IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF NORTH CAROLINA
SOUTHERN DIVISION
No. 7:23-CV-897

IN RE:	)	**NOTICE OF CONTINUATION OF FILING**
	)	**ADDITIONAL EXHIBITS REGARDING**
CAMP LEJEUNE WATER LITIGATION	)	**UNITED STATES' MOTION TO EXCLUDE**
	)	**PLAINTIFFS' PHASE I EXPERT**
This Document Relates To:	)	**TESTIMONY IN SUPPORT OF USING**
ALL CASES	)	**ATSDR'S WATER MODELS TO**
	)	**DETERMINE EXPOSURE LEVELS FOR**
	)	**INDVIDUAL PLAINTIFFS**

The United States files this Notice of Continuation of Filing Additional Exhibits in support of its Motion to Exclude Plaintiffs' Phase I Expert Testimony in Support of Using ATSDR's Water Models to Determinate Exposure Levels for Individual Plaintiffs and Memorandum in Support.

[Signature page to follow.]

Dated: April 29, 2025

Respectfully submitted,

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CERTIFICATE OF SERVICE

I hereby certify that on April 29, 2025, I electronically filed the foregoing using the Court's Electronic Case Filing system, which will send notice to all counsel of record.

/s/ Haroon Anwar
HAROON ANWAR

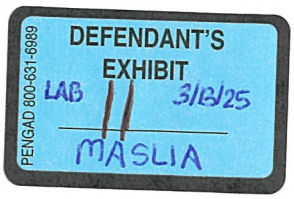
Exhibit Index

Exhibit	Description
1	Mary P. Anderson & William W. Woessner, *Applied Groundwater Modeling: Simulation of Flow and Advective Transport* (2d ed. 2015)
2	Feb. 13, 2025, Deposition Transcript of R. Jeffrey Davis
3	Jan. 16, 2013, Letter from ATSDR to Veterans Affairs
4	Aug. 3, 2015, Veteran Affairs Press Release
5	Expert Report of Morris Maslia
6	Rebuttal Report of Morris Maslia
7	March 28, 2005, ATSDR Expert Panel Transcript (Day 1)
8	March 29, 2005, ATSDR Expert Panel Transcript (Day 2)
9	April 29, 2009, ATSDR Expert Panel Transcript (Day 1)
10	April 30, 2009, ATSDR Expert Panel Transcript (Day 2)
11	Expert Report of Mustafa Aral
12	Feb. 25, 2025, Deposition Transcript of Leonard F. Konikow
13	Feb. 14. 2025, Deposition Transcript of Norman L. Jones
14	Mar. 13, 2025, Deposition Transcript of Morris Maslia
15	Rebuttal Report of Leonard F. Konikow
16	Expert Report of R. Jeffrey Davis and Norman L. Jones
17	Rebuttal Report of R. Jeffrey Davis and Norman L. Jones
18	*The Handbook of Groundwater Engineering*, Chapter 20 on Groundwater Modeling by Leonard F. Konikow & Thomas E. Reilly
19	ATSDR "Chapter A: Summary of Findings" Report for Tarawa Terrace Model
20	Frank Bove, Morris Maslia et al., *Evaluation of exposure to contaminated drinking water and specific birth defects and childhood cancers at Marine Corps Base Camp Lejeune, North Carolina: a case–control study* 12 Env't Health 104 (2013)
21	Jun. 19, 2008, Navy Letter to ATSDR
22	June 30, 2010, Deposition Transcript of Morris Maslia
23	March 10, 2009, ATSDR Response to Navy Letter
24	ATSDR Disclaimer for Tarawa Terrace Water Modeling
25	ATSDR "Chapter A: Summary of Findings" Report for Hadnot Point/Holcomb Boulevard Modeling
26	U.S. Government Accountability Office Report on Camp Lejeune (May 2007)
27	2009 ATSDR Expert Panel Summary Report
28	ATSDR Chapter A– Supplement. 6 Report for Hadnot Point/Holcomb Boulevard Model
29	2009 National Research Council Report on Camp Lejeune
30	2011 T. Prabhakar Clement Issue Paper
31	2012 ATSDR Response to T. Prabhakar Clement Issue Paper
32	Feb. 6, 2025 Deposition Transcript of Mustafa Aral
33	Feb. 21, 2007, ATSDR/Robert Faye Comments to Leonard L. Konikow
34	ATSDR Chapter H Report for Tarawa Terrace Model
35	Sept. 26, 2024, Deposition Transcript of Morris Maslia
36	Jan. 12, 2007, Email from Morris Maslia
37	Jan. 13, 2007, Email from Robert Faye

Exhibit	Description
38	Sept. 26, 2011 Email from Barbara Anderson

EXHIBIT 24

CONTAINS INFORMATION SUBJECT TO PROTECTIVE ORDER: DO NOT DISCLOSE TO UNAUTHORIZED PERSONS



Appendix I5

Simulated concentration of tetrachloroethylene (PCE) in finished water at the water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina

Reference: Maslia ML, Suárez-Soto RJ, Wang J, Aral MM, RE Faye, Sautner JB, and Valenzuela C. Analyses of Groundwater Flow, Contaminant Fate and Transport, and Distribution of Drinking Water at Tarawa Terrace and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina: Historical Reconstruction and Present-Day Conditions—Chapter I: Parameter sensitivity, uncertainty, and variability associated with model simulations of groundwater flow, contaminant fate and transport, and distribution of drinking water. Atlanta, GA: Agency for Toxic Substances and Disease Registry; 2008.

Disclaimer: The water-modeling analysis results presented herein are provided as a service to the public for informational purposes. All data, analyses, and computer-simulation results have been reviewed for accuracy and completeness based on available information and current modeling assumptions. The results however, may not reflect the actual exposure of specific individuals to contaminants in the water system. In addition, more updated information, if and when obtained, may change interpretations presented herein. For details pertaining to assumptions and limitations, the public should refer to the aforementioned reference listed above.

Appendix I5. Simulated concentrations of tetrachloroethylene in finished water at the water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina.

[PCE, tetrachloroethylene; µg/L, microgram per liter; $P_{2.5}$, Monte Carlo simulation results for the 2.5 percentile; P_{50}, Monte Carlo simulation results for the 50 percentile; $P_{97.5}$, Monte Carlo simulation results for the 97.5 percentile; WTP, water treatment plant; Jan, January; Feb, February; Mar, March; Apr, April; Aug, August; Sept, September; Oct, October; Dec, December]

Stress period	Month and year	Calibrated PCE concentration, in µg/L[1]	Range of concentrations derived from Monte Carlo simulations[2]					
			Monte Carlo simulation (Scenario 1)[3]			Monte Carlo simulation (Scenario 2)[4]		
			$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L	$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L
1-12	Jan–Dec 1951		WTP not operating					
13	Jan 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	Feb 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Mar 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Apr 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	May 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	June 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	July 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	Aug 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	Sept 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	Oct 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	Nov 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	Dec 1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	Jan 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	Feb 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	Mar 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	Apr 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	May 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	June 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	July 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	Aug 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	Sept 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	Oct 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	Nov 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	Dec 1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	Jan 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	Feb 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	Mar 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	Apr 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	May 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42	June 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	July 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44	Aug 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	Sept 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	Oct 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	Nov 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	Dec 1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	Jan 1955	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	Feb 1955	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	Mar 1955	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	Apr 1955	0.00	0.00	0.00	0.01	0.00	0.00	0.01
53	May 1955	0.00	0.00	0.00	0.01	0.00	0.00	0.01
54	June 1955	0.01	0.00	0.00	0.01	0.00	0.00	0.01
55	July 1955	0.01	0.00	0.01	0.02	0.00	0.01	0.02
56	Aug 1955	0.01	0.00	0.01	0.03	0.00	0.01	0.02
57	Sept 1955	0.02	0.00	0.01	0.04	0.00	0.01	0.03
58	Oct 1955	0.03	0.01	0.02	0.05	0.01	0.02	0.04
59	Nov 1955	0.04	0.01	0.03	0.07	0.01	0.03	0.07
60	Dec 1955	0.06	0.01	0.04	0.09	0.01	0.03	0.09

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Appendix I5. Simulated concentrations of tetrachloroethylene in finished water at the water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina.—Continued

[PCE, tetrachloroethylene; µg/L, microgram per liter; $P_{2.5}$, Monte Carlo simulation results for the 2.5 percentile; P_{50}, Monte Carlo simulation results for the 50 percentile; $P_{97.5}$, Monte Carlo simulation results for the 97.5 percentile; WTP, water treatment plant; Jan, January; Feb, February; Mar, March; Apr, April; Aug, August; Sept, September; Oct, October; Dec, December]

Stress period	Month and year	Calibrated PCE concentration, in µg/L[1]	Range of concentrations derived from Monte Carlo simulations[2]					
			Monte Carlo simulation (Scenario 1)[3]			Monte Carlo simulation (Scenario 2)[4]		
			$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L	$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L
61	Jan 1956	0.08	0.02	0.05	0.12	0.02	0.04	0.12
62	Feb 1956	0.10	0.02	0.07	0.16	0.02	0.06	0.15
63	Mar 1956	0.13	0.03	0.09	0.21	0.03	0.08	0.18
64	Apr 1956	0.17	0.04	0.12	0.26	0.04	0.10	0.24
65	May 1956	0.23	0.05	0.15	0.33	0.05	0.12	0.29
66	June 1956	0.29	0.07	0.20	0.42	0.06	0.15	0.34
67	July 1956	0.36	0.09	0.25	0.52	0.08	0.18	0.41
68	Aug 1956	0.46	0.12	0.31	0.65	0.10	0.23	0.51
69	Sept 1956	0.57	0.15	0.38	0.79	0.13	0.29	0.65
70	Oct 1956	0.70	0.18	0.47	0.96	0.16	0.35	0.78
71	Nov 1956	0.85	0.23	0.57	1.16	0.22	0.47	1.03
72	Dec 1956	1.04	0.28	0.69	1.38	0.24	0.54	1.14
73	Jan 1957	1.25	0.35	0.83	1.63	0.31	0.63	1.38
74	Feb 1957	1.47	0.41	0.97	1.89	0.37	0.77	1.69
75	Mar 1957	1.74	0.49	1.16	2.21	0.43	0.88	1.84
76	Apr 1957	2.04	0.59	1.36	2.57	0.53	1.09	2.08
77	May 1957	2.39	0.70	1.59	2.97	0.60	1.20	2.40
78	June 1957	2.77	0.83	1.84	3.40	0.64	1.31	2.51
79	July 1957	3.21	0.98	2.12	3.87	0.74	1.50	3.08
80	Aug 1957	3.69	1.15	2.45	4.42	0.87	1.73	3.38
81	Sept 1957	4.21	1.33	2.80	4.99	1.07	2.11	3.83
82	Oct 1957	4.79	1.54	3.20	5.64	1.20	2.31	4.48
83	Nov 1957	5.41	1.77	3.61	6.32	1.46	2.95	5.33
84	Dec 1957	6.10	2.02	4.08	7.07	1.61	3.08	5.81
85	Jan 1958	6.86	2.29	4.60	7.87	1.81	3.43	6.42
86	Feb 1958	7.60	2.57	5.11	8.67	2.04	3.97	7.10
87	Mar 1958	8.47	2.88	5.71	9.58	2.36	4.36	7.74
88	Apr 1958	9.37	3.22	6.33	10.56	2.68	5.04	8.73
89	May 1958	10.37	3.61	7.02	11.61	2.99	5.37	9.15
90	June 1958	11.39	4.00	7.73	12.67	2.98	5.43	9.32
91	July 1958	12.91	4.59	8.78	14.26	4.03	6.88	11.46
92	Aug 1958	14.12	5.09	9.61	15.49	4.55	7.67	12.57
93	Sept 1958	15.35	5.62	10.47	16.74	4.62	8.07	13.12
94	Oct 1958	16.69	6.19	11.39	18.13	5.24	8.98	14.89
95	Nov 1958	18.03	6.79	12.32	19.54	5.71	9.88	16.33
96	Dec 1958	19.49	7.45	13.33	21.07	6.32	10.83	17.27
97	Jan 1959	20.97	8.11	14.36	22.62	6.84	11.56	18.53
98	Feb 1959	22.35	8.77	15.34	23.97	7.74	12.87	20.40
99	Mar 1959	23.92	9.53	16.47	25.59	7.80	13.07	20.81
100	Apr 1959	25.49	10.24	17.59	27.22	8.26	14.30	23.52
101	May 1959	27.15	11.08	18.81	29.01	8.82	15.02	23.60
102	June 1959	28.81	11.94	20.01	30.78	10.46	16.86	25.74
103	July 1959	30.56	12.79	21.37	32.69	11.14	17.71	27.35
104	Aug 1959	32.36	13.70	22.77	34.63	12.06	18.88	28.65
105	Sept 1959	34.14	14.62	24.11	36.56	12.39	19.29	28.82
106	Oct 1959	36.01	15.60	25.59	38.60	13.35	20.99	31.36
107	Nov 1959	37.85	16.60	27.04	40.57	13.30	22.66	35.03
108	Dec 1959	39.78	17.68	28.50	42.59	14.48	23.99	36.02

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Appendix I5. Simulated concentrations of tetrachloroethylene in finished water at the water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina.—Continued

[PCE, tetrachloroethylene; µg/L, microgram per liter; $P_{2.5}$, Monte Carlo simulation results for the 2.5 percentile; P_{50}, Monte Carlo simulation results for the 50 percentile; $P_{97.5}$, Monte Carlo simulation results for the 97.5 percentile; WTP, water treatment plant; Jan, January; Feb, February; Mar, March; Apr, April; Aug, August; Sept, September; Oct, October; Dec, December]

Stress period	Month and year	Calibrated PCE concentration, in µg/L[1]	Range of concentrations derived from Monte Carlo simulations[2]					
			Monte Carlo simulation (Scenario 1)[3]			Monte Carlo simulation (Scenario 2)[4]		
			$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L	$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L
109	Jan 1960	41.86	18.82	30.15	44.74	15.99	24.99	38.89
110	Feb 1960	43.85	19.92	31.62	46.80	16.98	27.00	41.00
111	Mar 1960	46.03	21.13	33.16	49.07	17.85	26.94	41.01
112	Apr 1960	48.15	22.35	34.81	51.31	18.45	29.03	43.84
113	May 1960	50.37	23.59	36.60	53.65	19.84	30.13	44.48
114	June 1960	52.51	24.80	38.35	55.92	22.20	33.22	47.21
115	July 1960	54.74	26.08	40.12	58.27	23.30	34.55	50.18
116	Aug 1960	56.96	27.37	42.13	60.60	24.49	36.32	51.82
117	Sept 1960	59.09	28.64	43.80	62.82	24.27	35.66	51.64
118	Oct 1960	61.30	29.98	45.51	65.09	26.27	38.51	55.86
119	Nov 1960	63.42	31.31	47.25	67.22	26.43	40.46	59.79
120	Dec 1960	65.61	32.81	48.96	69.64	26.91	43.02	60.66
121	Jan 1961	67.69	34.22	50.74	71.88	28.21	43.30	63.65
122	Feb 1961	69.54	35.52	52.42	73.96	30.97	45.69	70.43
123	Mar 1961	71.56	36.93	54.16	76.28	31.47	45.72	66.14
124	Apr 1961	73.49	38.31	55.82	78.51	32.33	47.92	70.86
125	May 1961	75.49	39.76	57.54	80.74	32.37	49.12	70.32
126	June 1961	77.39	41.04	59.14	82.99	38.28	53.02	73.49
127	July 1961	79.36	42.45	60.87	84.92	36.88	54.13	75.55
128	Aug 1961	81.32	43.86	62.61	86.79	38.78	56.07	77.30
129	Sept 1961	83.19	45.25	64.23	88.82	38.62	54.74	76.56
130	Oct 1961	85.11	46.69	65.85	90.84	40.37	58.11	80.91
131	Nov 1961	86.95	48.10	67.44	92.75	39.55	59.92	87.09
132	Dec 1961	88.84	49.61	69.03	94.71	42.20	62.63	86.40
133	Jan 1962	60.88	34.23	47.47	64.96	27.60	42.46	62.20
134	Feb 1962	62.10	35.17	48.52	66.43	30.36	45.91	68.03
135	Mar 1962	62.94	35.84	49.35	67.26	31.00	45.13	66.06
136	Apr 1962	63.59	36.33	50.10	68.07	32.57	48.08	68.30
137	May 1962	64.17	36.80	50.73	68.98	31.10	46.57	66.06
138	June 1962	64.70	37.21	51.33	69.81	29.45	43.47	61.90
139	July 1962	65.23	37.65	51.82	70.45	28.63	44.36	62.01
140	Aug 1962	65.74	38.07	52.41	71.23	29.87	45.14	64.88
141	Sept 1962	66.22	38.47	52.91	71.97	32.00	47.51	67.91
142	Oct 1962	66.71	38.89	53.53	72.74	30.29	47.30	68.59
143	Nov 1962	67.18	39.30	54.16	73.38	35.13	53.53	77.51
144	Dec 1962	67.65	39.72	54.77	74.05	33.21	50.53	75.06
145	Jan 1963	68.06	40.19	55.24	74.67	32.41	49.74	74.10
146	Feb 1963	68.39	40.63	55.56	75.17	34.46	52.70	77.58
147	Mar 1963	68.73	41.15	56.03	75.76	35.61	52.41	73.73
148	Apr 1963	69.03	41.66	56.47	76.32	36.91	55.39	79.81
149	May 1963	69.33	42.03	56.98	77.17	34.47	53.02	77.36
150	June 1963	69.62	42.25	57.46	77.94	34.18	49.23	70.00
151	July 1963	69.90	42.45	57.98	78.48	32.75	49.62	71.03
152	Aug 1963	70.17	42.67	58.43	79.00	34.06	51.05	73.06
153	Sept 1963	70.43	42.87	58.82	79.47	36.62	52.90	76.53
154	Oct 1963	70.69	43.17	59.15	79.90	36.26	52.47	77.15
155	Nov 1963	70.93	43.60	59.49	80.31	38.46	59.09	84.58
156	Dec 1963	71.17	43.90	59.88	80.88	36.71	56.06	80.60

Appendix I5. Simulated concentrations of tetrachloroethylene in finished water at the water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina.—Continued

[PCE, tetrachloroethylene; µg/L, microgram per liter; $P_{2.5}$, Monte Carlo simulation results for the 2.5 percentile; P_{50}, Monte Carlo simulation results for the 50 percentile; $P_{97.5}$, Monte Carlo simulation results for the 97.5 percentile; WTP, water treatment plant; Jan, January; Feb, February; Mar, March; Apr, April; Aug, August; Sept, September; Oct, October; Dec, December]

Stress period	Month and year	Calibrated PCE concentration, in µg/L[1]	Range of concentrations derived from Monte Carlo simulations[2]					
			Monte Carlo simulation (Scenario 1)[3]			Monte Carlo simulation (Scenario 2)[4]		
			$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L	$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L
157	Jan 1964	71.40	44.18	60.32	81.34	35.81	55.22	80.71
158	Feb 1964	63.77	39.66	54.00	72.84	37.51	58.47	83.80
159	Mar 1964	63.95	39.92	54.36	73.38	37.37	57.84	81.58
160	Apr 1964	64.08	40.09	54.68	73.85	40.30	60.39	85.06
161	May 1964	64.19	40.31	54.98	74.28	39.56	57.23	84.15
162	June 1964	64.27	40.51	55.23	74.64	37.14	53.54	75.21
163	July 1964	64.34	40.61	55.45	74.98	35.59	54.24	76.87
164	Aug 1964	64.39	40.68	55.64	75.27	37.29	55.12	77.08
165	Sept 1964	64.43	40.75	55.82	75.62	39.55	57.96	80.84
166	Oct 1964	64.47	40.81	56.00	75.94	38.57	56.64	78.51
167	Nov 1964	64.49	40.88	56.18	76.19	42.49	63.10	91.13
168	Dec 1964	64.50	40.96	56.36	76.45	39.06	59.01	88.36
169	Jan 1965	64.50	41.10	56.58	76.70	37.87	59.05	88.52
170	Feb 1965	64.49	41.12	56.70	76.94	39.46	61.35	94.71
171	Mar 1965	64.47	41.14	56.78	77.17	41.20	60.99	89.98
172	Apr 1965	64.45	41.16	56.92	77.24	42.66	64.07	93.10
173	May 1965	64.42	41.20	57.06	77.13	41.03	61.17	87.07
174	June 1965	64.38	41.23	57.20	77.34	36.64	56.23	81.33
175	July 1965	64.33	41.26	57.22	77.80	38.15	57.32	81.83
176	Aug 1965	64.27	41.14	57.22	77.91	38.93	57.04	84.04
177	Sept 1965	64.20	41.03	57.22	77.92	41.40	60.36	84.29
178	Oct 1965	64.13	40.92	57.30	78.03	38.84	59.61	87.79
179	Nov 1965	64.05	40.85	57.34	78.10	44.47	66.00	95.45
180	Dec 1965	63.97	40.78	57.39	78.10	39.95	61.88	91.31
181	Jan 1966	63.88	40.81	57.48	78.26	39.34	61.61	91.59
182	Feb 1966	63.79	40.88	57.54	78.38	42.06	64.63	99.81
183	Mar 1966	63.68	41.01	57.62	78.45	41.44	63.87	94.47
184	Apr 1966	63.57	41.20	57.61	78.33	43.72	66.91	97.21
185	May 1966	63.46	41.28	57.64	78.43	42.05	64.21	91.37
186	June 1966	63.34	41.40	57.70	78.44	38.28	58.86	86.56
187	July 1966	63.21	41.54	57.70	78.65	39.70	58.20	87.29
188	Aug 1966	63.08	41.69	57.74	78.94	39.57	60.11	87.73
189	Sept 1966	62.94	41.79	57.79	78.91	41.82	62.94	91.60
190	Oct 1966	62.80	41.73	57.82	78.87	40.67	60.35	90.52
191	Nov 1966	62.65	41.67	57.78	78.78	44.43	68.76	99.82
192	Dec 1966	62.50	41.60	57.82	78.70	40.92	63.19	97.26
193	Jan 1967	62.25	41.42	57.70	78.67	40.95	62.45	96.88
194	Feb 1967	61.99	41.20	57.61	78.56	41.00	66.51	98.39
195	Mar 1967	61.67	40.98	57.36	78.37	43.47	64.42	95.01
196	Apr 1967	61.35	40.74	57.12	78.11	44.75	66.63	97.65
197	May 1967	61.02	40.52	56.84	77.78	42.71	64.23	95.11
198	June 1967	60.69	40.22	56.65	77.54	38.89	58.53	86.55
199	July 1967	60.37	40.03	56.43	77.45	38.46	59.64	87.57
200	Aug 1967	60.05	39.87	56.26	77.39	39.01	59.72	89.18
201	Sept 1967	59.74	39.69	56.04	77.26	40.93	61.91	90.19
202	Oct 1967	59.43	39.49	55.86	77.12	40.30	60.56	90.27
203	Nov 1967	59.13	39.31	55.71	76.98	44.01	68.01	99.90
204	Dec 1967	58.83	39.12	55.50	76.83	41.94	63.60	97.99

Appendix I5. Simulated concentrations of tetrachloroethylene in finished water at the water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina.—Continued

[PCE, tetrachloroethylene; µg/L, microgram per liter; $P_{2.5}$, Monte Carlo simulation results for the 2.5 percentile; P_{50}, Monte Carlo simulation results for the 50 percentile; $P_{97.5}$, Monte Carlo simulation results for the 97.5 percentile; WTP, water treatment plant; Jan, January; Feb, February; Mar, March; Apr, April; Aug, August; Sept, September; Oct, October; Dec, December]

