TCP = 1,2,3-Trichloropropane; TCE = Trichloroethylene; ND = Not Detected; µg/L = micrograms of contaminant per liter of water; pCi/L = picocuries/liter of water (measure of radioactivity); a = ATSDR Cancer Risk Evaluation Guide(CREG); b = USEPA Screening Level [May 2018]; c = ATSDR Reference Media Evaluation Guide (RMEG); d = ATSDR Environmental Media Evaluation Guide(EMEG); e = USEPA Maximum Contaminant Level(MCL); *Regulated substances TCE and Gross Alpha were contaminants of concern mentioned by the Moorestown Water Community Group; The maximum concentration of Gross Alpha was reported in the 2015 Moorestown Annual Water Quality Report

As noted in **Table 6**, the following seven contaminants were detected in the Moorestown drinking water supply at levels above their comparison values:

TCP *TCE* *1,4-Dioxane* *Chlorate*
Hexavalent chromium *Cobalt* *Gross alpha*

These contaminants will be further evaluated for public health implications.

Data Issues with TCP

The sensitivity of analytical methods for measuring TCP in water is an important issue. Different analytical methods have variable detection limits. For example, USEPA Method 524.2 and USEPA Method 502.2 have a detection limit of 0.5 µg/L. This means that if TCP was present in a water sample at a level below 0.5 µg/L, it would not be detected, and the sample would be considered "non-detect" for TCP. Beginning in 2013, NJDEP requested that Moorestown analyze samples using more sensitive methods known as USEPA Method 504.1

and/or USEPA Method 524.3 to measure TCP in water. These methods can detect lower levels of TCP than Method 524.2.

A review of analytical methods used for the data reported in **Table 6** showed that most samples collected from the Moorestown public water supply were analyzed using USEPA Method 524.2. Since the detection limit in samples collected prior to 2013 was significantly higher than the levels detected with improved methodology, we do not know what the TCP levels were before 2013. Therefore, data collected between 2013 and 2016 was used to approximate historical concentrations. We do not know if samples collected prior to 2013 may have had lower or higher levels of TCP. Since the origin of TCP contamination is unknown, it is possible that the wells were not impacted until more recently. The public health implications of chronic TCP exposure were evaluated using the data collected during 2013 to 2016, which are reflected in **Table 7**.

Table 7. TCP Results Used to Evaluate Public Health Implications

Sample Date	TCP Concentration (µg/L)	USEPA Analytical Method	Sample Location/Source
2/3/2016	0.067	504.1	North Church St.
1/6/2016	0.064	504.1	North Church St.
11/18/2015	0.058	504.1	North Church St.
10/21/2015	0.068	504.1	North Church St.
9/23/2015	0.068	504.1	North Church St.
8/19/2015	0.066	504.1	North Church St.
7/24/2015	0.07	504.1	North Church St.
9/10/2014	0.067	504.1	North Church St.
6/25/2014	0.066	504.1	North Church St.
11/20/2013	0.09	524.2*	North Church St.
9/10/2013	0.051	524.3	North Church St.
7/2/2013	0.0465	504.1	North Church St.
3/12/2013	0.038	524.3	North Church St.
6/24/2014	ND (0.03)	524.3	Kings Highway
9/10/2013	ND (0.03))	524.3	Kings Highway
7/2/2013	ND (0.00467)	504.1	Kings Highway
9/10/2013	ND (0.03)	524.3	NJ American Water Co.
6/11/2013	ND (0.03)	524.3	NJ American Water Co.
3/12/2013	ND (0.03)	524.3	NJ American Water Co.

ND = Not Detected, detection limit is in parenthesis; µg/L = micrograms of TCP per liter of water;
* This analytical method was included because there was a TCP detection using this less sensitive method.

Discussion

The NJDOH assesses whether a health hazard exists by determining whether there is a completed exposure pathway from a contaminant source to people who could be exposed to that contaminant. It is then determined whether exposures to the contaminants are high enough to be

of health concern. Site-specific exposure doses can be calculated and compared with health guideline comparison values.

Assessment Methodology – Exposure Pathways

An exposure pathway is a series of steps starting with the release of a contaminant in environmental media and ending at the interface with the human body. A completed exposure pathway consists of five elements:

1. Source of contamination
2. Environmental media and transport mechanisms
3. Point of exposure
4. Route of exposure
5. Receptor population (people who may come into contact with hazardous substances)

Generally, ATSDR considers three exposure categories:

1. Completed exposure pathways — all five elements of a pathway are present
2. Potential exposure pathways — one or more of the elements might not be present, but information is insufficient to eliminate or exclude the element
3. Eliminated exposure pathways — a receptor population does not come into contact with contaminated media

Exposure pathways are used to evaluate specific ways in which people were, are, or will be exposed to environmental contamination in the past, present, and future. The population of Moorestown is the exposed population for this evaluation. This is because we assume that anyone living or working in Moorestown has been drinking water from the community water supply. It should be noted that the North Church Street treatment plant typically serves industrial facilities and residences in close proximity to the treatment plant.

Completed Exposure Pathways

<u>Ingestion of contaminated drinking water:</u> For the past, current, and future, there is a completed exposure pathway for Moorestown residents ingesting contaminated drinking water.

- Past – Prior to the installation of the GAC treatment system in February 2017, residents were consuming water containing the following contaminants of concern which were detected in the North Church Street treatment plant:
    - TCP
    - TCE
    - Gross alpha
    - 1,4-Dioxane
    - Hexavalent Chromium
    - Chlorate
    - Cobalt

- Current/future – The GAC treatment system installed on the North Church Street plant in February 2017 removes TCP and TCE prior to distribution to the community water supply. Therefore, current and future exposures to these contaminants have been eliminated. The GAC is not designed to treat the remaining contaminants. Therefore, these contaminants may still be present in the water supply.

Data show that since the installation of the GAC treatment system in February 2017, gross alpha has been below the USEPA MCL. Data through April 2018 also show that 1,4-dioxane is still present at the North Church Street plant. Hexavalent chromium, chlorate and cobalt have not been sampled since the UCMR3 program and are not known to be removed by the GAC. Hexavalent chromium was also detected in the water being purchased from New Jersey American Water Company. Based on this information, some unregulated contaminants are still present in the Moorestown drinking water supply.

