UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF RHODE ISLAND

EMHART INDUSTRIES, INC., Plaintiff and Counterclaim Defendant, v. NEW ENGLAND CONTAINER COMPANY, INC; et al., Defendants and Counterclaim Plaintiffs.	C.A. No. 06-218 S
EMHART INDUSTRIES, INC., Plaintiff and Counterclaim Defendant, v. UNITED STATES DEPARTMENT OF THE AIR FORCE; et al., Defendants, Counterclaim Plaintiffs, and Third-Party Plaintiffs, v. BLACK & DECKER, INC.; et al., Third-Party Defendants.	C.A. No. 11-023 S

PHASE I FINDINGS OF FACT AND CONCLUSIONS OF LAW

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Introduction

This environmental case arises from pollution discovered within the Centredale Manor Restoration Project Superfund Site ("Site") located in North Providence, Rhode Island. Plaintiff and Counterclaim Defendant, Emhart Industries, Inc. ("Emhart"), initiated this case in May 2006, when it asserted cost recovery and contribution claims under §§ 107(a) and 113(f) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("CERCLA"), see 42 U.S.C. §§ 9607(a), 9613(f), against New England Container Co. ("NECC") and its

insurers related to the pollution at the Site.[1] (C.A. No. 06-218, ECF No. 1.)[2] In January 2011, Emhart filed suit against the United States Department of the Air Force, the United States Department of the Navy, the United States Department of Defense, the secretaries of each of these departments, and the United States (collectively, "the DOD"), asserting CERCLA claims similar to those asserted in its case against NECC.[3] (Emhart's Compl. ¶¶ 41-54, ECF No. 1.)

Since that time, the parties have filed a bevy of claims against one another: the DOD filed a CERCLA contribution counterclaim against Emhart (Counterclaim ¶¶ 42-44, ECF No. 32);

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[1] This case represents the second installment in Emhart's Site-related litigation in this Court. In Emhart Industries, Inc. v. Home Insurance Co., C.A. No. 02-53 S ("Home Insurance"), Emhart sought a defense and indemnity from several of its insurance carriers related to remediation of the environmental contamination at the Site. The factual and procedural background of the Home Insurance case is not pertinent to this case and is discussed elsewhere. See Emhart Indus., Inc. v. Home Ins. Co., 515 F. Supp. 2d 228 (D.R.I. 2007), aff'd sub nom. Emhart Indus., Inc. v. Century Indem. Co., 559 F.3d 57 (1st Cir. 2009).

[2] Unless otherwise indicated, all ECF numbers provided herein correspond to C.A. No. 11-23.

[3] Emhart also asserted claims against the DOD for divisibility, equitable indemnity, and declaratory judgment with respect to divisibility and equitable indemnity ("the additional claims") (see Compl. ¶¶ 56-66, ECF No. 1), but this Court granted the DOD's motion to dismiss the additional claims. (See Order Granting the DOD's Mot. to Dismiss 4-7, ECF No. 27.) Emhart's case against the DOD was consolidated with its suit against NECC on July 2, 2012. (ECF No. 51.)

the United States, on behalf of the Environmental Protection Agency ("the EPA" and, collectively with the DOD, "the Government"), filed a CERCLA cost recovery counterclaim against Emhart (Counterclaim ¶¶ 45-50, ECF No. 32); the Government filed a third-party complaint against Black & Decker, Inc. ("Black & Decker"), Emhart's successor, asserting the same claims as those asserted in its counterclaim against Emhart (ECF No. 34); Black & Decker filed a third-party counterclaim against the DOD, asserting the same claims that are asserted by Emhart in its claims against the DOD (ECF No. 49);[4] the Government filed a crossclaim against NECC, asserting a CERCLA cost recovery claim and a CERCLA contribution claim on behalf of the DOD (ECF No. 67); NECC asserted CERCLA cost recovery and contribution crossclaims against the DOD (ECF No. 93); and the Government filed a claim against Emhart arising from its failure to comply with a CERCLA cleanup order (Gov't's 2d Am. Answer & Counterclaims ¶¶ 53-60, ECF No. 357; Gov't's 2d Am. 3d Party Compl. ¶¶ 65-72, ECF No. 358).

This Court set a phased-trial schedule for this case (8th Rev. Case Mgmt. Order 2, ECF No. 295), which was modified

[4] The parties have agreed that Black & Decker is responsible for satisfying any judgment entered against Emhart in this case. (Stipulation & Proposed Order 2-3, ECF No. 323.) For simplicity's sake, this Court refers to Emhart and Black & Decker collectively as "Emhart."

multiple times to accommodate the parties' discovery needs.[5] The first phase was slated to address the liability of Emhart and NECC, including divisibility and the proper allocation of responsibility between Emhart and NECC in the event that both were found jointly and severally liable under CERCLA. (Id.) However, shortly before trial on the first phase commenced, NECC, which had "limited financial ability to pay for response costs incurred and to be incurred at the Site" (Consent Decree 2, ECF No. 375) settled with the Government for $8,750,000, the remainder of NECC's insurance coverage (id. at 2, 5), and a consent decree reflecting this settlement was approved and

[5] As the written document makes pellucid, the trial in this first phase was over nine years in the making and involved an extraordinary line-up of scientific and technical experts. Along the way, at the suggestion of the Government, Emhart, and NECC, this Court engaged a scientific advisor, Dr. William M. Risen, Jr., Professor of Chemistry (Emeritus), Brown University. As the case proceeded, Dr. Risen participated in the depositions of several expert witnesses. And, at trial, with the consent of both Emhart and the Government, Dr. Risen was permitted to pose questions to witnesses following the conclusion of the parties' respective examinations of each witness. At the conclusion of Dr. Risen's questioning, the parties were entitled to follow up with the witness as they saw fit. Dr. Risen's contributions to this Court's understanding of the complex science at the heart of the case cannot be understated, and the Court is most thankful for his assistance. In addition, as the Court has made clear on the record, the skill and professionalism of all counsel was second to none. The Court is very appreciative of the efforts of counsel, their experts, and their trial teams for their skilled management and presentation of this complex matter.

entered by this Court during trial.[6] (Id.) Therefore, the focus of the first phase of this case was narrowed to the questions of whether Emhart is liable under CERCLA and, if so, whether the harm is divisible. In addition, because of the "somewhat unique" position that the DOD occupied in this case based on the connection between its alleged conduct and Emhart's defenses (8th Rev. Case Mgmt. Order 2, ECF No. 295), this Court ordered the following:

> All evidence pertaining to the [DOD's] liability for contamination of the Site will be presented during the first phase (the liability phase) of the trial. However, during this phase, the evidence will be used solely to determine the liability of Emhart and NECC and whether this liability (if proven) is divisible among the two parties. The Court will not rule on the liability of the [DOD], or its amount in contribution, if any, until the third phase when it considers the contribution of the Third-Party Defendants.

(Id. at 3.)[7]

As is relevant to the first phase of this case, the Government asserts a CERCLA cost recovery claim ("Count Two")

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[6] In recognition of this settlement, all claims asserted by Emhart against NECC and its insurers and by NECC against Emhart were dismissed with prejudice by stipulation of Emhart, NECC, and NECC's insurers. (ECF No. 362.)

[7] After the first phase, the phased-trial schedule contemplates the following phases, if necessary: a second phase to address costs, whether the remedy selected by the EPA is consistent with CERCLA, and the Government's claim that Emhart failed to comply with a CERCLA cleanup order ("Count Three") (see ECF Nos. 357-58); and a third phase to address the liability and contribution of the third-party defendants and the DOD. (See 8th Rev. Case Mgmt. Order 2, ECF No. 295; Order Granting Gov't's Mot. to Amend 1-2, ECF No. 350.)

and, on behalf of the DOD, a CERCLA contribution claim ("Count One") against Emhart. (See Gov't's 2d Am. Answer & Counterclaims ¶¶ 42-52, ECF No. 357; Gov't's 2d Am. 3d Party Compl. ¶¶ 53-64, ECF No. 358.) Emhart principally denies any liability under CERCLA. (See Emhart's Proposed Findings of Fact & Conclusions of Law ("Emhart's Post-trial Br.") 150-62, ECF No. 378.) As a fallback, Emhart claims that, even if it is liable under § 9607(a), it is not jointly and severally liable for all response costs because the environmental harm for which it may be responsible is divisible from that caused by NECC. (See id. at 162-77, ECF No. 378.) Finally, Emhart continues to assert a CERCLA contribution claim ("Count Two") and a CERCLA cost recovery claim ("Count One") (and an accompanying declaratory-judgment claim relating to those claims) against the DOD.[8] (See

[8] Additionally, notwithstanding this Court's dismissal of the additional claims asserted in Emhart's original complaint, see supra note 3, Emhart purports to reassert those claims in its operative pleadings. (See Emhart's 2d Am. Compl. ¶¶ 56-68, ECF No. 69.) This appears to be an oversight on Emhart's part, as the additional claims for divisibility and equitable indemnity are asserted in Emhart's Second Amended Complaint but not in Black & Decker's Answer & First Amended Counterclaim. In any event, to the extent that Emhart intended to reassert the additional claims, they fail for the reasons stated in the Court's order dismissing those claims. (See Order Granting the DOD's Mot. to Dismiss 4-7, ECF No. 27.) Moreover, even assuming that the additional claims are cognizable, Emhart has abandoned its equitable-indemnity claim and its independent claim for "divisibility" (as opposed to its effort to avoid joint-and-several liability under CERCLA by invoking the defense of divisibility) by failing to press them either at trial or in its post-trial brief.

Emhart's 2d Am. Compl. ¶¶ 42-55, 65-68, ECF No. 69; Black & Decker's Answer & 1st Am. Counterclaim ¶¶ 30-50, ECF No. 367.)

The Court presided over a twenty-day bench trial beginning on May 18, 2015. After trial, the parties submitted post-trial briefs. (ECF Nos. 378-79.) After considering the evidence presented at trial and the pre- and post-trial memoranda submitted by the parties, the Court makes the following findings of fact and conclusions of law, pursuant to Rule 52(a) of the Federal Rules of Civil Procedure.[9] This Court's findings of fact have been grouped into the following categories: a brief background of the Site and the relevant operational history of the entities that occupied it; a general overview of the industrial practices of NECC and Metro Atlantic, Inc. ("Metro Atlantic");[10] an in-depth discussion of Metro Atlantic's manufacture of hexachlorophene ("HCP"); findings regarding principles of fate and transport of contaminants and their application to the Site; and a brief discussion of the costs incurred by the EPA, as well as future costs, for the remediation of the contamination on the Site. In broad strokes,

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[9] To the extent that any finding of fact reflects a legal conclusion, it should be, to that extent, deemed a conclusion of law, and vice versa.

[10] The parties agree that Emhart is the corporate successor to Metro Atlantic. (Stipulation & Proposed Order 2, ECF No. 323.)

this Court finds that Metro Atlantic released a hazardous substance – namely, 2,3,7,8-tetrachlorodibenzo-p-dioxin ("2,3,7,8-TCDD") – to the Site through its manufacture of HCP, that the 2,3,7,8-TCDD was transported to downstream areas, and that the EPA incurred response costs as a result of the release of dioxin.[11] From these findings of fact, this Court ultimately concludes that Emhart is jointly and severally liable under § 107(a) of CERCLA and that Emhart has not proved by a preponderance of the evidence that there is a reasonable basis in this evidentiary record to apportion the harm. This Court also finds that Emhart's claims against the DOD fail because Emhart did not prove by a preponderance of the evidence that the DOD drums purchased by NECC contained a hazardous substance. The tale follows.

I. Findings of Fact

A. Site Description and Operational History

The Site, which is depicted in Appendix A, spans a three-mile stretch of the Woonasquatucket River,[12] and encompasses an area labeled the Source Area ("peninsula"), Allendale Pond, the

[11] 2,3,7,8-TCDD is the most toxic dioxin and one of the most toxic substances found on the Site. (Trial Tr., vol. I, 96:2-96:4, May 18, 2015, ECF No. 383; Trial Tr., vol. XII, 17:1-17:8, June 8, 2015, ECF No. 394.)

[12] The Woonasquatucket River is one of fourteen American Heritage rivers identified by the EPA pursuant to the American Heritage Rivers program. (Trial Tr., vol. I, 69:23-70:3, ECF No. 383.)

Oxbow Area,[13] Lyman Mill Pond, Manton Pond, and Dyerville Pond. (Remedial Investigation Report ("RIR") 1-2, U.S. Ex. 43.) The Site also contains residential areas along portions of the Woonasquatucket River and on either side of the Lyman Mill Dam. (Trial Tr., vol. I, 70:19-71:6, May 18, 2015, ECF No. 383.) The descriptively named Source Area, depicted in Appendix B, is a nine-acre peninsula in the northern portion of the Site that the EPA has identified as the source of the hazardous substances with which the Site is contaminated.[14] (Id. at 71:15-71:20, 72:4-72:10, 92:16-92:19.) The peninsula is bounded to the north by Smith Street, to the south by Allendale Pond, to the west by the Woonasquatucket River, and to the east by the "tailrace," a remnant of a narrow body of water used for water power by the mills that used to occupy the peninsula. (Id. at 72:13-73:1; RIR 1-2, U.S. Ex. 43.) There are currently two elderly housing facilities located on the peninsula: Brook Village and

[13] The Oxbow Area is a wetland area in the middle of the Site that was described as "a very high habitat area in Rhode Island." (Id. at 70:10-70:15.)

[14] The EPA reached this conclusion because its sampling revealed significantly higher levels of contamination in the peninsula and in areas of the Woonasquatucket River that run alongside and south of the peninsula when compared to areas of the Woonasquatucket River north of the peninsula. (Id. at 73:4-73:10.)

Centredale Manor. (Trial Tr., vol. I, 73:13-73:21, ECF No. 383.)

In 1996, dioxin was discovered in fish collected from the Woonasquatucket River. (Id. at 74:14-74:17; RIR 1-4, U.S. Ex. 43.) The EPA investigated the Site and, in 2000, listed it on the National Priorities List ("NPL") of Superfund sites.[15] (Trial Tr., vol. I, 74:23-75:1, ECF No. 383; RIR 1-4, U.S. Ex. 43.) Ultimately, the EPA determined that the Site was polluted by a variety of contaminants, including dioxins, volatile organic compounds ("VOCs"), polychlorinated biphenyls ("PCBs"), semi-volatile organic compounds ("SVOCs"), polycyclic aromatic hydrocarbons ("PAHs"), and various metals. (Trial Tr., vol. I, 83:24-84:9, 85:9-85:12, 95:16-95:19, ECF No. 383; RIR 7-2 to 7-3, U.S. Ex. 43.) The EPA considers dioxins – and 2,3,7,8-TCDD, in particular – to be one of the primary contaminants of concern at the Site.[16] (Trial Tr., vol. I, 96:5-96:12, 105:12-105:20, ECF No. 383; RIR 1-6, 4-1, U.S. Ex. 43.) Although the EPA identified several entities as potentially responsible parties

[15] When a site is listed on the NPL, it becomes potentially eligible for "remedial action financed by the Superfund," 1 James T. O'Reilly, Superfund & Brownfields Cleanup § 6:5, at 143-44 (2014-15 ed.), a trust fund established by CERCLA to pay certain costs for the cleanup of hazardous-waste sites. See 42 U.S.C. § 9611(a).

[16] Depictions of the 2,3,7,8-TCDD contamination on the peninsula and in downstream areas of the Site are contained in Appendices C and D.

("PRPs") (Record of Decision ("ROD"), Part 2, at 7-9, U.S. Ex. 68), its investigation zeroed in on two primary culprits: Metro Atlantic and NECC (see RIR 7-1, U.S. Ex. 43).

Following a period dating back to the 1800s in which the peninsula was occupied by other entities, including textile mills,[17] Metro Atlantic began operating on the peninsula in approximately 1943.[18] (Id. at 1-3.) Metro Atlantic conducted its operations on the peninsula in several different buildings. (Trial Tr. vol. I, 126:19-126:25, ECF No. 383; U.S. Exs. 234-38.) Metro Atlantic's main building was in the northeast corner of the peninsula.[19] (See U.S. Exs. 234-38; Emhart Ex. 15; Trial Tr., vol. XIV, 8:20-8:24, 9:13-9:23, June 10, 2015, ECF No.

[17] Neither party appears to ascribe responsibility for the hazardous substances found on the Site to the entities that occupied the peninsula before Metro Atlantic.

[18] The entity that began operations on the peninsula in 1943 was known as Atlantic Chemical Company. (RIR 1-3, U.S. Ex. 43.) This entity changed its name to Metro Atlantic in 1953 (id. at 1-3, Table 1-1), and the parties agree that Metro Atlantic – and, by extension, Emhart – is liable for any of Atlantic Chemical Company's activities on the peninsula.

[19] Although witnesses and the parties have consistently referred to Metro Atlantic's "main building" as if it was a single unit, there were several discrete components of Metro Atlantic's operations in that area, including the principal manufacturing building, offices to the north, a laboratory to the east, a maintenance building and dryer room to the west, and a boiler room to the south. (See Tr. of Oct. 29, 2008 Deposition of John Turcone ("Turcone 10/29/08 Dep. Tr.") 10:15-11:5, 14:9-14:16, 15:17-15:19, 30:17-31:3, 70:1-70:13, 70:25-71:8; Emhart Ex. 139.) With that caveat, this Court also uses "main building" to encompass Metro Atlantic's area of operations in the northeast portion of the peninsula.

396.) In addition to this facility, Metro Atlantic also conducted two operations for brief periods of time on the western side of the peninsula, along the bank of the Woonasquatucket River, southwest of its main building. (See U.S. Exs. 237-38, 240; Trial Tr., vol. I, 127:18-127:20, 140:25-141:14, 143:24-144:8, ECF No. 383.) For "about a year" in approximately 1962 or 1963, Metro Atlantic manufactured trifluralin, a pesticide, in an approximately thirty-foot high, two-story temporary structure – referred to as the "Texas Tower" by employees who worked there – that it constructed in that area. (Tr. of Deposition of Daniel Paterson ("Paterson Dep. Tr.") 24:21; see also id. at 23:4-23:11, 24:18-24:22, 25:19-25:25; Trial Tr., vol. I, 140:25-141:14, ECF No. 383; Trial Tr., vol. VII, 48:7-48:13, June 1, 2015, ECF No. 389; U.S. Ex. 237; Emhart Exs. 13, 329.)[20] Later, in the mid-1960s, Metro Atlantic manufactured HCP in a separate building ("HCP building") located in the same area as Metro Atlantic's previous trifluralin operation.[21]

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[20] The parties have designated portions of the prior testimony of 33 individuals to be used in lieu of in-court testimony for those witnesses.