Stress period	Month and year	Calibrated PCE concentration, in µg/L[1]	Range of concentrations derived from Monte Carlo simulations[2]					
			Monte Carlo simulation (Scenario 1)[3]			Monte Carlo simulation (Scenario 2)[4]		
			$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L	$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L
205	Jan 1968	58.41	38.91	55.32	76.43	40.60	63.04	98.22
206	Feb 1968	57.95	38.69	55.12	75.94	39.51	63.91	98.67
207	Mar 1968	57.43	38.44	54.74	75.51	41.62	63.54	94.21
208	Apr 1968	56.94	38.22	54.56	75.12	42.61	65.79	99.98
209	May 1968	56.45	37.99	54.20	74.61	39.39	62.35	92.79
210	June 1968	55.98	37.72	53.86	74.13	37.49	57.23	84.15
211	July 1968	55.49	37.46	53.50	73.63	37.51	56.92	83.56
212	Aug 1968	55.02	37.31	53.27	73.27	37.52	58.08	84.83
213	Sept 1968	54.58	37.16	53.00	73.05	40.06	60.24	89.84
214	Oct 1968	54.13	36.94	52.72	72.83	37.61	59.46	87.96
215	Nov 1968	53.71	36.71	52.49	72.61	42.84	64.11	96.77
216	Dec 1968	53.28	36.45	52.16	72.34	39.36	60.93	93.74
217	Jan 1969	53.07	36.40	52.03	72.40	37.42	60.60	90.38
218	Feb 1969	52.97	36.41	52.07	72.32	38.68	63.83	100.33
219	Mar 1969	52.94	36.41	52.21	72.23	40.85	62.20	90.15
220	Apr 1969	52.93	36.50	52.33	72.58	41.71	63.74	95.37
221	May 1969	52.93	36.55	52.41	72.94	40.51	60.54	94.64
222	June 1969	52.92	36.59	52.49	73.24	37.99	56.86	82.85
223	July 1969	52.90	36.61	52.54	73.52	35.02	57.32	85.75
224	Aug 1969	52.86	36.63	52.71	73.77	36.90	57.85	85.34
225	Sept 1969	52.81	36.64	52.74	73.98	39.74	59.97	89.19
226	Oct 1969	52.75	36.64	52.75	74.13	37.64	59.44	92.22
227	Nov 1969	55.19	38.34	55.24	77.72	36.74	55.89	84.87
228	Dec 1969	55.19	38.30	55.23	77.70	32.94	51.96	81.13
229	Jan 1970	55.01	38.10	55.14	77.54	32.78	50.97	81.62
230	Feb 1970	54.79	37.97	55.03	77.34	33.13	52.80	83.08
231	Mar 1970	54.49	37.71	54.76	77.08	32.85	52.72	79.35
232	Apr 1970	54.20	37.46	54.48	76.72	34.85	54.22	82.26
233	May 1970	53.90	37.21	54.17	76.27	33.91	51.26	78.11
234	June 1970	53.61	37.01	53.91	75.89	29.54	47.08	71.71
235	July 1970	53.32	36.82	53.59	75.68	28.77	46.80	72.48
236	Aug 1970	53.04	36.64	53.32	75.44	29.60	47.37	70.90
237	Sept 1970	52.78	36.47	53.06	75.25	31.55	49.00	74.82
238	Oct 1970	52.53	36.31	52.78	75.02	30.14	48.10	73.55
239	Nov 1970	52.29	36.19	52.67	74.93	32.50	53.01	81.51
240	Dec 1970	52.05	36.05	52.54	74.88	32.47	48.94	76.35
241	Jan 1971	51.96	35.96	52.53	75.02	30.00	48.86	77.29
242	Feb 1971	51.93	35.90	52.50	75.19	32.51	50.78	80.73
243	Mar 1971	51.95	35.87	52.60	75.42	32.25	49.82	78.27
244	Apr 1971	51.99	35.86	52.73	75.65	32.74	52.65	81.01
245	May 1971	52.03	35.86	52.88	75.88	30.15	49.32	76.96
246	June 1971	52.08	35.85	52.86	76.11	29.02	45.87	72.87
247	July 1971	52.12	35.92	52.88	76.35	29.03	45.64	72.37
248	Aug 1971	52.16	35.93	52.97	76.52	29.30	46.61	71.75
249	Sept 1971	52.20	35.93	53.07	76.72	30.33	48.38	74.56
250	Oct 1971	52.23	35.95	53.13	76.91	29.27	46.98	73.25
251	Nov 1971	52.26	35.98	53.25	77.05	32.40	52.55	82.47
252	Dec 1971	52.29	35.91	53.28	77.28	30.91	49.57	76.35

Appendix I5. Simulated concentrations of tetrachloroethylene in finished water at the water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina.—Continued

[PCE, tetrachloroethylene; µg/L, microgram per liter; $P_{2.5}$, Monte Carlo simulation results for the 2.5 percentile; P_{50}, Monte Carlo simulation results for the 50 percentile; $P_{97.5}$, Monte Carlo simulation results for the 97.5 percentile; WTP, water treatment plant; Jan, January; Feb, February; Mar, March; Apr, April; Aug, August; Sept, September; Oct, October; Dec, December]

Stress period	Month and year	Calibrated PCE concentration, in µg/L[1]	Range of concentrations derived from Monte Carlo simulations[2]					
			Monte Carlo simulation (Scenario 1)[3]			Monte Carlo simulation (Scenario 2)[4]		
			$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L	$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L
253	Jan 1972	49.34	33.93	50.30	73.12	29.17	48.14	77.82
254	Feb 1972	49.01	33.72	50.06	72.93	30.19	50.33	81.13
255	Mar 1972	48.68	33.47	49.71	72.72	31.69	48.44	75.80
256	Apr 1972	48.40	33.25	49.54	72.47	30.79	50.77	79.48
257	May 1972	48.14	33.10	49.27	72.26	30.44	48.53	73.97
258	June 1972	47.90	32.98	49.08	72.17	27.68	44.98	68.87
259	July 1972	47.67	32.85	48.97	72.02	27.13	43.58	66.62
260	Aug 1972	47.45	32.72	48.78	71.78	26.91	43.63	68.46
261	Sept 1972	47.25	32.60	48.69	71.47	28.10	46.38	72.80
262	Oct 1972	47.05	32.49	48.58	71.34	28.15	44.90	70.07
263	Nov 1972	46.87	32.41	48.43	71.26	30.68	49.80	78.83
264	Dec 1972	46.69	32.29	48.21	71.16	28.36	46.21	76.56
265	Jan 1973	54.28	37.52	56.04	82.79	27.54	44.70	72.51
266	Feb 1973	54.19	37.39	55.96	82.69	29.05	47.31	78.50
267	Mar 1973	53.98	37.15	55.78	82.35	28.09	46.20	73.11
268	Apr 1973	53.76	36.91	55.44	81.94	28.95	46.73	77.52
269	May 1973	53.52	36.68	55.24	81.51	26.12	45.17	70.36
270	June 1973	53.30	36.46	55.22	81.10	25.61	40.75	66.70
271	July 1973	53.08	36.24	55.12	80.74	25.25	40.82	63.84
272	Aug 1973	52.87	36.03	54.99	80.59	25.02	41.47	64.39
273	Sept 1973	52.68	35.84	54.88	80.46	26.43	43.33	68.68
274	Oct 1973	52.51	35.66	54.87	80.34	26.17	41.28	65.28
275	Nov 1973	52.35	35.49	54.80	80.25	27.77	45.41	72.92
276	Dec 1973	52.20	35.33	54.72	80.17	25.66	42.21	68.89
277	Jan 1974	52.43	35.41	54.97	80.49	25.72	42.62	69.65
278	Feb 1974	52.82	35.59	55.42	80.98	26.19	43.80	72.53
279	Mar 1974	53.39	35.86	55.92	81.66	25.08	42.86	68.49
280	Apr 1974	53.99	36.16	56.60	82.41	28.14	45.59	71.28
281	May 1974	54.63	36.49	57.21	83.20	25.84	42.70	72.49
282	June 1974	55.25	36.80	57.69	84.15	25.00	40.00	64.50
283	July 1974	55.90	37.13	58.15	85.07	24.17	40.57	65.57
284	Aug 1974	56.53	37.50	58.85	85.98	24.29	40.75	65.98
285	Sept 1974	57.10	37.85	59.43	86.86	27.22	43.16	69.98
286	Oct 1974	57.70	38.22	60.00	87.74	25.22	42.68	67.27
287	Nov 1974	58.30	38.56	60.59	88.58	28.99	47.52	76.53
288	Dec 1974	58.92	38.98	61.11	89.45	25.07	44.15	72.46
289	Jan 1975	61.00	40.30	63.17	92.62	27.61	45.83	75.73
290	Feb 1975	61.24	40.39	63.33	92.97	28.46	48.17	80.43
291	Mar 1975	61.41	40.51	63.43	93.20	28.98	46.39	77.50
292	Apr 1975	61.57	40.61	63.45	93.38	29.37	48.59	82.56
293	May 1975	61.72	40.78	63.62	93.32	28.00	46.55	76.49
294	June 1975	61.88	40.92	63.77	93.48	24.95	42.93	67.44
295	July 1975	62.05	41.05	64.04	93.91	25.59	42.20	68.93
296	Aug 1975	62.25	41.13	64.22	94.27	26.21	42.72	68.78
297	Sept 1975	62.46	41.20	64.36	94.54	25.88	44.92	73.09
298	Oct 1975	62.69	41.18	64.65	94.84	26.24	43.56	70.58
299	Nov 1975	62.92	41.12	64.91	95.15	27.40	49.02	80.06
300	Dec 1975	63.18	41.12	65.11	95.44	26.23	45.41	76.07

Appendix I5. Simulated concentrations of tetrachloroethylene in finished water at the water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina.—Continued

[PCE, tetrachloroethylene; µg/L, microgram per liter; $P_{2.5}$, Monte Carlo simulation results for the 2.5 percentile; P_{50}, Monte Carlo simulation results for the 50 percentile; $P_{97.5}$, Monte Carlo simulation results for the 97.5 percentile; WTP, water treatment plant; Jan, January; Feb, February; Mar, March; Apr, April; Aug, August; Sept, September; Oct, October; Dec, December]

Stress period	Month and year	Calibrated PCE concentration, in µg/L[1]	Range of concentrations derived from Monte Carlo simulations[2]					
			Monte Carlo simulation (Scenario 1)[3]			Monte Carlo simulation (Scenario 2)[4]		
			$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L	$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L
301	Jan 1976	73.96	48.06	76.13	111.62	27.44	47.37	78.75
302	Feb 1976	74.94	48.64	77.01	112.96	28.08	50.08	82.73
303	Mar 1976	75.97	49.28	77.88	114.29	30.00	49.48	77.65
304	Apr 1976	76.97	49.90	78.87	115.66	29.89	51.83	83.45
305	May 1976	78.00	50.66	79.94	117.25	28.96	49.32	81.75
306	June 1976	79.02	51.42	80.86	118.78	27.37	44.69	74.98
307	July 1976	80.07	52.20	81.82	120.35	28.29	45.16	75.62
308	Aug 1976	81.13	52.86	82.70	121.82	27.95	46.57	76.48
309	Sept 1976	82.17	53.51	83.71	123.46	29.17	49.14	79.62
310	Oct 1976	83.25	54.25	84.81	124.74	28.92	48.10	80.30
311	Nov 1976	84.31	55.09	85.76	126.00	31.09	53.61	90.47
312	Dec 1976	85.41	55.90	86.67	127.61	28.21	50.51	82.95
313	Jan 1977	86.61	56.70	87.66	129.36	28.88	49.71	81.57
314	Feb 1977	87.70	57.45	88.70	131.09	30.18	52.13	85.43
315	Mar 1977	88.91	58.14	89.80	133.02	29.18	51.65	83.61
316	Apr 1977	90.10	58.86	90.90	134.30	32.23	54.40	88.91
317	May 1977	91.32	59.61	91.86	135.48	30.43	50.86	86.19
318	June 1977	92.53	60.38	93.08	136.61	28.97	47.43	78.24
319	July 1977	93.75	61.24	94.29	137.80	29.03	47.45	77.48
320	Aug 1977	94.99	62.11	95.48	139.43	28.20	48.28	81.51
321	Sept 1977	96.20	62.97	96.44	140.89	30.24	50.29	85.19
322	Oct 1977	97.42	63.86	97.49	142.51	28.33	51.14	82.53
323	Nov 1977	98.62	64.58	98.62	144.08	32.33	56.02	92.86
324	Dec 1977	99.84	65.31	99.65	145.59	29.86	53.22	90.47
325	Jan 1978	101.18	66.16	101.09	147.13	44.02	75.70	120.92
326	Feb 1978	102.77	67.25	102.62	148.91	39.93	67.26	112.31
327	Mar 1978	103.04	67.39	103.04	149.08	52.50	84.64	133.87
328	Apr 1978	104.31	68.24	104.52	150.32	46.79	76.94	126.94
329	May 1978	105.19	68.81	105.34	151.12	50.49	85.95	136.76
330	June 1978	106.88	70.00	107.10	153.19	42.45	73.13	119.19
331	July 1978	107.95	70.77	108.05	154.56	45.08	75.24	121.43
332	Aug 1978	108.69	71.12	108.58	155.63	48.54	80.46	135.92
333	Sept 1978	109.61	71.68	109.40	156.91	48.81	83.51	139.85
334	Oct 1978	111.18	72.89	110.78	158.60	44.55	75.04	121.83
335	Nov 1978	111.08	72.99	110.76	158.33	59.23	100.40	162.58
336	Dec 1978	111.93	73.52	111.71	159.48	58.45	100.01	162.64
337	Jan 1979	113.14	74.30	112.93	161.01	57.81	95.20	164.77
338	Feb 1979	114.05	74.80	113.75	162.04	58.23	99.50	166.62
339	Mar 1979	114.98	75.32	114.60	163.14	59.21	101.26	162.26
340	Apr 1979	115.82	76.01	115.14	164.14	64.03	105.77	169.77
341	May 1979	116.68	76.83	115.85	165.22	60.49	104.49	166.33
342	June 1979	117.47	77.56	116.62	166.12	57.29	95.08	158.63
343	July 1979	118.29	78.22	117.32	166.52	60.76	97.83	159.43
344	Aug 1979	119.08	78.87	117.95	167.11	60.40	101.30	162.28
345	Sept 1979	119.83	79.50	118.62	167.82	67.04	105.09	167.67
346	Oct 1979	120.59	80.14	119.49	168.59	63.07	104.48	172.01
347	Nov 1979	121.31	80.74	120.12	169.34	74.24	119.14	191.45
348	Dec 1979	122.04	81.35	120.77	170.09	68.90	113.89	186.42

Appendix I5. Simulated concentrations of tetrachloroethylene in finished water at the water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina.—Continued

[PCE, tetrachloroethylene; µg/L, microgram per liter; $P_{2.5}$, Monte Carlo simulation results for the 2.5 percentile; P_{50}, Monte Carlo simulation results for the 50 percentile; $P_{97.5}$, Monte Carlo simulation results for the 97.5 percentile; WTP, water treatment plant; Jan, January; Feb, February; Mar, March; Apr, April; Aug, August; Sept, September; Oct, October; Dec, December]

Stress period	Month and year	Calibrated PCE concentration, in µg/L[1]	Range of concentrations derived from Monte Carlo simulations[2]					
			Monte Carlo simulation (Scenario 1)[3]			Monte Carlo simulation (Scenario 2)[4]		
			$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L	$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L
349	Jan 1980	123.28	82.20	122.09	171.34	61.30	101.54	159.81
350	Feb 1980	122.98	81.93	121.80	171.45	77.70	131.23	206.13
351	Mar 1980	124.03	82.63	122.99	172.63	67.73	114.94	183.21
352	Apr 1980	123.90	82.42	123.27	172.41	86.02	143.61	229.05
353	May 1980	124.69	82.89	123.73	173.81	85.23	138.95	220.28
354	June 1980	125.83	83.92	124.67	175.54	80.14	128.55	203.28
355	July 1980	0.72	0.10	0.43	1.67	0.06	0.32	1.22
356	Aug 1980	0.75	0.11	0.45	1.73	0.07	0.34	1.28
357	Sept 1980	121.36	80.64	120.61	170.25	74.54	128.20	195.86
358	Oct 1980	121.72	80.95	121.00	170.55	82.88	137.09	215.09
359	Nov 1980	122.14	81.32	121.73	171.07	89.83	145.35	231.15
360	Dec 1980	122.95	81.96	122.56	171.97	87.97	143.51	226.80
361	Jan 1981	114.05	76.20	113.83	159.33	81.35	131.65	210.19
362	Feb 1981	114.39	76.42	114.22	159.76	71.73	120.32	185.47
363	Mar 1981	115.60	77.32	115.10	161.62	65.38	104.23	164.75
364	Apr 1981	116.55	78.07	116.07	163.34	61.89	101.55	158.35
365	May 1981	117.30	78.64	116.91	164.52	63.14	99.62	156.29
366	June 1981	118.36	79.53	117.92	165.37	54.95	86.73	140.98
367	July 1981	133.29	89.77	132.96	186.08	58.22	92.47	142.21
368	Aug 1981	134.31	90.57	133.94	187.73	59.68	95.47	151.17
369	Sept 1981	120.72	81.40	120.32	168.91	58.90	98.56	150.82
370	Oct 1981	121.04	81.71	120.86	169.57	61.42	99.80	157.59
371	Nov 1981	121.41	82.04	121.17	170.30	60.76	101.36	158.08
372	Dec 1981	121.81	82.41	121.56	171.08	63.30	102.27	160.36
373	Jan 1982	103.95	70.61	103.86	145.41	55.35	91.05	141.55
374	Feb 1982	105.86	71.96	105.76	147.68	56.60	92.63	140.40
375	Mar 1982	107.52	73.05	107.51	149.67	59.57	93.91	147.10
376	Apr 1982	108.83	74.01	108.79	151.25	58.43	97.00	147.50
377	May 1982	148.50	101.45	147.91	206.23	66.65	107.89	166.05
378	June 1982	110.78	75.70	110.41	153.60	61.01	99.03	151.27
379	July 1982	111.98	76.77	111.69	154.90	62.24	97.91	154.37
380	Aug 1982	113.07	77.74	112.66	156.03	63.70	99.09	152.90
381	Sept 1982	114.04	78.49	113.60	157.00	65.21	100.91	153.98
382	Oct 1982	114.60	79.03	114.14	157.69	67.41	108.99	165.07
383	Nov 1982	113.87	78.41	113.67	157.37	88.82	142.12	223.75
384	Dec 1982	115.16	79.21	114.95	158.89	79.98	128.05	193.75
385	Jan 1983	1.25	0.25	0.75	2.48	0.17	0.61	1.90
386	Feb 1983	1.29	0.27	0.78	2.56	0.18	0.63	1.94
387	Mar 1983	111.76	77.09	112.19	156.29	78.57	123.82	194.41
388	Apr 1983	112.66	77.92	112.99	157.31	74.18	119.77	182.63
389	May 1983	113.97	79.21	114.10	158.82	70.85	117.76	174.86
390	June 1983	106.10	74.18	106.03	147.67	68.30	103.53	162.13
391	July 1983	116.70	81.48	116.62	162.17	66.41	108.10	166.88
392	Aug 1983	117.72	82.09	117.54	163.39	67.97	107.12	161.29
393	Sept 1983	117.83	82.03	117.63	163.40	76.74	120.27	183.16
394	Oct 1983	117.97	82.03	117.88	163.53	84.95	133.04	207.24
395	Nov 1983	118.63	82.60	118.70	164.81	89.04	142.71	224.56
396	Dec 1983	120.78	84.23	120.74	167.35	72.65	113.38	171.38

Appendix I5. Simulated concentrations of tetrachloroethylene in finished water at the water treatment plant, Tarawa Terrace, U.S. Marine Corps Base Camp Lejeune, North Carolina.—Continued

[PCE, tetrachloroethylene; µg/L, microgram per liter; $P_{2.5}$, Monte Carlo simulation results for the 2.5 percentile; P_{50}, Monte Carlo simulation results for the 50 percentile; $P_{97.5}$, Monte Carlo simulation results for the 97.5 percentile; WTP, water treatment plant; Jan, January; Feb, February; Mar, March; Apr, April; Aug, August; Sept, September; Oct, October; Dec, December]

Stress period	Month and year	Calibrated PCE concentration, in µg/L[1]	Range of concentrations derived from Monte Carlo simulations[2]					
			Monte Carlo simulation (Scenario 1)[3]			Monte Carlo simulation (Scenario 2)[4]		
			$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L	$P_{2.5}$, in µg/L	P_{50}, in µg/L	$P_{97.5}$, in µg/L
397	Jan 1984	132.87	92.63	133.27	185.03	103.04	159.84	247.01
398	Feb 1984	180.39	126.52	180.97	249.43	94.25	150.35	230.69
399	Mar 1984	183.02	128.61	183.55	252.50	99.38	159.70	240.42
400	Apr 1984	151.46	106.37	151.54	208.97	97.90	155.71	236.45
401	May 1984	153.42	107.63	153.20	211.58	92.85	146.63	220.85
402	June 1984	182.13	127.45	181.99	250.57	94.11	152.75	228.36
403	July 1984	156.39	109.41	156.40	214.58	101.95	160.97	234.39
404	Aug 1984	170.47	106.73	158.25	238.65	108.76	168.54	261.54
405	Sept 1984	181.22	113.28	168.51	253.93	117.53	184.30	295.64
406	Oct 1984	173.73	108.42	161.84	245.02	120.12	182.33	281.84
407	Nov 1984	173.77	108.41	161.92	245.70	124.18	187.60	287.36
408	Dec 1984	173.18	107.82	161.69	246.06	127.85	193.50	301.23
409	Jan 1985	176.12	109.98	164.71	251.48	122.98	187.00	293.19
410	Feb 1985	3.64	1.13	2.67	6.57	0.47	1.41	3.74
411	Mar 1985	8.71	3.21	6.58	14.79	8.83	20.01	41.59
412	Apr 1985	8.09	2.99	6.16	13.70	9.00	20.41	42.30
413	May 1985	4.76	1.50	3.46	8.36	0.58	1.68	4.47
414	June 1985	5.14	1.65	3.80	9.21	0.64	1.81	4.78
415	July 1985	5.54	1.80	4.12	10.04	0.69	1.96	5.12
416	Aug 1985	6.01	1.98	4.50	10.97	0.76	2.14	5.56
417	Sept 1985	6.50	2.19	4.88	11.89	0.83	2.30	6.03
418	Oct 1985	7.06	2.43	5.33	12.88	0.92	2.53	6.53
419	Nov 1985	7.64	2.68	5.78	13.90	1.02	2.76	7.07
420	Dec 1985	8.27	2.93	6.32	14.99	1.13	3.00	7.59
421	Jan 1986	8.85	3.18	6.82	15.87	1.24	3.22	8.14
422	Feb 1986	9.42	3.45	7.30	16.67	1.35	3.46	8.69
423	Mar 1986	12.14	4.55	9.43	21.18	1.85	4.67	11.50
424	Apr 1986	10.83	4.09	8.44	18.71	1.64	4.08	9.90
425	May 1986	11.56	4.42	9.06	19.63	1.79	4.41	10.49
426	June 1986	12.28	4.77	9.70	20.59	1.94	4.76	11.08
427	July 1986	13.06	5.14	10.35	21.75	2.11	5.12	11.77
428	Aug 1986	13.84	5.54	11.01	23.04	2.29	5.51	12.50
429	Sept 1986	14.61	5.90	11.70	24.30	2.49	5.89	13.19
430	Oct 1986	15.42	6.28	12.41	25.59	2.71	6.33	13.94
431	Nov 1986	16.21	6.66	13.11	26.70	2.93	6.73	14.77
432	Dec 1986	17.03	7.06	13.77	27.86	3.17	7.20	15.65
433	Jan 1987	17.85	7.47	14.46	29.04	3.41	7.66	16.46
434	Feb 1987	18.49	7.82	15.02	29.91	3.62	8.04	17.16
435	Mar 1987				**WTP closed**			

[1]Results from Faye (2008) and reported in Maslia et al. (2007, Appendix A2)

[2]$P_{97.5}$ and $P_{2.5}$ represent the upper and lower bound, respectively, of 95 percent of Monte Carlo simulations; for a Gaussian (normal) distribution, the median (P_{50}) should equal the mean value

[3]Scenario 1 Monte Carlo simulation is for pumping uncertainty excluded

[4]Scenario 2 Monte Carlo simulation is for pumping uncertainty included

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EXHIBIT 26

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United States Government Accountability Office

GAO

Report to Congressional Committees

May 2007

DEFENSE HEALTH CARE

Activities Related to Past Drinking Water Contamination at Marine Corps Base Camp Lejeune

GAO-07-276

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May 2007

DEFENSE HEALTH CARE

Activities Related to Past Drinking Water Contamination at Marine Corps Base Camp Lejeune

GAO Accountability•Integrity•Reliability

Highlights

Highlights of GAO-07-276, a report to congressional committees

Why GAO Did This Study

In the early 1980s, volatile organic compounds (VOCs) were discovered in some of the water systems serving housing areas on Marine Corps Base Camp Lejeune. Exposure to certain VOCs may cause adverse health effects, including cancer. In 1999, the Department of Health and Human Services' (HHS) Agency for Toxic Substances and Disease Registry (ATSDR) began a study to examine whether individuals who were exposed in utero to the contaminated drinking water are more likely to have developed certain childhood cancers or birth defects. ATSDR has projected a December 2007 completion date for the study.

The National Defense Authorization Act of Fiscal Year 2005 required GAO to report on past drinking water contamination and related health effects at Camp Lejeune. In this report GAO describes (1) efforts to identify and address the past contamination, (2) activities resulting from concerns about possible adverse health effects and government actions related to the past contamination, and (3) the design of the current ATSDR study, including the study's population, time frame, selected health effects, and the reasonableness of the projected completion date. GAO reviewed documents, interviewed officials and former residents, and contracted with the National Academy of Sciences to convene an expert panel to assess the design of the current ATSDR study.

www.gao.gov/cgi-bin/getrpt?GAO-07-276.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Marcia Crosse at (202) 512-7119 or crossem@gao.gov.

What GAO Found

Efforts to identify and address the past drinking water contamination at Camp Lejeune began in the 1980s, when Navy water testing at Camp Lejeune detected VOCs in some base water systems. In 1982 and 1983, continued testing identified two VOCs—trichloroethylene (TCE), a metal degreaser, and tetrachloroethylene (PCE), a dry cleaning solvent—in two water systems that served base housing areas, Hadnot Point and Tarawa Terrace. In 1984 and 1985 a Navy environmental program identified VOCs, such as TCE and PCE, in some of the individual wells serving the Hadnot Point and Tarawa Terrace water systems. Ten wells were subsequently removed from service. Department of Defense (DOD) and North Carolina officials concluded that on- and off-base sources were likely to have caused the contamination. It has not been determined when contamination at Hadnot Point began. ATSDR has estimated that well contamination at Tarawa Terrace from an off-base dry cleaner began as early as 1957.

Activities related to concerns about possible adverse health effects began in 1991, when ATSDR initiated a public health assessment evaluating the possible health risks from exposure to the contaminated drinking water. The health assessment was followed by two health studies, one of which is ongoing. While ATSDR did not always receive requested funding and experienced delays in receiving information from DOD for its Camp Lejeune-related work, ATSDR officials said this has not significantly delayed their work. Former residents and employees have filed about 750 claims against the federal government. Additionally, three federal inquiries into issues related to the contamination have been conducted—one by a Marine Corps-chartered panel and two by the Environmental Protection Agency (EPA).

Members of the expert panel that the National Academy of Sciences convened generally agreed that many parameters of ATSDR's current study are appropriate, including the study population, the exposure time frame, and the selected health effects. ATSDR's study is examining whether individuals who were exposed in utero to the contaminated drinking water at Camp Lejeune between 1968 and 1985 were more likely to have specific birth defects or childhood cancers than those not exposed.