Public Health Implications of Completed Exposure Pathways

After determining that people have or are likely to come in contact with site-related contaminants, the next step in the public health assessment process is to calculate site-specific exposure doses. This is called a health guideline comparison. It involves looking more closely at site-specific exposure conditions, estimating exposure doses, and comparing those doses to health guideline comparison values.

Health guideline comparison values are based on data from epidemiologic and toxicological literature. These values often include safety factors to ensure that they are protective of human health. If a person is exposed to site-related contaminants, there are several factors that will determine whether harm will occur. These factors include:

- the amount of contaminant that enters the body,
- the duration and frequency that a person contacts the contaminant, and
- how that person comes in contact with it.

Additional considerations regarding potential harmful health effects from exposures to a contaminant include age, sex, diet, family traits, lifestyle, and state of health.

Determining the Exposure Concentration for Contaminants of Concern

When assessing an exposure risk to a contaminant of concern, the USEPA recommends using the 95 percent upper confidence limit (95% UCL) of the arithmetic mean to determine the exposure point concentrations (EPC) for site-related contaminants [USEPA 2015]. The 95% UCL is considered a “conservative estimate” of average contaminant concentrations in an environmental medium.

For this health consultation, the 95% UCL was used as the EPC for TCP, hexavalent chromium, 1,4 dioxane, TCE and gross alpha. These contaminants had a sufficient number of samples with detections needed to calculate the 95% UCL. The maximum concentration was used as the EPC for the remaining contaminants due to the small number of detections.

TCP was detected in Well 7 and Well 9 and information on water usage was provided by the NJDEP. The concentration of TCP was adjusted in relation to the contribution of Well 7 and Well 9 to the community's total water supply.

Table 4 above lists the water usage for all wells and water purchased from New Jersey American Water Company for the years 1981 through 2016. As shown in **Table 5** above, the average contribution of Wells 7 and 9 during this period was approximately 51% in relation to the other wells and water purchased from New Jersey American Water Company.

We adjusted the concentration of TCP by taking the 95% UCL from all water sources of 0.057 µg/L and multiplying it by 0.51. This gives an adjusted TCP concentration of 0.029 µg/L. This level was used to evaluate the potential for health effects from exposure to TCP in the Moorestown water supply. The remaining contaminants of concern were also adjusted in the same way by multiplying the EPC (95% UCL or the maximum) by 0.51. The only exception is hexavalent chromium, which was adjusted by 0.66 (66%) because this contaminant was found in both the North Church Street plant and the purchased water.

This adjusted concentration reflects the assumption that historic TCP levels were the same as the recent data collected between 2013 and 2016. This adjusted concentration does not mean that all Moorestown properties received 51% of contaminated water, but that properties closest to the North Church Street plant may have received a higher percentage of TCP contaminated water while properties farther away would have received less.

Table 8 shows the EPCs for each contaminant of concern. These concentrations will be used to evaluate the potential for health effects.

Table 8. Exposure Point Concentrations for Contaminants of Concern

Contaminant	Regulated Contaminant	EPC *	Adjustment Factor	EPC Type
TCP	Yes	0.029 µg/L	0.51	95% UCL
1,4-Dioxane	No	00.26 µg/L	0.51	95% UCL
Hexavalent Chromium	No	0.51 µg/L	0.66	95% UCL
Chlorate	No	46 µg/L	0.51	Maximum
Cobalt	No	3.3 µg/L	0.51	Maximum
TCE	Yes	0.22 µg/L	0.51	95% UCL
Gross Alpha	Yes	3.6 pCi/L	0.51	95% UCL

TCP = 1,2,3-Trichloropropane; TCE = Trichloroethylene; pCi/L = picocuries/liter of water (measure of radioactivity; µg/L = micrograms of contaminant per liter of water; EPC = Exposure Point Concentration derived using maximum concentration or EPA Pro UCL Version 5.1 [USEPA 2015]; * The EPC was adjusted to account for the contribution of the North Church Street plant to the water supply. The adjustment includes the purchased water and the North Church Street plant for Hexavalent chromium.

Potential Health Effects for Regulated Contaminants

Regulated contaminants TCE and gross alpha were selected for further evaluation due to specific concerns raised by the Moorestown Water community group. These contaminants had also exceeded their respective MCLs. The 95% UCL EPC for both contaminants are below the most conservative regulatory MCL. Harmful non-cancer and cancer health effects would not be

expected (**See Table 9**). The recently adopted MCL for TCP is not health-based but based on the Practical Quantitation Limit (PQL) and the ability of treatment removal technology to achieve this level [DWQI 2009].

Table 9. Regulated Contaminants of Concern Detected in Moorestown Drinking Water

Contaminant	EPC *	MCL **	Potential for Health Effects (Cancer and Non-cancer)
TCE ^	0.22 µg/L	1 µg/L	No
TCP ^	0.029	0.03 µg/L	No
Gross Alpha ^	3.6 pCi/L	15 pCi/L	No

TCE = Trichloroethylene; *= Adjusted Exposure Point concentration derived using EPA Pro UCL Version 5.1 [USEPA 2015]
**MCL = Maximum Contaminant Level (NJDEP MCL for TCE and TCP; EPA MCL for Gross Alpha)
µg/L = micrograms per liter (micrograms of contaminant per liter of water)
pCi/L = picocuries per liter (measure of radioactivity)
^ Additional data since the GAC was installed shows no MCL exceedances at the North Church Street Plant

Non-Cancer Health Effects - Unregulated Substances in Drinking Water

To assess non-cancer health effects, ATSDR has developed Minimal Risk Levels (MRLs) for contaminants that are commonly found at hazardous waste sites. An MRL is an estimate of the daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of adverse, non-cancer health effects. MRLs are developed for a route of exposure, such as swallowing or breathing, over a specified period. Exposure periods are classified as

- acute (less than 14 days),
- intermediate (15-364 days), or
- chronic (365 days or more).

MRLs are based largely on toxicological studies in animals and on reports of human occupational (workplace) exposures. MRLs are usually extrapolated doses from observed effect levels in animal toxicological studies or occupational studies. They are adjusted by a series of uncertainty factors or through the use of statistical models. In toxicological literature, observations might be reported as

- no-observed-adverse-effect level (NOAEL) or
- lowest-observed-adverse-effect level (LOAEL).

A NOAEL is the highest tested dose of a substance that has been reported to have no harmful health effects on people or animals. A LOAEL is the lowest tested dose of a substance that has been reported to cause harmful health effects in people or animals. To provide perspective on these health effects, the calculated exposure doses are compared to the applicable NOAEL or LOAEL. As the exposure dose increases beyond the MRL to the level of the NOAEL and/or LOAEL, the likelihood of adverse health effects increases.