[21] At trial, the parties appeared to dispute whether the HCP building represented a mere expansion of the trifluralin building or was a completely separate structure erected after the Texas Tower was disassembled. Ultimately, this Court need not resolve this dispute because, even if the HCP building was a

NECC began to operate its drum-reconditioning business on the peninsula in approximately 1952. (See RIR Table 1-1, U.S. Ex. 43.) NECC's buildings were south of Metro Atlantic's main building on the eastern side of the peninsula. (See Trial Tr., vol. I, 126:25-127:1, ECF No. 383; U.S. Ex. 238.) The area in which Metro Atlantic manufactured trifluralin and HCP was situated to the west of the NECC buildings. (See Trial Tr., vol. I, 126:25-127:1, ECF No. 383; U.S. Ex. 238.) Like Metro Atlantic's buildings, the NECC buildings also underwent change throughout NECC's tenure on the peninsula.

An access road ran in a north-south direction on the peninsula, past NECC's buildings and Metro Atlantic's main building and HCP building (during the time period in which that building existed). (See Trial Tr., vol. I, 124:1-124:9, ECF No. 383; Trial Tr., vol. VII, 110:4-110:8, ECF No. 389; U.S. Ex. 238.) The road provided unimpeded access from Smith Street at the northern portion of the peninsula to a waste disposal area ("the WDA") in the southern portion of the peninsula. (See Trial Tr., vol. I, 124:1-124:9, ECF No. 383.) During Metro Atlantic's and NECC's time on the peninsula, the WDA increased

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mere expansion, the differences in drainage systems in the two buildings are significant. (See Trial Tr., vol. III, 161:14-161:18, 163:7-163:25, 177:16-178:4, May 20, 2015, ECF No. 385.) This Court therefore assumes, in accordance with Emhart's position, that the HCP building was new construction.

in size, and the amount of material discarded in the WDA also increased through the years. (See id. at 123:18-123:21, 133:23-134:1, 136:10-136:25, 139:7-139:19, 143:13-143:23, 149:19-149:21; Trial Tr., vol. VII, 34:9, 34:12-34:14, 38:13-38:16, 39:5-39:11, 42:2-42:5, ECF No. 389; U.S. Exs. 234-38, 240, 242; Emhart Exs. 325A, 326A, 327A.)

In 1972, a large fire damaged all of the buildings on the peninsula and, as of March 1974, all of them had been demolished. (See N. Providence Fire Dept. Fire Reports 36-37, U.S. Ex. 16; Trial Tr., vol. III, 141:20-142:8, May 20, 2015, ECF No. 385; Trial Tr., vol. VII, 97:1-97:12, ECF No. 389; Emhart Ex. 24.)

B. Overview of Industrial Practices

1. Metro Atlantic's Main-Building Operations

In its main building, Metro Atlantic manufactured several textile chemicals, including water repellants, resins, cotton softeners, powdered soaps, reserve salt (an anti-bleeding agent for textile dyes or a metal stripper), and sulfonated tallow for wool. (See Trial Tr., vol. VII, 203:10-203:17, ECF No. 389; Tr. of Deposition of Lawrence R. Bello ("Bello Dep. Tr.") 9:6-9:13.) In addition, Metro Atlantic received and relabeled packages of dye. (See Tr. of May 13, 2013 Deposition of Joseph Buonanno, Jr. ("J. Buonanno 5/13/13 Dep. Tr.") 106:19-107:17.) The raw materials used in connection with the manufacture of these

products included alcohols, formaldehyde, urea, sulfur trioxide, metal salts, fixatives, melamine, detergents, silicone, nitrobenzene, boric acid, sulfuric acid, citric acid, hydrochloric acid, tallow, methanol, and isopropyl. (See Trial Tr., vol. VII, 203:18-203:22, ECF No. 389; Bello Dep. Tr. 34:16-35:19; Tr. of Jan. 17, 2003 Deposition of Joseph Buonanno, Jr. 17:7-17:21, 84:10-85:20.)

Because the Court finds that Emhart is liable under CERCLA as a result of releases that occurred in connection with Metro Atlantic's manufacture of HCP (which is detailed below), it need not decide whether Metro Atlantic is liable under CERCLA for a release of a hazardous substance in connection with its main-building operations. However, findings regarding two aspects of Metro Atlantic's main-building operations – the destinations of solid and liquid waste – bear on critical factual disputes in this case. Therefore, these two aspects are addressed below.

a. Destination of Solid Waste

The evidence demonstrates that, through the years that it operated on the peninsula, Metro Atlantic deposited some of its solid waste from its main-building operations in the WDA in the southern portion of the peninsula. Numerous witnesses recounted observing varying types of Metro Atlantic refuse, including laboratory jars and other glassware (some of which contained residues), galvanized steel 20-gallon or 25-gallon DuPont

Chemical cans (some with shipping labels to Metro Atlantic), dyes, barrels, and drums. (Trial Tr., vol. I, 220:13-220:18, 220:21-221:23, ECF No. 383; Trial Tr., vol. II, 10:6-10:20, 11:2-11:15, 11:21-12:7, 12:16-13:2, 38:9-38:16, 42:17-43:4, 48:8-48:10, May 19, 2015, ECF No. 384; Trial Tr., vol. III, 132:6-132:17, ECF No. 385; U.S. Exs. 183-84, 186; Tr. of June 12, 2013 Deposition of Raymond Nadeau ("R. Nadeau 6/12/13 Dep. Tr.") 78:11-78:14; Tr. of May 16, 2013 Deposition of Vincent Buonanno ("V. Buonanno 5/16/13 Dep. Tr.") 382:13-382:16, 399:19-400:22, 401:3-401:13, 402:8-402:16; see also U.S. Ex. 34 (minutes from a 1964 meeting of the North Providence Town Council in which a representative of Metro Atlantic acknowledged "years of dumping").) Don Asselin, who "used to scavenge through the dumpsite looking for lumber to build treehouses" as a child in the early 1960s, recalled seeing Metro Atlantic employees back trucks emblazoned with Metro Atlantic's name up to the WDA in order to allow them to conveniently dump waste. (Trial Tr., vol. II, 28:18, 32:18-33:5, 36:13-36:14, 40:14-40:17, 47:25-48:5, 50:9-50:17, ECF No. 384.) Similarly, Raymond Nadeau, who worked for NECC from the mid-1950s to 1969, referred to the WDA as "Metro's dump" and recalled seeing Metro Atlantic employees drive Metro Atlantic trucks down to the WDA to dump waste. (R. Nadeau 6/12/13 Dep. Tr. 78:5-78:7, 78:15-78:25; Tr. of Raymond Nadeau's Trial Testimony in Home Insurance Case ("R.

Nadeau Home Ins. Trial Tr.") 79:24-80:4; Tr. of Sept. 10, 2008 Deposition of Raymond Nadeau ("R. Nadeau 9/10/08 Dep. Tr.") 7:4-7:5.) Nadeau testified that Metro Atlantic used the WDA throughout the period of his employment with NECC. (R. Nadeau Home Ins. Trial Tr. 79:16-80:8.)[22]

However, the WDA was not always the exclusive destination for the solid waste generated in Metro Atlantic's main-building operations. Several former Metro Atlantic employees testified that, during the mid-1960s, there was a dumpster adjacent to the southwest corner of Metro Atlantic's main building in which the waste generated in that building was deposited. (See Trial Tr., vol. XIV, 4:11-4:13, 17:24-18:23, 21:2-21:17, 24:9-24:13, 33:20-34:12, ECF No. 396; Emhart Ex. 351A; Tr. of John Turcone's Trial Testimony in Home Insurance Case ("Turcone Home Ins. Trial Tr.") 47:19-47:22, 49:11-49:20; Tr. of Sept. 12, 2013 Deposition of John Turcone ("Turcone 9/12/13 Dep. Tr.") 27:18-27:23; Tr. of Dec. 16, 2002 Deposition of John Turcone ("Turcone 12/16/02 Dep. Tr.") 11:21-12:9, 44:6-45:5, 57:23-58:9; J. Buonanno 5/13/13 Dep. Tr. 118:19-118:25; see also Locke Slide 14, Emhart Ex.

[22] Metro Atlantic's practice of dumping its solid waste on the same land on which it manufactured chemicals was not uncommon for that time period. (See Waste Disposal Site Survey X, U.S. Ex. 290 (results of a 1979 congressionally-commissioned survey of 53 of the largest United States chemical manufacturers indicating that 94% of the chemical waste generated by the chemical manufacturers since 1950 was "disposed of on the immediate property of the chemical plants" and only 6% was "sent off-site for disposal").)

342.) The dumpster was described as a "Truk-Away" or roll-off container. (J. Buonanno 5/13/13 Dep. Tr. 119:12-119:21; see Tr. of Oct. 29, 2008 Deposition of John Turcone ("Turcone 10/29/08 Dep. Tr.") 18:15-18:25; Tr. of Nov. 30, 1999 Deposition of John Turcone ("Turcone 11/30/99 Dep. Tr.") 15:2-15:15.) Consistent with this testimony, Robert D. Mutch, an expert in aerial-photographic interpretation, identified a possible roll-off dumpster adjacent to Metro Atlantic's main building in an April 1965 aerial photograph. (Trial Tr., vol. VII, 12:6, 24:12-24:18, 64:2-64:11, ECF No. 389; Emhart Ex. 336B.)

Therefore, this Court finds that, during the time that it operated on the peninsula, Metro Atlantic disposed of the solid waste generated in its main-building operations in both dumpsters and the WDA.

b. Destination of Liquid Waste

This Court finds that, at some point between 1956 and 1964, Metro Atlantic's main building was connected to North Providence's municipal sewer system and that at least some of the chemical waste generated in that building was discharged into this sewer system. An article from the Providence Journal dated November 22, 1956 indicated that, intermittingly, Metro Atlantic's wastewaters were dumped into the tailrace. (U.S. Ex. 84; see also Trial Tr., vol. X, 89:10-89:12, June 4, 2015, ECF No. 392.) North Providence Town Council meeting minutes from

the 1950s and 1960s indicate that Metro Atlantic's main building connected to the town sewer system at some point between 1956 and 1964. Minutes from October 1, 1956 stated that Metro Atlantic had, by that date, tied its domestic sewage system in with the town's. (Emhart Ex. 275.) Minutes from November 19, 1956 related that State of Rhode Island health officials had advised Metro Atlantic to cease dumping chemicals into the tailrace under threat of civil or criminal action. (Emhart Ex. 276.) According to the minutes from June 22, 1964, a Metro Atlantic representative told members of the North Providence Town Council that Metro Atlantic's chemical waste went to the sewer system and not to the tailrace. (Emhart Ex. 277.) At this same meeting, the representative also explained that, after its chemical waste was analyzed, Metro Atlantic was given permission to discharge its chemical waste into the town's sewer system. (Id.) The November 22, 1956 Providence Journal article quoted Carleton Maine, who worked for the Division of Water Supply and Pollution Control with the Rhode Island Department of Health ("RIDOH") from the mid- to late-1950s through the mid-1970s (see Tr. of April 29, 2009 Deposition of Carleton Maine ("Maine 4/29/09 Dep. Tr.") 6:1-6:11; Tr. of May 22, 2013 Deposition of Carleton Maine ("Maine 5/22/13 Dep. Tr.") 36:3-36:8), as stating that the RIDOH Division of Sanitary Engineering "[had] advised Metro-Atlantic Co. to discharge wash

waters into the town sewerage system." (U.S. Ex. 84; see also Trial Tr., vol. X, 89:10-89:12, ECF No. 392.) Meeting minutes from July 6, 1964 explained that a committee that was formed to tour Metro Atlantic's facilities concluded after its view of the premises that "nothing . . . [was] going into the water, except water off of drain pipes[,] and [that] all chemical waste was deposited through the sewer system." (Emhart Ex. 278.)

Similarly, Maine testified that Metro Atlantic was connected to the North Providence sanitary-sewer system in 1956. (Maine 4/29/09 Dep. Tr. 18:2-18:7, 34:19-34:25, 35:5-36:12; Maine 5/22/13 Dep. Tr. 28:2-28:5, 58:17-58:22, 59:12-59:13.) Maine explained that a representative of Metro Atlantic showed him a concrete pit in the basement of Metro Atlantic's main building where all the drainage from Metro Atlantic's main-building operations drained before being pumped to the sewer. (Maine 5/22/13 Dep. Tr. 28:10-30:9, 31:12-32:17, 58:17-58:22, 59:12-59:13.) Maine did not observe any pipes leading to the tailrace at this time. (Id. at 30:18-30:19.) Maine testified that he "found no waste going to the [tailrace] from [Metro Atlantic] . . . . Everything was tied into the sewer system."[23] (Maine 4/29/09 Dep. Tr. 35:16-35:18.)

[23] As noted by Emhart during opening statements, many of the witnesses used the term "river" when referring to the tailrace. (Trial Tr., vol. I, 52:12-53:3, ECF No. 383.) Although it is not entirely clear from the above-quoted passage to which

Based on his review of the town council meeting minutes, the transcripts of Maine's depositions, and various plans depicting sewer lines in the vicinity of the peninsula, as well as his inspections of sewer lines in the 1970s, L. Robert Smith – an expert in sewer systems and waste disposal practices – concluded that Metro Atlantic's main building was connected to the sanitary-sewer system for all of its chemical and sanitary waste, beginning sometime between 1942 and 1956.[24] (Trial Tr., vol. X, 3:11, 11:23-12:5, 12:17-15:2, 26:23-27:3, 32:9-32:13, 33:10-33:19, 45:6-45:9, 47:18-47:24, ECF No. 392.) One of the plans reviewed by Smith depicted several wyes connected to the main sewer line on Smith Street.[25] (Emhart Ex. 343B; Trial Tr., vol. X, 19:22-20:4, ECF No. 392.) A notation on this plan states: "Engineer see owner about drains." (Emhart Ex. 343B; Trial Tr., vol. X, 20:15-21:16, ECF No. 392.) The orientation and location of the wyes on this plan, along with Maine's testimony about the sewer pit, led Smith to conclude that Metro Atlantic's sewer connection ran from the sewer pit, through the

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waterway Maine was referring, it appears as though he was discussing the tailrace.

[24] Any records reflecting Metro Atlantic's connection to the sewer system were likely destroyed in a fire in the North Providence Building Official's office. (Trial Tr., vol. X, 45:4-45:5, 63:14-63:20, June 4, 2015, ECF No. 392.)

[25] A wye is a piece of pipe connected to a sewer line; persons or entities wishing to connect to the sewer line do so by connecting to one of these wyes. (Id. at 20:5-20:11.)

main building and over the tailrace, and connected to the main sewer line via one of the wyes depicted in the plan. (Trial Tr., vol. X, 47:18-47:24, 48:9-48:22, 53:18-53:23, 134:15-135:1, 135:13-135:17, 136:5-136:16, ECF No. 392.)

Smith's opinions were also informed by his experience as a part-time sewer inspector for North Providence in the early 1970s. (Id. at 6:12-6:19, 6:25-7:3, 8:8-8:10.) On one occasion during his tenure, the sewer line on Smith Street in the vicinity of the peninsula was inspected and found not to need repair. (Id. at 14:21-15:2, 21:17-21:19, 22:4-22:24.) On another occasion, Smith descended a manhole in an area away from the peninsula and observed a sewer line extending towards the direction of the tailrace and the area where Metro Atlantic's main building once stood, although he acknowledged that he could not say for certain whether the line extended onto the peninsula. (Id. at 13:16-13:18, 14:10-14:19, 24:14-25:21, 60:17-61:7, 132:6-133:20; Emhart Ex. 344.)

Indeed, Ray K. Forrester – a chemical engineer and the Government's expert in the fields of chemical process engineering, chemical manufacturing waste handling practices, and environmental forensics – agreed that, at some point between 1956 and 1964, Metro Atlantic began discharging its chemical waste from its main-building operations into North Providence's municipal sewer system. (Trial Tr., vol. II, 97:9-97:10, 97:17,

107:18-108:11, ECF No. 384; Trial Tr., vol. III, 147:6-147:13, ECF No. 385; Trial Tr., vol. IV, 112:20-113:9, May 21, 2015, ECF No. 386.)

Although this Court finds that Metro Atlantic's main building was connected to the municipal sewer system, the evidence also suggests that some of the liquid chemical waste that was generated in this building was nonetheless discharged into the tailrace during the time when the building was connected to the sewer system. Joseph Nadeau, who worked as a laborer for Metro Atlantic in the 1964-65 timeframe, recalled washing residual waste from filter presses, leaky drums, and leaky pipes into a drain. (Trial Tr., vol. XIV, 3:11, 4:11-4:13, 4:17-4:20, 17:10-17:11, 17:15-17:19, 37:25-38:12, 40:20-41:3, 43:5-43:13, 43:18-43:22, 44:11-45:4, 55:21-56:2, ECF No. 396.) Nadeau saw the drain discharging liquid wastes into the tailrace. (Id. at 38:13-39:3, 41:2-41:10, 45:5-45:8.) Although Emhart characterizes Nadeau's testimony in this regard as "based more on assumptions and speculation than actual knowledge" (Emhart's Post-trial Br. 88, ECF No. 378), Nadeau testified that he personally observed materials discharging from Metro Atlantic's main building into the tailrace (Trial Tr., vol. XIV, 38:13-39:3, ECF No. 396).

2. Metro Atlantic's Trifluralin Operations

For approximately one year in 1962 or 1963, Metro Atlantic manufactured trifluralin on the western side of the peninsula in a small temporary structure known as the Texas Tower. (See Paterson Dep. Tr. 12:13-12:21, 23:4-23:11, 24:18-24:22, 25:19-26:11; Tr. of Feb. 10, 2003 Deposition of Thomas F. Cleary ("Cleary Dep. Tr.") 60:6-61:19; Turcone 9/12/13 Dep. Tr. 26:19-27:11, 56:3-56:7, 60:16-60:22; Turcone 10/29/08 Dep. Tr. 24:21-26:3, 78:25-79:19; Turcone 12/16/02 Dep. Tr. 32:6-32:12, 47:19-47:20; see also Trial Tr., vol. VII, 48:7-48:13, ECF No. 389; Emhart Exs. 13, 329.) The Texas Tower had no drains or troughs; liquid waste was washed out of the building and onto the ground outside. (See Turcone 9/12/13 Dep. Tr. 110:1-110:14; Turcone 12/16/02 Dep. Tr. 32:16-32:21.) Additionally, a pipe ran approximately one foot off the ground from the Texas Tower to the Woonasquatucket River and discharged an unknown clear liquid. (See Turcone 9/12/13 Dep. Tr. 97:13-97:15; Turcone 10/29/08 Dep. Tr. 28:17-29:8, 97:11-97:23.) The liquid corroded the discharge pipe, which needed to be replaced frequently as a result.[26] (See Turcone 12/16/02 Dep. Tr. 19:14-20:8.)