DOD, EPA, and HHS provided technical comments on a draft of this report, which GAO incorporated where appropriate. Three members of an ATSDR community assistance panel for Camp Lejeune provided oral comments on issues such as other VOCs that have been detected at Camp Lejeune, and compensation, health benefits, and additional notification for former residents. GAO focused its review on TCE and PCE because they were identified by ATSDR as the chemicals of primary concern. GAO's report notes that other VOCs were detected. GAO incorporated the panel members' comments where appropriate, but some issues were beyond the scope of this report.

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Abbreviations

1, 1-DCE	1,1-dichloroethylene
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CID	Criminal Investigation Division
DERP	Defense Environmental Restoration Program
DOD	Department of Defense
DOJ	Department of Justice
EPA	Environmental Protection Agency
HHS	Department of Health and Human Services
JAG	Judge Advocate General
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
NACIP	Navy Assessment and Control of Installation Pollutants
NAS	National Academy of Sciences
NEHC	Navy Environmental Health Center
OIG	Office of Inspector General
PCE	tetrachloroethylene
SARA	Superfund Amendments and Reauthorization Act
TCE	trichloroethylene
Trans-1,2-DCE	trans-1,2-dichloroethylene
TTHMs	total trihalomethanes
USAEHA	U.S. Army Environmental Hygiene Agency
VOC	volatile organic compound

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GAO
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United States Government Accountability Office
Washington, DC 20548

May 11, 2007

The Honorable Carl Levin
Chairman
The Honorable John McCain
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Daniel Inouye
Chairman
The Honorable Ted Stevens
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Ike Skelton
Chairman
The Honorable Duncan Hunter
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable John P. Murtha
Chairman
The Honorable C. W. Bill Young
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

In the early 1980s, Department of the Navy water testing at Marine Corps Base Camp Lejeune identified contamination in water systems that served housing areas on the base.[1] Further water testing revealed that some of the individual wells serving two of the water systems were contaminated with

[1]Water testing was conducted at Camp Lejeune in preparation for meeting future drinking water regulations and to address concerns about chemicals that had been buried on base.

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volatile organic compounds (VOCs), such as trichloroethylene (TCE), which is a metal degreaser and an ingredient in adhesives and paint removers, and tetrachloroethylene (PCE), which is a solvent used in the textile industry and a dry cleaning solvent. By 1985, 10 wells that were determined to be contaminated with VOCs had been removed from service.[2] Although it is not known precisely when the wells became contaminated, the Department of Health and Human Services' (HHS) Agency for Toxic Substances and Disease Registry (ATSDR), which is investigating the issue, has estimated that the contamination may have begun as early as the 1950s. According to ATSDR, the VOCs of primary concern at Camp Lejeune were TCE and PCE, and the agency notes that exposure to these chemicals may cause adverse health effects. For example, exposure to low levels of TCE may cause headaches and difficulty concentrating.[3] Exposure to high levels of both TCE and PCE may cause dizziness, headaches, nausea, unconsciousness, cancer, and possibly death.[4]

As required by federal law,[5] ATSDR conducted a public health assessment at Camp Lejeune after the Environmental Protection Agency (EPA) designated the base as a National Priorities List[6] site in 1989. The health assessment recommended that studies be conducted to evaluate the risks of childhood cancer related to VOC exposure at Camp Lejeune and noted that adverse pregnancy outcomes were also of concern.[7] The first study based on the health assessment was released in 1998[8] and found a

[2]VOCs had initially been detected in two other wells. Additional test results did not detect VOCs and these wells were not removed from service.

[3]According to ATSDR, health effects from exposure to low levels of PCE are unknown.

[4]ATSDR did not define "low levels" or "high levels" of TCE or PCE.

[5]Superfund Amendments and Reauthorization Act of 1986, Pub. L. No. 99-499, §110, 100 stat. 1613, 1642 (codified at 42 U.S.C. § 9604(i).

[6]The National Priorities List is a list of seriously contaminated hazardous waste sites that have been identified by EPA's Superfund Program. Under the Superfund Program, EPA may compel parties responsible for contaminated sites to clean them up or reimburse EPA for its cleanup costs. Camp Lejeune was designated as a National Priorities List site due to environmental contamination at various areas on the base.

[7]Agency for Toxic Substances and Disease Registry, *Public Health Assessment U.S. Marine Corps Camp Lejeune Onslow County, North Carolina* (Atlanta, Ga: 1997).

[8]U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, *Volatile Organic Compounds in Drinking Water and Adverse Pregnancy Outcomes* (Atlanta, Ga: 1998).

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statistically significant association between exposure and some adverse pregnancy outcomes. In 1999, ATSDR initiated a second study that currently is examining whether individuals who were exposed in utero (i.e., as developing fetuses during gestation) and as infants up to 1 year of age to the contaminated drinking water at Camp Lejeune between 1968 and 1985 are more likely to have developed specific childhood cancers or birth defects than those who were not exposed. ATSDR has projected a December 2007 completion date for the study. In addition to ATSDR's Camp Lejeune-related work, three inquiries into the issues related to the past drinking water contamination have been conducted, one by a Marine Corps-chartered panel, one by EPA's Office of Inspector General (OIG), and one by EPA's Criminal Investigation Division (CID).

Former residents of Camp Lejeune have taken legal action against the federal government for injuries alleged to have resulted from exposure to the contaminated water. In addition, some former residents have expressed concern over the Marine Corps' handling of and response to the drinking water contamination, noting that even though contaminants were detected as early as 1980, the wells that were determined to be contaminated were not removed from service until 1985. Some former residents have also asserted that there have been delays in the provision of funding and information from the Department of Defense (DOD) to ATSDR,[9] and have said that DOD and EPA's responses to their requests for drinking water contamination-related documents have sometimes been inadequate. Finally, some former residents have raised concerns about various aspects of ATSDR's ongoing study, including whether the study population, time frame, and selected health effects are too limited to adequately represent those who were potentially affected, and about ATSDR's projected December 2007 study completion date because the federal government plans to wait to adjudicate their claims until the study is complete.

The Ronald W. Reagan National Defense Authorization Act of Fiscal Year 2005 directed that we study and report on the past drinking water contamination and related adverse health effects at Camp Lejeune, including identifying the type, source, and duration of the contamination, determining the actions taken to address the contamination, and assessing

[9]DOD is required by law to provide funding and data as necessary for ATSDR to carry out certain health-related activities, including public health assessments.

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the current ATSDR health study.[10] The act also requires that our study consider information and opinions from individuals who lived and worked at Camp Lejeune during the period when the drinking water may have been contaminated. As discussed with the committees of jurisdiction, in this report we examine the history of events related to drinking water contamination at Camp Lejeune. Specifically, we (1) examine efforts to identify and address the past contamination; (2) describe activities resulting from concerns about possible adverse health effects and government actions related to the past contamination, such as the current ATSDR health study; and, (3) describe an assessment by an independent panel of experts of the design of the current ATSDR health study, including the study's population, the exposure time frame, selected health effects being measured, and the reasonableness of the projected completion date.

To examine efforts to identify and address the past contamination,[11] we reviewed more than 1,600 documents related to past and current drinking water activities at Camp Lejeune. We focused our review on the past TCE and PCE contamination because ATSDR had noted that these chemicals were the VOCs of primary concern at Camp Lejeune. However, we also reviewed documentation regarding other VOCs detected at Camp Lejeune. We interviewed current and former officials from various DOD entities, including Camp Lejeune, Headquarters Marine Corps, and the Department of the Navy, to obtain information about the history of events related to the past drinking water contamination at Camp Lejeune, including efforts to identify and address the contamination. The current and former officials interviewed often provided information based on their memory of events that occurred more than 20 years ago. We attempted to corroborate their testimonial evidence with documentation whenever possible. The former officials we interviewed were responsible for environmental activities at Camp Lejeune or the Department of the Navy during the time in which the contamination was detected. The current officials we interviewed are responsible for environmental activities at Camp Lejeune, Headquarters Marine Corps, or the Department of the Navy. Some of these current

[10]Pub. L. No. 108-375, § 317, 118 Stat. 1811, 1844.

[11]Throughout this report we use the term "contamination," which is also used by the law requiring us to do this work, as well as by EPA and DOD, to describe the drinking water at Camp Lejeune in the early 1980s. However, EPA had not yet established maximum contaminant levels for the chemicals TCE and PCE during this period. *See* 40 C.F.R. §§ 141.2 and 141.12 (1975-1985).

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officials were also responsible for environmental activities during the time in which the contamination was detected. We also met with 19 interested former residents and individuals who worked on the base during the 1960s, 1970s, and 1980s, in order to obtain their perspective on historical events and to learn about their concerns related to the drinking water contamination. A former resident who is active in matters related to the past drinking water contamination at Camp Lejeune identified most of the interested former residents; others were identified at an ATSDR public meeting. Additionally, we examined reports from and interviewed officials with EPA and with the North Carolina Department of Environment and Natural Resources who were knowledgeable about activities and costs related to the cleanup of the suspected sources of contamination.

To describe activities resulting from concerns about the possible adverse health effects and government actions related to past drinking water contamination, including efforts to study potential health effects and federal inquiries into the response to the contamination, we reviewed documents, interviewed agency officials, and attended agency meetings. To examine the activities undertaken by ATSDR to study possible adverse health effects related to the drinking water contamination, we interviewed ATSDR officials and reviewed ATSDR's Camp Lejeune-related documents and publications, including the 1997 public health assessment and the ATSDR health study released in 1998. We did not evaluate the methodology or findings of the health assessment or health study. We also attended the meetings and reviewed the reports of expert review panels convened by ATSDR in 2005 regarding improving the study's water modeling efforts and future studies of health effects. We attended the February and April 2006 meetings of the ATSDR community assistance panel which is made up of seven former residents of Camp Lejeune. We also reviewed meeting transcripts from the July and September 2006 meetings. We also interviewed officials with the Department of the Navy and the U.S. Army Center for Health Promotion and Preventive Medicine, which serves as a liaison between DOD and ATSDR. We also interviewed officials with the Department of the Navy Judge Advocate General and the Department of Justice regarding the status of the legal claims related to Camp Lejeune. To describe the three federal inquiries into issues related to the drinking water contamination, we reviewed the reports of a Marine Corps panel, the EPA OIG, and the EPA CID, and we interviewed EPA officials.

To assess the design of the current ATSDR health study, we contracted with the National Academy of Sciences (NAS) to convene a panel of seven subject area experts for a 1-day meeting on July 29, 2005. The expert panel

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was charged with evaluating the study's population, exposure time frame, selected health effects, and completion date. For the assessment of the ATSDR study, we relied primarily on information gleaned from the expert panel meeting and the panel experts' subsequent written responses to the set of questions that were discussed during the 1-day meeting. Panel members were invited as individual experts, not as organizational representatives, and were not asked to reach consensus on any topics. NAS was not asked to provide advice or produce any report, and the comments made during the meeting of the expert panel should not be interpreted to represent the views of NAS, of the organizations with which the panel members were affiliated, or of all experts regarding health studies related to drinking water contamination. Not all panel members commented individually about each of the questions discussed during the 1-day meeting. Additionally, some panel members noted that certain questions addressed subjects that were outside their areas of expertise. We also reviewed study-related documentation furnished by officials from ATSDR, Marine Corps, and Navy Environmental Health Center, and interviewed officials from those agencies. We conducted our work from May 2005 through April 2007 in accordance with generally accepted government auditing standards. (See app. I for further detail on our scope and methodology.)

Results in Brief

Efforts to identify and address past drinking water contamination at Camp Lejeune began in the 1980s, when the Navy initiated water testing, and are continuing with long-term cleanup and monitoring. In 1980, VOCs, including TCE, were first detected at Camp Lejeune during an analysis by a Navy-contracted laboratory that combined treated water from all base water systems. During the same year, the Navy began monitoring Camp Lejeune's treated water for total trihalomethanes (TTHMs), contaminants that are a byproduct of the water treatment process. The TTHM monitoring indicated interference from unidentified chemicals. In 1982 and 1983, continued TTHM monitoring identified TCE and another VOC, PCE, as contaminants in two separate water systems that served base housing areas, Hadnot Point and Tarawa Terrace. Sampling results indicated that the levels of TCE and PCE found in the water systems varied. Former Camp Lejeune environmental officials said that they did not take additional steps to address the contamination after TCE and PCE were identified. The former officials recalled that they did not act because at that time they had little knowledge about TCE and PCE, there were no drinking water regulations that gave enforceable limits for these chemicals, and variation in water testing results raised questions about the tests' validity. Also in 1982, a Navy environmental program began

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investigating potentially contaminated sites at many Marine Corps and Navy bases, including Camp Lejeune. Testing initiated under that program in 1984 and 1985 found that individual wells in the Hadnot Point and Tarawa Terrace water systems were contaminated with TCE, PCE, and other VOCs. Camp Lejeune officials removed 10 contaminated wells from service in 1984 and 1985. Camp Lejeune officials determined that several areas on base where hazardous waste and other materials were disposed may have been the sources of contamination for the Hadnot Point water system, and North Carolina environmental officials determined that an off-base dry cleaner was the likely source of contamination for the Tarawa Terrace water system. Efforts are ongoing by ATSDR to determine when contamination at Hadnot Point began. In 2006, ATSDR estimated that well contamination from the off-base dry cleaner began as early as 1957. In 1989, EPA placed both Camp Lejeune and the off-base dry cleaner on the National Priorities List. Since that time, federal, state, and Camp Lejeune officials have partnered to take long-term actions to clean up the sources of contamination and to monitor and protect the base's drinking water. Cleanup activities have included the removal of contaminated soils and gasoline storage tanks and the treatment of contaminated groundwater and soils.

Concerns about possible adverse health effects and government actions related to the past drinking water contamination have led to additional activities, including health studies, claims against the federal government, and federal inquiries. From 1991 to 1997, ATSDR conducted a public health assessment at Camp Lejeune. The assessment recommended that studies be carried out to evaluate the risks of childhood cancer related to exposure to the contaminated drinking water. In 1998, an ATSDR study found a statistically significant association between exposure to the contaminated drinking water at Camp Lejeune and some adverse pregnancy outcomes, such as small for gestational age.[12] In 1999, ATSDR began its current study to determine whether individuals who were exposed in utero and as infants up to 1 year of age to the contaminated drinking water at Camp Lejeune between 1968 and 1985 were more likely to have developed specific birth defects or childhood cancers. Since ATSDR began its Camp Lejeune-related work in 1991, the agency has not always received requested funding and experienced delays in receiving

[12]Small for gestational age means that a fetus or an infant is smaller in size than is expected for the baby's gender, race and ethnicity, and length of time from conception until the baby is delivered.

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information from DOD. For example, for 3 of the 16 fiscal years during which ATSDR has conducted its Camp Lejeune-related work (fiscal years 1998 through 2000), no funding was provided to ATSDR by the Navy or any DOD entity. However, ATSDR officials said that these funding and information issues had not significantly delayed ATSDR's work at Camp Lejeune. Former Camp Lejeune residents and employees have filed about 750 tort claims against the federal government for injuries alleged to have resulted from exposure to the contaminated drinking water. Additionally, three federal inquiries into issues related to the drinking water contamination at Camp Lejeune have been conducted—one in 2004 by a Marine Corps-chartered panel, one in 2005 by the EPA OIG, and one from 2003 through 2005 by the EPA CID. The inquiry conducted by the Marine Corps-chartered panel found that the Marine Corps acted responsibly and found no evidence that the Marine Corps had attempted to cover up information that indicated contamination in Camp Lejeune's drinking water. However, the Marine Corps-chartered panel also criticized some actions taken by Camp Lejeune and Department of the Navy officials, such as inadequate communications among these entities about the drinking water contamination. The EPA OIG found that some EPA officials' responses to a citizen's requests regarding Camp Lejeune-related documents were inadequate or inappropriate. The EPA CID investigation did not find any violations of federal law but criticized some actions taken by Marine Corps and Department of the Navy officials, such as a lack of diligence by a Navy environmental support entity in providing technical expertise to Camp Lejeune's environmental officials.

The experts convened by the National Academy of Sciences generally agreed that many parameters of ATSDR's current study are appropriate, but some experts suggested potential modifications to the study. Regarding the study population, all seven panel experts agreed that ATSDR's study population of individuals who were potentially exposed in utero to the contaminated drinking water at Camp Lejeune between 1968 and 1985 was appropriate, as this population was arguably the most vulnerable to the effects of the contamination. Panel experts generally agreed that the 1968-1985 study time frame was reasonable, based on limitations in data availability for the years prior to 1968. However, six of the panel experts said that extending the time frame after 1985 to include a comparison population of individuals who were not exposed to the contamination could help strengthen the ATSDR study. Regarding the health effects studied, the five panel experts who discussed health effects said that the selected birth defects and childhood cancers were relevant. Four panel experts said that additional adverse health outcomes not included in the study could also be related to this exposure, including

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adverse neurological or behavioral effects and pregnancy loss. Regarding the proposed completion date, the panel experts had mixed opinions: three of the five panel experts who commented said that the projected December 2007 date appeared reasonable, while two said that the date might be optimistic. Four panel experts said that if ATSDR modified its study to use a simpler method of analysis, it could expedite completion of the study. Panel experts identified some potential modifications to the design of the current ATSDR study, such as conducting separate analyses for individuals who were born on base and for those who were born off base.

DOD, EPA, and HHS provided technical comments on a draft of this report, which we incorporated where appropriate. We provided the seven former Camp Lejeune residents who are members of the ATSDR community assistance panel for Camp Lejeune the opportunity to provide comments on our draft—three of the panel members provided both technical and general oral comments, and four declined to review the draft report. The three panel members commented generally on issues such as VOCs other than TCE and PCE that have been detected at Camp Lejeune, compensation and health benefits for former residents, and additional notification for former residents. We incorporated the panel members' technical comments where appropriate, but some issues they discussed were beyond the scope of this report.

Background

Drinking water can come from either groundwater sources, via wells, or from surface water sources such as rivers, lakes, and streams. All sources of drinking water contain some naturally occurring contaminants. As water flows in streams, sits in lakes, and filters thorough layers of soil and rock in the ground, it dissolves or absorbs the substances that it touches. Some of these contaminants are harmless, but others can pose a threat to drinking water, such as improperly disposed-of chemicals, pesticides, and certain naturally occurring substances. Likewise, drinking water that is not properly treated or disinfected, or which travels through an improperly maintained water system, may pose a health risk. However, the presence of contaminants does not necessarily indicate that water poses a health risk—all drinking water may reasonably be expected to contain at least small amounts of some contaminants. As of July 2006, EPA had set standards for approximately 90 contaminants in drinking water that may pose a risk to human health. According to EPA, water that contains small amounts of these contaminants, as long as they are below EPA's standards, is safe to drink. However, EPA notes that people with severely

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compromised immune systems and children may be more vulnerable to contaminants in drinking water than the general population.

General Information about Camp Lejeune and Its Water Systems

Camp Lejeune began operations in the 1940s. The base covers approximately 233 square miles in Onslow County, North Carolina, and includes training schools for infantry, engineers, service support, and medical support, as well as a Naval Hospital and Naval Dental Center. Base housing at Camp Lejeune consists of enlisted family housing, officer family housing, and bachelor housing, which consists of barracks for unmarried service personnel. The base has nine family housing areas, and families live in base housing for an average of 2 years. Additionally, schools, day care centers, and administrative offices are located on the base. Approximately 54,000 people currently live and work at Camp Lejeune, including about 43,000 active duty personnel and 11,000 military dependents and civilian employees.

In the 1980s, Camp Lejeune obtained its drinking water from as many as eight water systems, which were fed by more than 100 individual wells that pumped water from a freshwater aquifer located approximately 180 feet below the ground. Each of Camp Lejeune's water systems included wells, a water treatment plant, reservoirs, elevated storage tanks, and distribution lines to provide the treated water to the systems' respective service areas. Drinking water at Camp Lejeune has been created by combining and treating groundwater from multiple individual wells that are rotated on and off, so that not all wells are providing water to the system at any given time. Water is treated in order to remove minerals and particles and to protect against microbial contamination. (See fig. 1 for a description of how a Camp Lejeune water system operates.)

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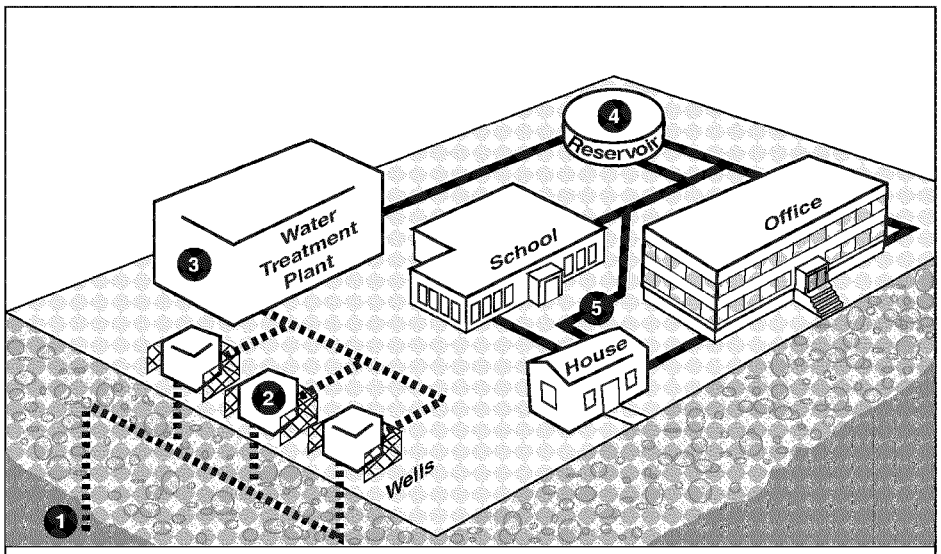
Figure 1: Conceptual Model of a Camp Lejeune Water System



1 The drinking water at Camp Lejeune is obtained from groundwater pumped from a freshwater aquifer located approximately 180 feet below the ground. 2 Groundwater is pumped through wells located near the water treatment plant. 3 In the water treatment plant, the untreated water is mixed and treated through several processes: removal of minerals to soften the water, filtration through layers of sand and carbon to remove particles, chlorination to protect against microbial contamination, and fluoride addition to help prevent tooth decay. 4 After the water is treated, it is stored in ground and elevated storage reservoirs. 5 When needed, treated water is pumped from the reservoirs and tanks to facilities such as offices, schools, or houses on the base.

Untreated water

Treated water

Sources: GAO, Art Explosion, and Marine Corps Base Camp Lejeune.

Note: Water treatment processes may not remove all contaminants present in untreated water.

From the 1970s through 1987, Hadnot Point, Tarawa Terrace, Holcomb Boulevard, and Rifle Range water systems provided drinking water to most of Camp Lejeune's housing areas. (See fig. 2 for the locations of these water service areas.) The water treatment plants for the Hadnot Point and Tarawa Terrace water systems were constructed during the 1940s and 1950s. The Rifle Range water system was constructed in 1965. The water treatment plant for the Holcomb Boulevard water system began operating at Camp Lejeune in 1972; prior to this time, the Hadnot Point water system provided water to the Holcomb Boulevard service area. In the 1980s, each of these four systems had between 4 and 35 wells that could provide water to their respective service areas. In 1987 the Tarawa Terrace water

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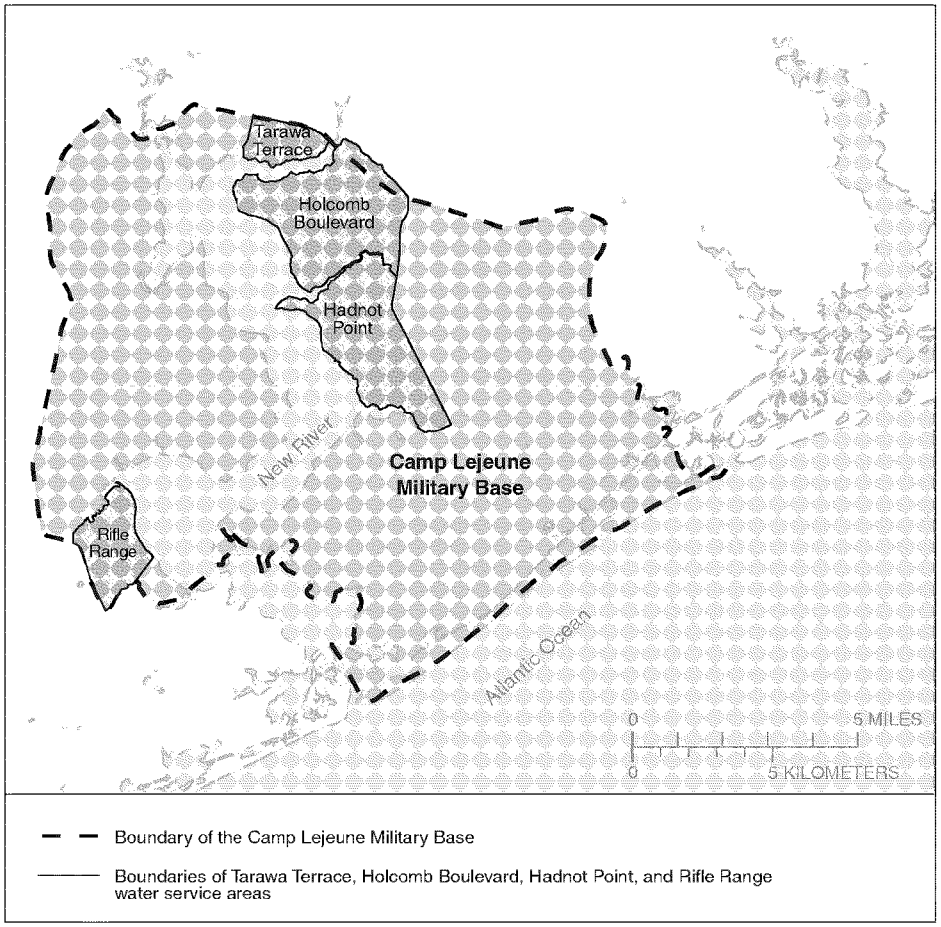
treatment plant was shut down and the Holcomb Boulevard water distribution system was expanded to include the Tarawa Terrace water service area.