When MRLs for specific contaminants are unavailable, other health-based comparison values such as the USEPA's Reference Dose (RfD) are used. The Reference Dose is an estimate of daily ingestion exposure to the human population (including sensitive subgroups) that is not likely to cause harmful non-cancer health effects over a lifetime of exposure.

Calculation of Non-Cancer Exposure Doses - Ingestion

The non-cancer exposure doses were calculated using the following formula [ATSDR 2005]:

$$\textit{Exposure Dose (mg/kg/day)} = \frac{C \times IR}{BW}$$

where, mg/kg/day = milligrams of contaminant per kilogram of body weight per day;
C = exposure point concentration of contaminant in water (mg/L);
IR = ingestion rate (L/day);
BW = body weight (kg).

Non-cancer health effects are assessed by comparing the exposure dose to the reference dose (or MRL) via a ratio known as the "hazard quotient". The hazard quotient is defined as follows:

$$\textit{Hazard Quotient} = \frac{\textit{Exposure Dose}}{\textit{Reference Dose (or MRL)}}$$

As the hazard quotient increases above 1, the potential for harmful effects increases. Contaminants of concern with a hazard quotient exceeding a value of 1 were evaluated further to determine whether these contaminants pose a health threat to exposed or potentially exposed populations.

Exposure Dose Assumptions and Scenarios

ATSDR's exposure dose guidance for water ingestion and USEPA's Exposure Factor Handbook were used to calculate exposure doses [ATSDR 2016, USEPA 2011]. Exposure doses were calculated for adults and children drinking water from the Moorestown public water supply.

Exposure doses were calculated for two water ingestion scenarios. For people with typical, or average water ingestion rates, we used a "central tendency exposure" (CTE) scenario. For people with higher than average ingestion rates, a "reasonable maximum exposure" (RME) scenario was used. The RME refers to people with higher than average exposures but still within a realistic exposure range.

For both CTE and RME scenarios, the age range for children is from infant through less than 21 years. The adult scenario is for people 21 years of age and over. **Tables 10 and 11** show the exposure parameters and assumptions used to calculate exposure doses for both scenarios.

Tables 12 and 13 show the dose calculations and hazard quotients for the contaminants of concern for non-cancer health effects for both scenarios. Toxicological information for the

contaminants of concern can be found in **Appendix A**. An example dose calculation for non-cancer health effects is shown in **Appendix B**.

Table 10. Exposure Parameters Used in Dose Calculations

Age Group	Ingestion Rate (Liters/day)		Body Weight (kg)
	Average (CTE)	Above Average (RME)	
Child - Birth to < 1 year	0.5	1.1	7.8
Child - 1 to < 2 years	0.31	0.89	11.4
Child - 2 to < 6 years	0.38	0.98	17.4
Child - 6 to < 11 years	0.51	1.4	31.8
Child - 11 to < 16 years	0.64	1.98	56.8
Child - 16 to < 21 years	0.77	2.4	71.6
Adult ≥ 21 years	1.2	3.1	80

Table 11. Exposure Assumptions Used in Dose Calculations

Exposed Population	Ingestion Rate (Liters/day)	Body Weight (kg)	Exposure Frequency
Child	Age Specific *	Age Specific	365 days/year
Adult	1.2 (CTE); 3.1 (RME) *	80	

*= See parameters in Table 8

Table 12. Average Ingestion Rates (CTE Scenario) – Hazard Quotients

Contaminants of Concern	EPC * (mg/L)	Milligrams/Kilogram/Day			Hazard Quotient (d)		Potential for Non-Cancer Health Effects
		Exposure Dose		Reference Dose (RfD) (c)	Child	Adult	
		Child a	Adult b				
TCP	0.000029	1.9E-06	4.4E-07	4.0E-03 (RfD)	4.7E-04	1.1E-04	No
1,4-Dioxane	0.00026	1.7E-05	4.0E-06	1.0E-01 (MRL)	1.7E-04	4.0E-05	No
Hexavalent Chromium	0.00051	3.3E-05	7.8E-06	9.0E-04 (MRL)	3.7E-02	8.7E-03	No
Cobalt	0.0033	2.1E-04	5.1E-05	3.0E-04 (RfD)	7.0E-01	1.7E-01	No

a = Child CTE Assumption: 0-1 year (most conservative assumption for children); b = Adult CTE Assumption: ≥ 21 years
c = USEPA Oral Reference Dose (USEPA 2018] or chronic ATSDR MRL; d = Hazard Quotient = Exposure Dose/Reference Dose; * = Adjusted Exposure point concentration – derived using maximum concentration for Cobalt; derived using EPA Pro UCL Version 5.1 [USEPA 2015] for TCP, 1,4-Dioxane and hexavalent chromium; mg/L = milligrams of contaminant per liter of water

Table 13. Above Average Ingestion Rates (RME Scenario) – Hazard Quotients

Contaminants of Concern	EPC * (mg/L)	Milligrams/Kilogram/Day			Hazard Quotient (d)		Potential for Non-Cancer Health Effects
		Exposure Dose		Reference Dose (RfD) (c)	Child	Adult	
		Child[a]	Adult[b]				
TCP	0.000029	4.1E-06	1.1E-06	4.0E-03 (RfD)	1.0E-03	2.8E-04	No
1,4-Dioxane	0.00026	3.7E-05	1.0E-05	1.0E-01 (MRL)	3.7E-04	1.0E-04	No
Hexavalent Chromium	0.00051	7.3E-05	2.0E-05	9.0E-04 (MRL)	8.1E-02	2.2E-02	No
Cobalt	0.0033	4.7E-04	1.3E-04	3.0E-04 (RfD)	**1.6E+00**	4.3E-01	**Yes**

a = Child RME Assumption: 0-1 year (most conservative assumption for children); b = Adult RME Assumption: ≥ 21 years
c = USEPA Oral Reference Dose [USEPA 2018] or chronic ATSDR MRL; d = Hazard Quotient = Exposure Dose/Reference Dose;
*EPC = Adjusted Exposure point concentration derived using maximum concentration for Cobalt; derived using EPA Pro UCL Version 5.1 [USEPA 2015] for TCP, 1,4-Dioxane and hexavalent chromium; mg/L = milligrams of contaminant per liter of water

Chlorate – Chlorate was detected in two out of eleven samples with a maximum concentration of 90.4 µg/L and an adjusted concentration of 46 µg/L. The NJDOH is unable to evaluate the potential public health implications of exposure to this contaminant. This is due to the lack of comparison values and toxicological information.