[26] This Court need not decide whether Metro Atlantic is liable under CERCLA for a release of a hazardous substance in connection with its trifluralin operations.

3. NECC's Drum-Reconditioning Operations

NECC reconditioned 55-gallon drums on the peninsula from approximately the late 1940s or early 1950s until the early 1970s. (See RIR Table 1-1, U.S. Ex. 43; Trial Tr., vol. VII, 195:23-196:9, ECF No. 389.) During its time on the peninsula, NECC received drums from a litany of entities, including Metro Atlantic, the DOD, and a group of unknown drum "peddlers."[27] (Tr. of Feb. 13, 2003 Deposition of Joseph Cifelli ("Cifelli 2/13/03 Dep. Tr.") 8:5; see Tr. of March 28, 2003 Deposition of Vincent J. Buonanno ("V. Buonanno 3/28/03 Dep. Tr.") 123:23-135:20; R. Nadeau 6/12/13 Dep. Tr. 22:21-23:7, 72:14-72:25; Tr. of May 21, 2013 Deposition of Joseph Cifelli ("Cifelli 5/21/13 Dep. Tr.") 28:12-28:14; Trial Tr., vol. VIII, 53:25-54:4, June 2, 2015, ECF No. 390; Trial Tr., vol. IX, 90:10-90:13, 90:20-90:25, 164:21-165:3, June 3, 2015, ECF No. 391; Locke Slide 68, Emhart Ex. 342.) Many of the drums that NECC received contained residues of the substances that were once contained in the drums. (See Tr. of Oct. 1, 2002 Deposition of Raymond Nadeau ("R. Nadeau 10/1/02 Dep. Tr.") 12:14-12:16; Tr. of Sept. 10,

[27] When NECC began operations, Metro Atlantic was its half parent and primary customer. (See Tr. of March 25, 2003 Deposition of Vincent J. Buonanno ("V. Buonanno 3/25/03 Dep. Tr.") 12:21-13:21, 15:19-16:19.) While the import of this relationship has been debated in the post-trial briefing, because of the Court's conclusions with respect to Emhart's CERCLA liability, the Court need not dwell on the connection between the two companies.

2008 Deposition of Raymond Nadeau ("R. Nadeau 9/10/08 Dep. Tr.") 29:21-29:24, 31:25-32:9; Cifelli 2/13/03 Dep. Tr. 41:23-42:11; Turcone 11/30/99 Dep. Tr. 27:5-27:9.) Some of this residual material would leak onto the beds of the NECC trucks, and the drivers would hose these materials onto the ground on the peninsula. (Tr. of Jan. 7, 2003 Deposition of John Priest ("Priest Dep. Tr.") 24:9-25:5.)

a. Drum Storage

NECC stacked drums in several locations on the peninsula, including to the south of the NECC buildings and to the east and west of the access road. (Trial Tr., vol. I, 130:1-130:6, 133:18-133:19, 136:6-136:7, 157:25-159:2, ECF No. 383; Trial Tr., vol. VII, 33:19-33:21, 38:11-38:12, 41:19-41:25, 54:12-54:15, 69:1-69:2, ECF No. 389; U.S. Exs. 234-35, 239, 242; Emhart Exs. 326-32.) Additionally, there is evidence that NECC routinely stored barrels along the western side of the peninsula, which abuts the Woonasquatucket River. (See Emhart Exs. 10, 329, 330A, 331-33, 340; Locke Slides 80, 82-83, Emhart Ex. 342; Trial Tr., vol. VII, 51:4-51:8, 69:1-69:2, ECF No. 389.) However, although small quantities of drums were sometimes stored in the specific area where Metro Atlantic manufactured trifluralin and HCP along the western side of the peninsula (see Emhart Exs. 330A, 332-33, 340; Locke Slides 80, 82-83, Emhart Ex. 342; U.S. Exs. 241, 243; Trial Tr., vol. I,

147:6-147:11, 151:8-151:11, ECF No. 383; Trial Tr., vol. VII, 69:2-69:8, 71:14-71:20, 91:14-91:16, ECF No. 389), this was not an area of significant drum storage by NECC. (See Trial Tr., vol. XX, 81:15-82:1, 83:5-83:8, 84:6-84:9, June 25, 2015, ECF No. 402.)

The amount of stockpiled drums and the places in which those drums were stored increased during NECC's tenure on the peninsula. (See Trial Tr., vol. I, 123:12-123:17, ECF No. 383; Trial Tr., vol. VII, 34:7-34:8, 34:12-34:14, 41:25-42:1, 84:13-84:15, ECF No. 389; Emhart Exs. 325A, 333.) Although there is some testimony that NECC took everything away when it left the peninsula in the early 1970s (see, e.g., V. Buonanno 3/28/03 Dep. Tr. 178:8-178:16; Tr. of May 16, 2013 Deposition of Vincent J. Buonanno ("V. Buonanno 5/16/13 Dep. Tr.") 400:19-400:22), it is clear (and the parties agree) that a significant number of drums remained just to the north of the impoundment, an area of standing liquid discussed in more detail below, see infra Section I.B.3.b.ii. (See Trial Tr., vol. VII, 97:22-97:24, ECF No. 389; Emhart Ex. 24.) An aerial photograph from March 1974 revealed evidence of tracks from earth-moving equipment in the area of the NECC buildings. (Trial Tr., vol. VII, 97:13-97:18, 98:13-98:16, ECF No. 389; Emhart Ex. 24.) Mutch concluded from the orientation of the tracks that material had been pushed into the tailrace. (Trial Tr., vol. VII, 97:15-97:18, ECF No. 389.)

Additionally, several drums in this area had found their way into the impoundment. (Id. at 97:24-98:2, 98:23-99:10; Emhart Ex. 24.)

Over the years of NECC's operations on the peninsula, NECC employees often stacked drums on their sides in pyramids on the ground. (See Cifelli 5/21/13 Dep. Tr. 28:15-29:14, 30:5-30:16; Tr. of Sept. 30, 2002 Deposition of Joseph Cifelli ("Cifelli 9/30/02 Dep. Tr.") 13:9-13:18; Trial Tr., vol. II, 38:2-38:6, 41:1-41:9, ECF No. 384.) Stacking drums in this fashion caused residual material to leak out of the drums and spill onto the ground. (See Cifelli 5/21/13 Dep. Tr. 29:21-30:1; Cifelli 2/13/03 Dep. Tr. 52:23-53:14; Cifelli 9/30/02 Dep. Tr. 18:7-19:2, 44:7-45:4.) Aerial photography demonstrated significant soil staining near NECC's buildings. (See, e.g., Trial Tr., vol. I, 129:19-129:24, ECF No. 383; Trial Tr., vol. VII, 45:24-46:2, 84:15-84:16, ECF No. 389; Emhart Exs. 10, 328, 333; U.S. Ex. 239.) Additionally, elevated concentrations of 2,3,7,8-TCDD were found in areas south of the HCP building footprint and north of the WDA on the western side of the peninsula, locations where NECC stored drums that do not appear to be associated with Metro Atlantic's HCP-manufacturing operations. (See Locke Slide 97, Emhart Ex. 342; Medine Slide 22, U.S. Ex. 501; Andrews Slide 5, U.S. Ex. 542; Trial Tr., vol. XX, 123:10-124:9, 125:15-

125:21, 127:10-127:17, 157:20-159:22, 162:3-162:11, ECF No. 402.)

b. Drum-Reconditioning Processes

NECC reconditioned both open-head drums and closed-head drums, and it employed a separate reconditioning process for each type of drum.

i. Open-Head Drums

NECC reconditioned open-head drums by passing them through a large, open-air incinerator. (See Trial Tr., vol. XIV, 48:25-50:22, ECF No. 396; Cifelli 9/30/02 Dep. Tr. 12:1-12:5, 14:13-15:15.) Before open-head drums could be passed through the incinerator, NECC employees rejected or set aside the drums that could not be reconditioned because of their condition or if they contained too much residue or a product that could not or should not be burned. (See Cifelli 2/13/03 Dep. Tr. 24:19-25:13, 26:13-26:21; R. Nadeau 10/1/02 Dep. Tr. 12:1-12:7; Turcone 10/29/08 Dep. Tr. 48:17-49:4; see also Cifelli 5/21/13 Dep. Tr. 46:14-47:2.) The set-aside drums would eventually deteriorate. (See Cifelli 5/21/13 Dep. Tr. 47:3-47:16.) After unusable drums were rejected or set aside, NECC employees prepared the open-head drums for incineration by burning off any flammable liquids with a match and removing any plastic liners that the drums contained. (See R. Nadeau 6/12/13 Dep. Tr. 105:9-105:20, 205:12-205:24; R. Nadeau 10/1/02 Dep. Tr. 14:15-15:3, 67:20-

69:1; Oct. 27, 2000 Aff. of Raymond Nadeau ("R. Nadeau 10/27/00 Aff.") ¶ 4, Emhart Ex. 206.)

The drums were fed into the incinerator by a conveyor. (See R. Nadeau 10/27/00 Aff. ¶ 4, Emhart Ex. 206.) The drums were placed upside down onto the conveyor, and any residual material in the drums fell into a concrete pit below the conveyor.[28] (See Cifelli 5/21/13 Dep. Tr. 26:3-26:6; R. Nadeau 10/27/00 Aff. ¶ 4, Emhart Ex. 206.) The conveyor took the drums through the incinerator, and ash and any further residual material dropped into the pit; as the conveyor continued along its route, a chain at the bottom of the conveyor belt scraped into the pit any residual material that fell from the barrels but did not fall directly into the pit. (See R. Nadeau 9/10/08 Dep. Tr. 9:14-13:11; Cifelli 5/21/13 Dep. Tr. 19:22-20:23.) Although the contents of the concrete pit were periodically emptied by "a cesspool-type truck" (Cifelli 5/21/13 Dep. Tr. 26:14-26:18) and by NECC employees shoveling pit contents into empty 55-gallon drums (R. Nadeau 9/10/08 Dep. Tr. 44:19-44:23), the residues in the pit would occasionally overflow and seep into the ground (see Cifelli 5/21/13 Dep. Tr. 26:19-27:10; Cifelli 2/13/03 Dep. Tr. 30:11-30:13). Additional steps in the

[28] NECC employees sometimes dumped drum residues directly into this pit before placing the drum onto the conveyor. (See Cifelli 9/30/02 Dep. Tr. 30:11-31:8.)

reconditioning process for open-head drums included sandblasting and painting.[29] (See R. Nadeau 9/10/08 Dep. Tr. 14:12-15:22; R. Nadeau 10/1/02 Dep. Tr. 49:19-50:2; Apr. 2, 2002 Aff. of Raymond Nadeau ("R. Nadeau 4/2/02 Aff.") ¶ 4, Emhart Ex. 207.)

Incineration creates dioxins, especially octochlorodibenzo-p-dioxin (see Trial Tr., vol. XI, 24:22-25:7, 26:8-26:10, 73:7-73:10, 73:13-73:15, 74:12-74:16, 75:4-75:10, June 5, 2015, ECF No. 393), and a Government expert referred to NECC's open-head drum reconditioning operation as "a dioxin manufacturing machine." (Trial Tr., vol. XVIII, 161:18, June 23, 2015, ECF No. 400; see also id. at 161:16-161:24, 162:18-162:22.) In addition to OCDD, incineration can generate some 2,3,7,8-TCDD. (See id. at 162:11-162:17; Trial Tr., vol. XX, 163:11-164:2, ECF No. 402.)

ii. Closed-Head Drums

NECC's reconditioning process for closed-head drums entailed submerging drums in a tank of cleaning solution, referred to as caustic soda, and then transferring the drums to a second tank, where rinse water was applied. (See Cifelli 5/21/13 Dep. Tr. 34:20-36:14; Cifelli 2/13/03 Dep. Tr. 14:13-14:24, 43:15-46:24; Tr. of March 25, 2003 Deposition of Vincent J. Buonanno ("V. Buonanno 3/25/03 Dep. Tr.") 52:4-52:8.) The

[29] Open-head drum lids were reconditioned in similar fashion. (See Cifelli 2/13/03 Dep. Tr. 42:15-43:3.)

caustic soda was recycled "[u]ntil it became too strong to use" (Cifelli 2/13/03 Dep. Tr. 16:14; see id. at 16:9-16:16); at that point, the tank containing the caustic soda was drained into the floor of the building. (See id. at 15:8-15:20.)

Until the early 1960s, NECC conducted its closed-head drum reconditioning operations in its northernmost building, which is south of Metro Atlantic's main building. (See Trial Tr., vol. VIII, 7:19-7:25, 10:9-11:3, ECF No. 390; Emhart Ex. 10; Locke Slides 39, 49, Emhart Ex. 342; R. Nadeau 6/12/13 Dep. Tr. 188:20-189:18, 204:18-205:1.) An aerial photograph from February 7, 1962 reveals a possible drainage feature from this building to the tailrace. (See Trial Tr., vol. VII, 47:5-47:15, 87:21-88:11, ECF No. 389; Trial Tr., vol. VIII, 14:1-15:1, ECF No. 390; Emhart Exs. 10, 339; Locke Slide 46, Emhart Ex. 342.) The Court therefore concludes that NECC likely discharged its spent caustic soda into the tailrace up until the early 1960s.

Sometime between 1962 and 1963, NECC moved its closed-head drum reconditioning operations to its southernmost building. (See Trial Tr., vol. VIII, 19:25-20:18, ECF No. 390; Locke Slides 48, 51, Emhart Ex. 342; R. Nadeau 6/12/13 Dep. Tr. 204:23-205:1; Cifelli 5/21/13 Dep. Tr. 33:19-34:1.) An aerial photograph from 1965 revealed an area of ponding liquid south of this building. (See Trial Tr., vol. VII, 55:21-55:24, ECF No. 389; Trial Tr., vol. VIII, 22:15-22:22, ECF No. 390; Emhart Exs.

15, 329A, 330.) From the 1970 aerial photographs, it is apparent that NECC was discharging liquid from its closed-head drum reconditioning building into this area, which the parties refer to as the impoundment. (See Trial Tr., vol. VII, 69:9-69:16, 70:25-71:4, 73:19-74:4, 75:22-76:9, ECF No. 389; Emhart Exs. 19-20, 332; Locke Slide 57, Emhart Ex. 342.) Storm water runoff in an area where NECC stored drums also drained into the impoundment. (Trial Tr., vol. VII, 74:12-74:25, ECF No. 389; Emhart Ex. 19.) The impoundment increased in size from 1970 to 1972. (Trial Tr., vol. VII, 84:17-84:21, 88:23-89:2, ECF No. 389; Emhart Exs. 332A, 333.) A berm of soil was constructed on the southwest side of the impoundment in order to contain the liquid that was discharged there. (Trial Tr., vol. VII, 85:22-86:2, 86:10-86:13, 89:2-89:3, ECF No. 389; Emhart Exs. 23, 333.)

NECC's discharges into the impoundment did not escape the notice of the RIDOH. A letter dated January 23, 1970 from the RIDOH to NECC related that "wastes are still being discharged into an area adjacent to [the NECC buildings] where they are likely to be washed into the Woonasquatucket River." (Emhart Ex. 282; see also Maine 5/22/13 Dep. Tr. 52:2-52:15, 54:21-55:1.) Maine testified that the RIDOH was concerned about the impoundment because it was susceptible to overflow with excess rainwater and because the materials in the pit could travel with the groundwater; either scenario, Maine feared, could lead to

the discharge of the materials in the impoundment into the Woonasquatucket River or the tailrace. (See Maine 4/29/09 Dep. Tr. 17:18-17:24, 18:18-18:22; Maine 5/22/13 Dep. Tr. 15:7-15:18, 25:14-25:20, 26:14-27:6.)

This Court therefore concludes that NECC discharged its liquid waste from its closed-head drum reconditioning operations into the impoundment. (See Trial Tr., vol. VIII, 12:8-12:15, ECF No. 390.) Sampling from areas immediately adjacent to the impoundment revealed elevated concentrations of 2,3,7,8-TCDD, OCDD, PCBs, perchloroethylene ("PCE"), toluene, 1,4-dichlorobenzene, and hexachloroxanthene ("HCX"). (See Locke Slides 21, 97, 99-100, Emhart Ex. 342; Sandau Slide 19, Emhart Ex. 348; Kastrinos Slides 15-16, 26, 39-40, Emhart Ex. 352; Andrews Slides 5-6, 14, U.S. Ex. 542.) However, this Court is unable to say what contaminants were present in the impoundment itself. In the early 1980s, approximately 6,000 cubic yards of soil were removed from the peninsula in connection with the construction of the Centredale Manor housing complex; although the precise boundaries of this excavation are unclear, it appears as though soil in the approximate area of the impoundment was removed.[30] (See Trial Tr., vol. VIII, 134:3-134:7, ECF No. 390; Trial Tr., vol. IX, 150:19-151:9, ECF No.

[30] The removed soil was not sampled for dioxins. (Trial Tr., vol. VIII, 134:8-134:15, June 2, 2015, ECF No. 390.)