Figure 2: Selected Water Service Areas at Camp Lejeune Serving Base Housing from the 1970s through 1987



Source: ATSDR.

Generally, housing units served by the Tarawa Terrace and Holcomb Boulevard water systems consisted of family housing, which included single- and multifamily homes and housing in trailer parks. Housing units served by the Hadnot Point water system included mainly bachelor housing with limited family housing. The housing area served by the Rifle

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Range water system included both family housing and bachelor housing. Based on available housing data for the late 1970s and the 1980s,[13] the estimated annual averages of the number of people living in family housing units[14] served by these water systems at that time were:

- 5,814 people in units served by the Tarawa Terrace water system,
- 6,347 people in units served by the Holcomb Boulevard water system,
- 71 people in units served by the Hadnot Point water system, and
- 14 people in units served by the Rifle Range water system.

In addition to serving housing units, all four water systems provided water to base administrative offices. The Tarawa Terrace, Holcomb Boulevard, and Hadnot Point water systems also served schools and other recreational areas. Additionally, the Hadnot Point water system also served an industrial area and the base hospital, and the Rifle Range water system also served an area used for weapons training.

Department of the Navy Environmental Functions

The Department of the Navy consists of the Navy and the Marine Corps; consequently, certain Navy entities provide support functions for Marine Corps bases, such as Camp Lejeune. Two entities provide support for environmental issues:

- The Naval Facilities Engineering Command began providing environmental support for bases in the 1970s. The Naval Facilities Engineering Command, Atlantic Division (LANTDIV) provides environmental support for Navy and Marine Corps bases in the Atlantic and mid-Atlantic regions of the United States.[15] For example, LANTDIV officials work with Camp Lejeune officials to establish environmental cleanup priorities and cost estimates and to allocate funding to ensure compliance with state and federal environmental regulations.

[13]To determine the estimated annual average of people who lived in family housing units served by these four water systems, we used limited housing data from 1977 to 1989 provided to us by Camp Lejeune officials. Camp Lejeune officials could not provide housing data prior to 1977.

[14]Camp Lejeune housing officials could not provide occupancy rates for bachelor housing.

[15]LANTDIV also manages the planning, design, construction, contingency engineering, real estate, and public work support at Navy and Marine Corps facilities in the United States.

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- The Navy Environmental Health Center (NEHC) has provided environmental and public health consultation services for Navy and Marine Corps environmental cleanup sites since 1991. NEHC is also designated as the technical liaison between Navy and Marine Corps installations and ATSDR, and as a part of this responsibility, reviews and comments on all ATSDR reports written for Navy and Marine Corps sites prior to publication. Prior to 1991, no agency was designated to provide public health consultation services for Navy and Marine Corps sites.

In 1980, the Department of the Navy established the Navy Assessment and Control of Installation Pollutants (NACIP) program to identify, assess, and control environmental contamination from past hazardous material storage, transfer, processing, and disposal operations. Under the NACIP program, initial assessment studies were conducted to determine the potential for environmental contamination at Navy and Marines Corps bases. If, as a result of the study, contamination was suspected, a follow-up confirmation study and corrective measures were initiated. In 1986 the Navy replaced its NACIP program with the Installation Restoration Program. The purpose of the Installation Restoration Program is to reduce, in a cost effective manner, the risk to human health and the environment from past waste disposal operations and hazardous material spills at Navy and Marine Corps bases. Cleanup is done in partnership with EPA, state regulatory agencies, and members of the community.

EPA and Environmental Laws and Regulations Related to Drinking Water Contamination and Hazardous Waste Contamination at Camp Lejeune

EPA was established in 1970 to consolidate in one agency a variety of federal research, monitoring, standard-setting, and enforcement activities to ensure environmental protection. EPA's primary roles and functions include developing and enforcing environmental regulations; conducting environmental research; providing financial assistance to states, educational institutions, and other nonprofit entities that conduct environmental research; and furthering public environmental education.

Congress passed the Safe Drinking Water Act in 1974[16] to protect the public's health by regulating the nation's public drinking water supply. The Safe Drinking Water Act, as amended, is the key federal law protecting public water supplies from harmful contaminants. For example, the act requires that all public water systems conduct routine tests of treated water to ensure that the water is safe to drink. Required water testing

[16]Pub. L. No. 93-523, 88 Stat. 1660 (codified, as amended, at 42 U.S.C. §§ 300f et seq.).

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frequencies vary and range from weekly testing for some contaminants to testing every 3 years for other contaminants. The act also established a federal-state arrangement in which states may be delegated primary implementation and enforcement authority for the drinking water program. For contaminants that are known or anticipated to occur in public water systems and that EPA determines may have an adverse impact on health, the act requires EPA to set a nonenforceable maximum contaminant level goal, at which no known or anticipated adverse health effects occur and that allows an adequate margin of safety. Once the maximum contaminant level goal is established, EPA sets an enforceable standard for water as it leaves the treatment plant, the maximum contaminant level. A maximum contaminant level is the maximum permissible level of a contaminant in water delivered to any user of a public water system. The maximum contaminant level must be set as close to the goal as is feasible using the best technology or other means available, taking costs into consideration. The North Carolina Department of Environment and Natural Resources and its predecessors[17] have had primary responsibility for implementation of the Safe Drinking Water Act in North Carolina since 1980.

In 1979, EPA promulgated final regulations applicable to certain community water systems establishing the maximum contaminant levels for the control of TTHMs, which are a type of VOC that are formed when disinfectants—used to control disease-causing contaminants in drinking water—react with naturally occurring organic matter in water. The regulations required that water systems that served more than 10,000 people and which added a disinfectant as part of the drinking water treatment process to begin mandatory water testing for TTHMs by November 1982 and comply with the maximum contaminant level by November 1983. TCE and PCE were not among the contaminants included in these regulations.

[17]In the 1980s the North Carolina Department of Human Resources administered the Safe Drinking Water Act and the Department of Natural Resources and Community Development was responsible for other environmental functions in the state of North Carolina. In 1989, sections of these departments underwent a reorganization and name change, becoming the Department of Environment, Health, and Natural Resources. In 1997, the department was again reorganized and took on its current name, the Department of Environment and Natural Resources.

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In 1979 and 1980 EPA issued nonenforceable guidance establishing "suggested no adverse response levels" for TCE and PCE in drinking water and in 1980 issued "suggested action guidance" for PCE in drinking water.[18] Suggested no adverse response levels provided EPA's estimate of the short- and long-term exposure to TCE and PCE in drinking water for which no adverse response would be observed and described the known information about possible health risks for these chemicals. Suggested action guidance recommended remedial actions within certain time periods when concentrations of contaminants exceeded specific levels. Suggested action guidance was issued for PCE related to drinking water contamination from coated asbestos-cement pipes, which were used in water distribution lines.

The initial regulation of TCE and PCE under the Safe Drinking Water Act began in 1989 and 1992, respectively, when maximum contaminant levels became effective for these contaminants. (See table 1 for the suggested no adverse response levels, suggested action guidance, and maximum contaminant level regulations for TCE and PCE.)

[18]Neither issuance was published in *The Federal Register*.

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Table 1: EPA Guidance and Regulations for Trichloroethylene (TCE) and Tetrachloroethylene (PCE) in Drinking Water

	Nonenforceable guidance						Enforceable regulation
	Suggested no adverse response level[a] for various exposure periods in parts per billion (ppb) issued in 1979 (TCE) and 1980 (PCE)			Suggested action guidance[b] for various exposure periods in ppb issued in 1980 (PCE)			Maximum contaminant level in milligrams per liter (mg/l) and ppb[c] effective in 1989 (TCE) and 1992 (PCE)
Chemical	1-Day[d]	10-Day[e]	Long-term[f]	1-Day[d]	10-Day[e]	Long-term[f]	
TCE	2,000	200	75	N/A[g]	N/A[g]	N/A[g]	0.005 mg/l or 5 ppb
PCE	2,300	175	20	2,300	180	40	0.005 mg/l or 5 ppb

Source: GAO analysis of EPA data.

[a]Suggested no adverse response levels are EPA-issued nonenforceable guidance for community water systems regarding TCE and PCE in drinking water.

[b]Suggested action guidance is EPA-issued nonenforceable guidance suggesting that remedial action be taken when PCE exceeded specific levels.

[c]These are the maximum permissible levels of a contaminant in water that is delivered to a public water system. Maximum contaminant levels are not specific to period of exposure. The maximum contaminant level for TCE became effective in 1989. *See 52. Fed. Reg.* 25716 (July 8, 1987). The maximum contaminant level for PCE became effective in 1992. *See 52. Fed. Reg.* 3593 (January 30, 1991). The maximum contaminant levels were issued in milligrams per liter. EPA also reports these contaminant levels in the equivalent ppb.

[d]One-day suggested no adverse response levels and suggested action guidance were the maximum levels for one 24-hour period of exposure.

[e]Ten-day suggested no adverse response levels and suggested action guidance were the maximum levels each day for 10 days of exposure.

[f]Long-term suggested no adverse response levels and suggested action guidance were the maximum levels each day for long-term exposure. Long-term exposure was based on a 70-year exposure.

[g]There was no suggested action guidance for TCE.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980[19] established what is known as the Superfund program to clean up highly contaminated waste sites and address the threats that these sites pose to human health and the environment, and assigned responsibility to EPA for administering the program.[20] CERCLA was amended by the Superfund Amendments and

[19]Pub. L. No. 96-510, 94 Stat. 2767 (codified, as amended, at 42 U.S.C. §§ 9601 et seq.).

[20]At privately owned sites, EPA can require that responsible parties either perform the cleanup themselves, or reimburse EPA for the costs of Superfund-funded cleanups. Federal agencies generally must pay for cleanups and other Superfund activities from their own appropriations.

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Reauthorization Act (SARA) of 1986.[21] Among other things, SARA requires that federal agencies, including DOD, that own or operate facilities on EPA's CERCLA list of seriously contaminated sites, known as the National Priorities List, enter into an interagency agreement with EPA.[22] The agreement is to specify what cleanup activities, if any, are required, and to set priorities for carrying out those activities.[23] SARA also established the Defense Environmental Restoration Program, through which DOD conducts environmental cleanup activities at military installations.[24] Under the environmental restoration program, DOD's activities addressing hazardous substances, pollutants, or contaminants are required to be carried out consistent with the provisions of CERCLA governing environmental cleanups at federal facilities.[25] Based on environmental contamination at various areas on the base, Camp Lejeune was designated as a National Priorities List site in 1989. EPA, the Department of the Navy, and the state of North Carolina entered into a Federal Facilities Agreement concerning cleanup of Camp Lejeune with an effective date of March 1, 1991.

ATSDR's Assessment of the Adverse Health Effects of Hazardous Substances at DOD Superfund Sites

ATSDR was created by CERCLA and established within the Public Health Service of HHS in April 1983 to carry out Superfund's health-related activities. These activities include conducting health studies, laboratory projects, and chemical testing to determine relationships between exposure to toxic substances and illness. In 1986, SARA expanded ATSDR's responsibilities to include, among other things, conducting public health assessments, toxicological databases, information dissemination, and medical education. SARA requires that ATSDR conduct a public health assessment at each site proposed for or on the National Priorities List, and that ATSDR conduct additional follow-up health studies

[21]Pub. L. No. 99-499, 100 Stat. 1613 (1986) (codified, as amended, at various sections of titles 10, 26, 29, and 42 U.S.C.).

[22]To determine which sites are eligible for listing on the National Priorities List, EPA uses the Hazard Ranking System, a numerical scoring system that assesses the hazards a site poses to human health and the environment as its principal determining fact. Once EPA has determined that the risks posed by a site make it eligible for the National Priorities List, EPA regions then consider many other factors in selecting the sites to submit to EPA headquarters for proposal to the National Priorities List.

[23]*See* 42 U.S.C. § 9620(e).

[24]*See* 10 U.S.C. §§ 2701-2709.

[25]*See* 10 U.S.C. § 2701(a)(2).

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if needed. Potentially responsible parties, including federal agencies, are liable for the costs of any health assessment or health effects study carried out by ATSDR.[26]

SARA requires that ATSDR and DOD enter into a memorandum of understanding to set forth the authorities, responsibilities, and procedures between DOD and ATSDR for conducting public health activities at DOD Superfund sites.[27] Based on the memorandum of understanding signed between ATSDR and DOD, ATSDR is required to submit an annual plan of work to DOD, in which it must describe the public health activities it plans to conduct at DOD sites in the following fiscal year, as well as the amount of funding required to conduct these activities. After the annual plan of work has been submitted, DOD has 45 days to respond and negotiate the scope of work to be conducted by ATSDR. The memorandum of understanding states that DOD must seek sufficient funding through the DOD budgetary process to carry out the work agreed upon.

Possible Adverse Health Effects of TCE and PCE

According to ATSDR's Toxicological Profile, inhaling small amounts of TCE may cause headaches, lung irritation, poor coordination, and difficulty concentrating, and inhaling or drinking liquids containing high levels of TCE may cause nervous system effects, liver and lung damage, abnormal heartbeat, coma, or possibly death.[28] ATSDR also notes that some animal studies suggest that high levels of TCE may cause liver, kidney, or lung cancer, and some studies of people exposed over long periods to high levels of TCE in drinking water or workplace air have shown an increased risk of cancer. ATSDR's Toxicological Profile notes that the National Toxicology Program has determined that TCE is reasonably anticipated to be a human carcinogen and the International Agency for Research on Cancer has determined that TCE is probably carcinogenic to humans. Unlike TCE, the health effects of inhaling or drinking liquids containing low levels of PCE are unknown, according to ATSDR. However, ATSDR reports that exposure to very high

[26]*See* 42 U.S.C. § 9607(a)(4)(D).

[27]*See* 10 U.S.C. § 2704(c).

[28]ATSDR did not define "small amounts" or "high levels" of TCE. According to ATSDR's Toxicological Profiles, when exposure to TCE or PCE occurs many factors determine whether an individual will be harmed. These factors include the amount of exposure, duration of exposure, and how an individual came in contact with these chemicals (i.e., ingestion, inhalation, or contact with the skin).

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concentrations of PCE may cause dizziness, headaches, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, or death.[29] HHS has determined that PCE may reasonably be anticipated to be a carcinogen.

Efforts to Identify and Address Past Drinking Water Contamination at Camp Lejeune Began in the 1980s and Continue with Long-Term Cleanup and Monitoring

Efforts to identify and address past drinking water contamination at Camp Lejeune began in the 1980s, when the Navy initiated water testing at Camp Lejeune. In 1980, one water test identified the presence of VOCs and a separate test indicated contamination by unidentified chemicals. In 1982 and 1983, water monitoring for TTHMs by a laboratory contracted by Camp Lejeune led to the identification of TCE and PCE as the contaminants in two water systems at Camp Lejeune. Sampling results indicated that the levels of TCE and PCE varied. Former Camp Lejeune environmental officials said they did not take additional steps to address the contamination after TCE and PCE were identified. The former officials recalled that they did not take additional steps because at that time they had little knowledge of TCE and PCE, there were no regulations establishing enforceable limits for these chemicals in drinking water, and variations in water testing results raised questions about the tests' validity. In 1984 and 1985, NACIP, a Navy environmental program, identified VOCs, including TCE and PCE, in 12 of the wells serving the Hadnot Point and Tarawa Terrace water systems. Camp Lejeune officials removed 10 wells from service in 1984 and 1985. Additionally, information about the contamination was provided to residents. Upon investigating the contamination, DOD and North Carolina officials concluded that both on- and off-base sources were likely to have caused the contamination in the Hadnot Point and Tarawa Terrace water systems. Since 1989, federal, state, and Camp Lejeune officials have partnered to take actions to clean up the sources of contamination and to monitor and protect the base's drinking water.

Navy Water Testing Beginning in 1980 Identified VOCs in Camp Lejeune Water Systems

The presence of VOCs in Camp Lejeune water systems was first detected in October 1980. On October 1, 1980, samples of water were collected from all eight water systems at Camp Lejeune by an official from LANTDIV, a Navy entity which provided environmental support to Camp Lejeune. The water samples were combined into a single sample, and a "priority pollutant scan" was conducted in order to detect possible contaminants in

[29] ATSDR did not define "low levels" or "high concentrations" of PCE.

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the water systems. The results of this analysis, conducted by a Navy-contracted private laboratory and sent to LANTDIV, identified 11 VOCs, including TCE, at their detection limits, that is, the lowest level at which the chemicals could be reliably identified by the instruments being used.[30] LANTDIV officials we interviewed said they do not remember why this testing was conducted. A memorandum written by a Camp Lejeune environmental official noted that LANTDIV initiated the testing because North Carolina had assumed responsibility in March 1980 for oversight of the Safe Drinking Water Act and therefore would have the right to sample and test the drinking water at Camp Lejeune for any contaminants regulated under the act.[31] The memorandum stated that LANTDIV officials were concerned that the state's testing might discover problems that the Navy had not previously identified. The Camp Lejeune memorandum characterized the 1980 analysis as indicating "no problems" from the pollutants when the samples from eight water systems were tested as one combined sample, but also noted that this might not have been true if the samples had been analyzed individually. Current and former LANTDIV officials told us that they did not recall any actions taken as a result of this analysis.

Separately, in 1980 the Navy began monitoring programs for TTHMs at various Navy and Marine Corps bases, including Camp Lejeune, in preparation for meeting a future EPA drinking water regulation.[32] LANTDIV arranged for an Army laboratory to begin testing the treated water from two Camp Lejeune water systems, Hadnot Point and New River, in October 1980. At that time, these two water systems were the only ones that served more than 10,000 people and therefore would be required to meet the future TTHM regulation. From October 1980 to

[30]Additionally, two metals—cadmium and selenium—were identified at levels slightly above detection limits.

[31]This memorandum was prepared after Camp Lejeune officials received these testing results in 1982.

[32]According to an August 1980 memorandum, which cited a 1979 amendment to the National Interim Primary Drinking Water Regulations, LANTDIV initiated monitoring programs at various naval facilities, including Camp Lejeune, in order to develop a TTHM database prior to the effective dates for the enforcement of the maximum contaminant levels. For Camp Lejeune community water systems such as Hadnot Point and New River that served 10,000 to 74,999 individuals, the maximum contaminant levels for TTHMs took effect in November 1983 and an EPA requirement to begin monitoring TTHM levels in the systems began 1 year prior to that date. *See* 44 *Fed. Reg.* 68641 (Nov. 29, 1979) (to be codified at 40 C.F.R. § 141.6).

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September 1981, eight samples were collected from the Hadnot Point water system and analyzed for TTHMs. Results from four of the eight samples indicated the presence of unidentified chemicals that were interfering with the TTHM analyses.[33] Reports for each of the four analyses contained an Army laboratory official's handwritten notes about the unidentified chemicals: two of the notes classified the water as "highly contaminated" and notes for the other two analyses recommended analyzing the water for organic compounds.

The exact date when LANTDIV officials began receiving results from TTHM testing is not known, and LANTDIV officials told us that they had no recollection of how or when the results were communicated from the Army laboratory. Available Marine Corps documents indicate that Camp Lejeune environmental officials[34] learned in July 1981 that LANTDIV had been receiving the results of TTHM testing and was holding the results until all planned testing was complete. Subsequently, Camp Lejeune environmental officials requested copies of the TTHM results that LANTDIV had received to date, and LANTDIV provided these results in August 1981. The next documented correspondence from LANTDIV to Camp Lejeune regarding TTHM monitoring occurred in a February 1982 memorandum in which LANTDIV recommended that TTHM monitoring be expanded to all of Camp Lejeune's water systems and noted that Camp Lejeune should contract with a North Carolina state-certified laboratory for the testing.

In early 1981, additional water testing unrelated to the TTHM monitoring began at the Rifle Range area within Camp Lejeune for various contaminants, including TCE and PCE. A former Camp Lejeune official recalled that the testing was initiated because of concerns about chemicals that had been buried at Rifle Range. In March, April, and May 1981, water samples were collected from areas surrounding the chemical dump, including a nearby creek; treated water from the Rifle Range water system; and untreated water from the individual wells serving the water system. These water samples were sent to a Navy-contracted private laboratory for

[33]The results from the other four samples did not note the presence of unidentified chemicals.

[34]In the early 1980s the environmental staff at Camp Lejeune consisted of three primary staff members: a director specializing in natural resources, a supervisory ecologist, and a chemist. These staff members were responsible for water monitoring and compliance with environmental regulations, among other responsibilities. Over time as environmental laws have changed, the environmental staff has grown and obtained additional responsibilities.

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analysis, and the results were sent to a LANTDIV official in April and May 1981. The results for the samples collected from the areas surrounding the chemical dump identified VOCs, including TCE and PCE. The results for the samples collected from the water system's treated water and for the samples from the untreated water from the individual wells also identified VOCs. In July 1981, LANTDIV communicated the results to Camp Lejeune officials and noted that one of the VOCs detected was a trihalomethane and arrangements had been made to add the Rifle Range water system to the base TTHM testing. LANTDIV also recommended that no further action be taken until additional data became available from TTHM monitoring or the planned NACIP program to identify, assess, and control environmental contamination.

Current and former LANTDIV officials recalled that their agency played a limited role in providing information or guidance regarding environmental issues at Camp Lejeune, and that this assistance generally would have been at the request of Camp Lejeune officials. However, former Camp Lejeune environmental officials recalled that at that time they had little experience in water quality issues and relied on LANTDIV to serve as their environmental experts. Documents from 1981 indicate that LANTDIV officials continuously communicated information about the Rifle Range area to Camp Lejeune environmental officials, including providing sampling results, discussing the implications of these results, providing copies of related regulations and standards, and making recommendations for additional action. (See app. II for a more detailed description of selected events related to drinking water contamination at Camp Lejeune from 1980 through 1981.)

Further Tests Identified TCE and PCE in Two Camp Lejeune Water Systems in 1982 and 1983; Camp Lejeune Officials Do Not Recall Taking Action to Address the Contamination at That Time

Following LANTDIV's recommendation to expand TTHM monitoring to all base water systems, Camp Lejeune officials contracted with a private state-certified laboratory to test samples of treated water from all eight of their water systems. According to an August 1982 memorandum, in May 1982 a Camp Lejeune official was informed during a telephone conversation with a private laboratory official that organic cleaning solvents, including TCE, were present in the water samples for TTHM monitoring from the Hadnot Point and Tarawa Terrace water systems. In July 1982, additional water samples from the two systems were collected in an effort to investigate the presence of these chemicals. In August 1982 the contracted laboratory sent a letter to base officials informing them that TCE and PCE were identified from the May and July samples as the contaminants. According to the letter, the testing determined that the Hadnot Point water system was contaminated with both TCE and PCE and

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the Tarawa Terrace water system was contaminated with PCE. The letter also noted that TCE and PCE "appeared to be at high levels" and were "more important from a health standpoint" than the TTHM monitoring. Sampling results indicated that the levels of TCE and PCE varied. The letter noted that one sample taken in May 1982 from the Hadnot Point water system contained TCE at 1,400 parts per billion and two samples taken in July 1982 contained TCE at 19 and 21 parts per billion. Four samples taken in May 1982 and July 1982 from the Tarawa Terrace water system contained levels of PCE that ranged from 76 to 104 parts per billion. (See table 2 for the May and July 1982 sampling results.)

Table 2: Sampling Results from Hadnot Point and Tarawa Terrace Water Systems for May 1982 and July 1982

		Concentrations of chemicals in parts per billion[a]	
Housing area	**Samples[b]**	**TCE[c]**	**PCE[d]**
May samples[e]			
Hadnot Point	1	1,400	15
Tarawa Terrace	2	—[f]	80
July samples			
Hadnot Point	3	19	<1
	4	21	<1
	5	No data[g]	1.0
Tarawa Terrace	6	—[f]	76
	7	—[f]	82
	8	—[f]	104

Source: GAO analysis of Headquarters Marine Corps data.

[a]The August 1982 letter from the contracted laboratory in which these sampling results were provided did not include the detection limit. The detection limit is the lowest level at which the chemicals could be reliably identified by the instruments being used.

[b]Camp Lejeune's samples were identified by nonconsecutive numbers. We renumbered the samples to provide consecutive number identifiers.

[c]Trichloroethylene (TCE) is a volatile organic compound typically used as a metal degreaser.

[d]Tetrachloroethylene (PCE) is a volatile organic compound typically used as a dry cleaning solvent.

[e]The May samples were analyzed in July.

[f]The laboratory did not report results for TCE in these samples.

[g]A memorandum by a Camp Lejeune environmental official indicated that this sample was analyzed for TCE, but exact quantities were not determined.

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Former Camp Lejeune environmental officials recalled that after the private laboratory identified the TCE and PCE in the two water systems, they did not take additional steps to address the contamination for three reasons. First, they had limited knowledge of these chemicals; second, there were no regulations establishing enforceable limits for these chemicals in drinking water; and third, they made assumptions about why the levels of TCE and PCE varied and about the possible sources of the TCE and PCE. The former Camp Lejeune environmental officials told us that they were aware of EPA guidance, referred to as "suggested no adverse response levels," for TCE and PCE when these contaminants were identified at Camp Lejeune. However, they noted that the levels of these contaminants detected at Camp Lejeune generally were below those outlined in the guidance. One Camp Lejeune environmental official also recalled that at the time they were unsure what the health effects would be for the lower amounts detected at the base. Additionally, in an August 1982 document and during our interviews with current Camp Lejeune environmental officials, it was noted that EPA had not issued regulations under the Safe Drinking Water Act for TCE and PCE when the private laboratory identified these chemicals in the drinking water. The former Camp Lejeune environmental officials also said that they made assumptions about why the levels of TCE and PCE varied in sampling results and about the possible sources of the TCE and PCE. Specifically, because the levels of TCE and PCE varied, they attributed the higher levels to short-term environmental exposures, such as spilled paint inside a water treatment plant, or to laboratory or sampling errors. Additionally, in an August 1982 memorandum, a Camp Lejeune environmental official suggested that, based on the sampling results provided by the private laboratory, the levels of PCE detected could be the result of using coated pipes in the untreated water lines at Tarawa Terrace. The former Camp Lejeune environmental officials told us that in retrospect, it was likely that well rotation in these water systems contributed to the varying sampling results because the contaminated wells may not have been providing water to the Hadnot Point and Tarawa Terrace systems at any given time. However, both they and current Camp Lejeune environmental officials said that at that time the base environmental staff did not know that the wells serving both systems were rotated.