Cobalt – Cobalt was detected in two out of eleven samples. The hazard quotients for children with above average exposures were above 1.0. Cobalt is a naturally occurring element found in rocks, soil, water, plants, and animals. It is used to manufacture aircraft engines, magnets, grinding and cutting tools, artificial hip and knee joints. Cobalt compounds are also used to color glass, ceramics and paints, and used to dry porcelain enamel and paints [ATSDR 2004].

In the absence of a chronic oral ATSDR MRL, the USEPA oral reference dose was used as a health guideline comparison value. The reference dose for cobalt is derived from the USEPA's Provisional Peer Reviewed Toxicity Values for Superfund [USEPA 2008]. A Provisional Peer Reviewed Toxicity Value is derived for use in the USEPA Superfund Program when a value is not available in EPA's Integrated Risk Information System.

All provisional peer-reviewed toxicity values receive internal review by USEPA scientists and external peer review by independent scientific experts. These values do not receive the multi-program consensus review as with the EPA's Integrated Risk Information System. The USEPA does not support use of Provisional Peer Reviewed Toxicity Values for purposes other than Superfund. However, in the absence of other chronic health guideline values, this value was used to evaluate the potential public health implications of exposure cobalt for this health consultation.

The study used to derive the Provisional Peer Reviewed Toxicity Value for cobalt was based on a study of low confidence conducted by Roche and Layrisse (1956). In this study, 12 people with normal thyroid function were orally exposed to cobalt for 2 weeks. The results of

this study showed decreased thyroid iodine uptake at a LOAEL of 1 mg/kg/day. An uncertainty factor of 3,000 was applied to this LOAEL to get the reference dose of 0.0003 mg/kg/day [USEPA 2008].

The highest calculated exposure dose for the most sensitive target population (children ages 0-1 year) using the above average (RME) exposure scenario was 0.0005 mg/kg/day. This calculated exposure dose is approximately 2,000 times lower than the LOAEL. Therefore, adverse health effects from exposure to cobalt in drinking water is not likely.

Based on this evaluation, harmful non-cancer health effects from exposures to TCP, hexavalent chromium, 1,4-Dioxane and cobalt are not likely.

Cancer Health Effects – Unregulated Substances in Drinking Water

The site-specific lifetime excess cancer risk (LECR) estimates the cancer-causing potential of contaminants. LECR estimates are usually expressed in terms of excess cancer cases in an exposed population. For perspective, the lifetime risk of being diagnosed with cancer in the United States is 42 per 100 individuals for males, and 38 per 100 for females [ACS 2017].

Comparison values developed for carcinogens are typically based on one excess cancer case per 1,000,000 individuals. The NJDOH considers estimated cancer risks of less than one additional cancer case among one million persons exposed as an unlikely increased risk (expressed exponentially as 10^{-6}).

For the purposes of this evaluation, the calculated LECRs are based on the theoretical risk of developing cancer and do not portray actual risk. The actual risk of developing cancer from exposure to a carcinogen cannot be determined. Therefore, the LECRs are provided as a gauge to highlight the significance of actions that may be required to protect public health.

NJDOH also characterizes cancer risk consistent with the USEPA's acceptable risk range approach. This approach recommends that corrective steps be taken for cancer risks greater than one excess cancer case per 10,000 individuals.

Cancer Classifications for Contaminants of Concern

According to the U.S. Department of Health and Human Services, the cancer class of contaminants detected at a site is as follows:

1 = Known human carcinogen
2 = Reasonably anticipated to be a carcinogen
3 = Not classified

TCP: The U.S. Department of Health and Human Services has not classified TCP for carcinogenicity. We do not know whether TCP causes cancer in humans, but animals that swallowed low doses for most of their lives developed tumors in several organs [ATSDR 1995].

The International Agency for Research on Cancer classified TCP as "probably carcinogenic to humans." The National Toxicology Program classified TCP as "reasonably anticipated to be a carcinogen." This is based on clear evidence of carcinogenicity in experimental animals [ATSDR 2011].

The USEPA's Integrated Risk Information System (IRIS) classifies TCP as "likely to be carcinogenic to humans." This is based on the Weight of Evidence Characterization under the Guidelines for Carcinogenic Risk Assessment [USEPA 2005].

Hexavalent chromium: The U.S. Department of Health and Human Services, the International Agency for Research on Cancer, and the USEPA have determined that hexavalent chromium compounds are known human carcinogens. Inhalation of hexavalent chromium has been shown to cause lung cancer in workers. Hexavalent chromium also causes lung cancer in animals [ATSDR 2012].

For ingestion exposure, the National Toxicology Program (NTP) has completed a two-year study indicating clear evidence that ingestion of drinking water contaminated with hexavalent chromium caused malignant tumors in mice (small intestine) and rats (oral cavity). The NTP rodent studies are used by regulatory agencies to promulgate regulations to protect human health and are used in the hazard identification process for risk assessment [NTP 2008].

1,4-Dioxane: The U.S. Department of Health and Human Services considers 1,4-Dioxane as reasonably anticipated to be a human carcinogen [ATSDR 2007]. The limited number of studies available do not show whether 1,4-Dioxane causes cancer in humans. Laboratory rats that breathed vapors of 1,4-Dioxane during most of their lives developed cancer inside the nose and abdominal cavity. Laboratory rats and mice that drank water containing 1,4-Dioxane during most of their lives developed liver cancer. Rats also developed cancer inside the nose. Scientists are currently debating the degree to which the findings in rats and mice apply to exposure situations commonly encountered by people.