391; Trial Tr., vol. XV, 55:12-55:22, June 11, 2015, ECF No. 397.) Consequently, a data gap exists with respect to this area of the peninsula. (See Trial Tr., vol. VIII, 134:24-135:16, ECF No. 390; Trial Tr., vol. IX, 151:18-156:5, ECF No. 391; Trial Tr., vol. XV, 55:23-56:15, ECF No. 397; Trial Tr., vol. XX, 96:18-97:22, 149:2-150:6, ECF No. 402.)

c. NECC's Use of the WDA

NECC deposited a variety of material into the WDA, including sludge and ash that was generated by the incinerator during reconditioning of open-head drums (see R. Nadeau 4/2/02 Aff. ¶ 3, Emhart Ex. 207; R. Nadeau 10/1/02 Dep. Tr. 15:21-16:14, 19:4-19:20); drum contents and residues (see Trial Tr., vol. II, 37:5-37:12, 55:1-55:19, 90:3-91:1, ECF No. 384; Oct. 28, 2000 Aff. of Edmund Izzo ("Izzo 10/28/00 Aff.") ¶¶ 2-3, U.S. Ex. 483; R. Nadeau 4/2/02 Aff. ¶ 2, Emhart Ex. 207); drums that could not be reconditioned (see Izzo 10/28/00 Aff. ¶ 2, U.S. Ex. 483; Tr. of Jan. 28, 2003 Deposition of David Carbone ("Carbone 1/28/03 Dep. Tr.") 11:23-12:3; Tr. of Oct. 20, 2008 Deposition of David Carbone ("Carbone 10/20/08 Dep. Tr.") 22:11-22:21; Turcone 11/30/99 Dep. Tr. 40:1-40:17); and sandblasting and painting waste (see R. Nadeau 4/2/02 Aff. ¶ 4, Emhart Ex. 207; Trial Tr., vol. II, 11:16-11:20, ECF No. 384; R. Nadeau 6/12/13 Dep. Tr. 102:25-103:19; R. Nadeau 12/17/02 Dep. Tr. 19:2-19:24; R. Nadeau 10/1/02 Dep. Tr. 49:19-50:10).

C. Metro Atlantic's HCP-Manufacturing Operations

Sometime between September 1963 and April 1965, Metro Atlantic constructed the HCP building. (See Emhart Ex. 15.) The "indispensable . . . starting material" for the production of HCP is 2,4,5-trichlorophenol ("2,4,5-TCP"). (Cleary Dep. Tr. 26:20-27:1; see also id. at 22:7-22:14.) Metro Atlantic purchased its 2,4,5-TCP in a crude sodium form ("crude Na 2,4,5-TCP") exclusively from Diamond Alkali Company ("Diamond Alkali"). (Id. at 48:6-48:12; see also Trial Tr., vol. XII, 120:16-120:22, June 8, 2015, ECF No. 394.) It is undisputed that Diamond Alkali's manufacture of Na 2,4,5-TCP created 2,3,7,8-TCDD and that, consequently, the crude Na 2,4,5-TCP that Diamond Alkali delivered to Metro Atlantic contained 2,3,7,8-TCDD, although it is doubtful that Metro Atlantic knew of its presence.[31] (See NIOSH Report for Diamond Alkali 45, U.S. Ex. 48; Trial Tr., vol. II, 188:14-189:1, ECF No. 384; Trial Tr., vol. III, 37:2-37:6, ECF No. 385; Trial Tr., vol. XII, 44:19-44:25, ECF No. 394; Trial Tr., vol. XIII, 35:18-35:20, 76:5-76:7, June 9, 2015, ECF No. 395; Cleary Dep. Tr. 80:9-80:13, 90:11-90:23, 91:13-91:19.) Because of the undisputed presence

[31] 2,3,7,8-TCDD is formed as an impurity during the synthesis of 2,4,5-TCP. (Trial Tr., vol. XI, 41:16-41:19, June 5, 2015, ECF No. 393; Trial Tr., vol. XII, 16:20-17:8, 43:23-44:18, ECF No. 394; Trial Tr., vol. XVII, 116:17-116:20, 117:1-117:4, June 17, 2015, ECF No. 399.)

of 2,3,7,8-TCDD on the peninsula during Metro Atlantic's manufacture of HCP, it is critical to examine several aspects of Metro Atlantic's HCP-manufacturing operation in detail.

1. Storage of Crude Na 2,4,5-TCP

Upon its arrival to Metro Atlantic, the crude Na 2,4,5-TCP was transferred from Diamond Alkali's tanker trucks into storage tanks immediately outside of the HCP building. (Trial Tr., vol. II, 172:2-172:5, 187:22-187:23, 191:10-191:22, ECF No. 384.) The aerial photograph experts agree that a 1965 aerial photograph shows three vertical tanks immediately to the south of the HCP building that appear to be sitting on a concrete pad. (Trial Tr., vol. I, 142:22-143:3, ECF No. 383; Trial Tr., vol. VII, 54:1-54:2, 58:17-58:21, 59:15-59:16, ECF No. 389; U.S. Ex. 240; Emhart Exs. 15, 330.) Forrester opined that two of these tanks likely were used to store the crude Na 2,4,5-TCP from Diamond Alkali and that the third tank was used to store PCE, a solvent that was used in the HCP-manufacturing process. (Trial Tr., vol. II, 172:2-172:5, 187:22-187:23, 191:10-191:22, ECF No. 384; Trial Tr., vol. III, 28:10-28:12, ECF No. 385.) Additionally, a May 30, 1965 article from the Providence Sunday Journal reported that "[r]aw materials are fed from large storage tanks outside the [HCP] plant." (U.S. Ex. 193.)

In reaching the conclusion that the crude Na 2,4,5-TCP was stored in outdoor storage tanks at Metro Atlantic, this Court

necessarily rejects the deposition testimony of Thomas Cleary, an organic chemist who invented and patented the process that Metro Atlantic used to manufacture HCP,[32] and the testimony of Dr. James R. Kittrell, Emhart's expert in chemical engineering. (See Cleary Dep. Tr. 7:9, 9:16-9:17, 32:12-32:20; Trial Tr., vol. XII, 144:13-144:14, 157:24-158:8, ECF No. 394.) During his deposition, Cleary stated that Metro Atlantic did not store any of the chemicals used in the HCP process in tanks. (Cleary Dep. Tr. 59:6-59:9.) However, this assertion contradicts the Providence Sunday Journal article, which was written while Metro Atlantic's manufacture of HCP was ongoing. Additionally, although Cleary speculated that the crude Na 2,4,5-TCP from Diamond Alkali was perhaps kept in the tanker truck that delivered it, he acknowledged that he did not know where the crude Na 2,4,5-TCP was stored. (Id. at 59:9-59:16.) This is unsurprising; Cleary was not a Metro Atlantic employee, and he visited the peninsula only two or three times per year over a period of four or five years. (Id. at 10:22-11:1, 59:17-59:23, 92:2-92:5.)

Like Cleary, Kittrell was of the opinion that the crude Na 2,4,5-TCP was transferred directly from the Diamond Alkali

[32] Cleary died in July 2008. (See Mem. and Order Granting Defs.' Mot. in Limine 3, ECF No. 325.) His deposition testimony was given in 2003 (Cleary Dep. Tr. 1:15), nearly forty years after Metro Atlantic manufactured HCP on the peninsula.

tanker trucks into a connection at the side of the building that led to a pipe that, in turn, led to the reaction vessel inside the plant. (Trial Tr., vol. XII, 187:11-187:23, 197:9-197:14, ECF No. 394.) In addition to relying on Cleary's testimony for this conclusion (id. at 186:23-187:24), Kittrell reasoned that storage of the crude Na 2,4,5-TCP in the side-by-side outdoor storage tanks would be problematic for two reasons. First, Kittrell opined that the long, tall tanks identified by Forrester as the crude Na 2,4,5-TCP tanks were the wrong shape for storage of a substance, like Diamond Alkali's crude Na 2,4,5-TCP, containing particulates that would likely settle to the bottom of the tank; rather, short and squat tanks of large diameter would be the preferable build for storing the crude Na 2,4,5-TCP. (Id. at 195:17-196:6.) Second, Kittrell opined that the long, tall tanks outside of the HCP building were susceptible to freezing. (Id. at 196:7-196:17.) Therefore, Kittrell concluded that the tanker truck unloaded one batch size into the reaction vessel and was moved someplace else until the next batch of crude Na 2,4,5-TCP was needed. (Id. at 187:3-187:8, 197:9-197:14.)

This Court is unpersuaded by Kittrell's theory. The problem of particulate matter in the crude Na 2,4,5-TCP in the outdoor storage tanks would have been somewhat addressed by Metro Atlantic's practice of air sparging in the tanks, which

caused much of the particulate matter to remain suspended in the tanks. (See Emhart Ex. 83; Trial Tr., vol. II, 190:9-191:6, ECF No. 384.) Additionally, the danger of freezing in the storage tanks would have been mitigated by the presence of salts and sodium hydroxide in the crude Na 2,4,5-TCP as well as the air sparging of the tanks. (Trial Tr., vol. XIX, 18:4-18:13, June 24, 2015, ECF No. 401; see also Trial Tr., vol. XIII, 106:11-106:16, ECF No. 395.) Furthermore, the tanks could have been insulated without great expense.[33] (Trial Tr., vol. XIX, 18:14-18:20, ECF No. 401.)

Moreover, Kittrell's theory that the crude Na 2,4,5-TCP remained in the tanker truck, which, in turn, remained on or near the peninsula, strikes this Court as impractical. Indeed, as Kittrell acknowledged, the truck driver would either have to stay somewhere close by until the truck was emptied one batch at a time or make some other arrangements for transportation from the peninsula. (See Trial Tr., vol. XIII, 188:3-188:4, ECF No. 395 ("I don't know whether the drivers stayed there or whether he took a bus home . . . .").) Additionally, Kittrell acknowledged that he did not have a full explanation for how the

[33] Indeed, Forrester noted that, unlike for the storage tanks, air sparging would not be employed if the crude Na 2,4,5-TCP was stored in the tanker trucks. (Trial Tr., vol. XIX, 19:5-19:7, June 24, 2015, ECF No. 401.) Therefore, he opined, "the concern with freezing in the tank truck would be as great or greater" than the danger of freezing in the outdoor storage tanks. (Id. at 19:8-19:10.)

cost to Metro Atlantic of keeping one of Diamond Alkali's tanker trucks on the peninsula would have impacted the profitability of its manufacture of HCP. (See id. at 187:14-188:18.) Furthermore, if the crude Na 2,4,5-TCP was loaded directly from the tanker truck one batch at a time, a second tanker truck would need to arrive before the crude Na 2,4,5-TCP in the first truck ran out in order to maintain continuity of the HCP operations. (See id. at 100:8-100:20.) Thus, under Kittrell's theory, at least one Diamond Alkali truck (and sometimes a second truck) would remain on or near the peninsula for periodic unloading of crude Na 2,4,5-TCP, all while three large outdoor storage tanks sat just to the south of the HCP building.

For all of these reasons, this Court finds that the crude Na 2,4,5-TCP from Diamond Alkali was stored in outdoor storage tanks. There are two points of release of 2,3,7,8-TCDD that are associated with storage of the crude Na 2,4,5-TCP in outdoor storage tanks: inadvertent leaks and spills during transfer of the crude Na 2,4,5-TCP into the storage tanks; and flushing out material that settled in the storage tanks.

Inadvertent leaks and spills likely occurred during the transfer of the crude Na 2,4,5-TCP from the Diamond Alkali tanker trucks to the outdoor storage tanks. (Trial Tr., vol. II, 172:18-172:20, 180:23-180:25, 187:24-188:13, ECF No. 384; see also Trial Tr., vol. XX, 153:19-153:23, ECF No. 402.)

Forrester opined that the quick-connect couplings that were typically installed on tanker trucks in the mid-1960s were prone to leakage and that leakage would have occurred throughout the entire unloading process. (Trial Tr., vol. II, 186:19-187:16, ECF No. 384.) Indeed, Emhart acknowledged the possibility of leaks from tanker trucks in at least one of its filings in the Home Insurance litigation. (Emhart Reply Brief in Home Insurance Case 19, U.S. Ex. 87.)

Kittrell opined that it was unlikely that spills or leaks occurred during the transfer of the crude Na 2,4,5-TCP from the tanker trucks. (Trial Tr., vol. XII, 190:8-191:3, ECF No. 394.) Kittrell reasoned that the aerial photographs revealed no evidence of ground staining. (Id. at 193:1-193:6.) Additionally, he emphasized that the crude Na 2,4,5-TCP was a foul, odiferous substance that "operators would [not] willingly drop in and around their feet" during the transfer. (Id. at 192:20-193:1.)

However, Kittrell acknowledged that the spillage of a few drops during the transfer was typical. (Id. at 191:4-191:6; Trial Tr., vol. XIII, 38:2-38:13, 108:2-108:3, 195:19-195:22, ECF No. 395.) Similarly, William Locke – Emhart's expert in environmental engineering and environmental forensics (among other areas) – testified that no expert could rule out the possibility that inadvertent leaks and spills occurred during

the transfer. (Trial Tr., vol. VII, 138:24, 149:18-150:17, ECF No. 389; Trial Tr., vol. VIII, 153:15-153:19, ECF No. 390.) Additionally, Kittrell acknowledged that spills could happen if the transfer was performed "sloppily." (Trial Tr., vol. XII, 190:21-190:22, ECF No. 394.) The history of industrial activities on the peninsula is replete with sloppy handling of chemicals by truck drivers making deliveries. For example, a tank of liquid formaldehyde exploded "when a deliveryman mistook a full tank of formaldehyde for an empty one." (N. Providence Fire Dept. Fire Reports 17, U.S. Ex. 16.) Along similar lines, Joseph Nadeau recalled a fire that was started when a truck driver attempted to direct methanol from a pipe in Metro Atlantic's main building to a portable heater that the truck driver used to keep warm in his truck. (Trial Tr., vol. XIV, 23:8-24:2, ECF No. 396.)

Thus, this Court finds that inadvertent leaks and spills occurred during the transfer of the crude Na 2,4,5-TCP from the tanker truck into the outdoor storage tanks. With respect to the quantity of those leaks and spills, Forrester opined that the spills could consist of a gallon or less. (Trial Tr., vol. XIX, 61:3-61:17, ECF No. 401.) In each gallon, there was approximately 30 milligrams, or 0.00003 kilograms, of 2,3,7,8-

TCDD.[34] (Id. at 63:16-64:8; Forrester Slide 4, Emhart Ex. 354.) Thus, the total concentration of 2,3,7,8-TCDD spilled during all of the transfers from the tanker truck to the storage tanks was between approximately 0.00009 to 0.00039 kilograms, depending on the quantity of crude Na 2,4,5-TCP that Metro Atlantic brought onto the peninsula during the time period it manufactured HCP.[35] (Trial Tr., vol. XIX, 67:5-67:19, ECF No. 401; Forrester Slide 8, Emhart Ex. 354.)

Some of the salt and other particles, including some 2,3,7,8-TCDD, from the crude Na 2,4,5-TCP would settle in the storage tanks. (Trial Tr., vol. II, 180:25-181:2, 182:20-182:22, 183:15-183:19, 193:20-193:21, ECF No. 384; see also Trial Tr., vol. XIII, 101:1-101:4, ECF No. 395.) This settled material was likely flushed out of the storage tank with hot

[34] At the time that the crude Na 2,4,5-TCP arrived at the peninsula, the concentration of 2,3,7,8-TCDD would be, on average, about 18.2 parts per million. (See Trial Tr., vol. II, 188:14-189:1, ECF No. 384; Trial Tr., vol. XIX, 61:24-62:2, ECF No. 401; Forrester Slide 2, Emhart Ex. 354; NIOSH Report for Diamond Alkali 45, U.S. Ex. 48.) However, Forrester opined that the 18.2 parts per million figure would have been expressed on a "total phenols basis," such that the TCDD concentration was based on the mass of Na 2,4,5-TCP in solution and not on the total solution mass, making the concentration of 2,3,7,8-TCDD in the crude Na 2,4,5-TCP solution approximately 6.74 parts per million. (Trial Tr., vol. XIX, 60:1, ECF No. 401; see also id. at 59:15-60:5, 60:1; 62:3-62:16.)

[35] The questions of the duration of Metro Atlantic's HCP-manufacturing operations and the quantity of crude Na 2,4,5-TCP brought onto the peninsula during that timeframe are addressed below, see infra Section I.C.2.

water and was directed to either a drain of some type inside the HCP building or the ground next to the storage tank. (Trial Tr., vol. II, 193:6-193:8, 194:22-194:24, 195:13-195:17, 196:1-196:7, ECF No. 384; Trial Tr., vol. III, 32:21-32:25, 70:8-70:12, ECF No. 385; Trial Tr., vol. IV, 14:16-15:6, ECF No. 386.) Forrester opined that the disposal of the salt and other particles that had settled in the storage tanks "would have been a significant release" of 2,3,7,8-TCDD. (Trial Tr., vol. II, 182:17-182:22, ECF No. 384; see also id. at 194:12-194:15.) He estimated that 20 percent of the 2,3,7,8-TCDD contained in the crude Na 2,4,5-TCP that was unloaded into the tanks would have settled at the bottom of the tanks. (Trial Tr., vol. III, 31:14-31:17, ECF No. 385.)

2. Duration of Metro Atlantic's HCP-Manufacturing Operations

The parties dispute the duration of Metro Atlantic's HCP-manufacturing operations. (See Gov't's Proposed Findings of Fact ("Gov't's PFOF") ¶¶ 8, 214, ECF No. 379 (approximately two years); Emhart's Post-trial Br. 29, 36-39, ECF No. 378 (less than a year).) Cleary testified that he "[o]nly vaguely" recalled the duration of Metro Atlantic's HCP-manufacturing process and thought that it was "[p]robably -- less than a year." (Cleary Dep. Tr. 53:25.) Similarly, Kittrell opined, based on his Gantt-chart analysis, that Metro Atlantic manufactured HCP for eight to nine months. (Trial Tr., vol.

XIII, 32:8-32:22, 33:13-33:16, ECF No. 395; Kittrell Slide 13, Emhart Ex. 350.) However, a bill of materials that was used by Metro Atlantic in the HCP-manufacturing process was admitted into evidence in this case, and it bears a date of June 1964. (See U.S. Ex. 90.) Forrester opined that the commencement of Metro Atlantic's HCP-manufacturing operations closely followed on the heels of the preparation of this bill of materials. (See Trial Tr., vol. III, 15:2-15:9, ECF No. 385.) Additionally, in late March 1966, Metro Atlantic and Diamond Alkali discussed a titration problem that Metro Atlantic was having with its crude Na 2,4,5-TCP, and this correspondence indicates that Metro Atlantic was still manufacturing HCP at this date. (See Emhart Ex. 83; Trial Tr., vol. II, 189:21-191:6, ECF No. 384; Trial Tr., vol. XIX, 39:17-39:24, ECF No. 401.) Although this Court need not definitively decide the duration of Metro Atlantic's HCP-manufacturing operation, it appears most likely that it went on for longer than one year. (See Trial Tr., vol. XIX, 39:17-39:24, ECF No. 401.)