After August 1982, the private laboratory continued to communicate with Camp Lejeune officials about the contamination of treated water from the Hadnot Point and Tarawa Terrace water systems. All eight of Camp Lejeune's water systems were sampled again for TTHMs in November 1982. In a December 1982 memorandum, a Camp Lejeune environmental official noted that during a phone conversation with a chemist from the

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private laboratory the chemist expressed concern that TCE and PCE were interfering with Tarawa Terrace and Hadnot Point TTHM samples. The chemist said the levels of TCE and PCE were "relatively high" in the November 1982 samples, though the specific levels of TCE and PCE were not provided to Camp Lejeune officials. The private laboratory report providing the November 1982 results said that the samples from Tarawa Terrace "show contamination" from PCE and the samples from Hadnot Point "show contamination" from both TCE and PCE. All eight of Camp Lejeune's water systems were sampled again for TTHMs in August 1983, and the private laboratory report providing these results said that the samples from Tarawa Terrace "show contamination" from PCE and the samples from Hadnot Point "show contamination" from both TCE and PCE.[35] Former Camp Lejeune environmental officials recalled that they did not take any actions related to these findings. (See app. III for a more detailed timeline of selected events from 1982 through 1983.)

Discovery of Contamination at Individual Wells in 1984 and 1985 Prompted Their Removal from Service, and Information Was Provided to Residents and the Media

In 1982, Navy officials initiated the NACIP program at Camp Lejeune as part of its overall strategy to identify, assess, and control environmental contamination at Navy and Marine Corps bases.[36] The first step of the NACIP program was an initial assessment study, which was designed to collect and evaluate evidence that indicated the existence of pollutants that may have contaminated a site or that posed a potential health hazard for people located on or off a military installation. The initial assessment study for Camp Lejeune, which was completed in April 1983, determined that further investigation was warranted at 22 priority sites with potential contamination, including a site near wells that served the Hadnot Point water system.

In July 1984, the base initiated a NACIP confirmation study to investigate the 22 priority sites. As a part of the confirmation study, a Navy contractor took water samples from water supply wells located near priority sites where groundwater contamination was suspected. Current and former Camp Lejeune officials told us that previous water samples usually had been collected from treated water at sites such as reservoirs or buildings within the water systems rather than being collected directly from

[35]The reports of the November 1982 and August 1983 TTHM analyses did not provide further details about the levels of TCE and PCE detected.

[36]The NACIP program at Camp Lejeune was unrelated to the prior water testing that identified TCE and PCE contamination.

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individual wells at Camp Lejeune.[37] In November 1984, Camp Lejeune officials received sampling results for one Hadnot Point well located near a priority site, which showed that TCE and PCE, among other VOCs, were detected in the well. This well was removed from service, and in December 1984, water samples from six Hadnot Point wells that were located in the same general area and treated water samples from the Hadnot Point water plant were also tested. Results of the analysis of the well samples indicated that both TCE and PCE were detected in one well, TCE was detected in two additional wells, and other VOCs were detected in all six wells. Results for the treated water samples also detected TCE and PCE. Four of these six wells were removed from service, in addition to the original well removed from service. For the two wells that were not taken out of service, while initial results indicated levels of VOCs, including TCE, other test results showed no detectable levels of VOCs. Documents we reviewed show that continued monitoring of those two wells indicated no detectable levels of TCE. During December 1984, seven additional samples were taken from the treated water at Hadnot Point water plant and revealed no detectable levels of TCE and PCE. According to two former Camp Lejeune environmental officials, once the wells had been taken out of service and the samples from the water plant no longer showed detectable levels of TCE or PCE, they believed the water from the Hadnot Point water system was no longer contaminated.

Although the December 1984 testing of water from the Hadnot Point water system showed no detectable levels of TCE or PCE, in mid-January 1985 Camp Lejeune environmental staff began collecting water samples from all wells on the base. Sampling results were received in February 1985 and detected VOCs, including TCE and PCE, in 3 wells serving the Hadnot Point water system and 2 wells serving the Tarawa Terrace water system. As a result, those 5 wells were removed from service. According to current Camp Lejeune officials, all 10 wells had been removed from service by February 8, 1985.[38] According to memoranda dated March 1985 and May 1985, 1 of the 2 wells removed from service at Tarawa Terrace was used on 1 day in March 1985 and on 3 days in April 1985 for short periods of time to meet water needs at the base. See table 3 for the dates that wells

[37]During the water testing conducted at the Rifle Range area, samples were also collected from the individual wells serving the Rifle Range water system.

[38]Although 1981 sampling results from a well that served the Rifle Range water system indicated the presence of VOCs, including TCE, the subsequent 1985 sampling results of Rifle Range wells performed under NACIP showed no detectable levels of VOCs.

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were removed from service and for the levels of TCE and PCE which were detected in the wells prior to their removal from service in 1984 and 1985. See app. IV for the levels of other VOCs which were detected in the wells prior to their removal from service in 1984 and 1985.

Table 3: Dates Wells Were Removed from Service in 1984 and 1985 at Hadnot Point and Tarawa Terrace Water Systems, and TCE and PCE Levels Detected in Each Well

			Concentrations of chemicals in parts per billion[a]	
Water systems	Wells	Date removed from service	TCE[b]	PCE[c]
Hadnot Point	602	Nov. 30, 1984	1,600	24
	601	Dec. 6, 1984	210	5
	608	Dec. 6, 1984	110	ND
	634[d]	Dec. 14, 1984	ND	ND
	637[d]	Dec. 14, 1984	ND	ND
	651	Feb. 4, 1985	3,200	386
	652	Feb. 8, 1985	9	ND
	653	Feb. 8, 1985	5.5	ND
Tarawa Terrace	TT-26	Feb. 8, 1985	57	1,580
	TT-23[e]	Feb. 8, 1985	ND	132

Source: GAO analysis of Headquarters Marine Corps data.

Notes: The detection limit for the instruments used to analyze the samples was 10 parts per billion. The detection limit is the lowest level at which the chemicals could be reliably identified by the instruments being used. A Marine Corps document providing the sampling results stated that ND meant "none detected."

[a]The concentrations provided are those detected prior to each well's removal from service and are one-time sampling results. We did not find documentation that tied the decision to remove the wells from service to any particular level of contamination included in related EPA guidance or enforceable regulation. DOD sampling also detected other VOCs. (See app. IV).

[b]Trichloroethylene (TCE) is a volatile organic compound typically used as a metal degreaser.

[c]Tetrachloroethylene (PCE) is a volatile organic compound typically used as a dry cleaning solvent.

[d]TCE and PCE were not detected in this well prior to its removal from service. Documents indicate that this well was taken out of service after detection of "significant levels" of methylene chloride, a VOC used in various industrial processes such as paint stripping, paint remover manufacturing, and metal cleaning and degreasing.

[e]Tarawa Terrace well TT-23 is also referred to as "TT-new well" in Marine Corps documents.

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In addition, while base officials were waiting for sampling results from January 1985 of samples collected from wells serving Hadnot Point, water from this system was provided to a third water system for about 2 weeks. In late January 1985, a fuel line break caused gasoline to leak into the Holcomb Boulevard water treatment plant. During the approximately 2-week period the treatment plant was shut down, water from the Hadnot Point system was pumped into the Holcomb Boulevard water lines. Former Camp Lejeune environmental officials said that they used water from the Hadnot Point water system because it was the only water system interconnected with the Holcomb Boulevard water system, and because they believed the water from the Hadnot Point water system was no longer contaminated. Prior to restarting the Holcomb Boulevard water system, samples of treated water were tested and no gasoline was detected in any of these samples. However, the samples were found to contain various levels of TCE; these results were attributed to the use of water from the Hadnot Point water system. About 5 days after these samples were taken, the Holcomb Boulevard water system was restarted because the fuel line had been repaired.

Following the discovery of contamination at individual wells in 1984, Camp Lejeune published articles in the base newspaper, provided one notification to residents of housing areas served by the Tarawa Terrace water system, and created a press release about issues related to drinking water at Camp Lejeune. In December 1984 the base newspaper published its first story about sampling efforts, detection of VOCs, and removal of wells from service in the Hadnot Point water system. At this time, Camp Lejeune environmental officials had not begun sampling all other wells on the base, including those at the Tarawa Terrace water system. Subsequently, in April 1985 the Commanding General of Camp Lejeune issued a notice to residents who lived in housing areas served by the Tarawa Terrace water system.[39] According to the notice:

"Two of the wells that supply Tarawa Terrace have had to be taken off line because minute (trace) amounts of several organic chemicals have been detected in the water. There are no definitive State or Federal regulations regarding a safe level of these compounds, but as a precaution, I have ordered the closure of these wells for all but emergency situations when fire protection or domestic supply would be threatened."

[39]Documents do not indicate how this notice was provided to residents.

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The notice asked residents to reduce water use until early June, when the construction of a new water line was to be completed. In May 1985, another article in the base newspaper stated the number of wells that had been removed from service, stated why the wells were removed from service, and noted the potential for water shortage at Tarawa Terrace as a result. In addition, the Marine Corps provided us with copies of three North Carolina newspaper articles published from May 1985 to September 1985 discussing contamination at Camp Lejeune.[40] All three articles included information about the drinking water contamination and noted that 10 wells serving two water treatment systems at Camp Lejeune had been removed from service. (See app. V for a more detailed timeline of selected documented events from 1984 through 1985.)

Past Contamination Was Estimated to Have Originated from Both On-base and Off-base Sources

The sources of past contamination for the Hadnot Point water system have not been conclusively determined. However, DOD officials have estimated that eight contaminated on-base sites in the proximity of the Hadnot Point water system may be the sources of contamination for that water system. (See table 4.) These eight sites were contaminated by leaking underground storage tanks containing fuel, by degreasing solvents, by hazardous chemical spills, and by other waste disposal practices.[41] Efforts by ATSDR are ongoing to conclusively determine the sources of past contamination in the Hadnot Point water system, as well as when the contamination began.

[40]According to a May 1985 memorandum, Camp Lejeune officials issued a press release regarding removal of wells from service at Camp Lejeune in May 1985. However, the memorandum did not describe the contents of the press release, and the Marine Corps was unable to locate a copy of the press release for our review.

[41]The sources of contamination at these eight sites were identified through the NACIP program and the Installation Restoration Program, which replaced NACIP as the Navy and Marine Corps environmental program.

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Table 4: Information about Potential Sites of Contamination for the Hadnot Point Water System

Sites	Uses of the site[a]
Open field storage lots	Storage, disposal, and handling of potentially hazardous waste and materials, such as cleaning solvents, used batteries, and waste oils
Piney Green Road, an area adjacent to the open field storage lots	Storage, disposal, and handling of potentially hazardous waste and materials, such as pesticides, used batteries, and fuel
Transformer storage lot	Pesticide mixing and cleaning and disposal of oil from electric transformers
Firefighting training pit	Firefighting training exercises in which flammable liquids (including used oil, solvents, and fuels) were used
An industrial fly ash dump	Disposal of waste, including fly ash (which is residue resulting from the combustion of ground or powdered coal), solvents, water treatment sludge, and used paint stripping compounds
An industrial area which includes 75 buildings and facilities such as maintenance shops, gas stations, administrative offices, commissaries, snack bars, warehouses, and storage yards	Mixed uses; due to the industrial nature of the site, many spills and leaks of gas-related products and solvents occurred
A service station within the industrial area	Fuel storage; includes four underground gasoline storage tanks
A fuel farm within the industrial area	Fuel storage; includes 15 fuel storage tanks, 14 of which are underground

Sources: Camp Lejeune Site Management Plan, Fiscal Year 2006, EPA Superfund Record of Decision for Camp Lejeune 1993 and 1994, and interviews with current Camp Lejeune officials.

[a]Some sites may have multiple uses. The only uses of the sites that were included were those that may be related to the contamination.

For the Tarawa Terrace water system, North Carolina officials determined that an off-base source was the likely cause of the drinking water contamination. After the Marine Corps requested assistance in identifying the source of the contamination, North Carolina state officials conducted an investigation from April 1985 through September 1985 to determine whether two off-base dry cleaning facilities located near the two contaminated wells were the sources of the PCE contamination at Tarawa Terrace. The state officials concluded that the contamination likely came from dry cleaning solvent that had been released into a leaking septic tank at one of the cleaners—ABC One Hour Cleaners—which built its septic

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system and began operation in 1954. Both the dry cleaning facility and its septic tank were located off base but adjacent to a supply well for the Tarawa Terrace water system. Based on the environmental contamination at this site, ABC One Hour Cleaners was designated as a National Priorities List site in 1989. As part of its current health study, ATSDR has estimated that beginning as early as 1957 individuals were exposed to PCE in treated drinking water at levels equal to or greater than what became effective in 1992 as EPA's maximum contaminant level of 5 parts per billion.

Cleanup and Monitoring Activities Are Under Way to Address the Contamination

Since 1989, officials from Camp Lejeune, North Carolina, and federal agencies, including EPA, have taken actions to clean up the suspected sources of the contamination in the Hadnot Point and Tarawa Terrace water systems. Because the contamination is thought to have come from both on- and off-base sources, and because those sources are part of two separate National Priorities List sites—Camp Lejeune and ABC One Hour Cleaners—cleanup activities for the suspected sources of contamination are being managed separately.

Following Camp Lejeune's listing as a National Priorities List site in October 1989 and the signing of a Federal Facilities Agreement in February 1991, on-base cleanup activities have been managed by a partnership of DOD, EPA, and North Carolina environmental officials. Cleanup of the eight sites suspected to be possible sources of contamination for the Hadnot Point water system has included the removal of contaminated soils and gasoline storage tanks and the treatment of contaminated groundwater and soils. The cleanup activities at four of the eight sites were completed by 2006. The estimated completion date for cleanup activities of contaminated groundwater and soils at three of the other four sites is 2025. There is no estimated completion date for the fourth site. Funding for the cleanup of the on-base sites has come from Department of the Navy Environmental Restoration Program funds, and Navy officials estimated that about $70 million would be needed to complete the cleanup of all eight sites.

Efforts to clean up the suspected source of contamination that affected the Tarawa Terrace water system began after ABC One Hour Cleaners was listed as a National Priorities List site in 1989. Cleanup activities at the site, which have been designed to address both the contaminated groundwater and soil, have been managed by EPA, with support from North Carolina officials. While treatment of some of the areas with contaminated soil has been completed, the EPA official who serves as project manager for the

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ABC One Hour Cleaners site could not provide an estimated completion date for cleanup of either the soil or the groundwater. Funding for the cleanup of this site comes primarily from the Superfund, though a portion of the funds has been provided by ABC One Hour Cleaners and North Carolina. The total estimated cost for the cleanup of this site is about $4.3 million. According to a North Carolina official, North Carolina will assume authority for cleanup at the site in August 2013.

Currently, Camp Lejeune uses various methods to monitor and protect the base's drinking water. In drinking water reports published in 2004 and available on the Camp Lejeune Web site, base officials stated that their efforts to monitor the drinking water supply had met or exceeded all required testing standards. For example, Camp Lejeune reported that "in accordance with Safe Drinking Water Act sampling requirements" it had regularly tested its treated drinking water for more than 80 different EPA-regulated contaminants and additional unregulated contaminants. The reports noted that testing of treated water for VOCs had been conducted on a monthly basis—exceeding the requirement to test every 3 years—"in order to show that there should be no concern about current VOC contamination." The Camp Lejeune reports stated that the base had sampled the wells at least annually for VOCs. Additionally, the Water Quality Program at Camp Lejeune produces annual reports about each drinking water system on the base in order to inform water consumers about the quality of their water. The 2004 reports also stated that Camp Lejeune officials have undertaken numerous efforts to protect the drinking water supply, including restricting land uses near well fields,[42] locating well fields in undeveloped areas, constructing wells in a manner that minimizes the potential for contamination, and using new technologies to prevent groundwater contamination. Examples of some of these new technologies included a computer-based monitoring system for underground storage tanks that immediately alerts personnel when a leak occurs, and the installation of bullet traps at firing areas, which prevent lead and copper bullets from contaminating the groundwater and soil.

[42]Well fields are areas containing one or more wells that produce usable amounts of water.

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Concerns about Possible Adverse Health Effects and Government Actions Related to the Past Contamination Have Led to Additional Activities

Concerns about possible adverse health effects and government actions related to the past drinking water contamination have led to additional activities, including health studies, claims against the federal government, and federal inquiries. Activities resulting from concerns about possible adverse health effects began in 1991, when ATSDR initiated a public health assessment that evaluated the possible health risks from past exposure to the contaminated drinking water at Camp Lejeune. The health assessment was followed by two studies, one of which was ongoing as of April 2007. Since ATSDR began its work, the agency did not always receive requested funding and experienced delays in receiving information from DOD entities. However, ATSDR officials said that the agency's Camp Lejeune-related work was not significantly delayed by DOD. As of January 2007, about 750 claims had been filed by former Camp Lejeune residents and employees against the federal government for injuries alleged to have resulted from past exposure to the contaminated drinking water at Camp Lejeune. Additionally, three federal inquiries into issues related to the drinking water contamination at Camp Lejeune have been conducted, one by a Marine Corps-chartered panel, one by the EPA OIG, and one by the EPA CID. The inquiry conducted by the Marine Corps-chartered panel found that the Marine Corps acted responsibly and found no evidence that the Marine Corps had attempted to cover up information that indicated contamination in Camp Lejeune's drinking water. However, the Marine Corps-chartered panel also criticized some actions taken by Camp Lejeune and Department of the Navy officials, such as inadequate communications among these entities about the drinking water contamination. The EPA OIG found that some EPA officials' responses to a citizen's requests regarding Camp Lejeune-related documents were inadequate or inappropriate. The EPA CID investigation did not find any violations of federal law but criticized some actions taken by Marine Corps and Department of the Navy officials, such as a lack of diligence by a Navy environmental support entity in providing technical expertise to Camp Lejeune's environmental officials.

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ATSDR Has Undertaken Several Activities to Study Possible Adverse Health Effects Related to the Drinking Water Contamination at Camp Lejeune

Beginning in 1991, ATSDR has undertaken several activities to study the possible adverse health effects related to the past drinking water contamination at Camp Lejeune, including a public health assessment and two studies. From 1991 to 1997, ATSDR conducted a public health assessment at Camp Lejeune that was required by law because of the base's listing on the National Priorities List. The health assessment evaluated several ways in which people on base had been exposed to hazardous substances, including exposure to the VOC-contaminated drinking water.[43] ATSDR concluded that (1) cancerous and noncancerous health effects were unlikely in adults exposed to VOC-contaminated drinking water, (2) the likelihood of either noncancerous or cancerous health effects in children could not be determined because of insufficient scientific information, and (3) there was evidence that suggested that, because of their developing systems, individuals who were exposed in utero were potentially more sensitive to the effects of VOCs than individuals who were exposed as adults or children.[44] In its 1997 report, ATSDR recommended that a study be carried out to evaluate the risks of childhood cancer in those who were exposed in utero to the contaminated drinking water and also noted that adverse pregnancy outcomes were of concern. ATSDR officials said that the health assessment did not recommend a study of adverse pregnancy outcomes because such a study was already under way.

In 1995, while the health assessment was being conducted, ATSDR initiated a study to determine whether there was an association between exposure to VOCs in drinking water and specific adverse pregnancy outcomes among women who had lived at Camp Lejeune from 1968 through 1985.[45] The study, released in 1998, originally concluded that there was a statistically significant elevated risk for several poor pregnancy outcomes, including (1) small for gestational age among male infants born

[43]While conducting the health assessment, ATSDR also considered two other types of past exposures at Camp Lejeune as possibly a public health hazard: lead in tap water and pesticides in soil at a former day care facility.

[44]Agency for Toxic Substances and Disease Registry, *Public Health Assessment U.S. Marine Corps Camp Lejeune Onslow County, North Carolina* (Atlanta, Ga.: 1997).

[45]Although there was no evidence of an increased rate of adverse pregnancy outcomes at Camp Lejeune at that time, the 1998 study report states that the agency believed it was prudent to research this topic because fetuses tend to be more sensitive to toxic chemical exposures and many pregnant women had resided in housing areas supplied with contaminated water. In addition to small for gestational age, other adverse pregnancy outcomes evaluated in the study included pre-term birth and mean birth weight.

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to mothers living at Hadnot Point, (2) small for gestational age for infants born to mothers over 35 years old living at Tarawa Terrace, and (3) small for gestational age for infants born to mothers with two or more prior fetal losses living at Tarawa Terrace.[46] However, ATSDR officials said they are reanalyzing the findings of this study because of an error in the original assessment of exposure to VOCs in drinking water. While the study originally assessed births from 1968 to 1972 in the Holcomb Boulevard service area as being unexposed to VOCs, these births were exposed to contaminants from the Hadnot Point water system. An ATSDR official said the reanalysis may alter the study's results.

In 1999, ATSDR initiated its current study examining whether certain birth defects and childhood cancers are associated with exposure to TCE or PCE at Camp Lejeune. The study examines whether individuals born during 1968 through 1985 to mothers who were exposed to the contaminated drinking water at any time while they were pregnant and living at Camp Lejeune were more likely than those who were not exposed to have neural tube defects, oral cleft defects, or childhood hematopoietic cancers.[47] The current study began with a survey to identify potential cases of the selected birth defects and childhood cancers. The study is also using water modeling[48] to help ATSDR determine the potential sources of past contamination and estimate when the water became contaminated and which housing units received the contaminated water. The water modeling data will help ATSDR identify which pregnant women may have been exposed to the contaminated water, and will also help ATSDR estimate the amount of TCE and PCE that may have been in the drinking water. ATSDR officials said that the study is expected to be completed by December 2007.

ATSDR also has hosted two expert panel meetings related to the past drinking water contamination at Camp Lejeune. In February 2005, ATSDR hosted an expert scientific advisory panel to explore opportunities for conducting additional health studies of people who were potentially

[46]U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, *Volatile Organic Compounds in Drinking Water and Adverse Pregnancy Outcomes* (Atlanta, Ga.: 1998).

[47]Childhood hematopoietic cancers include childhood leukemia and non-Hodgkin's lymphoma.

[48]Water modeling is a scientific method that is used to help estimate past water system conditions.

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exposed to contaminated drinking water at Camp Lejeune. The agency noted that it convened this panel in response to continuing public concern about health effects from past exposure to contaminated drinking water. ATSDR received nine recommendations from its scientific advisory panel in a final report released in June 2005, which include a recommendation to create an advisory panel to oversee future studies and a recommendation that funding for future studies should come from appropriations to ATSDR, not from DOD's budget.[49] In an August 2005 published response, ATSDR agreed with all but three of the scientific advisory panel's recommendations.[50] (See app. VI for ATSDR's panel recommendations and ATSDR's response.)

ATSDR has taken steps to accomplish three of the recommended activities. In February 2006, ATSDR created a community assistance panel to respond to the two recommendations urging a closer partnership with former Camp Lejeune residents and development of an advisory panel to oversee health studies related to VOC exposures at Camp Lejeune.[51] As of January 2007, the community assistance panel had held four meetings. The panel includes seven former Camp Lejeune residents. Also participating in CAP meetings are one representative from DOD, two independent scientific experts, and ATSDR staff. ATSDR officials said the community assistance panel is comparable with other panels that ATSDR had set up for community participation at National Priorities List sites similar to Camp Lejeune. In response to a recommendation to conduct feasibility or pilot studies before beginning full-scale health studies, ATSDR had begun conducting a feasibility assessment to determine the availability and sufficiency of data needed to conduct several additional health studies related to past drinking water contamination. At the February 2006

[49]U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, *Report of the Camp Lejeune Scientific Advisory Panel* (Atlanta, Ga.: 2005).

[50]Agency for Toxic Substances and Disease Registry, *ATSDR Response to the Report of the Camp Lejeune Scientific Advisory Panel Held February 17-18, 2005* (Atlanta, Ga.: 2005).

[51]In 1992, ATSDR announced that it was developing community assistance panels at selected Superfund sites in order to enhance effective communication of environmental health concerns to ATSDR by the public and provide a means for community participation in ATSDR activities. ATSDR noted that among the factors that influence its decision to establish a community assistance panel at a particular site are the degree of community interest, whether there are varying viewpoints regarding the health issues, and a willingness on the part of the public to actively participate in the process. 57 *Fed. Reg.* 27779 (June 22, 1992).

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community assistance panel meeting, the panel members and ATSDR officials agreed that ATSDR should move forward with the initial stages of planning a mortality study and an adult cancer incidence study of those potentially exposed to contaminated water at Camp Lejeune so long as necessary data are available. ATSDR officials said that they had identified databases such as the National Death Index,[52] which contains death records, and state cancer registries[53] that could be used to assist ATSDR with conducting these studies. An ATSDR official said that mortality and cancer incidence studies would potentially be easier to carry out than some other health studies because of the existence of these databases. Since the February 2006 community assistance panel meeting, ATSDR officials have begun reviewing additional databases at the Defense Manpower Data Center and Naval Health Research Center to determine if those databases could be linked to both the National Death Index and state cancer registries, and to Camp Lejeune family housing records.[54] If the feasibility assessment shows that these databases can be used, ATSDR will likely proceed with the two studies, officials said. Additionally, ATSDR officials said they plan to computerize the family housing records at Camp Lejeune that were still in paper format. Officials noted that the fully computerized family housing records might be used as the basis for defining a registry of potentially affected residents, as recommended by the scientific advisory panel, if the feasibility assessment indicates that it is possible to obtain social security numbers and dates of birth for each potential member of the registry.