Calculation of Cancer Exposure Doses – Ingestion

Cancer exposure doses were calculated using the following formula:

$$\textit{Cancer Exposure Dose (mg/kg-day)} = \frac{C \times IR}{BW} \times \frac{ED}{AT}$$

where, C = exposure point concentration in mg/L
IR = ingestion rate in L/day
BW = age specific body weight for children, 80 kg for adults
ED = exposure duration in years (varies with exposure scenario)
AT= averaging time = 78 years

The site-specific assumptions and recommended exposure factors used to calculate the LECR are the same as those used to assess non-cancer health effects. Using the ATSDR water exposure dose guidance, the LECR was calculated by multiplying the cancer exposure dose by

the cancer slope factor (CSF). The CSF is defined as the slope of the dose-response curve obtained from animal and/or human cancer studies. It is expressed as the inverse of the daily exposure dose, i.e., $(mg/kg/day)^{-1}$. The LECRs for drinking water exposures were calculated using the following formula [ATSDR 2005]:

LECR = Cancer Exposure Dose x CSF

where,

CSF = Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$

For TCP and hexavalent chromium, the USEPA's Age Dependent Adjustment Factor (ADAF) was used to calculate the LECR. This is because these substances have a mutagenic mode of action for carcinogenicity (i.e. genetic changes). The ADAF accounts for the cancer potency at various ages. The ADAF model was not used for evaluating the cancer risk for 1,4-Dioxane since it is not a mutagen. The age-specific doses were added to determine the total cancer risk for children. **Appendix B** shows an example LECR calculation. These LECRs were then added to determine the total LECR for both CTE and RME scenarios for both children and adults.

Table 14 shows cumulative LECRs of approximately 2 in 100,000 individuals for children and 3 in 1,000,000 individuals for adults with average water ingestion rates. **Table 15** shows the cumulative LECRs for adults and children with above average ingestion rates range from 2 to 6 in 100,000 individuals. The LECR for children who lived as adults in the same house with above average ingestion rates is approximately 7 in 100,000 individuals. These scenarios all represent a low cancer risk from cumulative exposures to TCP, 1,4-Dioxane and hexavalent chromium.

Table 14. Average Ingestion Rates (CTE Scenario) – Lifetime Excess Cancer Risk

Exposed Population	Contaminant of Concern	EPC [a] (mg/L)	Mutagen*	CSF [b] $(mg/kg\text{-}day)^{-1}$	LECR [c]	Total LECR
Child **	TCP	0.000029	Yes	30	1.6E-05	2.1E-05
	1,4-Dioxane	0.00026	No	0.1	9.0E-08	
	Hexavalent Chromium	0.00051	Yes	0.5	4.7E-06	
Adult **	TCP	0.000029	Yes	30	2.1E-06	2.7E-06
	1,4-Dioxane	0.00026	No	0.1	6.1E-08	
	Hexavalent Chromium	0.00051	Yes	0.5	6.0E-07	

a = Adjusted Exposure point concentration derived using EPA Pro UCL Version 5.1 [USEPA 2015] b = oral Cancer Slope Factor [USEPA 2018]; c = Lifetime Excess Cancer Risk; mg/L = milligrams of contaminant per liter of water; *LECRs for mutagens were calculated using the Age Dependent Adjustment Factor (ADAF) which accounts for the cancer potency at various ages; **Exposure duration = 12 years for children, 12 years for adults

Table 15. Above Average Ingestion Rates (RME Scenario) – Lifetime Excess Cancer Risk

Exposed Population	Contaminant of Concern	EPC[a] (mg/L)	Mutagen*	CSF[b] (mg/kg-day)$^{-1}$	LECR[c]	Total LECR	Combined LECR [d]
Child **	TCP	0.000029	Yes	30	4.7E-05	6.1E-05	6.8E-05
	1,4-Dioxane	0.00026	No	0.1	3.4E-07		
	Hexavalent Chromium	0.00051	Yes	0.5	1.4E-05		
Adult **	TCP	0.000029	Yes	30	1.4E-05	1.9E-05	
	1,4-Dioxane	0.00026	No	0.1	4.3E-07		
	Hexavalent Chromium	0.00051	Yes	0.5	4.2E-06		

a = Adjusted Exposure point concentration derived using EPA Pro UCL Version 5.1 [USEPA 2015]); b = oral Cancer Slope Factor [USEPA 2018]; c = Lifetime Excess Cancer Risk; d = Combined LECR represents conservative scenario where children live as adults in the same house (21 years as a child plus 12 years as an adult); mg/L = milligrams of contaminant per liter of water
*LECRs for mutagens were calculated using the Age Dependent Adjustment Factor (ADAF) which accounts for the cancer potency at various ages; **Exposure duration = 21 years for children; 33 years for adults

Hexavalent chromium was found in water supplied by New Jersey American Water Company and from the North Church Street plant. 1,4-Dioxane was found at the North Church Street plant. The GAC treatment system installed at the North Church Street plant is not designed to remove 1,4-Dioxane. The calculated EPC for hexavalent chromium used to calculate cancer risks includes UCMR3 data from the North Church Street plant and New Jersey American Water Company. Data used to calculate the EPC for 1,4-Dioxane includes the North Church Street plant both prior to and after the GAC system was installed. These contaminants were not found in the Kings Highway treatment plant.

The calculated LECRs in **Tables 14 and 15** show the cancer risks for hexavalent chromium and 1,4-Dioxane separate from TCP which is removed with the GAC system. As shown in **Table 14**, the cumulative LECRs for hexavalent chromium and 1,4-Dioxane for people with average ingestion rates is less than 1 in 1,000,000 for adults and approximately 5 in 1,000,000 for children. This represents an unlikely increase in cancer risk for adults and a low cancer risk for children.

As shown in **Table 15**, the cumulative LECR for hexavalent chromium and 1,4-Dioxane is approximately 1 in 100,000 individuals for children with above average ingestion rates. For adults with above average ingestion rates, the LECR is approximately 5 in 1,000,000 individuals. Both LECRs represent a low cancer risk. For children growing up and living in the same house as adults, the cumulative LECR for hexavalent chromium and 1,4-Dioxane is approximately 2 in 100,000 individuals, representing a low cancer risk.

To put these risks in perspective, based on U.S. cancer rates, the lifetime risk of cancer in the general population is about 1 in 2.6, or about 38,000 out of every 100,000 individuals [NIH 2018].

Cancer Health Effects – Unadjusted Contaminant Concentration

The NJDOH evaluated the contaminants of concern using an unadjusted concentration to represent the small portion of the population which may have consumed most or all of the water coming from each of the water sources. As shown in **Table 16**, the cancer risks could have been as high as two in 10,000 individuals. This is considered to be an increased cancer risk for residents located close to the North Church Street plant.

This "worst-case" scenario represents people with above average ingestion rates consuming contaminated water without adjusting for the water contribution from the other sources. It is important to note that the area surrounding the North Church Street plant is primarily industrial.