Additionally, there are two interrelated issues that flow from the dispute about the duration of Metro Atlantic's HCP operation: the number of days that it took for Metro Atlantic to process a batch of HCP; and the volume of Na 2,4,5-TCP brought onto the peninsula in connection with Metro Atlantic's manufacture of HCP. Experts on both sides offer competing

answers to these questions. Kittrell opined that, based on the number of employees who worked in the HCP building, it would take three days of eight to twelve hours of operation to manufacture one batch of HCP. (See Trial Tr., vol. XII, 182:14-183:12, ECF No. 394.) Kittrell noted that manufacturing HCP at this rate for 8-9 months would consume about 25,000 kilograms, or approximately 55,000 pounds, of Na 2,4,5-TCP, which was the quantity that Cleary informed the EPA that Metro Atlantic used.[36] (See id. at 183:13-183:25; Cleary Addendum to Gardner Mem. 1, Emhart Ex. 108; Kittrell Slide 13, Emhart Ex. 350.)

However, Forrester opined that Metro Atlantic likely manufactured one batch of HCP per day, operating on a 24-hour basis. (Trial Tr., vol. III, 174:20-174:22, ECF No. 385.) There is evidence supporting the notion that Metro Atlantic operated 24 hours per day. (See Trial Tr., vol. XIV, 34:22-35:21, ECF No. 396.) These hours of operation would cast doubt on the accuracy of the 25,000 kilograms figure for the quantity of Na 2,4,5-TCP brought onto the peninsula by Metro Atlantic. (See Trial Tr., vol. IV, 116:2-116:9, ECF No. 386.) Although Kittrell reasoned that Cleary likely accurately recalled the

[36] Cleary informed the EPA that "[t]he amount of TCP supplied to [Metro Atlantic] by Diamond Alkali, probably didn't exceed 25,000 kgs." (Cleary Addendum to Gardner Mem. 1, Emhart Ex. 108 (emphasis added).) This Court assumes that Cleary meant that Diamond Alkali provided 25,000 kilograms of Na 2,4,5-TCP to Metro Atlantic.

quantity of Na 2,4,5-TCP used by Metro Atlantic because he was likely paid a commission by Metro Atlantic on the basis of pounds of HCP that Metro Atlantic sold (see Trial Tr., vol. XIII, 32:23-33:13, ECF No. 395), this Court is unconvinced. Cleary "[o]nly vaguely" remembered the duration of Metro Atlantic's HCP-manufacturing process (Cleary Dep. Tr. 53:25), and his statement regarding the quantity of Na 2,4,5-TCP used by Metro Atlantic was equally uncertain: "The amount of TCP supplied to [Metro Atlantic] by Diamond Alkali, probably didn't exceed 25,000 kgs." (Cleary Addendum to Gardner Mem. 1, Emhart Ex. 108 (emphasis added).)

This Court finds that there is simply too much uncertainty to definitively resolve the questions of the duration of Metro Atlantic's manufacture of HCP, the frequency with which a batch of HCP was manufactured, and the total quantity of Na 2,4,5-TCP used by Metro Atlantic over the life of the process. However, even if Cleary's recollection that Metro Atlantic "probably" did not use more than 25,000 kilograms of Na 2,4,5-TCP is correct (id. at 1), that would still mean that Metro Atlantic brought a substantial quantity of 2,3,7,8-TCDD onto the Site. Using Forrester's interpretation of the TCDD concentrations contained in the NIOSH Report for Diamond Alkali,[37] Metro Atlantic's HCP-

[37] Diamond Alkali's NIOSH Report contains a table of concentrations of 2,3,7,8-TCDD contained in Diamond Alkali's Na

manufacturing process would have brought somewhere in the ballpark of 0.455 kilograms of 2,3,7,8-TCDD onto the peninsula if only 25,000 kilograms of Na 2,4,5-TCP were used.[38] And,

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2,4,5-TCP solution from May 1965 to November 1967. (See NIOSH Report for Diamond Alkali 45-46, U.S. Ex. 48.) Forrester used fourteen of the 2,3,7,8-TCDD concentrations contained in the NIOSH Report to calculate an average concentration of 2,3,7,8-TCDD in the crude Na 2,4,5-TCP during the approximate timeframe when Metro Atlantic manufactured HCP; that average concentration was 18.2 parts per million. (See Trial Tr., vol. II, 186:14-186:17, 188:14-189:1, May 19, 2015, ECF No. 384; Trial Tr., vol. XIX, 41:2-41:7,61:24-62:2, ECF No. 401; Forrester Slide 2, Emhart Ex. 354.) However, Forrester opined that the concentrations listed in the NIOSH Report were likely calculated on a "total phenols basis," meaning that the TCDD concentration was "based upon the mass of Na[2,4,5-]TCP in solution, not the total solution mass." (Forrester Slide 2, Emhart Ex. 354; see also Trial Tr., vol. XIX, 59:15-60:5, 61:24-62:16, ECF No. 401.) The upshot is that Forrester's average concentration of 18.2 parts per million means that, on average, there were 18.2 parts of 2,3,7,8-TCDD for every million parts of Na 2,4,5-TCP (mass basis). (See Forrester Slide 2, Emhart Ex. 354; Trial Tr., vol. XIX, 61:24-62:2, ECF No. 401.) Forrester also explained that, because the Na 2,4,5-TCP arrived at Diamond Alkali in a solution, the average concentration of 2,3,7,8-TCDD in that solution would be 6.74 parts per million: that is, 6.74 parts of 2,3,7,8-TCDD per million parts of solution. (Trial Tr., vol. XIX, 59:15-60:5, 62:3-62:16, ECF No. 401.)

Forrester's interpretation of the 2,3,7,8-TCDD concentrations in the NIOSH Report has not been contradicted. Although Kittrell used the lowest concentration listed in the NIOSH report for the purposes of a different calculation (see Trial Tr., vol. XIII, 46:2-46:11, June 9, 2015, ECF No. 395), which is discussed below, see infra Section I.C.3.b.ii.B, the concentration used by Kittrell was ten parts of 2,3,7,8-TCDD per million parts of solution (see Trial Tr., vol. XIII, 46:12-46:21, ECF No. 395; see also Trial Tr., vol. XII, 190:5-190:7, 191:16-192:1, ECF No. 394; Kittrell Slide 14, Emhart Ex. 350), which is higher than Forrester's average of 6.74 parts of 2,3,7,8-TCDD per million parts of solution.

[38] This figure can be arrived at using each of Forrester's values for the average concentration of 2,3,7,8-TCDD. First,

because it seems likely that Metro Atlantic manufactured HCP for longer than eight to nine months and, therefore, likely used more than 25,000 kilograms of Na 2,4,5-TCP, it seems likely that 0.455 kilograms of 2,3,7,8-TCDD is an underestimate.

3. Waste Streams of HCP-Manufacturing Process

While a great deal of evidence was presented on the subject, the specifics of Metro Atlantic's manufacture of HCP need not be recounted in great detail. For present purposes, it suffices to say that at least the following steps occurred: (1) first, the crude Na 2,4,5-TCP was transformed into purified 2,4,5-TCP; (2) next, the purified 2,4,5-TCP was extracted into PCE; (3) the 2,4,5-TCP in PCE was then heated and

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18.2 parts of 2,3,7,8-TCDD per million parts of Na 2,4,5-TCP, with a total mass of 25,000 kilograms of Na 2,4,5-TCP, can be expressed as follows: (18.2 grams 2,3,7,8-TCDD/$1*10^{6}$ grams Na 2,4,5-TCP) * ($1*10^{-3}$ kilograms 2,3,7,8-TCDD/gram 2,3,7,8-TCDD) * 25,000 kilograms Na 2,4,5-TCP * ($1*10^{3}$ grams Na 2,4,5-TCP/kilogram Na 2,4,5-TCP) = 0.455 kilograms of 2,3,7,8-TCDD. Additionally, because the parties have assumed that the solution that Diamond Alkali delivered to Metro Atlantic contained approximately 37% of 2,3,7,8-TCDD, such that Metro Atlantic would use approximately 2,700 pounds of solution in order to start its manufacture of a batch of HCP with 1,000 pounds of Na 2,4,5-TCP (see U.S. Ex. 90; Trial Tr., vol. XII, 190:5-190:7, 191:16-192:1, ECF No. 394; Kittrell Slide 14, Emhart Ex. 350; Forrester Slide 2, Emhart Ex. 354), 25,000 kilograms of Na 2,4,5-TCP would have been contained in approximately 67,568 kilograms of solution. Therefore, 6.74 parts of 2,3,7,8-TCDD per million parts of solution, with a total solution mass of 67,568 kilograms, can be expressed as follows: (6.74 grams 2,3,7,8-TCDD/$1*10^{6}$ grams solution) * ($1*10^{-3}$ kilograms 2,3,7,8-TCDD/gram 2,3,7,8-TCDD) * 67,568 kilograms solution * ($1*10^{3}$ grams solution/kilogram solution) = approximately 0.455 kilograms of 2,3,7,8-TCDD.

paraformaldehyde and sulfuric acid were added to form an intermediate and then additional sulfuric acid was added to form HCP; (4) in order to decolorize the HCP (which at this point was still in PCE), an activated carbon product, Nuchar,[39] and calcium carbonate were added; (5) a filter was used to remove the Nuchar, calcium carbonate, and colored impurities from the HCP in PCE; (6) the now white to off-white HCP in PCE was then placed into a crystallizing vessel and cooled to allow for the HCP to crystallize; (7) the crystallized HCP in PCE was then placed into a centrifuge to separate the HCP crystals from the PCE, which was recovered by a centrifuge sump; and, finally, (8) the HCP crystals, which were still slightly wet with a small amount of PCE, were dried, ground, and packaged.[40] (See Cleary Dep. Tr. 40:14-42:21; see also U.S. Ex. 193; Trial Tr., vol. II, 213:10-214:3, 216:11-217:8, ECF No. 384; Trial Tr., vol. III, 45:19-45:21, ECF No. 385.) Although an in-depth discussion of the finer points of the HCP-manufacturing process is not required, findings regarding the waste streams generated by this process – and the destination of those waste streams – are critical to resolving the issues presented. In broad strokes,

[39] Nuchar is a trade name for activated-carbon products. (Trial Tr., vol. XVII, 24:10-24:11, ECF No. 399.)

[40] Certain aspects of this process, including Nuchar usage, are discussed in more detail below to the extent that they relate to the generation of waste streams.

Metro Atlantic's method of synthesizing HCP generated both liquid and solid waste streams. The parties hotly dispute whether the disposal of these waste streams resulted in releases of 2,3,7,8-TCDD on the peninsula or into the Woonasquatucket River. Each distinct waste stream is addressed in turn.

a. Destination of Liquid Waste

Several liquid waste streams were associated with Metro Atlantic's HCP-manufacturing operations. These liquid waste streams included: liquid waste generated during the purification of the crude Na 2,4,5-TCP (Trial Tr., vol. II, 205:5-205:7, ECF No. 384); liquid waste generated during the synthesis of HCP (U.S. Ex. 490); a still bottom of recycled PCE (Trial Tr., vol. III, 8:19-8:20, ECF No. 385); liquid waste generated by washing down the equipment and floors of the HCP building (id. at 14:1-14:17); leaks and spills from storage tanks inside the HCP building (Trial Tr., vol. II, 173:2-173:11, ECF No. 384); and accidental leaks and spills during the several stages of the manufacturing process (id. at 174:18-175:5, 176:25-177:3, 206:2-206:9; Emhart's Resp. to Statement of Undisputed Facts in Home Insurance Case 10, U.S. Ex. 88.) Several of these waste streams would have contained small concentrations of 2,3,7,8-TCDD.[41]

[41] As explained in more detail below, see infra Section I.C.3.b.ii.A.3 & note 50, the parties dispute whether Nuchar was used once or twice in Metro Atlantic's HCP-manufacturing process. Because the vast majority of the 2,3,7,8-TCDD that

(Trial Tr., vol. II, 205:7-205:13, ECF No. 384; Trial Tr., vol. III, 36:4-36:11, 44:19-45:7, ECF No. 385.)

However, Metro Atlantic's HCP-manufacturing operations likely generated at least two liquid waste streams that contained significant concentrations of 2,3,7,8-TCDD. First, as mentioned above, see supra Section I.C.1, the settled material from the outdoor storage tanks was likely flushed out and directed, if not to the ground immediately adjacent to the tank, to the drain inside the HCP building, and this settled material likely contained approximately 20 percent of the 2,3,7,8-TCDD contained in the crude Na 2,4,5-TCP. Second, small quantities of waste from the filter, which contained Nuchar, were likely washed down the trench drain in the HCP building. Joseph Nadeau, who cleaned out filter presses in Metro Atlantic's main building during the approximate timeframe when HCP was manufactured on the peninsula, testified that, after most of the filter cake that had fallen to the floor was shoveled into drums, the remainder was washed into a drain in the main building. (Trial Tr., vol. XIV, 17:10-17:16, 40:20-41:3, ECF No. 396.) Nadeau testified that "you could never get . . . all

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entered the HCP process adsorbed to the Nuchar the first time it was used, the liquid waste streams that were generated after Nuchar was first employed would have contained only trace amounts, if any, of 2,3,7,8-TCDD. (Trial Tr., vol. II, 210:5-210:6, 214:4-214:7, ECF No. 384; Trial Tr., vol. III, 68:18-69:2, 73:16-74:10, ECF No. 385.)

[of the filter cake] off" the floor by shoveling. (Id. at 40:17-40:22.) The amount of filter cake that was washed into the drain "depend[ed] on how ambitious the shoveller was." (Id. at 40:25-41:1.) Nadeau also testified that the filter presses would be rinsed down using high pressure hoses. (Id. at 17:16-17:19.) There is no reason to believe that Metro Atlantic's practices regarding filter cake generated in its main building and HCP buildings differed in this respect.[42] (See Trial Tr.,

[42] During closing argument, Emhart agreed that "it's a fair inference that there would have been some filter press materials washed down the drain in the HCP plant" (Trial Tr., vol. XXI, 90:15-90:17, July 22, 2015, ECF No. 403), although this concession came with several caveats. Primarily, Emhart noted that that the filter presses in the main building were older than the filter press in the HCP building and theorized that, although filter presses typically came with trays to catch the filter-press droppings, the trays may not have been an accessary in the older filter presses in the main building or that the main-building employees may have stopped using the trays because of the inconvenience their use occasioned. (Id. at 91:11-92:7.) This theory is contradicted by Joseph Nadeau's testimony that the filter presses in the main building came equipped with drip trays that caught the "valuable product" that might have leaked out of the filter press during the filtering process and that the first step in cleaning the filter presses in the main building consisted of "pull[ing] that drip pan away when the [filtering] process was done, and . . . releas[ing] the pressure on the press." (Trial Tr., vol. XIV, 15:4-15:14, June 10, 2015, ECF No. 396.) Additionally, Emhart also suggested that perhaps the small size of the HCP building when compared to that of the main building may have led to slightly different practices for disposing of the filter cake (see Trial Tr., vol. XXI, 90:17-91:6, ECF No. 403), although it is not clear why the relative building size would have impacted whether any residual amount of filter cake was washed down the floor drain. Neither of these caveats alters the conclusion that practices used at the main building were most likely also employed in the HCP operation.

vol. XIII, 91:23-92:2, ECF No. 395 ("Q. And you, as you described, you also agree that cleaning the filter press at the hexachlorophene building would have involved opening the filter and allowing the filter sludge to drop out; correct? A. It would drop out and/or be scraped out.").) And, as Kittrell opined, the concentration of 2,3,7,8-TCDD on the filter cake from the Nuchar application would have been very high (at least for the first time Nuchar was used): in the ballpark of 1.4 billion parts per trillion.[43] (Id. at 47:2-47:15; see also id. at 47:24-48:3 ("Q. So if I took a tablespoon of the filter cake that drops on the floor or dropped in the trough in the HCP plant of the filter cake from the Nuchar, it would have that kind of concentrations [sic]? A. That's correct.").)

These waste streams were directed into a trench drain that ran along the floor of the HCP building. (Trial Tr., vol. II, 163:10-163:19, 168:11-168:20, 169:19-169:21, 173:7-173:11, 205:14-205:18, 206:10-206:11, ECF No. 384; Trial Tr., vol. III,

[43] Because this Court finds that approximately 20 percent of the 2,3,7,8-TCDD that was unloaded into the outdoor storage tanks would have remained in the tanks along with the settled salts and because Kittrell's figure of 1.4 billion parts per trillion assumed that 100 percent of the 2,3,7,8-TCDD from each batch adsorbed to the first Nuchar application (Trial Tr., vol. XIII, 46:2-47:15, ECF No. 395), this Court acknowledges that the concentration of 2,3,7,8-TCDD on the filter cake might not have been this high. However, the fact remains that the concentration of 2,3,7,8-TCDD adsorbed to the filter cake from the first Nuchar application would be substantial.

8:22-8:23, 14:16-14:17, 45:8-45:10, 74:11-74:13, ECF No. 385; U.S. Ex. 496.) The destination of these waste streams after being directed into the trench drain is a critical point of contention between the parties: Emhart insists that all liquid waste from the HCP-manufacturing process was piped to the municipal sewer system through Metro Atlantic's main building, while the Government contends that the liquid waste was discharged into the Woonasquatucket River.[44] (See Emhart's Post-trial Br. 74-89, ECF No. 378; Gov't's PFOF ¶¶ 303-33, ECF No. 379.)