[52]The National Death Index is a central computerized index of death record information on file in state vital statistics offices. Working with these state offices, the National Center for Health Statistics established the index as a resource to aid epidemiologists and other health and medical investigators with mortality ascertainment activities.

[53]Cancer registries collect data about the occurrence of cancer, the types of cancer that occur, the cancer's location in the body, the extent of disease at the time of diagnosis, and the kinds of treatment patients receive. Cancer data are reported to a central statewide registry from various medical facilities including hospitals, physicians' offices, therapeutic radiation facilities, freestanding surgical centers, and pathology laboratories.

[54]The Defense Manpower Data Center maintains the largest archive of personnel, manpower, training, and financial data in DOD. The personnel data holdings are broad in scope and extend back to the early 1970s to cover all military services and all phases of the military personnel life cycle. The Naval Health Research Center is a laboratory that supports fleet operational readiness through research, development, test, and evaluation on the biomedical and psychological aspects of the Navy and Marine Corps.

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In March 2005, ATSDR hosted a separate expert peer review panel to evaluate the agency's water modeling and data-gathering efforts at Camp Lejeune. In a report published in October 2005, the expert peer review panel on water modeling made two primary recommendations urging the agency to make additional effort and expend more resources on more rigorous record searches to improve the information for the historical reconstruction of events.[55] ATSDR agreed and had hired new staff and consultants to begin record searches at Camp Lejeune; however, ATSDR officials did not proceed with their record search after they learned that the Marine Corps had separately hired a private contractor to conduct such a search. The Marine Corps' private contractor completed its document search in August 2006, which yielded more than 6,000 documents. An ATSDR official told us that during a preliminary review of the documents in July 2006, ATSDR determined that the documents were "extremely useful" for its water modeling activities. The remaining three recommendations of the expert peer review panel on water modeling were technical comments related to modeling activities, such as a recommendation to use simplified models that required less effort and resources. ATSDR officials said that they agreed with these technical recommendations and had subsequently used them to refine their modeling procedures.

Although ATSDR Did Not Always Receive Requested Funding and Experienced Delays in Receiving Information from DOD, Officials Said Their Work Has Not Been Significantly Delayed

Since ATSDR began its Camp Lejeune-related work in 1991, the agency did not always receive requested funding and experienced delays in receiving information from DOD entities. Although concerns have been raised by former Camp Lejeune residents, ATSDR officials said these issues have not significantly delayed its work and that such situations are normal during the course of a study.

[55]U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, *Expert Peer Review Panel Evaluating ATSDR's Water-Modeling Activities in Support of the Current Study of Childhood Birth Defects and Cancer at U.S. Marine Corps Base Camp Lejeune, North Carolina* (Atlanta, Ga.: 2005).

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Funding of ATSDR's Camp Lejeune Work

ATSDR received funding from DOD for 13 of the 16 fiscal years during which it has conducted its Camp Lejeune-related work, and ATSDR provided its own funding for Camp Lejeune-related work during the other 3 years. Under federal law and in accordance with a memorandum of understanding between DOD and ATSDR, DOD is responsible for funding public health assessments and any follow-up public health activities such as health studies or toxicological profiles related to DOD sites as agreed to in an annual plan of work. While ATSDR conducted the health assessment at Camp Lejeune, from fiscal year 1991 to fiscal year 1996 funding was provided by DOD as part of an annual payment for all ATSDR activities at DOD sites. These annual payments were provided from Defense Environmental Restoration Program funds. In fiscal year 1997, the individual military services assumed responsibility for making these payments. Therefore, for fiscal year 1997, funding for ATSDR's Camp Lejeune-related work came directly from the Navy (see Table 5).

Table 5: Funding of ATSDR Activities at Camp Lejeune from Fiscal Years 1991 through 2006

Fiscal year	Total amount[a]	Funding source
1991	95,018	Defense Environmental Restoration Program (DERP)[b]
1992	33,868	DERP
1993	97,000	DERP
1994	230,795	DERP
1995	434,328	DERP
1996	141,405	DERP
1997	109,045	Navy Environmental Restoration Program[c]
1998	731,247	ATSDR
1999	390,000	ATSDR
2000	935,312	ATSDR
2001	1,241,003	Navy Environmental Restoration Program
2002	1,021,437	Navy Environmental Restoration Program
2003	567,389	Marine Corps Operations & Maintenance[d]
2004	1,723,000	Marine Corps Operations & Maintenance
2005	1,549,000	Marine Corps Operations & Maintenance
2006	1,376,263[e]	Marine Corps Operations & Maintenance, Navy Environmental Restoration Program

Sources: ATSDR and DOD.

[a]Expenditure amounts, in dollars, as reported by ATSDR and DOD.

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[b]The DERP was established by the Superfund Amendments and Reauthorization Act of 1986. Through the DERP, DOD conducts environmental cleanup activities at military installations. The Office of the Secretary of Defense provides oversight for the DERP. Each of the military departments is responsible for implementing DERP requirements.

[c]Beginning in fiscal year 1997, the individual military services assumed responsibility for making payments to ATSDR. The Department of the Navy conducts DERP-related activies through the Navy Environmental Restoration Program.

[d]Marine Corps Operation & Maintenance appropriations provide the funding for various Marine Corps missions, functions, activities, and facilities.

[e]In fiscal year 2006, the Marine Corps provided $1,269,263 to support ATSDR's current study, and the Navy Environmental Restoration Program provided an additional $107,000, as submitted in a supplemental request by ATSDR to conduct community assistance panel meetings and a feasibility assessment to determine whether additional health studies could be conducted for the Camp Lejeune site.

From fiscal year 1998 through fiscal year 2000, no funding was provided to ATSDR by the Navy or any DOD entity for its Camp Lejeune-related work because the agencies could not reach agreement about the funding for Camp Lejeune. In June 1997, ATSDR proposed conducting a study of childhood leukemia and birth defects associated with TCE and PCE exposure at Camp Lejeune during fiscal years 1998 and 1999 at an estimated cost of almost $1.8 million. In a July 1997 letter to the Navy, an ATSDR official noted that during a June meeting the Navy appeared to be reluctant to fund the proposed study; however, the official noted that DOD was liable for the costs of the study under federal law. In an October 1997 letter responding to ATSDR, a senior Navy official stated that the Navy did not believe it should be required to fund ATSDR's proposed study because the cause of the contamination was an off-base source, ABC One Hour Cleaners. The Navy official said that it was more appropriate for ATSDR to seek funding for the study from the responsible party that caused the contamination.[56] However, ATSDR officials told us that while they expected that the study would focus primarily on contamination from the dry cleaner, the study was also expected to include people who were exposed to on-base sources of contamination. An ATSDR official reported that the agency submitted its funding proposals for the Camp Lejeune study to DOD in each of the annual plans of work from fiscal year 1998 to fiscal year 2000, but that during that time period the agency received no DOD funding and funded its Camp Lejeune-related work from general ATSDR funding.

[56]Additionally, the EPA CID concluded that funding for the current study was apparently delayed because of opposition characterized as a professional difference of opinion as to the scientific value of the study by a midlevel manager at the Navy Environmental Health Center.

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In fiscal year 2001 the Navy resumed funding of ATSDR's Camp Lejeune-related work. We could not determine why the Navy decided to resume funding of ATSDR's work at that time. Beginning in fiscal year 2003, funding for ATSDR's Camp Lejeune-related work has been provided by the Marine Corps. According to a DOD official, the Marine Corps has committed to funding the current ATSDR study. The DOD official also noted that per a supplemental budget request from ATSDR for fiscal year 2006, the Marine Corps agreed to fund community assistance panel meetings and portions of a feasibility assessment for future studies that will include computerization of Camp Lejeune housing records.

Provision of Information to ATSDR by DOD

ATSDR has experienced some difficulties obtaining information from Camp Lejeune and DOD officials. For example, while conducting its public health assessment in September 1994, ATSDR sent a letter to the Department of the Navy noting that ATSDR had had difficulties getting documents needed for the public health assessment from Camp Lejeune, such as Remedial Investigation[57] documents for Camp Lejeune. The letter also noted that ATSDR had sent several requests for information and Camp Lejeune's responses had been in most cases inadequate and no supporting documentation had been forwarded. ATSDR also had difficulty in obtaining access to DOD records while preparing to conduct its survey, the first phase of the current ATSDR health study. In October 1998, ATSDR requested assistance from the Defense Manpower Data Center, which maintains archives of DOD data, in locating residents of Camp Lejeune who gave birth between 1968 and 1985 on or off base. An official at the Defense Manpower Data Center initially did not provide the requested information because he believed that doing so could constitute a violation of the Privacy Act.[58] Between February and April 1999, Headquarters Marine Corps facilitated discussion between ATSDR and relevant DOD entities about these Privacy Act concerns and some information was subsequently provided to ATSDR by DOD. In April 2001, Headquarters Marine Corps sent a letter to the Defense Privacy Office suggesting that the Defense Manpower Data Center had only provided a limited amount of

[57]A Remedial Investigation is performed at a site after it is listed on the National Priorities List. The Remedial Investigation serves as a mechanism for collecting data. Data collected during the Remedial Investigation influence the development of remedial alternatives for the site.

[58]The Privacy Act of 1974 provides safeguards for individuals against invasions of privacy as a result of the collection of personal information by the federal government. Pub. L. No. 93-579, § 3, 88 Stat. 1896, 1897 (codified as amended at 5 U.S.C. § 552a).

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information to ATSDR.[59] However, in a July 2001 reply to Headquarters Marine Corps, the Defense Privacy Office noted that it believed that relevant data had been provided to ATSDR by the Defense Manpower Data Center in 1999 and 2001.

In December 2005, ATSDR officials told us that they had recently learned of a substantial number of additional documents that had not been previously provided to them by Camp Lejeune officials. ATSDR then sent a letter to Headquarters Marine Corps seeking assistance in resolving outstanding issues related to delays in the provision of information and data to ATSDR. In an attachment to the letter, ATSDR provided a list of data and information needed from the Marine Corps in order to complete water modeling activities for its current study. In a January 2006 response, a Headquarters Marine Corps official noted that a comprehensive review was conducted of responses to ATSDR's requests for information and that the Marine Corps believed it had made a full and timely disclosure of all known and available requested documents. The official also noted that while ATSDR had requested that the Marine Corps identify and provide documents that were relevant or useful to ATSDR's study, the Marine Corps did not always have the subject matter expertise to determine the relevance of documents. The official noted that the Marine Corps would attempt to comply with this request; however, the official also noted that ATSDR was the agency with the expertise necessary to determine the relevance of documents.

Effect on ATSDR's Work

Despite difficulties, ATSDR officials said the agency's Camp Lejeune-related work had not been significantly delayed or hindered by DOD. Officials said that while funding and access to records were probably slowed down and made more expensive by DOD officials' actions, their actions did not significantly impede ATSDR's health study efforts. The ATSDR officials also stated that while issues such as limitations in access to DOD data had to be addressed, such situations are normal during the course of a study. The officials stated that ATSDR's progress on the study has been reasonable in light of the complexity of the project. Nonetheless, as some former residents have learned that ATSDR has not always received requested funding and information from DOD entities, they have

[59]The Defense Privacy Office is responsible for implementation of DOD's Privacy Program, which regulates how and when DOD collects, maintains, uses, or disseminates personal information on individuals.

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raised questions about DOD's commitment to supporting ATSDR's work.[60] For example, when some former residents learned during a community assistance panel meeting that it took about 4 months for DOD to respond to a supplemental budget request from ATSDR for fiscal year 2006, they questioned DOD entities' commitment to ATSDR's Camp Lejeune-related work. However, DOD and ATSDR officials described this delay in responding as typical during the funding process.

Some Former Residents and Employees Have Filed Claims against the Federal Government

Some former residents have filed tort claims and lawsuits against the federal government related to the past drinking water contamination.[61] As of January 2007, about 750 former residents and former employees of Camp Lejeune have filed tort claims with the Department of the Navy related to the past drinking water contamination. According to an official with the U.S. Navy Judge Advocate General (JAG)—which is handling the claims on behalf of the Department of the Navy—the agency is currently maintaining a database of all claims filed. The official said that JAG is awaiting completion of the current ATSDR health study before deciding whether to settle or deny the pending claims in order to base its response on as much objective scientific and medical information as possible.[62]

As of February 2007, two of these claims had resulted in the filing of lawsuits in Federal District Courts in Texas and Mississippi.[63] Among other things, both lawsuits seek damages for various physical ailments and emotional distress alleged to have resulted from the government's

[60]The Marine Corps has issued multiple public statements indicating support for ATSDR's work at Camp Lejeune.

[61]The Federal Tort Claims Act provides a system for making claims against the federal government for, among other things, personal injury, property damage, or wrongful death allegedly caused by the negligence of its employees. Act of Aug. 2, 1946, ch. 753, 60 Stat. 842 (codified, as amended, to various sections of 28 U.S.C.). An individual must file a valid claim with the federal agency alleged to have caused the harm before filing a lawsuit against the federal government for negligence. 28 U.S.C. § 2675.

[62]DOD officials noted that other considerations may lead to an earlier adjudication of some claims.

[63]*Snyder et al. v. U.S.*, Civ. No. 627 (S.D. Miss. filed July 27, 2004); *Gros et al. v. U.S.*, Civ. No. 4665 (S. D. Tex. filed Dec. 13, 2004). The Federal Tort Claims Act requires that a claim must be presented in writing within 2 years after the claim accrues and that after a claim has been filed the agency has 6 months to make a decision. If the claim is denied or if no decision has been made after 6 months, the individual can then file a lawsuit against the federal government. 28 U.S.C. § 2675. The lawsuits were filed in the districts where the individuals resided at the time.

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negligence in protecting the water supply at Camp Lejeune. In the first lawsuit, a former servicemember's son alleged that he suffered a congenital heart defect as a result of his mother's exposure (while pregnant with him) as well as his subsequent direct exposure to contaminated water at Camp Lejeune during the early 1970s.[64] The outcome of the lawsuit was still pending as of February 2007. In the second lawsuit, a former servicemember and his family alleged injuries as a result of their past exposure to TCE and PCE while living at Camp Lejeune. The claims of the former service member and his wife were dismissed because his alleged injuries occurred while he was on active duty in the Marine Corps.[65] An appeal of the claims of the former service member and his family members remained pending in February 2007.[66]

Several Federal Inquiries Have Examined Events Related to the Drinking Water Contamination

Three federal inquiries into issues related to the drinking water contamination at Camp Lejeune have been conducted, each of which cited concerns by former residents as one of the reasons for conducting its inquiry. These include one by a Marine Corps-chartered panel, one by EPA's OIG, and one by EPA's CID.

Marine Corps-Chartered Panel Review

In March 2004 the Commandant of the Marine Corps created a fact-finding panel charged with conducting a review of the facts surrounding the decisions made following the 1980 discovery of VOCs in drinking water at Camp Lejeune.[67] The panel focused its review on the 1980 to 1985 time period. The panel released a report in October 2004 which found that the Marine Corps acted responsibly and found no evidence that the Marine

[64]Plaintiffs' Complaint, *Snyder et al.* (Civ. No. 627).

[65]Order Granting Defendant's Motion to Dismiss, *Gros et al.* (Civ. No. 4665). The Supreme Court has held that under the Federal Tort Claims Act the federal government is not liable for injuries to members of the armed forces sustained while on active duty and resulting from the negligence of others in the armed forces. *Feres v. U.S.*, 340 U.S. 135, 146 (1950). The claims of the former service member and his wife were dismissed on the grounds that the husband's alleged exposure to contaminated water occurred while he was on active duty in the military. Subsequently, in March 2006, the District Court entered a final judgment for the government on all individual claims alleged by the former service member's family members in this case. Final Judgment in Favor of Defendant, *Gros et al.* (Civ. No. 4665).

[66]*Gros et al. v. U.S.*, No. 06-20354 (5th Cir. filed May 8, 2006).

[67]Members of the panel consisted of a former member of Congress; an adviser on water management, treatment, and protection issues; a retired assistant commandant of the Marine Corps; a former acting Secretary of the Navy; and a former branch chief of EPA.

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Corps had attempted to cover up information that indicated contamination in Camp Lejeune's drinking water.[68] Additionally, the panel concluded that Camp Lejeune provided residents with drinking water at a level of quality consistent with general utility practices at the time. However, the panel noted that while Camp Lejeune made every effort to comply with existing regulations, it did not anticipate or independently evaluate health risks associated with chemicals such as TCE or PCE that were not yet regulated, and for which there was developing concern about possible adverse health effects. The panel noted that this "compliance-based approach to regulations," combined with factors including inadequate funding, staffing, and training of Camp Lejeune's Environmental Division, contributed to a lack of understanding about the potential significance of the contamination. Additionally, the panel identified other factors that appeared to have hindered Camp Lejeune personnel from quickly recognizing the significance of VOC contamination, including the absence of regulatory standards, no records of resident complaints about water quality, sampling errors, and inconsistent sampling results.

The panel also made several other findings critical of Camp Lejeune and the Department of the Navy, noting that:

- LANTDIV, as a technical advisory organization, was "not aggressive" in providing Camp Lejeune with the technical expertise to help base officials understand the significance of the contamination and how it could have been addressed;
- communications both internally among Camp Lejeune officials, and between Camp Lejeune and LANTDIV, were inadequate; and
- communications to Camp Lejeune residents regarding drinking water contamination were not detailed enough to completely characterize the contamination found at the time of the well closures.

EPA's OIG Inquiry

In January 2005 EPA's OIG completed an internal report describing a preliminary review of five complaints reported by three citizens regarding issues indirectly or directly related to the drinking water contamination at Camp Lejeune. The complaints were as follows:

[68]Drinking Water Fact-Finding Panel for Camp Lejeune, *Report to the Commandant United States Marine Corps* (October 2004).

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1. EPA inadequately responded to a Freedom of Information Act[69] request,

2. EPA inappropriately responded to a Freedom of Information Act fee waiver request,[70]

3. EPA did not adequately perform oversight of Camp Lejeune based on its responsibilities listed in the Safe Drinking Water Act,

4. EPA did not devote adequate resources to the review that was being conducted by its Criminal Investigation Division, and

5. the 1998 study conducted by ATSDR was inadequate.

The OIG conducted a preliminary review of these complaints to determine whether the complaints merited a full-scale audit of EPA activities. Regarding the first two complaints, the OIG determined that EPA's response to a Freedom of Information Act request for documents related to Camp Lejeune contamination was inadequate and that its denial of an associated fee waiver request was inappropriate and insensitive. The third complaint was closed because the OIG concluded that EPA had little oversight responsibility for the Safe Drinking Water Act until 1996, significantly later than the contamination occurred at Camp Lejeune. The OIG found no merit with the fourth complaint, noting that although only one agent was assigned to the case, that agent had access to other agents and resources when needed. OIG officials said the fifth complaint was closed in part because they knew we would also be reviewing this concern, and also because complaints regarding ATSDR's study are not related to any actions by EPA and are therefore outside the scope of an EPA review. Based on this preliminary review, a full audit of EPA officials' actions was not initiated.

[69]The Freedom of Information Act generally ensures public access to federal agency records. Upon written request, federal government agencies are required to disclose those records, unless they can be lawfully withheld from disclosure under specific exemptions in the act. 5 U.S.C. § 552.

[70]The Freedom of Information Act also provides that documents shall be furnished at no or reduced charge under specified circumstances.

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EPA's Criminal Investigation

A criminal investigation conducted by EPA and reviewed by the Department of Justice (DOJ) did not find any violations of federal law, but criticized some of the actions taken by Marine Corps and Navy officials.[71] From 2003 through 2005, EPA's CID conducted an investigation of allegations made by former residents that federal law was violated by the individuals and entities addressing the drinking water contamination at Camp Lejeune, including officials from the Marine Corps, Navy, and ATSDR. With regard to the Navy and Marine Corps, the CID investigated five principal allegations of violation of federal law:

1. violation of the Safe Drinking Water Act,
2. conspiracy to violate the Safe Drinking Water Act,
3. conspiracy to conceal records and prevent persons from talking with a federal agency conducting a congressionally mandated health study,
4. conspiracy to conceal Freedom of Information Act records from the public, and
5. providing material false statements to a federal law enforcement officer.

The CID concluded that in the absence of enforceable regulatory standards for both TCE and PCE between 1980 and 1985, there was no violation of the Safe Drinking Water Act at that time, and drinking water provided by Camp Lejeune during that time appeared to have met all state and federal regulatory requirements. A CID investigator told us that he looked for evidence of conspiracy from the 1980s, when the events occurred, through 2004. With regard to allegations that Marine Corps or Navy officials conspired to violate the Safe Drinking Water Act or to conceal records, the CID's report noted that investigators were unable to substantiate that a conspiracy by military or civilian employees of either entity existed. Regarding allegations that false statements were provided to a federal law enforcement officer, investigators noted that while they were concerned that LANTDIV officials were not completely forthcoming

[71]According to EPA, as part of the agency's responsibility for ensuring compliance with environmental laws, the CID investigates allegations that environmental laws have been violated and refers the cases that pose risks to human health and the environment for criminal prosecution.

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during their interviews, there was never any direct evidence that LANTDIV officials were aware of the contamination prior to 1984.

With regard to ATSDR, the CID investigated two principal allegations made by former residents of Camp Lejeune:

1. destruction of a federal agency's records, and

2. conspiracy to improperly administer a congressionally mandated health study.

Regarding an alleged order by an ATSDR official to destroy records related to the Camp Lejeune health study, CID investigators found that the records in question were never destroyed. Concerning allegations that ATSDR failed to properly address the drinking water contamination at Camp Lejeune because of influence from the Navy, the CID found no evidence that ATSDR's scientific work was influenced by regular meetings between ATSDR and Navy officials.

Although the CID found no evidence that federal law had been violated, because of the unique history and complexity of the case and an evaluation of statements from persons they interviewed, investigators noted that the case warranted a review by DOJ. Additionally, several of the allegations from the public had also been forwarded by DOJ to the CID for investigation. Following the CID's referral of this case to DOJ for its review, DOJ discussed its findings at an August 2005 meeting with former residents and officials from the Navy and Marine Corps.[72] DOJ concluded that it would not seek criminal prosecution, saying that the government's investigation had concluded that no federal criminal law was broken nor was there an attempt to conceal evidence regarding a violation of any law.

In addition to investigating whether federal law had been violated, the CID also investigated additional questions that were relevant to the case but were determined not to be violations of federal law. The CID noted that some of these matters appeared to have contributed to confusion, suspicion, and concern by retired Marines. Additionally, the CID commented on and criticized certain actions taken by Navy and Marine Corps officials. For example:

[72]The former residents at this meeting were those who helped initiate this investigation.

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- The CID concluded that as a technical advisory agency to Camp Lejeune, LANTDIV was not diligent in providing technical expertise to the base's environmental officials and noted that LANTDIV officials appeared to have been better suited by virtue of their training and expertise to recognize and address VOC contamination and the possible effects on public health than the environmental officials at Camp Lejeune.

- The CID commented that former Camp Lejeune environmental officials failed to properly investigate the contamination and determine the contamination was coming from individual wells. Until 1984, the Camp Lejeune environmental officials never sampled individual water wells and the CID noted that this was arguably their most significant lapse in judgment.

- Because of questions raised by Congress and former residents, the CID also investigated the provision of DOD funding for ATSDR's work. The CID concluded that funding for the current study was apparently delayed because of opposition characterized as a professional difference of opinion as to the scientific value of the study by a midlevel manager at the Navy Environmental Health Center, and that coupled with this opposition was confusion within the Navy hierarchy regarding what entity was responsible for the contaminated wells.

- Regarding the provision of records and data to ATSDR by the Marine Corps, the CID found no instances when data or records were intentionally withheld or false data were provided by Marine Corps officials to ATSDR. The CID noted the Marine Corps appeared not to have recognized the complexity and degree of attention this issue required in 1997 and that prior to 1997, the Marine Corps admitted that it failed to adequately address concerns and data requests from the public and ATSDR.

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Experts Convened by NAS Generally Agreed That Many Parameters of ATSDR's Current Study Were Appropriate but Some Experts Suggested Potential Modifications to the Study

The seven members of an expert panel convened by the National Academy of Sciences (NAS) at our request generally agreed that specific parameters of ATSDR's current study were appropriate, including the study population, the exposure time frame, and the selected health effects. The expert panel members had mixed opinions on ATSDR's projected completion date. Some panel experts suggested modifying the study to use a simpler method of analysis, with alternative ways to define exposure categories, in order to complete the study sooner. Some panel experts also identified other potential modifications to the study, such as conducting separate analyses for those who were born on the base and those born off the base. (See app. VII for a more detailed description of ATSDR's study.)

Experts Agreed That Study Population of Individuals Who Were Potentially Exposed in Utero Was Appropriate and Studying Children and Adults Could Also Be Reasonable

The seven panel experts concurred that ATSDR logically limited its study population to those individuals who were in utero while their mothers were pregnant and lived at Camp Lejeune during the 1968 through 1985 time frame, and who may have been exposed to the contaminated drinking water.[73] The current study follows recommendations from the agency's 1997 public health assessment of Camp Lejeune, which noted that studies of cancer among those who were exposed in utero should be conducted to further the understanding of the health effects in this susceptible population. Panel experts said that ideally a study would attempt to include all individuals who were potentially exposed, but that limited resources and data availability were practical reasons for limiting the study population. Additionally, panel experts agreed that those exposed while in utero were an appropriate study population because they could be considered at higher risk of adverse health outcomes than others, such as those exposed as children or adults. In addition, two panel experts said that studying only those who lived on base was reasonable because they likely had a higher risk of inhalation exposure to VOCs such as TCE and

[73]ATSDR's current study population of those individuals who were in utero includes individuals whom ATSDR determined were exposed during specific time periods of the mother's pregnancy or after their birth to contaminated drinking water because they lived in an area that was served by the Hadnot Point or Tarawa Terrace water systems, and those that ATSDR determined through its study analysis were not exposed because they did not live in those areas or were not exposed during specific time periods.