Table 16. Above Average Ingestion Rates (RME Scenario) – Lifetime Excess Cancer Risk

Exposed Population	Contaminant of Concern	EPC[a] (mg/L)	Mutagen*	CSF[b] (mg/kg-day)$^{-1}$	LECR[c]	Total LECR	Combined LECR [d]
Child **	TCP***	0.000069	Yes	30	1.1E-04	1.4E-04	1.5E-04
	1,4-Dioxane	0.00051	No	0.1	6.6E-07		
	Hexavalent Chromium	0.00077	Yes	0.5	2.1E-05		
Adult **	TCP***	0.000069	Yes	30	3.4E-05	4.1E-05	
	1,4-Dioxane	0.00051	No	0.1	8.3E-07		
	Hexavalent Chromium	0.00077	Yes	0.5	6.3E-06		

a = Exposure point concentration derived using EPA Pro UCL Version 5.1 [USEPA 2015]; b = oral Cancer Slope Factor [USEPA 2018]; c = Lifetime Excess Cancer Risk; d = Combined LECR represents conservative scenario where children live as adults in the same house (21 years as a child plus 12 years as an adult); mg/L = milligrams of contaminant per liter of water

*LECRs for mutagens were calculated using the Age Dependent Adjustment Factor (ADAF) which accounts for the cancer potency at various ages; **Exposure duration = 21 years for children; 33 years for adults

***The concentration of TCP is not adjusted to account for the contribution of other water sources. This concentration represents exposures for the portion of the population closest to the North Church Street treatment plant.

Conclusions

The NJDOH reviewed available data for contaminants detected in the Moorestown drinking water supply. Based on the information available, the NJDOH has reached the following conclusions:

1. *Current and future exposures to TCP in the Moorestown drinking water supply are not likely to harm people's health.* Current and future exposures to TCP from the North

Church Street plant have been interrupted through the installation of a GAC treatment system in February 2017. This system was installed specifically to remove TCP prior to the water being distributed for consumption.

2. *Current and future exposures to 1,4 dioxane in the Moorestown drinking water supply are not likely to harm people's health.* Data from the 2013-2015 UCMR3 program and subsequent data through April 2018 for 1,4-dioxane indicate no expected increase in cancer risk. Other non-cancer health effects would not be expected based on the comparison of calculated exposure doses with non-cancer health guideline values.

3. *We cannot conclude whether current and future exposures to hexavalent chromium in the Moorestown drinking water supply will harm people's health.* The NJDOH does not have current sampling results for hexavalent chromium in the Moorestown drinking water supply. If the hexavalent chromium levels have remained unchanged since the 2013-2015 UCMR3 sampling event, cancer risks would be low. Non-cancer health effects, such as anemia and gastrointestinal irritation, would not be expected based on the comparison of calculated exposure doses with non-cancer health guideline values.

4. *We cannot conclude whether past exposures (prior to the installation of the GAC system in February 2017) to contaminated drinking water in Moorestown harmed people's health.* The NJDOH does not have reliable data prior to the 2013-2015 UCMR3 program to determine whether levels of unregulated contaminants were similar to the data used in this evaluation. Specifically, it is possible that levels of TCP prior to 2013 may have been higher or lower than the data used to evaluate the potential for health effects. Therefore, data collected between 2013 and 2016 was used to approximate historical concentrations. Based on the available data, non-cancer health effects from exposures to drinking water contaminants are not expected for Moorestown. Cancer risks were low for combined exposures to TCP, 1,4-Dioxane and hexavalent chromium for the majority of the population. There may have been an increased cancer risk for a small portion of the population near the North Church Street plant, as some individuals may have received the majority of contaminated water from this plant.

Conclusion Uncertainties

There are many uncertainties associated with the findings of this Health Consultation:

- Moorestown residents receive drinking water from different sources. Some residents and businesses may have received all or most of their drinking water from the North Church Street Plant. Other parts of the town may have received little, if any, water from the North Church Street Plant.

- We are unable to quantify the percentage that each water source contributed to a particular household or business. Therefore, we do not know how much contaminated water each property received.

- It is unknown when the North Church Street water supply became contaminated with TCP.

    - Sampling data for TCP goes back to the late 1980's, but the detection limits for most of the data were very high. Therefore, we cannot determine whether TCP was present in these water samples.
    - We do not know the source of the TCP contamination; therefore, we are unable to estimate when the drinking water could have been impacted.

- The population of Moorestown grew significantly in the 1990's. Therefore, even if the water was contaminated with TCP for a long time, a significant portion of the current population was most likely not exposed for the entire duration assumed in our model. The exposure duration may be shorter for a large portion of the population.

Because of these uncertainties, we had to make assumptions to reach our conclusions. For example, in our risk assessment we assumed that Moorestown residents drank contaminated water for 33 years. You may have drunk water that was not contaminated. Therefore, the conclusions in this health consultation may not represent your actual risk. The scenario used in this health consultation represents the risk for the majority of the population.

Recommendations

1. The NJDOH recommends that the NJDEP work with Moorestown to ensure that the GAC treatment system at the North Church Street plant continues to remove TCP from the community drinking water supply.

2. The NJDOH recommends that the NJDEP continue to work with Moorestown to ensure that contaminants not currently removed with the GAC system be monitored and treated using another technology if necessary.

3. The NJDOH encourages the USEPA and/or the NJDEP to proceed with the development of MCLs for 1,4-Dioxane and hexavalent chromium. On September 4, 2018, the NJDEP adopted an MCL of 0.03 µg/L for TCP [NJDEP 2018]. At its December 19, 2018 meeting, the New Jersey Drinking Water Quality Institute (DWQI) initiated the process for developing an MCL recommendation for 1,4-Dioxane.

Public Health Action Plan

The purpose of a Public Health Action Plan is to ensure that this Health Consultation not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of the NJDOH to follow-up on this plan to ensure that it is implemented. The public health actions to be implemented by the NJDOH are as follows:

Public Health Actions Taken

The NJDOH has evaluated available drinking water data for potential health implications from exposures to contaminated drinking water. This was done in response to concerns expressed by the Moorestown Water community group.

Public Health Actions Planned

1. The NJDOH will continue to review and evaluate additional drinking water data as it becomes available.

2. Copies of this health consultation will be provided to the Moorestown Water Group to distribute to concerned residents. This document will be provided to Moorestown Township Officials, the NJDEP and made available via the town library and the Internet. Additionally, residents who contact the NJDOH will be assisted in understanding the findings of this report.