As with many critical issues in this case, there is no definitive proof one way or the other on this question. But while it is somewhat of a close call, this Court finds that, unlike Metro Atlantic's main building, the HCP building was not

[44] A third potential destination of these liquid waste streams would be intentional discharges into the soil underneath the HCP building. However, Smith opined that, if the liquid waste from the HCP-manufacturing process was intentionally discharged into the ground, a drywell would be necessary to prevent washout. (Trial Tr., vol. X, 35:1-35:24, ECF No. 392.) A 2009 excavation of the area surrounding where the HCP building once stood revealed no evidence of a drywell. (Id. at 35:22-36:2.) Smith's testimony in this regard is effectively unrebutted, and this Court therefore concludes that the liquid waste streams from the HCP-manufacturing process were not intentionally discharged into the soil underneath the HCP building. However, this conclusion does not address whether liquid waste streams that were directed elsewhere may have inadvertently leaked from the discharge pipes underneath the HCP building; that possibility is examined below. See infra Sections I.C.4.a, I.C.4.d.

connected to the sewer, and the liquid waste streams generated by the HCP-manufacturing process were discharged into the Woonasquatucket River. Pipes uncovered in the 2009 excavation of the area surrounding where the HCP building once stood are critical to this conclusion. Four different pipes were uncovered during the 2009 excavation. (Trial Tr., vol. I, 208:1-208:3, 211:13-212:18, ECF No. 383; U.S. Exs. 109, 116.) Two pipes – one copper and the other steel – protruded from the northeast corner of the excavation area and appeared to extend towards the eastern side of the peninsula, perpendicular to the river.[45] (Trial Tr., vol. I, 211:13-211:23, 226:4-226:7, 227:17-227:21, ECF No. 383; U.S. Ex. 116.) The metal pipe was contained within a clay pipe covering. (Trial Tr., vol. I, 211:24-212:8, ECF No. 383.) A third pipe, larger in diameter than the other two and connected to a right-angled piece, was also uncovered during the excavation and placed next to the two pipes protruding from the edge of the excavation area.[46] (Id. at 212:13-212:18, 232:19-232:22; U.S. Ex. 116.) Additionally, a metal pipe was discovered in the southwestern corner of the

[45] Although electromagnetic pipe tracing was attempted to discern the origins of these two pipes, the results were inconclusive. (Trial Tr., vol. X, 166:9-166:16, 167:20-167:22, 169:6-170:1, ECF No. 392.)

[46] The record is unclear on precisely where in the excavation area this larger-diameter pipe was found. (See Trial Tr., vol. X, 40:8-40:9, ECF No. 392.)

excavation area, close to the bank of the Woonasquatucket River.[47] (Trial Tr., vol. I, 214:16-214:20, 215:1-215:2, ECF No. 383; U.S. Ex. 109.)

The HCP plant used steam for its operations. (Trial Tr., vol. XIX, 24:21-25:1, ECF No. 401; see also Trial Tr., vol. XIII, 55:19-55:23, 84:9-84:16,, ECF No. 395.) Neither the large-diameter pipe nor the copper pipe was used for the purpose of delivery of steam. Smith opined that the large-diameter pipe was a water main and that the copper pipe would have been used for a "water service to a smaller take-off" for items such as sinks and hoses. (Trial Tr., vol. X, 40:9-40:14, ECF No. 392.) Smith and Forrester disagree on the pipe used to transport steam to the HCP building: Forrester opined that the steel pipe was used for this purpose (Trial Tr., vol. III, 151:4-151:14, ECF No. 385), while Smith opined that the clay pipe that covered the steel pipe was used for transporting steam to the HCP building. (Trial Tr., vol. X, 41:20-41:23, 72:7-72:10, ECF No. 392.) This Court finds, contrary to Smith's opinion, that the clay pipe could not be used to transport steam to the HCP building. The clay pipe appears to be segmented into pieces that are approximately eighteen to twenty-four inches long. (Trial Tr., vol. XIX, 23:1-23:7, ECF No. 401.) The pieces were connected by flanges or bells and sealed with tar and oakum. (Trial Tr.,

[47] Photos of these pipes are contained in Appendix E.

vol. X, 41:12-41:17, ECF No. 392; Trial Tr., vol. XIX, 23:8-23:10, 23:22-23:23, ECF No. 401.) Use of a segmented clay pipe sealed with tar and oakum to transport steam – even low-pressure steam – would result in loosening of the seal material and the fracturing of the pipe segments. (Trial Tr., vol. XIX, 23:11-24:4, 24:12-24:20, ECF No. 401.) Forrester opined that, if the clay pipe were used for steam transport, the seal material would last less than a day. (Id. at 24:5-24:10.) This Court therefore concludes that steam was transported to the HCP building through the 2″ steel pipe inside of the clay pipe. (See Trial Tr., vol. III, 151:4-151:14, ECF No. 385.)

Implicit in this conclusion is the rejection of Smith's opinion that the 2″ steel pipe was a force main pipe used to pump chemical waste back to the sewer connection in the Metro Atlantic main building and for the return of steam condensate. (Trial Tr., vol. X, 36:9-36:12, 40:15-40:16, 41:2-41:5, 41:18-42:2, 73:2-74:7, ECF No. 392.) There are two main reasons for rejecting this opinion. First, the diameter of the steel pipe is too small for it to effectively transport the liquid waste from the HCP-manufacturing process. (Trial Tr., vol. XIX, 25:4-25:23, ECF No. 401.) As Kittrell acknowledged (Trial Tr., vol. XIII, 80:8-80:13, 85:16-85:19, ECF No. 395), the liquid waste would contain some solids. (Trial Tr., vol. XIX, 25:17-25:18, ECF No. 401.) These solids would eventually plug a small-

diameter pipe. (Id. at 25:16-25:23; see also Trial Tr., vol. XIII, 80:24-81:1, ECF No. 395.) Additionally, Forrester opined that the steel pipe was not large enough to be cleaned out easily. (Trial Tr., vol. XIX, 25:24-26:1, ECF No. 401.) Second, Forrester opined that Smith's hypothesized hybrid use of the 2" steel pipe for chemical waste and steam condensate return would be inappropriate, and, even if it were theoretically possible, such an arrangement would likely be too burdensome to accomplish efficiently. (Id. at 28:8-30:10.) Therefore, this Court finds that liquid wastes from the HCP building were not directed to the municipal sewer system.

Because this Court finds that the liquid waste from the HCP-manufacturing process was neither intentionally discharged into the soil in the vicinity of the HCP building nor directed into the municipal sewer, this Court necessarily concludes that the liquid waste was discharged into the Woonasquatucket River. (Trial Tr., vol. II, 197:7-197:8, ECF No. 384; Trial Tr., vol. III, 74:16-74:20, ECF No. 385.) In reaching this conclusion, this Court has considered Smith's opinion that, given the suspicions voiced by the North Providence Town Council in the June 22, 1964 meeting minutes that Metro Atlantic might be discharging chemical waste into the tailrace or the Woonasquatucket River, it would defy common sense for Metro Atlantic to then construct the HCP building and allow liquid

waste generated therein to discharge into the Woonasquatucket River. (Trial Tr., vol. X, 37:19-38:6, ECF No. 392.) However, discharges of liquid waste from the HCP building into the Woonasquatucket River would not be the only discharges in defiance of the Town Council during this period. Notwithstanding the pressure from the Town Council, a drain in Metro Atlantic's main building still discharged liquid wastes into the tailrace during the period of Joseph Nadeau's employment in 1964-65. (Trial Tr., vol. XIV, 4:11-4:13, 38:13-39:3, 41:1-41:10, 45:5-45:8, ECF No. 396.) Additionally, although the Town Council threatened Metro Atlantic in 1956 with legal action if it did not cease dumping chemical waste into the tailrace (Emhart Ex. 276), Metro Atlantic discharged corrosive liquid waste from the Texas Tower in connection with its trifluralin-manufacturing operations in the early 1960s. (Turcone 11/30/99 Dep. Tr. 18:8-18:20.) Finally, Metro Atlantic could have covertly discharged its liquid wastes from the HCP building into the river by placing its discharge pipe below the water level of the Woonasquatucket River. (Trial Tr., vol. XIX, 70:17-70:20, 71:1-72:3, ECF No. 401.)

To be sure, as Smith pointed out, the 2009 excavation unearthed no evidence of a discharge pipe leading from the area

of the HCP building to the Woonasquatucket River.[48] (Trial Tr., vol. X, 36:3-36:6, ECF No. 392.) However, the fact that such a pipe was not found during the 2009 excavation does not foreclose the conclusion that it existed at one point in time. Forrester testified that the discharges of liquid waste from the HCP building would not have been of continuous high volume, such as to be observed from an ongoing process; he opined that a release of one of the largest liquid waste streams generated in the process was the equivalent of an hour-long discharge from a garden hose. (Trial Tr., vol. XIX, 70:6-70:24, ECF No. 401.) Additionally, he opined that the pipe could have been placed below the water level (id. at 70:17-70:20, 71:1-72:3), and Maine might have missed such a submerged pipe in his canoe ride along the Woonasquatucket River in the 1970s. Finally, contrary to the copper pipe and the steel pipe inside a clay pipe, which

[48] In a similar vein, during a canoe trip along the Woonasquatucket River sometime in the 1970s, Maine observed no evidence of pipes leading from the western side of the peninsula to the river. (Maine 5/22/13 Dep. Tr. 42:18-44:10, 71:9-72:9.)

Although a metal pipe was discovered at the southwestern corner of the excavation area and was oriented in the direction of the Woonasquatucket River, Smith testified that this pipe was not within the HCP building footprint (Trial Tr., vol. X, 67:4-67:8, 69:20-70:7, 70:11-70:17, ECF No. 392), and Nathan Emmons, who supervised the excavation, testified that it was a five- to six-foot section of pipe that appeared to simply constitute debris (Id. at 172:21-173:7). Indeed, Forrester expressly disclaimed any opinion that this pipe was a drainage pipe from the HCP plant to the Woonasquatucket River. (Trial Tr., vol. II, 201:11-201:14, ECF No. 384.) Therefore, this Court concludes that no evidence of a discharge pipe was found in the 2009 excavation.

extended away from the HCP building footprint for a considerable distance (see Trial Tr., vol. X, 166:9-166:16, 167:20-167:22, 169:6-170:1, ECF No. 392 (describing pipe-tracing efforts for those pipes)), a pipe discharging from the HCP building to the Woonasquatucket River could have been relatively short because the HCP building so closely abutted the bank of the river (see Trial Tr., vol. I, 143:24-144:8, ECF No. 383; U.S. Ex. 240). Thus, it is likely that, when the concrete pad on which the HCP building sat and through which the trench drain in the HCP building directed the liquid waste (see Trial Tr., vol. III, 163:13-163:25, ECF No. 385) was removed in connection with the construction of a parking lot for the Brook Village housing complex (see Trial Tr., vol. XV, 64:1-64:7, ECF No. 397), this relatively small discharge pipe was removed along with the concrete pad.

For these reasons, this Court concludes that Metro Atlantic discharged the liquid waste that was generated in the HCP-manufacturing process into the Woonasquatucket River by discharge pipe.

b. Destination of Solid Waste

It is undisputed that Metro Atlantic's HCP-manufacturing process generated solid waste streams, including waste from the

filter, known as "filter cake," which contained Nuchar.[49] (See Trial Tr., vol. III, 69:22-70:2 78:16-78:18, ECF No. 385; Trial Tr., vol. XIII, 40:18-40:24, ECF No. 395; see also Emhart's Post-trial Br. 43, ECF No. 378.) The vast majority of the 2,3,7,8-TCDD that entered the HCP process from the outdoor crude Na 2,4,5-TCP storage tanks would have adsorbed to the Nuchar the first time that Nuchar was used (irrespective of whether it was used once or twice in the process).[50] (Trial Tr., vol. II, 209:15-209:17, 210:2-210:6, 214:8-214:13, ECF No. 384; Trial Tr., vol. III, 46:10-46:18, ECF No. 385; Trial Tr., vol. XVII, 17:19-17:22, 64:11-64:14, June 17, 2015, ECF No. 399.) Emhart argues that this filter cake, like all solid waste generated in

[49] Forrester opined that, in addition to the solid waste stream of the filter cake containing Nuchar, spills of the wet HCP crystals during placement of the crystals into the drums and transportation of the crystals to be dried and spills during the handling of the finished HCP product represented other potential solid waste streams. (Trial Tr., vol. II, 217:15-217:20, ECF No. 384; Trial Tr., vol. III, 6:6-6:15, ECF No. 385.) However, he acknowledged that any releases of 2,3,7,8-TCDD that occurred in connection with these waste streams would be negligible. (Trial Tr., vol. II, 217:20, ECF No. 384; Trial Tr., vol. III, 6:12-6:15, 7:12-7:23, ECF No. 385.)

[50] The question of whether Nuchar was used once or twice in Metro Atlantic's HCP-manufacturing process has long been a point of disagreement between the parties, and spanned a vigorous round of pretrial-motion practice involving a prepared statement of Thomas Cleary. (See Order Granting Defs.' Mot. in Limine, ECF No. 325.) The dispute rages on (see Emhart's Post-trial Br. 43, ECF No. 378; Gov't's Proposed Findings of Fact ("Gov't's PFOF") ¶¶ 270-73, 280, ECF No. 379), and it is addressed below, see infra Section I.C.3.b.ii.A.3.

the HCP building, was placed in a dumpster that was routinely hauled offsite for disposal. (Emhart's Post-trial Br. 99, 107, ECF No. 378.) The Government, on the other hand, takes the position that the filter cake was disposed of in the WDA at the southern end of the peninsula. (Gov't's PFOF ¶ 279, ECF No. 379; Gov't's Proposed Conclusions of Law ¶ 28, ECF No. 379-1.)

Although the question is a close one, this Court finds that the preponderance of the evidence suggests that the Nuchar filter cake was not deposited exclusively in either the dumpster or the WDA; rather, some of the filter cake was placed into the dumpster, and some was deposited in the WDA. This Court deems this to be the most likely conclusion based on the testimony of fact witnesses and the sampling data for the peninsula. Each basis for this conclusion is discussed in turn.

i. Lay-Witness Testimony

On the one hand, there is testimony that, by the mid-1960s (when Metro Atlantic was manufacturing HCP), Metro Atlantic employees were discarding chemical waste, including filter cake from the operations in Metro Atlantic's main building, in the dumpster that was located next to the main building. (See Trial Tr., vol. XIV, 15:19-18:23, 20:11-20:22, ECF No. 396.) See also supra Section I.B.1.a. Joseph Nadeau cleaned filter presses in the Metro Atlantic main building in 1964-65. (Trial Tr., vol. XIV, 15:12-17:14, ECF No. 396.) This process entailed releasing

the pressure on the filter press and pulling the frames apart. (Id. at 15:13-15:20.) When the frames were pulled apart, some of the filter "sludge" would fall to the ground, and it was then shoveled into a drum. (Id. at 15:19-15:21, 16:24-17:1, 17:5-17:14.) Joseph Nadeau testified that he knew that some of these drums of filter cake went into the dumpster. (Id. at 17:20-17:24, 18:8-18:11.) Emhart insists that, like the filter cake from the main building, the filter cake containing spent Nuchar ("Nuchar filter cake") from the HCP-manufacturing process also was disposed of in the dumpster. (Emhart Post-trial Br. 99, 107, ECF No. 378.)

However, other testimony indicates that, during the timeframe that Metro Atlantic manufactured HCP, some filter cake from the Metro Atlantic main building was disposed of in the WDA. Joseph Nadeau's brother, Raymond Nadeau, worked for NECC from approximately 1956 to 1969. (R. Nadeau 10/1/02 Dep. Tr. 63:11-63:12; R. Nadeau Home Ins. Trial Tr. 80:3-80:4.) Raymond Nadeau testified that he observed Metro Atlantic employees dispose of filter press waste – which he described as "black like mud" – in drums that were subsequently disposed of in the WDA. (R. Nadeau 6/12/13 Dep. Tr. 90:3-90:17; see also R. Nadeau 9/10/08 Dep. Tr. 49:15-50:6; R. Nadeau 12/17/02 Dep. Tr. 16:9-16:10.) He further testified that he observed Metro Atlantic employees dump drums of "black sludge" in the WDA a few times a

week for every year he worked on the peninsula, including 1965.[51] (R. Nadeau Home Ins. Trial Tr. 72:23-73:8, 75:15-75:18, 79:16-80:8; see also R. Nadeau 9/10/08 Dep. Tr. 65:2-65:15.)

Notwithstanding Emhart's argument to the contrary (see Emhart Post-trial Br. 56 n.289, ECF No. 378), the conclusion that both the dumpster and the WDA were used for the disposal of filter cake from the HCP-manufacturing process is not inconsistent with Joseph Nadeau's testimony. Although he testified that he personally dumped barrels of filter cake from Metro Atlantic's main building into the dumpster, he also testified that some drums were left in the basement of the main

[51] Emhart argues that Raymond Nadeau's testimony on this score is unworthy of credence because he was employed as an NECC truck driver from 1962-69 and "[h]e never testified that he ever handled Metro-Atlantic filter press waste; that he ever observed Metro-Atlantic's filter presses in operation or being cleaned; that he ever observed filter press waste being placed in barrels; or that he ever observed Metro-Atlantic employees load barrels with filter press waste onto their trucks for disposal." (Emhart's Post-trial Br. 56 n.289, ECF No. 378.) However, Nadeau testified that he made deliveries to the area where the filter presses were located in Metro Atlantic's main building and observed Metro Atlantic employees cleaning the presses, placing the filter cake in drums, and disposing of the drums in the WDA. (R. Nadeau 6/12/13 Dep. Tr. 90:3-90:17.) Additionally, notwithstanding the time Nadeau spent away from the peninsula in the mid-1960s as a truck driver, he worked on the peninsula after he became a truck driver. (See Trial Tr., vol. IX, 32:5-32:7, June 3, 2015, ECF No. 391.) And he testified that he observed Metro Atlantic employees dump drums of "black sludge" in the WDA both before and after he started driving trucks for NECC. (R. Nadeau Home Ins. Trial Tr. 72:23-73:8, 75:15-75:18, 79:16-80:8; R. Nadeau 9/10/08 Dep. Tr. 65:2-65:15.)

building. (Trial Tr., vol. XIV, 18:3-18:7, ECF No. 396.) He was unsure of the destination of the drums that were stored in the basement: "[W]hen you went home at night, sometimes you would come back and it would be gone. Where it went, I don't know."[52] (Id. at 17:25-18:2.)

The combined effect of Joseph and Raymond Nadeau's testimony is that this Court cannot accept Emhart's position that the Nuchar filter cake was always placed in the dumpster. Instead, this Court finds that Metro Atlantic treated its filter cake from the HCP-manufacturing process the same way it treated its filter cake generated by its main-building operations: some was placed in the dumpster, and some was deposited in the WDA.[53]

[52] Joseph Nadeau also offered similar testimony about the dumpster occasionally being empty when he came to work. (Trial Tr., vol. XIV, 18:12-18:23, ECF No. 396.)