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PCE, which may be more potent than ingestion exposure.[74] Thus, pregnant women who lived in areas of base housing with contaminated water and conducted activities during which they could inhale water vapor—such as bathing, showering, or washing dishes or clothing—likely faced greater exposure than those who did not live on base but worked on base in areas served by the contaminated drinking water.

While supporting the decision to limit the study population to individuals who were in utero, the panel experts did not discount the possibility that children and adults who lived or worked on base may also be at risk for adverse health effects because of their potential exposure to contaminated drinking water. For example, four panel experts pointed out that exposed children and adults might have an elevated risk for neurological effects, and one of the four experts said exposed adults might have an elevated risk for certain cancers. Similarly, the ATSDR scientific advisory panel convened in February 2005 identified at least four groups of individuals at Camp Lejeune who might be at higher risk for adverse health effects because they could have been exposed to the contaminated drinking water. In addition to individuals who were in utero, these groups included children who lived on base, adults who lived on base, and adults who lived off base but worked on base, because they too spent time at Camp Lejeune and were potentially exposed to the contaminated drinking water.

Experts Agreed That the Study Time Frame of 1968 through 1985 Was Reasonable, but Could Be Extended Beyond 1985

The seven panel experts agreed that the 1968 through 1985 study time frame was reasonable, based on limitations in data availability. This time frame was adopted from ATSDR's 1998 study of adverse pregnancy outcomes, which limited the study population to include those potentially exposed between 1968 and 1985. According to ATSDR's study protocol, these years were chosen because 1968 was the first year that birth certificates were computerized in North Carolina and 1985 was when the affected water wells were removed from service. Four of the panel experts said they did not see any benefit in using an earlier start date than 1968 because collecting birth records before 1968 could require a significant amount of resources to collect data. In addition, while the initial exposure to contaminated drinking water may have occurred as early as the 1950s,

[74]According to ATSDR, inhalation of TCE and PCE that have evaporated from drinking water is likely to result in higher exposures than ingestion. Additionally, a 1991 EPA guidance on estimating exposure to VOCs during showering noted that scientific studies found that this exposure is approximately equivalent to exposure from ingesting two liters of the contaminated water per day.

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at the time the ATSDR study time frame was selected officials were unable to determine precisely when the contamination began. Four of the panel experts commented that exposure was likely highest in the latter part of the study time frame—presumably as a result of a higher accumulated level of contamination over time—thus making the uncertainty of when the contamination began less significant and supporting ATSDR's decision to study the later time frame.

Six of the panel experts said that extending the time frame past 1985 could help strengthen ATSDR's study by adding an additional unexposed population for comparison. Having an additional comparison population could help researchers reinforce any conclusions about whether TCE or PCE are associated with adverse health outcomes, panel experts said. For example, if the study found some association between adverse health outcomes and the pre-1985 exposed population, but no association with an additional unexposed comparison group, it would support any finding that TCE or PCE exposure was associated with adverse health outcomes, since the exposure ended in 1985. Two of the expert panel members said that if adverse health effects continued to be found in a comparison population after 1985, that finding could mean that exposure to the contaminated drinking water was not associated with the adverse health effects. However, one of the six experts also noted that extending the study time frame would be cost effective only if a significant association between TCE or PCE exposure and adverse health outcomes was first found among those exposed before 1985.

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Experts Said Health Effects Selected for the Study Were Valid, Though Other Neurological and Behavioral Health Effects May Also Occur

The five panel experts who discussed health effects said that those selected for the study were valid for individuals who were potentially exposed in utero at Camp Lejeune.[75] Based on previous ATSDR work and existing literature, the health effects chosen for the study were neural tube defects, oral cleft defects, and childhood hematopoietic cancers, including leukemia and non-Hodgkin's lymphoma.[76] Two panel experts said that ATSDR had limited its study to health effects that are rare and that generally occur at higher levels of exposure to VOCs such as TCE and PCE than are expected to have occurred at Camp Lejeune. They said that this may result in ATSDR not identifying enough individuals with these health effects to determine meaningful results in the study.[77]

Four panel experts added that other adverse health outcomes not included in the study could also be related to exposure to drinking water contaminated with TCE or PCE, including adverse neurological or behavioral effects, or pregnancy loss. However, three of these four panel experts said that studying adverse neurological or behavioral health effects would likely be difficult because of limited access to needed records, such as school records for children, or because there might be few databases for researchers to use to study these effects in adults.

Experts Had Mixed Opinions on ATSDR's Projected Completion Date and Some Said a Simpler Analysis Could Provide Earlier Results

ATSDR has projected a December 2007 completion date for the study, which would include activities such as identifying and enrolling study participants, conducting a parental interview, confirming each reported diagnosis, modeling the water system to quantify the amount and extent of each individual's exposure, analyzing the data, and drafting a final report. Panel experts had mixed opinions regarding ATSDR's completion date. Of the five panel experts who commented on the proposed completion date,

[75]The two panel experts who did not discuss health effects said that this discussion was outside their areas of expertise. One expert is a professor of geochemistry and the second is an environmental engineer.

[76]An ATSDR document setting out frequently asked questions about its health study states that the agency chose to study these birth defects and cancers based on the results of previous studies; two previous studies suggested that the chemicals in the drinking water at Camp Lejeune might cause these birth defects, while three studies suggested that these chemicals in drinking water might cause childhood leukemia. Additionally, ATSDR's study protocol noted that ATSDR's study could add to the body of scientific knowledge.

[77]ATSDR's public health assessment noted that the exposure levels experienced at Camp Lejeune were expected to be relatively low and experienced over a relatively short duration.

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three said that the date appeared reasonable, and two others said that based on the complexity of the water modeling the projected completion date might be optimistic.[78]

While none of the panel experts said that ATSDR's projected completion date should be earlier, several said that one way to provide analytical results sooner would be to conduct the study without using the water modeling analysis. Three of the experts explained that water modeling would be useful if it improved the classification of the study participants as either exposed or unexposed to contaminated water or provided more accurate estimates of individual exposure levels, as ATSDR intends. ATSDR officials said that a precise and accurate exposure assessment would enhance the scientific credibility of a study and strengthen the study's ability to identify any important exposure effects. But all of the panel experts raised concerns about the limited historical record of the amount of PCE or TCE concentration identified at individual Camp Lejeune wells. They said that with limited historical data there would be minimal potential for water modeling to provide accurate information about the level of concentration of the contamination and thus about each individual's total amount of exposure. As an alternative to estimating the extent of each study individual's exposure using the water modeling results, four panel experts suggested ATSDR could use simpler categories of whether and to what extent individuals were exposed to water contamination. These four experts said that analyzing the data on birth defects and childhood cancers by using the same exposure categories that were used in the 1998 ATSDR study could yield an effective study sooner than December 2007. The current ATSDR study expects to use more categories of exposure than were used in the 1998 study, based on data from its water modeling activities and from information gathered on the mothers' usage and consumption of the contaminated water.

[78]One of the panel experts did not discuss the completion date of the study. A second expert said he did not have sufficient data to make a determination on whether the projected completion date was reasonable.

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Experts Identified Additional Potential Modifications to the ATSDR Study

Panel experts identified several other possibilities for modifying the design of the ATSDR study. Four panel experts suggested conducting separate analyses for study individuals born in the county where Camp Lejeune is located, and for individuals who were born outside the county but whose mothers were pregnant with them while living in base housing.[79] Word of mouth among current and former residents and media campaigns were the primary methods used to identify and recruit those individuals born outside the county as study participants. According to three panel experts, the methods used to identify these study participants raise the possibility of selection bias for that group. Specifically, the experts suggested that eligible study individuals born out of county, or their parents, who had concerns about potential exposure to TCE or PCE or about existing health problems may have been more likely to sign up for the study than those who did not have these concerns. Selection bias could result in a mistaken estimate of an exposure's effect on the risk of disease.[80]

As another potential study modification, two panel experts suggested conducting separate analyses for those with childhood leukemias and non-Hodgkin's lymphoma, which they said ATSDR had inappropriately combined into one category of hematopoietic cancers. ATSDR study investigators had combined these health outcomes into one category following advice from the ATSDR scientific advisory panel at its meeting in February 2005. Before the February meeting, ATSDR study investigators had dropped plans to separately analyze childhood non-Hodgkin's lymphoma because they were unable to confirm a large enough number of individuals with this type of cancer to further study this health outcome.

Agency Comments

DOD, EPA, and HHS provided technical comments on a draft of this report, which we incorporated where appropriate. We provided the seven former Camp Lejeune residents who are members of the ATSDR community assistance panel for Camp Lejeune the opportunity to provide comments on our draft—three of the panel members provided technical and general oral comments, and four declined to review the draft report.

[79]The current study includes only those individuals whose mothers were pregnant with them and living on base at any time from 1968 through 1985 and who were born in Onslow County, where Camp Lejeune is located. Additionally, the study identified individuals whose mothers were pregnant with them while living on base during this time, but who gave birth outside Onslow County.

[80]Leon Gordis, *Epidemiology*, 1st ed. (Philadelphia, Pa.: W.B. Saunders Company, 1996), 183.

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Two of the panel members said that the report should address contaminants other than TCE and PCE with potential adverse health effects, such as benzene, that were identified at Camp Lejeune. Our report focused on TCE and PCE because ATSDR's health studies have focused on these chemicals and their associated health effects and ATSDR has identified TCE and PCE as the chemicals of primary concern at Camp Lejeune. However, in response to technical comments from ATSDR and the panel members' comments, we have added the sampling results for all other VOCs detected in wells that were taken out of service at Camp Lejeune during 1984 and 1985. Additionally, the three members expressed the belief that the Marine Corps had not fully disclosed information related to the past drinking water contamination and two of the members expressed disappointment that our report was not more critical of the Marine Corps. We believe that we have accurately described efforts to identify and address the past contamination and described activities resulting from concerns about possible adverse health effects and government actions related to the past contamination. Finally, the three members raised various other issues, such as compensation and health benefits for former residents and their families and the need for additional notification to be provided to former residents regarding the past drinking water contamination; however, these issues were beyond the scope of this report.

We are sending copies of this report to the Secretary of Defense, the Administrator of EPA, the Secretary of Health and Human Services, appropriate congressional committees, and other interested parties. We will also make copies available to others upon request. In addition, the report is available at no charge on the GAO Web site at http://www.gao.gov. If you or your staff have questions about this report, please contact me at (202) 512-7119. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions are listed in appendix VIII.

Marcia Crosse
Director, Health Care

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Appendix I: Scope and Methodology

To examine efforts to identify and address the past drinking water contamination at Camp Lejeune, we obtained and reviewed more than 1,600 documents related to past and current drinking water activities at Camp Lejeune. We focused our review on the past trichloroethylene (TCE) and tetrachloroethylene (PCE) contamination at Camp Lejeune because the Agency for Toxic Substances and Disease Registry (ATSDR) had noted that these chemicals were the VOCs of primary concern. However, we also reviewed documentation regarding other volatile organic compounds (VOCs) detected at Camp Lejeune. The documents we reviewed were obtained from Headquarters Marine Corps and had been collected and organized by a contractor for the Commandant of the Marine Corps' Drinking Water Fact-Finding Panel for Camp Lejeune. Documents related to past and current drinking water activities were also obtained during a visit to Camp Lejeune. The authors of the documents we collected included officials with Camp Lejeune, Headquarters Marine Corps, the Department of the Navy, other federal agencies such as the Environmental Protection Agency (EPA), the state of North Carolina, and private laboratories. The types of documents that were collected included results of laboratory analyses of drinking water samples, e-mails, memorandums, letters, reports, site maps, federal and state regulations, press releases, and newspaper articles.

Additionally, we reviewed a list of more than 6,000 historical documents collected by a contractor hired by Headquarters Marine Corps; this list was compiled by the contractor and included detailed descriptions and dates of the historical documents. We requested and reviewed more than 100 documents from this list that we thought might be relevant to the past drinking water contamination.

We interviewed 39 current and former officials from various Department of Defense (DOD) entities, including Camp Lejeune, Headquarters Marine Corps, and the Department of the Navy, who were involved in activities related to or knowledgeable about historical environmental activities at Camp Lejeune. The former officials we interviewed were responsible for environmental activities at Camp Lejeune or the Department of the Navy during the time in which the contamination was detected. The current officials we interviewed are responsible for environmental activities at Camp Lejeune, Headquarters Marine Corps, or the Department of the Navy. Some of these current officials were also responsible for environmental activities during the time in which the contamination was detected. The current and former officials interviewed often provided information based on their memory of events which occurred more than 20 years ago. We attempted to corroborate their testimonial evidence with

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documentation whenever possible. We also met with 19 interested former residents and individuals who worked on the base during the 1960s, 1970s, and 1980s in order to obtain their perspective on historical events. A former resident who is active in matters related to the past drinking water contamination at Camp Lejeune identified most of the interested former residents; others were identified at an ATSDR public meeting. We also interviewed current Camp Lejeune housing officials in order to obtain estimated historical occupancy rates, including the limitations of the occupancy data that were provided. Additionally, we examined reports from and interviewed current officials from Camp Lejeune, EPA, and the North Carolina Department of Environment and Natural Resources who were involved with or knowledgeable about past and current activities and costs related to the cleanup of the suspected sources of contamination. Finally, we obtained and analyzed information from ATSDR and EPA on drinking water contaminated with TCE and PCE, the possible adverse health effects related to exposure to these chemicals, and relevant federal regulations for TCE and PCE.

To describe activities resulting from concerns about the possible adverse health effects and government actions related to past drinking water contamination, including efforts to study potential health effects and federal inquiries into the response to the contamination, we reviewed documents, interviewed agency officials, and attended agency meetings. To examine the activities undertaken by ATSDR to study potential health effects related to the drinking water contamination at Camp Lejeune, we reviewed the agency's 1997 Public Health Assessment that evaluated the risks of adverse health effects from exposure to the contaminated drinking water, as well as released documents regarding ATSDR's 1998 health study of the association between exposure to TCE and PCE in drinking water at Camp Lejeune and a variety of adverse pregnancy outcomes. We did not evaluate the methodology or findings of the public health assessment or health study. For ATSDR's current study, we examined the study protocol, a progress report, and other documents describing ATSDR's current study examining whether birth defects and childhood cancers are associated with exposure to TCE or PCE at Camp Lejeune. We interviewed ATSDR officials involved with the Public Health Assessment, the 1998 study, and the current study, and also attended ATSDR expert panel meetings convened to evaluate and provide recommendations regarding the agency's work related to Camp Lejeune. In order to examine the sources of and issues surrounding funding for ATSDR's Camp Lejeune-related work, we obtained documents from and interviewed officials with ATSDR, the Department of the Navy, and the U.S. Army Center for Health Promotion and Preventive Medicine, which currently executes the

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memorandum of understanding between DOD and ATSDR and negotiates an annual plan of work with ATSDR. We examined documentation and interviewed DOD, ATSDR, and EPA officials about efforts to address the concerns of the former Camp Lejeune residents. To examine the recommendations of additional review panels convened by ATSDR in 2005 regarding improving the study's water modeling efforts and future studies of health effects, we attended two panel meetings and obtained and reviewed the final reports of both panels, which included ATSDR's response to the panels' recommendations. To determine the actions taken by ATSDR to address the panel recommendations, we interviewed relevant ATSDR officials and observed and subsequently reviewed transcripts of meetings of the Camp Lejeune community assistance panel held in 2006, where ATSDR officials reported on their activities. In order to describe the lawsuits and tort claims filed against the federal government for injuries alleged to have resulted from exposure to the contaminated drinking water at Camp Lejeune, we interviewed officials with the Department of the Navy's Judge Advocate General and the Department of Justice. To describe three federal inquiries into issues related to the drinking water contamination at Camp Lejeune, we reviewed the reports and statements of the Drinking Water Fact-Finding Panel for Camp Lejeune, the EPA Office of Inspector General, the EPA Criminal Investigation Division, and the Department of Justice. We also interviewed officials from the EPA Office of Inspector General and the EPA Criminal Investigation Division about their examinations of allegations made by former residents. We did not evaluate the methodology used by the officials who conducted these three inquiries.

When the source of evidence we cited is from an interview, we identified the respondent's agency and noted whether the individual was a current or former official. Whenever possible, we reviewed documents to verify testimonial evidence from DOD and ATSDR officials. When this was not possible, we attempted to corroborate testimonial evidence by interviewing multiple individuals about the information we obtained.

To assess the design of the current study by ATSDR on the possible health effects associated with the contaminated drinking water at Camp Lejeune, including the study population, time frame, health effects, and completion date, we contracted with the National Academy of Sciences (NAS) to convene a 1-day meeting of scientific experts in the areas of drinking water contamination, hydrologic modeling, and reproductive health. We identified for NAS the categories of expertise preferred at the meeting and expressed a preference that each participant have no conflict of interest with ATSDR, DOD, or EPA. NAS identified participants according to the

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preferred categories. Once we concurred with the proposed participants, NAS contacted the potential participants to determine interest and availability to participate in the meeting. In total, seven experts and one moderator participated in the meeting. The experts and the moderator had combined research expertise in environmental engineering; reproductive, environmental, and occupational epidemiology; statistics and modeling; public health investigations, risk assessment, and decision analysis; geochemistry; and water and wastewater treatment and water modeling. We observed the meeting, which took place in July 2005, and subsequently reviewed the written transcript of the meeting. The experts' discussion during the meeting was guided by a set of questions we prepared regarding the ATSDR study population, time frame, health effects, and completion date. Participants were invited as individual experts, not as organizational representatives, and were not asked to reach consensus on any topics. NAS was not asked to provide advice or produce any report, and the comments made during the meeting of the expert panel should not be interpreted to represent the views of NAS or of all experts regarding health studies related to drinking water contamination. As we requested, each of the experts also provided written responses to the set of questions that were discussed during the meeting. During the meeting and in their written responses, not all panel members commented individually about each of the questions discussed during the 1-day meeting. Additionally, some panel members noted that certain questions addressed subjects that were outside their areas of expertise. In addition to convening and attending the expert panel meeting, we also reviewed ATSDR documents related to the current study, including the study protocol and progress reports, and interviewed ATSDR officials involved in the study's epidemiologic and water modeling activities.

We conducted our work from May 2005 through April 2007 in accordance with generally accepted government auditing standards.

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Appendix II: Selected Events Related to Past Drinking Water Contamination at Camp Lejeune from 1980 through 1981

Date	Event
October 1, 1980	An official with the Naval Facilities Engineering Command, Atlantic Division (LANTDIV), collected samples from all eight water systems at Camp Lejeune to be combined into a single sample and analyzed in order to detect any potential contaminants in the water systems.
October 21 and October 24, 1980	At the direction of LANTDIV, Camp Lejeune collected separate samples to be analyzed for total trihalomethanes (TTHMs)[a] at two base water systems, Hadnot Point and New River. LANTDIV arranged for the U.S. Army Environmental Hygiene Agency (USAEHA) laboratory to conduct the testing.
October 31, 1980	A LANTDIV-contracted private laboratory reported results from the samples collected on October 1, 1980, from all eight water systems at Camp Lejeune. The results, sent to LANTDIV, indicated that 11 volatile organic compounds (VOCs) were detected, including trichloroethylene (TCE).[b] All VOCs detected in this analysis were identified at their detection limits, which were the lowest level at which the chemicals could be reliably identified by the instruments being used.
October 31, 1980	A report[c] from USAEHA of the results of the analysis of samples collected on October 21, 1980, contained a USAEHA official's handwritten notes which indicated unidentified chlorinated hydrocarbons were interfering with the testing for TTHMs at the Hadnot Point water system.
January 22, 1981	Handwritten notes from a USAEHA official on a USAEHA report indicated that continued interference with the TTHM analysis of samples collected on December 29, 1980, for the Hadnot Point water system, and recommended conducting analyses for chlorinated organics.
February 9, 1981	Handwritten notes from a USAEHA official on a USAEHA report indicated continued interference with the TTHM analysis of samples collected on January 30, 1980, for the Hadnot Point water system, and recommended conducting analyses for chlorinated organics.
March 9, 1981	Handwritten notes from a USAEHA official on a USAEHA report indicated that water samples collected on March 9, 1981, for analysis for TTHMs at the Hadnot Point water system were "highly contaminated" with other chlorinated hydrocarbons.
April 7, 1981	According to the private laboratory report sent to LANTDIV, an analysis of water samples collected on March 30, 1981, from areas surrounding the Camp Lejeune Rifle Range chemical dump detected VOCs. However, TCE and tetrachloroethylene (PCE)[d] were not among the VOCs detected in these samples.
April 16, 1981	According to the private laboratory report sent to LANTDIV, an analysis of water samples collected on April 10, 1981, was conducted from the untreated water in the wells that served the Rifle Range water system, from treated water from the Rifle Range water system, and from areas surrounding the Rifle Range chemical dump. VOCs, including TCE and PCE, were detected in water samples from the areas surrounding the chemical dump. VOCs, including TCE, were also detected in the well samples. TCE was detected at 1.8 parts per billion[e] in one of the well samples.
May 8, 1981	The Commander of LANTDIV wrote a memorandum to the Commanding General of Camp Lejeune that recommended resampling the Rifle Range area because of variation in the results from the April 7 and April 16 analysis reports. LANTDIV noted that three contaminants were detected in the treated and untreated water in the Rifle Range water system. Two of these contaminants, methylene chloride[f] and TCE, were not regulated and the third chemical, a TTHM, was detected at levels within the new regulatory standards. The LANTDIV official noted that no imminent threat to human health was presented by consumption of water from the Rifle Range water system.

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Date	Event
May 29, 1981	According to the private laboratory report sent to LANTDIV, an analysis of water samples collected on May 20, 1981, from treated water in the Rifle Range water system and from areas surrounding the Rifle Range chemical dump detected VOCs in the treated water at the Rifle Range water system and also detected VOCs, including TCE, in areas surrounding the Rifle Range chemical dump.
July 31, 1981	The Commander of LANTDIV wrote a memorandum to the Commanding General of Camp Lejeune that described the analyses of the additional water samples taken from the Rifle Range area. The official noted that of the organic contaminants detected at the Rifle Range area, only one, a TTHM, had an established regulation with a maximum contaminant level[g] though it did not apply to the Rifle Range water system because this system did not serve more than 10,000 people. The official noted that LANTDIV would add the Rifle Range water system to the TTHM testing that had been initiated in 1980. Additionally, he suggested no further action be taken until the Navy Assessment and Control of Installation Pollutants program[h] and TTHM analysis provided additional data. According to a handwritten note at the end of the memorandum, an environmental official at Camp Lejeune recommended arranging a meeting with the state in order to share these results.
August 26, 1981	The Commander of LANTDIV wrote a memorandum to the Commanding General of Camp Lejeune noting that in accordance with Camp Lejeune's request, it was providing the summary of TTHM regulations and copies of the TTHM testing reports for the two water systems that met the requirement to be tested.

Source: GAO analysis of Headquarters Marine Corps documents.

Note: We use the term "contamination," which is also used by the law requiring us to do this work, as well as by EPA and DOD, to describe the drinking water at Camp Lejeune in the early 1980s. However, EPA had not yet established maximum contaminant levels for the chemicals TCE and PCE during this period. See 40 C.F.R. §§ 141.2 and 141.12 (1975-1985).

[a]TTHMs are a type of volatile organic compound and are formed when disinfectants—used to control disease-causing contaminants in drinking water—react with naturally occurring organic matter in water.

[b]Many volatile organic compounds (VOCs) are human-made chemicals such as industrial solvents or components of fuels, paint thinners, and dry cleaning agents. TCE is a VOC typically used as a metal degreaser.

[c]Generally, the USAEHA reports did not indicate to whom they were sent.

[d]PCE is a VOC typically used as a dry cleaning solvent.

[e]Parts per billion are units commonly used to express contamination ratios of the amount of a contaminant in water, land, or air.

[f]Methylene chloride is a VOC used in various industrial processes including paint stripping, paint remover manufacturing, and metal cleaning and degreasing.

[g]Maximum contaminant levels are the maximum permissible level of a contaminant in water delivered to a public water system.

[h]The Navy Assessment and Control of Installation Pollutants program was established in 1980 to identify, assess, and control environmental contamination from past hazardous materials storage, transfer, processing, and disposal operations.