3. Residents can contact the NJDOH with health concerns about their exposures to drinking water contaminants. They will be assisted with outreach between their physician and trained experts specializing in environmental exposures to hazardous substances.

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REPORT PREPARATION

This health consultation evaluating the Moorestown drinking water contamination was prepared by the New Jersey Department of Health.

Author

Christa Fontecchio, M.P.H.
Environmental and Occupational Health Surveillance Program
New Jersey Department of Health

State Reviewers

Somia Aluwalia, Ph.D.
Katharine McGreevy, M.P.A., Ph.D.
Environmental and Occupational Health Surveillance Program
New Jersey Department of Health

Any questions concerning this document should be directed to:

New Jersey Department of Health
Environmental and Occupational Health Surveillance Program
Consumer, Environmental and Occupational Health Service
P.O. Box 369
Trenton, New Jersey 08625-0369

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Appendices

Appendix A – Toxicological Summaries

The toxicological summaries provided in this appendix are based on ATSDR's ToxFAQs accessible at: http://www.atsdr.cdc.gov/toxfaqs/index.asp. Health effects are summarized in this section for the chemicals of concern found at the site. The health effects described in the section are typically known to occur at levels of exposure much higher than those that occur from environmental contamination. The chance that a health effect will occur is dependent on the amount, frequency and duration of exposure, and the individual susceptibility of exposed persons.

1,2,3 – Trichloropropane (TCP). 1,2,3-Trichloropropane is a synthetic chemical that is also known as allyl trichloride, glycerol trichlorohydrin, and trichlorohydrin. It is a colorless, heavy liquid with a sweet but strong odor. It evaporates very quickly and small amounts dissolve in water. It is mainly used to make other chemicals. Some of it is also used as an industrial solvent, paint and varnish remover, and cleaning and degreasing agent. Very little information is available on the amounts manufactured and the specific uses.

Exposure to high levels of 1,2,3-Trichloropropane for a short time causes eye and throat irritation. People exposed to 100 parts of 1,2,3-Trichloropropane per million parts of air (ppm) felt irritation, and some people exposed to 50 ppm for an 8-hour workday also had throat and eye irritation. We don't know what would happen to someone who breathed low levels for a long time. We also don't know what happens to people who swallow it or get it on their skin.

Rats and mice died after breathing air containing 1,2,3-Trichloropropane at levels higher than we have in the environment. When rats breathed it at levels lower than those that irritated humans, they developed eye, nose, and lung irritation, and liver and kidney disease. The main health effect in both animals and people is damage to the respiratory system.

When rats swallowed 1,2,3-Trichloropropane at high levels, they died from liver and kidney damage. When exposed to moderate levels that did not cause death, the rats had minor liver and kidney damage, blood disorders, and stomach irritation. When it was applied to the skin of rabbits, it caused severe irritation followed by injury to internal organs. This happened only when large amounts were applied to the skin.

We do not know if 1,2,3-Trichloropropane damages people's ability to reproduce or if it causes birth defects. When rats breathed low levels for several weeks or swallowed a large amount for a few days there were no effects on their ability to reproduce and there was no increase in birth defects.

The U.S. Department of Health and Human Services has not classified 1,2,3-Trichloropropane for carcinogenicity. We do not know whether 1,2,3-Trichloropropane causes cancer in humans, but animals that swallowed low doses for most of their lives developed tumors in several organs. The International Agency for Research on Cancer classified 1,2,3-Trichloropropane as "probably carcinogenic to humans." The National Toxicology Program classified 1,2,3-Trichloropropane as "reasonably anticipated to be a carcinogen." This is based on clear evidence of carcinogenicity in experimental animals [ATSDR 2011].

1,4-Dioxane. 1,4-Dioxane is a clear liquid that easily dissolves in water. It is used primarily as a solvent in the manufacture of chemicals and as a laboratory reagent. 1,4-Dioxane is a trace contaminant of some chemicals used in cosmetics, detergents, and shampoos. However, manufacturers now reduce 1,4-Dioxane from these chemicals to low levels before these chemicals are made into products used in the home. Few studies are available that provide information about the effects of 1,4-Dioxane in humans. Exposure to very high levels of 1,4-Dioxane can result in liver and kidney damage and death. Eye and nose irritation was reported by people inhaling low levels of 1,4-Dioxane vapors for short periods (minutes to hours).

Studies in animals have shown that breathing vapors of 1,4-Dioxane affects mainly the nasal cavity, liver, and kidneys. Ingesting 1,4-Dioxane or having skin contact with 1,4-Dioxane also affects the liver and kidneys.

The limited number of studies available do not show whether 1,4-Dioxane causes cancer in humans. Laboratory rats that breathed vapors of 1,4-Dioxane during most of their lives developed cancer inside the nose and abdominal cavity. Laboratory rats and mice that drank water containing 1,4-Dioxane during most of their lives developed liver cancer. The rats also developed cancer inside the nose. Scientists are debating the degree to which the findings in rats and mice apply to exposure situations commonly encountered by people.

The U.S. Department of Health and Human Services considers 1,4-Dioxane as reasonably anticipated to be a human carcinogen. There are no studies of children exposed to 1,4-Dioxane. However, children might experience health problems similar to those in adults if they were exposed to high concentrations of 1,4-Dioxane. Scientists do not know whether exposure of pregnant women to 1,4-Dioxane can harm the unborn child.

Hexavalent chromium. Chromium is a naturally occurring element found in rocks, animals, plants, and soil. It can exist in several different forms. Depending on the form it takes, it can be a liquid, solid, or gas. The most common forms are chromium (0), trivalent chromium (chromium(III)), and hexavalent chromium (chromium(VI)). No taste or odor is associated with chromium compounds.

The metal chromium, which is the chromium (0) form, is used for making steel. Hexavalent chromium and trivalent chromium are used for chrome plating, dyes and pigments, leather tanning, and wood preserving.

The main health problems seen in animals following ingestion of hexavalent chromium compounds are anemia and irritation and ulcers in the stomach and small intestine. Sperm damage and damage to the male reproductive system have also been seen in laboratory animals exposed to hexavalent chromium. Skin contact with certain hexavalent chromium compounds can cause skin ulcers. Some people are extremely sensitive to hexavalent and trivalent chromium. Allergic reactions consisting of severe redness and swelling of the skin have been noted.