[53] It is worth noting that there would have been a practical advantage of depositing Nuchar filter cake in the WDA: better working conditions for those toiling in Metro Atlantic's main building. In the course of opining on the unlikelihood of leaks and spills of the crude Na 2,4,5-TCP from the tanker trucks during the transfer to the storage tanks, Kittrell emphasized that the crude Na 2,4,5-TCP "is a very foul material. Apart from being brown, it's very odiferous. It makes your eyes water. It stings you if it contacts with your skin." (Trial Tr., vol. XII, 192:20-192:23, ECF No. 394.) Consistent with this testimony, Kittrell acknowledged that the filter cake from the HCP-manufacturing process would have a "bad odor." (Trial Tr., vol. XIII, 93:6-93:9, ECF No. 395.) It stands to reason that those working in the main building may not have wanted this "foul material" deposited in the dumpster, which rested in close proximity to the main building and was not removed on a daily basis (see Trial Tr., vol. XIV, 18:17-18:23, ECF No. 396).

ii. Site Data

The sampling data also supports the conclusion that some amount of Nuchar filter cake – at least some of which had high concentrations of 2,3,7,8-TCDD adsorbed to it – from the HCP-manufacturing process was deposited in the WDA. (Trial Tr., vol. II, 210:19-210:20, ECF No. 384; Trial Tr., vol. III, 187:24-188:10, ECF No. 385.) In particular, the presence of two byproducts of the HCP-manufacturing process – 2,3,7,8-TCDD and

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Additionally, other practical considerations support the conclusion that some amount of Nuchar filter cake was deposited in the WDA. Forrester estimated that a 55-gallon drum could contain approximately 200 pounds of Nuchar and that, because the Nuchar filter cake was wet with PCE, the filter cake would be even heavier. (See Trial Tr., vol. IV, 116:22-117:9, May 21, 2015, ECF No. 386.) And, as with any industrial waste disposal practice, the ambition of the worker plays a large role in the effectiveness of the practice. (Cf. Trial Tr., vol. XIV, 40:25-41:1, ECF No. 396 (Joseph Nadeau's testimony that the amount of filter cake that was shoveled into drums "depend[ed] on how ambitious the shoveller was").) Therefore, as a matter of convenience, a Metro Atlantic employee working in the HCP building might elect to bring the heavy, wet Nuchar filter cake to a truck parked immediately outside of the HCP building and drive the filter cake down to the WDA instead of carrying the heavy filter cake across the access road and over to the dumpster next to the main building and lifting the heavy filter cake into the dumpster. Indeed, even Emhart acknowledged during closing argument that this scenario was a "reasonable interpretation" of the evidence. (Trial Tr., vol. XXI, 103:18, ECF No. 403; see also id. at 102:20-103:18.) Furthermore, economic considerations could have played a role in the decision to dispose of some of the Nuchar filter cake in the WDA: Because disposal rates are typically based on weight, there may have been an incentive to limit the amount of heavy, wet filter cake that went into the roll-off dumpster in order to save on tipping fees.

HCX – in the WDA indicate that filter cake from the HCP-manufacturing process was deposited in the WDA.

A. HCX

The parties dispute whether HCX – which was found in several locations across the peninsula, including the WDA (see Locke Slide 100, Emhart Ex. 342) – was formed as a byproduct under Metro Atlantic's HCP-manufacturing conditions. (See Emhart's Post-trial Br. 34, 45, ECF No. 378; Gov't's PFOF ¶¶ 722-44, ECF No. 379.) This Court finds that Metro Atlantic's HCP-manufacturing process generated HCX and that HCX can be used as a marker for releases of 2,3,7,8-TCDD.

1. Formation of HCX

Dr. Harry Eugene Ensley – a Government expert in chemistry, including organic chemistry and the formation of dioxins – synthesized HCX in his laboratory at Tulane University in the early 1990s. (Trial Tr., vol. XVIII, 3:11-3:12, 12:9-12:10, 15:13-15:20, 63:24-64:1, ECF No. 400.) In creating a laboratory standard of HCX (id. at 64:19-64:21), Ensley employed two methods for creating HCX from HCP that were outlined in an article by Rolf Göthe and Carl Axel Wachtmeister (Emhart Ex. 246). (Id. at 65:13-67:6, 67:15-67:18.) One of those methods involved the treatment of HCP with polyphosphoric acid, a "very strong acid," under "very harsh conditions." (Id. at 65:24-66:4.) When he treated HCP with acid under these conditions,

Ensley succeeded in synthesizing a one-percent yield of HCX.[54] (Id. at 56:16-56:18, 66:16-67:1, 67:19-68:8, 128:11-128:18, 164:1-164:15.)

Metro Atlantic's HCP-manufacturing process also involved generating HCP in the presence of acid, although the conditions that were employed by Ensley were much harsher than those employed by Metro Atlantic. (Id. at 68:12-69:7, 128:16-129:10; see also Trial Tr., vol. XII, 109:11-109:15, ECF No. 394.) Ensley opined that Metro Atlantic's HCP-manufacturing process would have generated HCX in concentrations of ten to one hundred parts per million and that the HCP-manufacturing process was the source of the HCX found on the Site. (Trial Tr., vol. XVIII, 69:8-69:21, 130:15-130:18, ECF No. 400.) Ensley further opined that the concentrations of the HCX found on the Site are consistent with the concentrations that would have been created during Metro Atlantic's manufacture of HCP. (Id. at 69:22-70:2, 164:16-166:24.)

[54] Ensley and Dr. Gregory C. Fu, Emhart's expert in organic chemistry (Trial Tr., vol. XII, 3:13-3:14, 10:22-11:3, ECF No. 394), disagree on whether the Göthe and Wachtmeister article can be read for the proposition that treatment of HCP with acid can generate small quantities of HCX. (See id. at 104:19-104:22, 107:17-107:24, 110:13-110:24; Trial Tr., vol. XVIII, 127:10-127:22, June 23, 2015, ECF No. 400.) This dispute need not be resolved here. Ensley testified that he successfully generated HCX by treating HCP with acid (Trial Tr., vol. XVIII, 56:16-56:18, 66:16-67:1, 67:19-68:8, 128:11-128:18, 164:1-164:15, ECF No. 400), and Fu does not contest that Ensley did so (Trial Tr., vol. XII, 131:14-131:23, ECF No. 394).

Although Dr. Gregory C. Fu, Emhart's expert in organic chemistry, testified on the unlikelihood that HCX was formed under Metro Atlantic's HCP-manufacturing conditions, he did not opine that Metro Atlantic's manufacture of HCP did not produce HCX. (Trial Tr., vol. XII, 3:13-3:14, 10:22-11:3, 117:11-117:15, ECF No. 394.) The most Fu could say was that "it could not be determined with a reasonable degree of scientific certainty that Metro[ ]Atlantic created HCX at the [HCP] plant." (Id. at 117:8-117:10.) Significantly, neither Ensley nor Fu knew of any industrial chemical-manufacturing process other than HCP manufacture that leads to the formation of HCX.[55] (Id. at 119:14-119:18; Trial Tr., vol. XVIII, 56:21-56:25, ECF No. 400; see also Id. at 80:3-80:5.) Ensley's testimony, which was based on his own work synthesizing HCX by applying acid to HCP, offers a plausible explanation for the HCX that was found on the Site.

This Court therefore concludes that HCX was generated under Metro Atlantic's HCP-manufacturing conditions. It is difficult to say with any degree of precision exactly how much HCX was created, however, because "the manufacture of [HCP] produce[s] . . . [HCX] in widely varying amounts depending on the reaction conditions of the manufacturing process." (June 20, 2005 Letter from Stephen Emsbo-Mattingly to Deirdre Dahlen ("Emsbo-Mattingly

[55] Ensley further testified that "you can't make [HCP] without generating small quantities of [HCX]." (Trial Tr., vol. XVIII, 56:13-56:15, ECF No. 400.)

Letter") 2, Emhart Ex. 312.) Therefore, any variation of Metro Atlantic's starting materials and reaction conditions from batch to batch would likely have affected the quantity of HCX that was produced.

2. Location of HCX

The Government contends that the presence of HCX in the WDA is an indicator of releases of 2,3,7,8-TCDD from Metro Atlantic's HCP-manufacturing process to the same area. (See Gov't's PFOF ¶¶ 722-49, ECF No. 379.) Emhart disputes this proposition for two reasons. First, Emhart argues that the "significant concentrations" of HCX in the tailrace adjacent to the areas of the former NECC buildings and the impoundment – areas that were not used by Metro Atlantic to dispose of Nuchar filter cake from its HCP operation – demonstrate that the presence of HCX on the peninsula cannot be used as a marker for releases of 2,3,7,8-TCDD by Metro Atlantic because no aspect of the HCP-manufacturing process involved the tailrace. (Emhart's Post-trial Br. 116-17, ECF No. 378.) Second, Emhart contends that the correlation of concentrations of HCX and 2,3,7,8-TCDD on the peninsula is not as strong as it should be if the two contaminants were released in the course of Metro Atlantic's

manufacture of HCP.[56] (Id. at 113-16.) Notwithstanding Emhart's arguments, this Court finds, for the reasons discussed below, that the presence of HCX in the WDA is indicative of releases of 2,3,7,8-TCDD adsorbed to Nuchar filter cake.

Locke testified that the concentrations of HCX in the tailrace adjacent to the former NECC buildings and impoundment are inconsistent with releases from the HCP-manufacturing process. (Trial Tr., vol. VIII, 149:25-150:7, ECF No. 390; see also Locke Slide 100, Emhart Ex. 342.) To pin these concentrations of HCX on NECC, Emhart weaves together three isolated strands of the evidentiary record. (See Emhart's Resp. to Court's Questions for the Parties to Address in Their Post-Trial Mem. & Arg. ("Emhart's Resp. to Court's Questions") 4-5, ECF No. 378-1.) First, Emhart notes that the Original Bradford Soap Works ("Bradford Soap") supplied drums to NECC. (Id. at 5; see Locke Slide 68, Emhart Ex. 342 (indicating that Bradford Soap supplied NECC with 50-75 drums every two weeks).) Next, Emhart points to 1972 congressional remarks from United States Representative Benjamin S. Rosenthal in which Bradford Soap is identified as a manufacturer of several HCP-containing products. (Emhart's Resp. to Court's Questions 5, ECF No. 378-1; see Cong. Remarks of Rep. Rosenthal 2, Emhart Ex. 249.) Finally, for the

[56] Appendix F depicts the locations of the HCX found on the peninsula and the correlation between the concentrations of HCX and 2,3,7,8-TCDD in those locations.

last link in this evidentiary chain, Emhart relies on Ensley's testimony that HCP generally contains between ten and 100 parts per million of HCX and that this concentration range is consistent with the concentrations detected on the peninsula. (Emhart's Resp. to Court's Questions 5, ECF No. 378-1.)

The inferences that Emhart seeks to draw from the snippets of evidence it has selected are weak. For starters, there is no evidence that HCP or an HCP-containing product had been stored in the drums that Bradford Soap supplied to NECC.[57] (Cf. Trial Tr., vol. XIII, 64:20-64:23, ECF No. 395 (Kittrell acknowledging that "[t]here's really no information that any particular company had a particular contaminant in a particular [drum] [that was] delivered to [NECC] for reconditioning"); see also id. at 169:12-169:15.) The Court is simply asked to assume that, because some barrels came from Bradford Soap and Bradford Soap made some products that contained HCP, the barrels from Bradford Soap contained HCP. This asks too much. Similarly,

[57] Indeed, it is not even clear to this Court that HCP was ever stored in the same type of drums that NECC reconditioned. The only evidence in this record concerning the storage of the final product of HCP is the testimony of Forrester and Kittrell that Metro Atlantic's HCP would have been stored in fiber drums with plastic liners. (See Trial Tr., vol. III, 5:25-6:2, ECF No. 385; Trial Tr., vol. XIII, 16:13-16:20, ECF No. 395; U.S. Ex. 491; Kittrell Slide 32, Emhart Ex. 350.) Thus, to the extent that Metro Atlantic's practice of storing its final product of HCP was in line with the industry practice, it is unlikely that any of the 55-gallon steel drums that NECC received from Bradford Soap had been used for storing HCP itself.

because the record is devoid of any evidence of the details of the manufacture of the HCP that Bradford Soap used in its products, it is difficult to know how much, if any, HCX would have accompanied the HCP presumably used by Bradford Soap. (See Emsbo-Mattingly Letter 2, 14, Emhart Ex. 312.) Finally, Emhart has made no effort to show that any trace amounts of HCX that might have accompanied the trace amounts of HCP that might have been in the drums that Bradford Soap supplied to NECC can explain the elevated concentrations of HCX that were found in the tailrace and across the peninsula.

At best, Emhart has identified a potential link between NECC and HCX, but nothing more.[58] Moreover, there are several possible explanations for the presence of HCX in the tailrace adjacent to the former NECC buildings and impoundment, and some implicate Metro Atlantic's HCP-manufacturing operations while others do not. At bottom, the evidentiary record is too slim to say for certain how HCX found its way into this area. However, the mere presence of this outlier – even if it remains unexplained – does not require this Court to throw the baby out with the bath water. The presence of HCX in the vicinity of the HCP building footprint and the WDA (see Locke Slide 100, Emhart Ex. 342) can be used as a marker for releases from Metro

[58] Whether there is more to this theory and whether Bradford Soap may be required to contribute to the cost of the cleanup is a question for another day.

Atlantic's HCP-manufacturing operations (see Emsbo-Mattingly Letter 14, Emhart Ex. 312).

3. Colocation of HCX: Number of Nuchar Treatments

Emhart also argues that the weak correlation between HCX and 2,3,7,8-TCDD dooms the Government's attempt to use the presence of HCX as a marker for Metro Atlantic's releases of 2,3,7,8-TCDD. (Emhart Post-trial Br. 113-16, ECF No. 378.) Emhart's primary argument in this regard is that, because Metro Atlantic's HCP-manufacturing process involved only one Nuchar application, both the HCX created during Metro Atlantic's manufacture of HCP and the vast majority of the 2,3,7,8-TCDD that entered the HCP building from the outdoor storage tanks would have adsorbed to the Nuchar. (Id. at 113.) If the Nuchar filter cake containing the HCX and the 2,3,7,8-TCDD was disposed of in the WDA, the argument goes, one would expect to find a consistent ratio of concentrations of HCX and 2,3,7,8-TCDD throughout the WDA. (Id.) Instead, Locke testified that the correlation between HCX and 2,3,7,8-TCDD is "extremely weak." (Trial Tr., vol. VIII, 148:20, ECF No. 390.) Therefore, Emhart argues, the presence of HCX in the WDA is not a reliable indicator that Metro Atlantic's solid waste from the HCP-manufacturing process ended up there as well. (Emhart's Post-trial Br. 113-15, ECF No. 378.) In opposing Emhart's correlation argument, the Government first challenges Emhart's

basic premise: that Metro Atlantic's HCP-manufacturing operation employed Nuchar only once.

The parties agree that Nuchar was used at least once in Metro Atlantic's HCP-manufacturing process: towards the end of the synthesis of HCP in order to remove color from the final product. (See Trial Tr., vol. III, 78:15-78:18, ECF No. 385; Trial Tr., vol. XIII, 40:18-40:24, ECF No. 395.) Emhart insists that this was the only time Nuchar was used, while the Government argues that it was first used earlier in the process, during the purification of the crude Na 2,4,5-TCP. (See Emhart's Post-trial Br. 43, 113, ECF No. 378; Gov't's PFOF ¶¶ 270, 280, ECF No. 379.) Although the issue is not entirely free from doubt, this Court concludes that Nuchar was used twice during Metro Atlantic's process for manufacturing HCP.

The dispute over the number of Nuchar treatments finds its genesis in the interplay between Cleary's deposition and an exhibit referenced during that deposition. Cleary testified that, before the HCP could be synthesized, "the crude [Na 2,4,5-TCP] that was shipped from Diamond Alkali . . . was treated with chemicals, of which I think I supplied you a list in one of those folders, in order to purify it." (Cleary Dep. Tr. 40:18-40:21.) Cleary later explained that this list, which was subsequently marked as Exhibit 8 to Cleary's deposition (id. at 48:21-49:2), was "the only thing that [Cleary] ha[d] that George

Huse put together."[59] (Id. at 48:17-48:18.) On the back of Exhibit 8 to Cleary's Deposition, which was entitled "ZEP Manufacture" ("ZEP List"), was a handwritten notation, presumably penned by Cleary, that read: "This is Geo[rge] Huse[']s bill of materials for purification of trichlorophenol[.] 'Zep' was our nickname for hexachlorophene." (U.S. Ex. 90.) The ZEP List set out the purification equipment and a "basic charge" of materials under the heading "Phase #1." (Id.) The materials listed included ten pounds of Nuchar. (Id.) During Cleary's deposition, the following exchange occurred regarding the ZEP list:

> Q. Now Exhibit 8 says --
>
> I'm sorry, Counsel, I only have the one copy received from the witness.
>
> It says, "ZEP Manufacture, Phase No. 1."
>
> A. Uh-huh.
>
> Q. Do you know whether there was -- there were further phases in the manufacturing process than just that phase?
>
> A. That was the phase of purifying the trichlorophenol.
>
> Q. Now, this is the trichlorophenol that was purchased from Diamond Alkali?
>
> A. That's right.

[59] Cleary referred to Huse as a chemical engineer who served as Metro Atlantic's "technical director." (Cleary Dep. Tr. 35:4-35:5, 36:17-37:6.)

Q. And the title "ZEP," once again, refers to hexachlorophene.

A. That's right.

(Cleary Dep. Tr. 50:6-50:21.) This Court finds that the import of this testimony is consistent with the handwritten notation on the back of the ZEP List: "That [i.e. Phase No. 1 of the ZEP List] was the phase of purifying the trichlorophenol."[60] (Id. at 50:14-50:15.) Therefore, both Cleary's deposition and the ZEP List indicate that Nuchar was used during the purification of the crude Na 2,4,5-TCP that Metro Atlantic received from Diamond Alkali.