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Appendix III: Selected Events Related to Past Drinking Water Contamination at Camp Lejeune from 1982 through 1983

Date	Event
April 19, 1982	Camp Lejeune environmental officials began collecting monthly samples for monitoring of total trihalomethanes (TTHMs)[a] at all eight base water systems.
May 6, 1982	A private laboratory contracted by Camp Lejeune to conduct the TTHM analysis informed Camp Lejeune by telephone that synthetic organic cleaning solvents, including trichloroethylene (TCE),[b] were detected in the samples that were collected from April 19 to April 22, 1982, from the Tarawa Terrace and Hadnot Point water systems. Grainger Laboratory stated that TCE interference with the analysis of the Hadnot Point samples prevented the detection of a precise reading for TTHMs.
May 27 and May 28, 1982	Camp Lejeune environmental officials took a second set of monthly water samples at the base water systems because of problems with the collection of earlier samples taken from May 17 through May 24, 1982.
June 9, 1982	The private laboratory report of the results of the analysis of monthly samples collected May 27 and May 28, 1982, noted that an unknown compound was interfering with the testing for TTHMs at the Hadnot Point water system.
July 13, 1982	The private laboratory report of the results of the analysis of monthly samples collected June 24 and June 25, 1982, did not specifically note interference with the testing for TTHMs at the Hadnot Point water system, but, as in previous reports, noted that there was some uncertainty in the measurements for this water system.
July 28, 1982	Camp Lejeune environmental officials collected samples, which were in addition to the monthly samples, from the Hadnot Point and Tarawa Terrace water systems. An internal Camp Lejeune memorandum noted that the additional sampling was conducted because the private laboratory identified interference by TCE and another synthetic organic cleaning solvent while analyzing earlier samples from the Hadnot Point and Tarawa Terrace water systems for TTHMs.
August 10, 1982	The private laboratory sent a letter to Camp Lejeune officials stating that the contaminants interfering with the TTHM monitoring at the Tarawa Terrace and Hadnot Point water systems were TCE and tetrachloroethylene (PCE).[c] The laboratory noted that these chemicals appeared to be at high levels and were thus more important from a health standpoint than the TTHM levels. The laboratory further noted that the levels of PCE detected in the Tarawa Terrace water system had been relatively stable over the time period examined, while levels of TCE and PCE detected in the Hadnot Point water system had varied, and the most recent Hadnot Point readings had been at significantly lower levels than the levels detected in May.
August 18, 1982	Camp Lejeune officials decided to reduce monitoring for TTHMs from monthly to quarterly for six of the eight water systems, including Tarawa Terrace and Hadnot Point, beginning in September 1982. Officials noted in a memorandum that federal and state regulations required only quarterly sampling.[d]
August 19, 1982	A Camp Lejeune environmental official sent a memorandum to her supervisor that discussed the TTHM sampling and interference at the Tarawa Terrace and Hadnot Point water systems. She explained that the additional samples had been collected on July 28, 1982, to identify the source of the interference in the earlier TTHM testing; TCE and PCE were identified as the interfering chemicals. The official detailed the possible adverse health effects from both TCE and PCE, but further explained that TCE and PCE were not regulated under the Safe Drinking Water Act. However, she noted that the EPA had issued "suggested no adverse response levels"[e] and "suggested action guidance,"[f] which provided some guidance on unregulated contaminants. The official explained that levels of TCE and PCE detected in the Hadnot Point water system were presently within the limits suggested by the suggested no adverse response levels, but she offered no explanation for the higher level detected in samples taken in May 1982 and analyzed in July 1982. She also noted that it was possible that the levels of PCE detected in the Tarawa Terrace water system were the result of the use of asbestos-coated pipe in the water lines carrying untreated water.

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Date	Event
December 9, 1982	The private laboratory report of the results of the analysis of samples collected in November from all eight water systems for quarterly TTHM testing was provided to Camp Lejeune officials. This report stated that all samples from Tarawa Terrace indicated contamination from PCE and all samples from Hadnot Point indicated contamination from TCE and PCE.
December 21, 1982	An environmental official at Camp Lejeune wrote a memorandum to her supervisor about the TTHM analysis from November 1982. She noted that during a telephone conversation with a chemist at the private laboratory, the chemist had expressed concerns over the solvents that interfered with the Tarawa Terrace and Hadnot Point samples, particularly those from Hadnot Point. According to the memorandum, the chemist told the Camp Lejeune official that while the levels of TCE and PCE had dropped for a period of time, the November samples showed levels of TCE and PCE that were relatively high again.
September 16, 1983	The private laboratory report of the results of the analysis of samples collected on August 25 and August 26, 1983, from all eight water systems for TTHM testing was provided to Camp Lejeune officials. The report stated that all samples from Tarawa Terrace exhibited contamination from PCE and all samples from Hadnot Point exhibited contamination from both TCE and PCE.

Source: GAO analysis of Headquarters Marine Corps documents.

Note: We use the term "contamination," which is also used by the law requiring us to do this work, as well as by EPA and DOD, to describe the drinking water at Camp Lejeune in the early 1980s. However, EPA had not yet established maximum contaminant levels for the chemicals TCE and PCE during this period. See 40 C.F.R. §§ 141.2 and 141.12 (1975-1985).

[a]TTHMs are a type of volatile organic compound and are formed when disinfectants—used to control disease-causing contaminants in drinking water—react with naturally occurring organic matter in water.

[b]Trichloroethylene (TCE) is a volatile organic compound typically used as a metal degreaser.

[c]Tetrachloroethylene (PCE) is a volatile organic compound typically used as a dry cleaning solvent.

[d]Amendments in 1979 to the National Interim Primary Drinking Water Regulations required that water systems serving more than 10,000 people and adding a disinfectant as part of the drinking water treatment process to begin mandatory water testing for TTHMs by November 1982 and comply with the maximum contaminant level by November 1983. Only two water systems at Camp Lejeune, Hadnot Point and New River, served more than 10,000 people when TTHM testing was initiated at Camp Lejeune.

[e]EPA's suggested no adverse response levels were nonenforceable guidance for community water systems regarding TCE and PCE in drinking water issued in 1979 and 1980.

[f]EPA's suggested action guidance was a nonenforceable guidance suggesting that remedial action be taken when PCE exceeded specific levels.

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Appendix IV: Selected Volatile Organic Compounds Detected in Wells at Hadnot Point and Tarawa Terrace Water Systems

			Concentrations of chemicals in parts per billion[a]					
Water systems	Wells	Date removed from service	Benzene[b]	Trans-1,2-DCE[c]	1,1-DCE[d]	Methylene chloride[e]	Toluene[f]	Vinyl chloride[g]
Hadnot Point	602	Nov. 30, 1984	120	630	2.4	—	5.4	18
	601	Dec. 6, 1984	ND	88	ND	ND	ND	ND
	608	Dec. 6, 1984	3.7	5.4	ND	ND	ND	ND
	634	Dec. 14, 1984	ND	2.3	—	130	—	ND
	637	Dec. 14, 1984	ND	ND	—	270	—	—
	651	Feb. 4, 1985	—	3,400	187	—	—	655
	652	Feb. 8, 1985	—	ND	ND	—	—	ND
	653	Feb. 8, 1985	—	ND	ND	—	—	ND
Tarawa Terrace	TT-26	Feb. 8, 1985	ND	92	—	—	—	27
	TT-23[h]	Feb. 8, 1985	ND	11	—	—	—	ND

Source: GAO analysis of Headquarters Marine Corps data.

Notes: The detection limit for the instruments used to analyze the samples was 10 parts per billion. The detection limit is the lowest level at which the chemicals could be reliably identified by the instruments being used. A Marine Corps document providing the sampling results stated that ND meant "none detected." Where no concentration or ND is provided, the laboratory did not report results for these samples.

[a]The concentrations provided are those detected prior to each well's removal from service in 1984 and 1985 and are one-time sampling results. We did not find documentation that tied the decision to remove the wells from service to any particular level of contamination included in related Environmental Protection Agency (EPA) guidance or enforceable regulation.

[b]Benzene is a widely used chemical formed from both natural processes and human activities. Some industries use benzene to make other chemicals which are used to make plastics, resins, and nylon and synthetic fibers. Benzene is also a natural part of crude oil, gasoline, and cigarette smoke. Breathing benzene can cause drowsiness, dizziness, and unconsciousness; long-term benzene exposure causes effects on the bone marrow and can cause anemia and leukemia. The Department of Health and Human Services (HHS) has determined that benzene is a known carcinogen.

[c]Trans-1,2-dichloroethylene (Trans-1,2-DCE) is an odorless organic liquid used as a solvent for waxes and resins; in the extraction of rubber; as a refrigerant; in the manufacture of pharmaceuticals and artificial pearls; in the extraction of oils and fats from fish and meat; and in making other organics. EPA has found trans-1,2-DCE to potentially cause central nervous system depression when people are exposed to it at levels above 100 parts per billion for relatively short periods of time. Trans-1,2-DCE has the potential to cause liver, circulatory, and nervous system damage from long-term exposure at levels above 100 parts per billion.

[d]1,1-dichloroethylene (1,1-DCE) is an organic liquid with a mild, sweet, chloroform-like odor. Virtually all of it is used in making adhesives, synthetic fibers, refrigerants, food packaging, and coating resins. EPA has found 1,1-DCE to potentially cause liver damage when people are exposed to it at levels above 7 parts per billion for relatively short periods of time. 1,1-DCE has the potential to cause liver and kidney damage, as well as toxicity to the developing fetus, and cancer from a lifetime exposure at levels above 7 parts per billion.

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[e]Methylene chloride is a VOC used in various industrial processes, including paint stripping, paint remover manufacturing, and metal cleaning and degreasing. Breathing in large amounts of methylene chloride can damage the central nervous system. Contact of eyes or skin with methylene chloride can result in burns. HHS has determined that methylene chloride can be reasonably anticipated to be a cancer-causing chemical.

[f]Toluene is a clear, colorless liquid which occurs naturally in crude oil and in the tolu tree. It is also produced in the process of making gasoline and other fuels from crude oil and making coke from coal. Toluene may affect the nervous system. Low to moderate levels can cause tiredness, confusion, weakness, drunken-type actions, memory loss, nausea, loss of appetite, and hearing and color vision loss. Inhaling high levels of toluene in a short time can result in feelings of light-headedness, dizziness, or sleepiness. It can also cause unconsciousness, and even death. High levels of toluene may affect kidneys. Studies in humans and animals generally indicate that toluene does not cause cancer.

[g]Vinyl chloride is a colorless gas. It is a manufactured substance that does not occur naturally. It can be formed when other substances such as trichloroethane, trichloroethylene, and tetrachloroethylene are broken down. Breathing high levels of vinyl chloride for short periods of time can cause dizziness, sleepiness, unconsciousness, and at extremely high levels can cause death. Breathing vinyl chloride for long periods of time can result in permanent liver damage, immune reactions, nerve damage, and liver cancer. HHS has determined that vinyl chloride is a known carcinogen.

[h]Well TT-23 is also referred to as "TT-new well" in Marine Corps documents.

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Appendix V: Selected Events Related to Past Drinking Water Contamination at Camp Lejeune from 1984 through 1985

Date	Event
July 1984	Camp Lejeune initiated the Navy Assessment and Control of Installation Pollutants (NACIP)[a] confirmation study. The purpose of the confirmation study was to further investigate potential contamination at 22 priority sites at Camp Lejeune that were identified in an initial assessment study. As part of the confirmation study, sampling began at any well in the vicinity of a priority site where groundwater contamination was suspected. Prior water samples at Camp Lejeune had usually been drawn at the water treatment plants or in the distribution system—not from individual wells.
November 30, 1984	Camp Lejeune officials received results from the confirmation study sampling which detected trichloroethylene (TCE) and tetrachloroethylene (PCE), among other volatile organic compounds[b] (VOC), at a well serving the Hadnot Point water system, one of eight water systems at Camp Lejeune. This well was removed from service.
December 4, 1984	Water samples were collected from six Hadnot Point wells and from the untreated and treated water at the Hadnot Point water treatment plant. These wells were sampled because of their proximity to the contaminated well that was removed from service on November 30, 1984.
December 6, 1984	Camp Lejeune officials received results of the analysis of samples collected on December 4, 1984, that indicated three additional wells and the untreated and treated water from the Hadnot Point water system had levels of TCE and PCE, among other VOCs. In one of the wells, TCE was detected at 210 parts per billion (ppb)[c] and PCE was detected at 5 ppb. In the second well, TCE was detected at 110 ppb. In the third well, TCE was detected at 4.6 ppb. The first two wells were removed from service.[d]
December 10, 1984	A Camp Lejeune official contacted a North Carolina state environmental official by telephone to discuss suspected contamination found in wells, untreated water, and treated water from the Hadnot Point water system. The Camp Lejeune official explained Camp Lejeune anticipated that a resampling program would be initiated, and indicated that some form of information might be released to the public.
December 10, 1984	Samples were again collected from the same seven Hadnot Point wells and the treated water at the Hadnot Point water treatment plant.
December 13, 1984 through December 19, 1984	Separately, daily samples were collected from the untreated water at the Hadnot Point water treatment plant.
December 13, 1984	The base newspaper published its first article about water testing, VOC contamination, and corrective actions taken by base officials, including removing wells from service. The article did not identify TCE or PCE as the VOC contaminants.
December 14, 1984	Camp Lejeune officials received results of the analysis of samples collected on December 10, 1984, that indicated two additional wells in the Hadnot Point water system had significant levels of a VOC, methylene chloride,[e] while a third well also indicated levels of methylene chloride. TCE and PCE were not detected in these wells. Two of these three wells were removed from service.[f]
December 21, 1984	Camp Lejeune officials received the results of the analysis of samples that were collected from December 13 to December 19, 1984, at the Hadnot Point water treatment plant. TCE and PCE were not detected in these samples.
January 8, 1985	The director of the NACIP program at Camp Lejeune received a report[g] reviewing the December 1984 sampling of wells, untreated water, and treated water at the Hadnot Point water system. In the report, sampling of all the wells and the water treatment plants at Camp Lejeune was proposed.

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Date	Event
January 16, 1985	Samples were collected at all wells serving the Hadnot Point and Holcomb Boulevard water systems to be tested for VOCs.
January 23, 1985	Samples were collected at all wells serving four other water systems, including Tarawa Terrace, to be tested for VOCs.
January 27, 1985	A fuel line from Holcomb Boulevard water treatment plant leaked fuel into the water system. The Holcomb Boulevard water treatment plant was subsequently shut down and water from the Hadnot Point water system was pumped into the Holcomb Boulevard water lines.
January 31, 1985	Samples were collected at various locations within the Hadnot Point and Holcomb Boulevard water systems for analysis required by North Carolina prior to restarting the Holcomb Boulevard water treatment plant.
February 4, 1985	Camp Lejeune officials received results of the analysis of the samples collected on January 16, 1985, that indicated one additional well in the Hadnot Point water system had significant levels of TCE and PCE, among other VOCs. TCE was detected at 3,200 ppb and PCE was detected at 386 ppb. This well was removed from service. The results also noted that trace amounts of TCE were detected in two other Hadnot Point wells. In one well, TCE was detected at 9 ppb and in the other well TCE was detected at 5.5 ppb.
February 4, 1985	Camp Lejeune officials received results of the analysis of the samples collected on January 31, 1985, from various locations within the Hadnot Point and Holcomb Boulevard water systems. No gasoline was detected in samples from Holcomb Boulevard. However, various levels of TCE were detected in all of the samples; TCE was detected at levels ranging from 24 ppb to 1,148 ppb.
February 4, 1985	The Holcomb Boulevard water treatment plant was restarted.
February 7, 1985	Camp Lejeune officials received results of the analysis of the samples collected on January 23, 1985, that indicated that two wells in the Tarawa Terrace water system had levels of TCE and PCE. In one well, TCE was detected at 57 ppb and PCE was detected at 158 ppb. In the other well, TCE was detected at 5.8 ppb and PCE was detected at 132 ppb.
February 8, 1985	The two wells in the Tarawa Terrace water system that were found to be contaminated with TCE and PCE on February 7, 1985, were removed from service. Additionally, the two wells in the Hadnot Point water system that were found to be contaminated with trace levels of TCE and PCE on February 4, 1985, were removed from service.
March 12, 1985	According to an internal Camp Lejeune memorandum, one of the wells removed from service on February 8, 1985, was restarted on March 11, 1985, after samples were taken. After 24 hours of operation, additional samples were taken and the well was removed from service.
April 30, 1985	The Commanding General of Camp Lejeune issued a notice to the residents of Tarawa Terrace housing area regarding problems with the water supply. According to the notice, two of the wells that supplied water to the Tarawa Terrace water system were taken off line because “minute (trace)” amounts of several organic chemicals were detected in the water. The notice stated that there were no regulations regarding safe levels of the organic chemicals found in these wells, but as a precaution the Commanding General had ordered the wells to be removed from service in all but emergency situations. Additionally, the notice provided ways for residents to reduce water usage because of concerns that a water shortage might result following the removal of these wells from service.

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Date	Event
May 9, 1985	An article was published in the base newspaper explaining that 10 wells that served the Tarawa Terrace and Hadnot Point water systems were removed from service because of contamination. The article also noted the potential for water shortages in the Tarawa Terrace water system and included information about how to conserve water.
May 10, 1985	An article was published in a North Carolina newspaper providing similar information as that included in the May 9, 1985, base newspaper article regarding the contamination in the Tarawa Terrace and Hadnot Point water systems.
May 11, 1985	An article was published in a second North Carolina newspaper providing similar information as that included in the May 9, 1985, base newspaper article regarding the contamination in the Tarawa Terrace and Hadnot Point water systems.
May 31, 1985	Camp Lejeune officials sent a memorandum to Headquarters Marine Corps and LANTDIV noting that all 10 contaminated wells remained out of service, although 1 of the contaminated wells at Tarawa Terrace had been used on April 22, 23, and 29 to maintain water production.
September 15, 1985	An article was published in a third North Carolina newspaper that provided similar information as that included in the May 9, 1985, base newspaper article regarding the contamination in the Tarawa Terrace and Hadnot Point water systems.

Source: GAO analysis of Headquarters Marine Corps documents.

Note: We use the term "contamination," which is also used by the law requiring us to do this work, as well as by the Environmental Protection Agency (EPA) and the Department of Defense (DOD), to describe the drinking water at Camp Lejeune in the early 1980s. However, EPA had not yet established maximum contaminant levels for the chemicals TCE and PCE during this period. See 40 C.F.R. §§ 141.2 and 141.12 (1975-1985).

[a]As part of the Navy Assessment and Control of Installations Pollutants (NACIP) program, initial assessment studies were conducted to determine the potential for environmental contamination and if potential contamination was identified, a follow-up confirmation study was initiated.

[b]Many volatile organic compounds (VOCs) are human-made chemicals such as industrial solvents or components of fuels, paint thinners, and dry cleaning agents. TCE is a VOC typically used as a metal degreaser. PCE is a VOC typically used as a dry cleaning solvent.

[c]Parts per billion are units commonly used to express contamination ratios of the amount of a contaminant in water, land, or air.

[d]The Marine Corps were not able to provide documents that indicated why one of these three wells was not removed from service.

[e]Methylene chloride is a VOC used in various industrial processes including paint stripping, paint remover manufacturing, and metal cleaning and degreasing

[f]The Marine Corps were not able to provide documents that indicated why one of these three wells was not removed from service.

[g]The report did not indicate from whom it was sent.

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Appendix VI: Agency for Toxic Substances and Disease Registry's Response to its 2005 Scientific Advisory Panel's Recommendations

Scientific advisory panel's recommendations regarding future health studies of past drinking water contamination at Camp Lejeune	Agency for Toxic Substances and Disease Registry's (ATSDR) response
1. Create an advisory panel to oversee health studies related to Volatile Organic Chemical (VOC) exposures at Camp Lejeune.	Agreed. ATSDR will create a community assistance panel (CAP) comparable to other panels it has set up for community participation at National Priorities List sites. ATSDR recommended that its Camp Lejeune CAP be comprised of five or more community members and one or two scientific advisers, along with ex officio members from the Navy.
2. Conduct future studies in full partnership with the potentially exposed community.	Agreed. ATSDR said it considered interaction with the community an important aspect of its on-site work and planned to continue to work closely with organized community advocacy groups. It agreed to be responsive to recommendations from the CAP.
3. Establish a registry to identify groups of potentially exposed individuals to study, including exposed and unexposed individuals who had lived and/or worked at Camp Lejeune during the period of interest, which would serve as the population base for further studies.	Agreed. In order to identify various distinct groups of individuals with potential exposure, ATSDR said that efforts or activities should be conducted to determine if potential databases exist that would identify these groups, such as children who lived on base and adults who lived or worked on base. However, the agency said that it believed that it had already identified as completely as possible those who may have been exposed while in utero for the years 1968-1985.
4. Conduct various types of feasibility or pilot studies—to determine whether study individuals can be identified and tracked and what types of medical records are available—before embarking on full-scale studies of the impact on health of exposures at Camp Lejeune.	Agreed. ATSDR will conduct a feasibility assessment to determine the number of adults and children that could be identified through available data sources.
5. Study additional health outcomes, such as mortality and cancer incidence. Also, conduct feasibility studies of other adverse health outcomes, such as autoimmune diseases; spontaneous abortion; neurological effects; organ failure; adult heart disease; reproductive outcomes of male and female children who were born (or were in utero) at Camp Lejeune; birth defects beyond those considered by ATSDR; and ocular problems.	Agreed. ATSDR agreed that mortality and cancer incidence should receive the highest priority and are the outcomes most feasible to study. The agency said that decisions concerning study period, study population, and study outcomes should be made in consultation with the CAP, and said that ATSDR would defer decisions about additional health studies until feasibility studies were completed and reviewed by the CAP.
6. Conduct future research activities in parallel with the current study and without awaiting completion of current ATSDR activities.	Agreed. The agency said that its highest priority is to complete the current study. Development of a CAP and further research activities would likely require additional staffing and resources, which ATSDR said it would request from the Department of Defense (DOD).
7. Amend the 1997 public health assessment to include the possibility that adult cancers and other adverse health outcomes may be related to VOC exposures. Additionally, in the period since release of the original public health assessment, much additional information on exposures at Camp Lejeune and their potential risks has been developed, and this additional material should be incorporated into an amended document.	Did not agree. ATSDR said revisions to the assessment would be needed only if new information changed the assessment's conclusions or recommendations. ATSDR noted that its assessment acknowledged that the science was inconclusive and did not rule out the possibility of cancerous health effects from low-dose exposure to VOCs.
8. Notify all persons potentially affected by exposure to VOCs in the drinking water at Camp Lejeune.	Did not respond directly. ATSDR indicated that it would work with the CAP to determine effective ways to disseminate information about its current study and any future health studies.

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Scientific advisory panel's recommendations regarding future health studies of past drinking water contamination at Camp Lejeune	Agency for Toxic Substances and Disease Registry's (ATSDR) response
9. Obtain future funding for Camp Lejeune health studies through direct congressional appropriation, not through DOD's budget, to avoid even the appearance of a conflict of interest.	Did not agree. ATSDR said it recognized that the affected community had some distrust of ATSDR and DOD, and said that the CAP was intended to help mitigate this distrust. However, ATSDR suggested that DOD is the most likely funding source for these research activities because no other funds are available outside those budgeted to complete the current study.

Sources: U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, *Report of the Camp Lejeune Scientific Advisory Panel* (Atlanta, Ga.: 2005). Agency for Toxic Substances and Disease Registry, *ATSDR Response to the Report of the Camp Lejeune Scientific Advisory Panel Held February 17-18, 2005* (Atlanta, Ga.: 2005).

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Appendix VII: Description of Current Agency for Toxic Substances and Disease Registry (ATSDR) Health Study

ATSDR is conducting a study of the potential health effects of exposure while in utero and as infants up to 1 year of age to trichloroethylene (TCE) and tetrachloroethylene (PCE)—two volatile organic chemicals found in drinking water at Marine Corps Base Camp Lejeune in the 1980s. ATSDR's study will analyze whether exposure to the TCE or PCE-contaminated drinking water at Camp Lejeune before birth is associated with increased risks of specific birth defects or childhood cancers. These birth defects include (1) neural tube defects, (2) oral cleft defects, and (3) childhood leukemias and non-Hodgkin's lymphoma, which have been combined into one category of hematopoietic cancers.

ATSDR's efforts to conduct this study began in 1999 with a telephone survey conducted with parents of 12,598 individuals born to women who were pregnant with them while living in on-base housing at Camp Lejeune any time from 1968 through 1985. Parents were asked if their child had a birth defect or developed a childhood cancer, along with other questions such as those to confirm residency on base during the specific time period and questions regarding water usage. A total of 106 potential cases of the childhood cancers or birth defects were reported by the interviewed parents.[1] ATSDR reviewed health records in order to verify the reported health problems and had confirmed 57 cases of the childhood cancers or birth defects as of June 2006. (See table 6.) The study population includes the 57 individuals with confirmed health problems and 548 comparison individuals chosen randomly from among the remaining individuals identified in the survey.

[1]There were 103 potential cases reported during the survey; 3 additional potential cases were reported to ATSDR after the survey was closed.

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Table 6: Potential and Confirmed Cases of Childhood Cancers and Birth Defects as of April 2006

Health condition	Reported cases of health conditions	Confirmed cases with diagnosis of health condition	Cases not yet confirmed	Cases confirmed as without health condition, refused to participate, or ineligible
Neural tube defects	35	17	2	16
Oral clefts	42	24	4	14
Childhood cancers	29	16	2	11
Total	**106**	**57**	**8**	**41**

Source: ATSDR.

As part of this study, ATSDR officials are also conducting computer modeling of the drinking water system at Camp Lejeune from 1968 through 1985 in order to determine which pregnant women were probably exposed to the contaminated drinking water and to estimate their levels of exposure. ATSDR's drinking water distribution system model is based on current and historical information for the base water system as well as historical information on the sources of the contamination. The results of the model are intended to establish whether the mothers of the individuals with the birth defects or childhood cancers were more likely to have been exposed during their pregnancy to the drinking water contaminants than were the mothers of the comparison individuals. ATSDR officials said they did not expect to finalize exposure categories for the current study until February or March 2007, after most water modeling activities were completed, but noted that they would use the water modeling results to assign multiple exposure levels to each study participant. Additionally, data gathered from the survey about the mothers' drinking water and other home water use activities, such as dishwashing, clothes washing, and bathing, will be combined with the estimated exposures levels to create another exposure measure. ATSDR officials also said the current study will analyze results for individuals who were exposed to TCE separately from those exposed to PCE and will analyze cancer and each type of birth defect separately. The study is expected to be completed by December 2007.

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Appendix VIII: GAO Contact and Staff Acknowledgments

GAO Contact

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Acknowledgments

In addition to the contact named above, Bonnie Anderson, Assistant Director; Karen Doran, Assistant Director; George Bogart; Helen Desaulniers; Cathleen Hamann; Danielle Organek; Roseanne Price; Christina Ritchie; and Stuart Ryba made key contributions to this report.

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