The U.S. Department of Health and Human Services, the International Agency for Research on Cancer, and the USEPA have determined that hexavalent chromium compounds are known human carcinogens. In workers, inhalation of hexavalent chromium has been shown to cause lung cancer. Hexavalent chromium also causes lung cancer in animals. An increase in stomach tumors was observed in humans and animals exposed to hexavalent chromium in drinking water. It is likely that health effects seen in children exposed to high amounts of chromium will be similar to the effects seen in adults. We do not know if exposure to chromium will result in birth defects or other developmental effects in people. Some developmental effects have been observed in animals exposed to hexavalent chromium.

Cobalt: Cobalt is a naturally occurring element found in rocks, soil, water, plants, and animals. Cobalt is used to produce alloys used in the manufacture of aircraft engines, magnets, grinding and cutting tools, artificial hip and knee joints. Cobalt compounds are also used to color glass, ceramics and paints, and used to dry porcelain enamel and paints.

Cobalt is beneficial for humans because it is part of vitamin B12. Exposure to high levels of cobalt can result in lung and heart effects and dermatitis. Liver and kidney effects have also been observed in animals exposed to high levels of cobalt.

Nonradioactive cobalt has not been found to cause cancer in humans or animals following exposure in food or water. We do not know whether children differ from adults in their susceptibility to cobalt. However, it is likely that health effects in children would be similar those in adults. Studies in animals suggest that children may absorb more cobalt than adults from foods and liquids containing cobalt.

We do not know if exposure to cobalt will result in birth defects or other developmental effects in people. Birth defects have been observed in animals exposed to nonradioactive cobalt.

Appendix B – Example Dose Calculations – Water Ingestion

Exposure Parameters Used in Dose Calculations for Water Ingestion

Age Group	Ingestion Rate (Liters/day)		Body Weight (kg)
	Average (CTE)	Above Average (RME)	
Child - Birth to < 1 year	0.5	1.1	7.8
Child - 1 to < 2 years	0.31	0.89	11.4
Child - 2 to < 6 years	0.38	0.98	17.4
Child - 6 to < 11 years	0.51	1.4	31.8
Child - 11 to < 16 years	0.64	1.98	56.8
Child - 16 to < 21 years	0.77	2.4	71.6
Adult ≥ 21 years	1.2	3.1	80

Non-Cancer Exposure Dose calculation for TCP (RME) scenario

The non-cancer exposure dose for the youngest children (ages 0-1 year) and adults associated with TCP, 1,4-Dioxane, hexavalent chromium, and cobalt was calculated using the following formula (See **Tables 12 and 13** in the document):

$$\textit{Age Specific Exposure Dose (mg/kg/day)} = \frac{C \times IR}{BW}$$

where,

C = exposure point concentration of contaminant (example TCP) in water = 0.000029 mg/L
IR = ingestion rate (RME) for 0-1-year-old child (from exposure parameter table) = 1.1 L/day
BW = body weight of 0-1-year-old child from exposure parameter table = 7.8 kg

Substituting the values for a child age 0-1 year with above average ingestion rate (RME):

$$\text{Exposure Dose (mg/kg-day)} = \frac{0.000029 \text{ mg/L} \times 1.1 \text{ L/day}}{7.8 \text{ kg}} = 4.1E\text{-}06 \text{ mg/kg/day}$$

LECR calculations

The LECRs associated with TCP, 1,4-Dioxane, and hexavalent chromium was calculated for children and adults using the following formula:

Example LECR calculations for TCP using the RME scenario:

$$\textit{Cancer Exposure Dose (mg/kg-day)} = \frac{C \times IR}{BW} \times \frac{ED}{AT} \times ADAF$$

LECR = Cancer Exposure Dose x Cancer Slope Factor

C x IR/BW = non-cancer dose from example above = 4.1E-06 mg/kg/day
ED = 1 year for children ages 0-1 year for this example (**see Table below**)
AT = Averaging Time = 78 years
ADAF = Age Dependent Adjustment Factor: 10 for children ages 0-1 year (**see Table Below**)
Cancer slope factor = 30 mg/kg-day^{-1} for TCP

Substituting values for a child age 0-1 year:

Cancer Exposure Dose (mg/kg/day) = 4.1E-06 mg/kg/day x $\frac{1 \text{ year}}{78 \text{ years}}$ x 10 = 5.3E-7 mg/kg/day

LECR = 5.3E-07 mg/kg/day x 30 mg/kg-day $^{-1}$ = 1.6E-05

Note: LECR results may vary slightly due to rounding

Parameters for calculating LECR for TCP – Adults and Children – RME Scenario

Cancer Risk by Age Group	Cancer Exposure Dose (mg/kg/day)	Exposure Duration (ED)	ADAF *	Lifetime Excess Cancer Risk (LECR) for TCP
Child Birth to < 1 year	5.3E-07	1	10	1.6E-05
Child 1 to < 2 years	2.9E-07	1	10	8.7E-06
Child 2 to < 6 years	2.5E-07	4	3	7.5E-06
Child 6 to < 11 years	2.5E-07	5	3	7.4E-06
Child 11 to <16 years	1.9E-07	5	3	5.8E-06
Child 16 to <21 years	6.3E-08	5	1	1.9E-06
Combined cancer risk for children exposed for 21 years	----------	21	----------	**4.7E-05 (Child)**
Adult	4.7E-07	33	1	**1.4E-05 (Adult)**

*Age Dependent Adjustment Factor for mutagens: Multiply dose by 10 for children < 2 years of age, by 3 for children ages 2 < 16 and by 1 for older children and adults

Example Total LECR Calculation

Above Average Water Ingestion Rates (RME Scenario)

Assumption:

Children grew up and live in the same house as adults (21 years as a child plus 12 years as an adult)

Formula:

Total LECR = RME Adult Dose x 12years/78 year lifetime x CSF plus RME LECR for child (21 years)

CSF = Cancer Slope Factor

Contaminant	RME Adult Dose (mg/kg/day) *	Cancer Slope Factor	RME LECR for Child ^	Total LECR for each contaminant (Adults and Children) **
TCP	1.1E-06	30	4.7E-05	5.2E-05
1,4-Dioxane	1.0E-05	0.1	3.4E-07	4.9E-07
Hexavalent Chromium	2.0E-05	0.5	1.4E-05	1.5E-05
Total LECR (all three Contaminants)				**6.8E-05**
Total LECR (1,4-Dioxane and Hexavalent chromium)				**1.6E-05**

* RME adult dose is from **Table 13** in the document;

^ RME child LECRs are from **Table 15** in the document

** Total LECR calculations may vary slightly due to rounding