Emhart disagrees with this conclusion for several reasons. It first points out that the ZEP List contains two separate entries for sulfuric acid when only one is necessary in the purification of the crude Na 2,4,5-TCP. (Emhart Post-trial Br. 49-50, ECF No. 378.) Relatedly, Emhart notes that the

[60] Kittrell offered a different take on this passage of Cleary's testimony. In Kittrell's opinion, Cleary's answer of "[t]hat was the phrase of purifying the trichlorophenol" was meant to identify the further phases in the HCP-manufacturing process. (See Trial Tr., vol. XIII, 114:18-115:13, 120:8-120:12, ECF No. 395.) This Court rejects this interpretation of Cleary's testimony. For starters, Kittrell's interpretation is inconsistent with the handwritten notation on the back of the ZEP List, which, as far as this Court can tell, was written by Cleary. Additionally, Cleary's use of "that" in the above-quoted passage more likely refers to "that phase" in the question, which, in turn, refers to Phase 1 of the ZEP List (Cleary Dep. Tr. 50:6-50:15), and even Kittrell acknowledged this possibility (Trial Tr., vol. XIII, 120:8-120:12, ECF No. 395).

descriptive terms next to each acid entry on the ZEP List – "Precipitating acid" and "Purification acid," respectively – are not chemically correct terms for the step of protonating the crude Na 2,4,5-TCP.[61] (Id. at 49; see U.S. Ex. 90; Trial Tr., vol. III, 66:1-66:7, ECF No. 385; Trial Tr., vol. XVIII, 139:21-140:5, ECF No. 400.) Additionally, Emhart focuses on the distinction that Cleary appears to draw in his deposition between the materials used to purify the crude Na 2,4,5-TCP – which Cleary refers to as "chemicals" (Cleary Dep. Tr. 40:20) – and the use of "the [de-]colorizing agent, the charcoal," towards the end of the synthesis of HCP (Cleary Dep. Tr. 41:9-41:10). (Emhart's Post-trial Br. 47, ECF No. 378.) Because "chemicals" were used to purify the crude Na 2,4,5-TCP and because Nuchar is not a chemical but a "[de-]colorizing agent," the argument goes, Nuchar was not used to purify the crude Na 2,4,5-TCP, notwithstanding its inclusion in the ZEP List. (Id. at 47; see Trial Tr., vol. III, 45:22-45:24, 50:7-50:19, 50:22-

[61] Emhart also notes that the ZEP List omits water from the list of materials used in the manufacturing process. (Emhart's Post-trial Br. 50, ECF No. 378.) This omission is insignificant. Although Forrester testified that he "would have thought that [the use of water in the process of purifying the crude Na 2,4,5-TCP] would have been the most efficient way to do it," he acknowledged that the use of water was not required (Trial Tr., vol. III, 40:12-40:13, ECF No. 385; see also id. at 40:7-40:18, 41:8-41:10), and there is no other evidence suggesting that Metro Atlantic used water in this stage of the HCP-manufacturing process.

51:8, ECF No. 385; Trial Tr., vol. XVIII, 133:12-133:20, ECF No. 400.)

These arguments, although not without some persuasive force, cannot carry the day. With respect to the two uses of sulfuric acid, Forrester opined that two treatments of sulfuric acid were used in the purification of the crude Na 2,4,5-TCP in order to increase the yield of the 2,4,5-TCP.[62] (Trial Tr., vol. II, 207:22-208:5, ECF No. 384.) In any event, although some degree of imprecision may be embedded in the ZEP List, it clearly is not a complete list of all of the materials that were used in Metro Atlantic's HCP-manufacturing process. (Trial Tr., vol. XIX, 7:20-9:3, ECF No. 401.) As Kittrell acknowledged, certain raw materials that undeniably were used in the HCP-manufacturing process, such as paraformaldehyde, are not included on the ZEP List. (Trial Tr., vol. XIII, 117:10-117:13, 124:9-124:15, ECF No. 395.) And, with the possible exception of the second sulfuric acid entry, it is undisputed that all of the other materials on the ZEP List (apart from Nuchar and Fiber Flo) were used by Metro Atlantic in the purification of the

[62] Emhart persuasively notes the uncertainties that surround the basis for Forrester's opinion on this score: an undated patent of Olin Corporation, which had no apparent connection to Metro Atlantic. (Emhart's Post-trial Br. 50 n.249, ECF No. 378.) Nonetheless, the existence of the Olin Corporation patent supports Forrester's opinion that the two-step addition of acid in the purification of crude Na 2,4,5-TCP was not necessarily senseless.

crude Na 2,4,5-TCP. (Id. at 120:14-123:13.) Additionally, at the bottom of the ZEP List are entries for the theoretical, maximum, and minimum yields of 2,4,5-TCP, as well as the melting point of 2,4,5-TCP; in contrast to its treatment of 2,4,5-TCP, the ZEP List does not contain any mention of yields or the melting point of HCP. (U.S. Ex. 90; Trial Tr., vol. XIII, 123:17-124:8, ECF No. 395; Trial Tr., vol. XIX, 9:4-9:8, ECF No. 401.) Notwithstanding Emhart's arguments to the contrary, this Court remains convinced that the ZEP List is exactly what its handwritten notation and Cleary's deposition testimony describe it as: a list of materials that Metro Atlantic used in the purification of the crude Na 2,4,5-TCP that it received from Diamond Alkali.[63]

Emhart argues that two uses of Nuchar would have been impractical. (See Emhart's Post-trial Br. 50-51, ECF No. 378.) Kittrell opined that using Nuchar in the purification of the crude Na 2,4,5-TCP would be unnecessary and a waste of time because the use of Nuchar towards the end of the synthesis of

[63] This Court is not alone in its understanding of the ZEP List. Dr. J. Ronald Hass, one of the experts previously retained by Emhart in connection with the EPA's investigation of the Site, wrote the following in 2006: "The purification procedure implicit with the supplied bill of materials [i.e. the ZEP List] and Mr. Cleary's testimony is a classical recrystallization followed by dissolution of the TCP in [PCE], with that solution being purified with activated charcoal." (Ex. A to October 19, 2006 Letter from Jerome C. Muys, Jr. to Anna Krasko 4, U.S. Ex. 46; see also id. at 3 (chart containing two uses of Nuchar).)

HCP would remove all color from the product. (Trial Tr., vol. XII, 224:1-224:24, ECF No. 394.) Along similar lines, Dr. Francesco Stellacci – Emhart's expert in nanomaterials and carbon materials – opined that using Nuchar during the purification of the crude Na 2,4,5-TCP would serve no purpose because the addition of sodium hydroxide to generate Na 2,4,5-TCP crystals is itself a purification step that would remove color. (Trial Tr., vol. XVII, 8:17-8:18, 15:17-15:23, 33:16-34:13, 34:16-34:17, 62:22-63:6, 63:10-63:16, ECF No. 399.) Stellacci also opined that using Nuchar during the purification of the crude Na 2,4,5-TCP would reduce the yield of 2,4,5-TCP, which would, in turn, reduce the yield of the final product. (Id. at 34:7-34:13, 62:6-62:11, 82:17-83:1.)

This Court is unconvinced. If Nuchar was not used in the purification of the crude Na 2,4,5-TCP, the purified 2,4,5-TCP would have contained several impurities.[64] (Trial Tr., vol. II, 210:25-211:3, ECF No. 384.) The existence of these impurities would have reduced the yield of HCP that was produced. (Id. at

[64] This is so even if, as Stellacci opined, the addition of sodium hydroxide to the crude Na 2,4,5-TCP would have removed color. Stellacci acknowledged that the addition of sodium hydroxide would not have purified the crude Na 2,4,5-TCP in the sense of removing impurities besides color; indeed, Stellacci conceded that the addition of sodium hydroxide did not remove all of the 2,3,7,8-TCDD and that some of the 2,3,7,8-TCDD went along with the Na 2,4,5-TCP crystals to subsequent stages in Metro Atlantic's HCP-manufacturing process. (Trial Tr., vol. XVII, 84:17-85:10, 86:20-87:6, ECF No. 399.)

211:3-211:24; Trial Tr., vol. XIX, 9:17-9:22, ECF No. 401.) Conversely, 2,4,5-TCP of higher purity would increase the yield of HCP. (Trial Tr., vol. XVIII, 54:20-54:23, ECF No. 400.) Indeed, Stellacci agreed that two uses of Nuchar would likely have resulted in a purer final product of HCP. (Trial Tr., vol. XVII, 64:21-64:24, ECF No. 399.) Thus, the loss of 2,4,5-TCP during the first Nuchar treatment was the lesser of two evils; without the first use of Nuchar to purify the 2,4,5-TCP, impurities in the 2,4,5-TCP would cause a greater loss in the yield of the final product, HCP.[65] (Trial Tr., vol. XIX, 10:5-10:11, ECF No. 401.) Finally, with respect to the additional time required by the use of Nuchar in the purification of the crude Na 2,4,5-TCP, Forrester opined that this step could be accomplished in less than an hour. (Id. at 11:18-11:19.)

Emhart presents two other arguments in support of its position that Nuchar was used only once in Metro Atlantic's HCP-manufacturing process, but neither is persuasive. First, Emhart emphasizes that the process outlined in Cleary's patent for the purification of crude 2,4,5-TCP does not provide for the use of activated carbon. (Emhart's Post-trial Br. 48-49, ECF No. 378;

[65] The ZEP List – with its recitation of the theoretical, maximum, and minimum yields of 2,4,5-TCP – anticipates some loss of 2,4,5-TCP during the purification of the crude Na 2,4,5-TCP. (See U.S. Ex. 90; Trial Tr., vol. XIX, 10:12-10:21, ECF No. 401.)

see Emhart Ex. 32; Trial Tr., vol. III, 59:22-60:1, ECF No. 385; Trial Tr., vol. XII, 223:10-223:14, ECF No. 394; Trial Tr., vol. XIII, 175:19-175:24, ECF No. 395; Trial Tr., vol. XVIII, 141:14-141:24, 144:8-144:10, ECF No. 400.) However, although Metro Atlantic could have conceivably used the process outlined in Cleary's TCP-purification patent to purify the crude Na 2,4,5-TCP it received from Diamond Alkali,[66] there is no evidence that they actually did so. (Trial Tr., vol. XIX, 6:2-6:6, ECF No. 401.) To be sure, the process Metro Atlantic used to purify crude Na 2,4,5-TCP and the process outlined in Cleary's TCP-purification patent are consistent in that both provided for the use of a base to purify low-purity crude 2,4,5-TCP. (Trial Tr., vol. XIII, 125:4-125:7, 175:25-176:8, ECF No. 395; Trial Tr., vol. XIX, 53:9-53:22, ECF No. 401.) But it does not necessarily follow from the similarity between the process outlined in Cleary's patent and the Metro Atlantic process for purifying crude Na 2,4,5-TCP that the two processes were identical; Cleary

[66] The application for Cleary's TCP-purification patent was filed on October 20, 1966 (and the patent itself is dated March 3, 1970) (Emhart Ex. 32), after Metro Atlantic had already begun to manufacture HCP. For this reason, Forrester declined to consider the patent in his analysis of whether Metro Atlantic used Nuchar once or twice. (Trial Tr., vol. XIX, 5:3-5:17, ECF No. 401.) However, Cleary explained in his deposition that the date on which a patent application is filed "might be years and years after the actual lab work was done." (Cleary Dep. Tr. 23:19-23:22.) Therefore, it is at least possible that Metro Atlantic used the process that was specified in Cleary's TCP-purification patent.

referred to the ZEP List as "Huse[']s bill of materials" (U.S. Ex. 90), and it may have been Huse's decision to use Nuchar in the purification of the crude Na 2,4,5-TCP. In any event, the fact that Cleary's patent for purifying crude 2,4,5-TCP – which Metro Atlantic may or may not have used in its own purification of crude Na 2,4,5-TCP – does not refer to the use of activated carbon cannot alter the fact that the ZEP List – which undeniably was used by Metro Atlantic – calls for the use of Nuchar in the purification of the crude Na 2,4,5-TCP that Metro Atlantic received from Diamond Alkali.

Second, Emhart relies on an exchange between Cleary and an EPA paralegal, Ann Gardner, as further support for its position that Metro Atlantic did not use Nuchar in the purification of the crude Na 2,4,5-TCP. (Emhart's Post-trial Br. 47-48, ECF No. 378.) After Gardner and Cleary discussed Metro Atlantic's HCP-manufacturing process by telephone, Gardner typed up a summary of the conversation and sent it to Cleary for his review. (Gardner Mem. 1, Emhart Ex. 105.) Cleary made several changes to Gardner's summary, including the section that dealt with the purification of the crude Na 2,4,5-TCP. (See id. at 2-4, Emhart Ex. 105; Cleary Addendum to Gardner Mem. 1-2, Emhart Ex. 108.) Gardner's summary does not mention the use of Nuchar during the purification of the crude Na 2,4,5-TCP, and Cleary did not address the absence of Nuchar in any of his comments or changes.

(Trial Tr., vol. III, 53:17-54:6, ECF No. 385; Trial Tr., vol. XVIII, 136:23-137:1, 137:10-137:12, ECF No. 400.)

However, this exchange is of minimal significance to the question of whether Metro Atlantic used Nuchar once or twice during the HCP-manufacturing process. Gardner's summary does not purport to chronicle Metro Atlantic's purification of the crude Na 2,4,5-TCP or its manufacture of HCP in great detail; its discussion of purification of the crude Na 2,4,5-TCP comprises only three sentences of the summary. (See Gardner Mem. 2, Emhart Ex. 105.) Similarly, Cleary's changes did not seek to appreciably augment the summary's treatment of the details of the HCP-manufacturing process. Instead, Cleary's lone change to the sentences relating to purifying crude Na 2,4,5-TCP consisted of deleting "and methyl alcohol" from the following sentence: "This [i.e. the purification of the crude Na 2,4,5-TCP] was accomplished by adding sodium hydroxide and methyl alcohol to 2,4,5-trichlorophenol." (Id. at 2.) Finally, neither the Gardner summary nor any of Cleary's changes and comments refer to the use of Nuchar at any point in Metro Atlantic's HCP-manufacturing process, even though, as the parties agree, it was used at least once in the process. Therefore, this Court is not persuaded by the exchange surrounding the Gardner summary that Nuchar was not used during the purification of the crude Na 2,4,5-TCP.

For these reasons, this Court finds that Metro Atlantic used Nuchar twice during its HCP-manufacturing process: once during the purification of crude Na 2,4,5-TCP, and a second time during the synthesis of HCP. (Trial Tr., vol. XVIII, 130:19-131:2, ECF No. 400.)

4. Colocation with Two Nuchar Treatments

Metro Atlantic's use of Nuchar twice in the HCP-manufacturing process changes the correlation calculus. The vast majority of the 2,3,7,8-TCDD that made it into the HCP process from the outdoor storage tanks would adsorb to Nuchar the first time it was used. (Trial Tr., vol. II, 209:15-209:17, 210:2-210:6, 214:8-214:13, ECF No. 384; Trial Tr., vol. III, 46:10-46:18, ECF No. 385; Trial Tr., vol. XVII, 17:19-17:22, 64:11-64:14, ECF No. 399.) The filter cake from this first Nuchar use would, therefore, contain relatively high concentrations of 2,3,7,8-TCDD, but no HCX. (Trial Tr., vol. III, 171:19-171:24, ECF No. 385; Trial Tr., vol. XVIII, 61:14-61:20, ECF No. 400.) By contrast, the filter cake from the second Nuchar application would contain the vast majority of the HCX that was generated during the synthesis of HCP, but relatively little, if any, 2,3,7,8-TCDD.[67] (Trial Tr., vol. III,

[67] The parties agree that HCX, like 2,3,7,8-TCDD, strongly adsorbs to activated charcoal. (See Emhart's Post-trial Br. 45, ECF No. 378; Gov't's PFOF ¶ 729, ECF No. 379; see also Trial Tr., vol. III, 75:24-76:2, ECF No. 385.)

76:3-76:6, 172:3-172:8, ECF No. 385; Trial Tr., vol. XIII, 49:2-49:10, ECF No. 395; Trial Tr., vol. XVIII, 61:21-61:24, ECF No. 400.) Thus, there was no universal ratio of HCX to 2,3,7,8-TCDD that applied to all of the filter cake generated in Metro Atlantic's HCP-manufacturing process.

To be sure, it is possible that the two different types of Nuchar filter cake – the first use with significant concentrations of 2,3,7,8-TCDD but no HCX and the second use with significant concentrations of HCX but little, if any, 2,3,7,8-TCDD – were disposed of together because they accumulated either in the same trash receptacle or at the same rate in different trash receptacles. (See Trial Tr., vol. III, 173:21-174:14, 175:19-176:19, ECF No. 385.) Based on this possibility and the fact that, under the Government's view, all Nuchar filter cake was deposited in the WDA, Locke testified that the correlation was too weak to be consistent with the simultaneous disposal of both types of Nuchar filter cake in the WDA. (Trial Tr., vol. VIII, 148:19-149:16, 151:1-151:21, ECF No. 390.)

However, this Court is not persuaded that the lack of a strong correlation between the concentrations of HCX and the concentrations of 2,3,7,8-TCDD in the WDA means that the presence of HCX in the WDA cannot be used as an indicator that 2,3,7,8-TCDD from Metro Atlantic's HCP-manufacturing process was

deposited there as well. For starters, the search for a consistent ratio between HCX and 2,3,7,8-TCDD is a bit quixotic. Because the quantity of HCX that is generated is dependent on the starting materials and reaction conditions for the manufacture of HCP (which can vary from one batch to the next), there may be little consistency between the ratio of HCX to 2,3,7,8-TCDD from batch to batch; indeed, the HCX to 2,3,7,8-TCDD ratio can vary widely from sample to sample at an HCP site due to manufacturing variations and other factors. (See Emsbo-Mattingly Letter 14, Emhart Ex. 312 ("[At the Site], [t]he concentration of HCX fluctuated independently relative to dioxins, like 2,3,7,8-TCDD. This phenomenon was observed in previous studies and attributed to varying manufacturing processes for hexachlorophene. However, we identified low levels of HCX in many Upstream background locations. Consequently, we used HCX as a Source Area marker above background samples collected from Upstream locations. Accordingly, residues of the historical manufacturing of hexachlorophene extended down gradient from the [S]ite to approximately half of the Downstream sampling locations.").)

The same can be said for the precise quantity of 2,3,7,8-TCDD that made its way into the HCP-manufacturing process from batch to batch: the quantity of 2,3,7,8-TCDD produced by Diamond Alkali's synthesis of crude Na 2,4,5-TCP varied from

batch to batch (see NIOSH Report for Diamond Alkali 45, U.S. Ex. 48), and the quantity of 2,3,7,8-TCDD that remained settled in either Diamond Alkali's tanker trucks or Metro Atlantic's outdoor storage tanks may have varied. Each of these variations would impact the quantity of 2,3,7,8-TCDD that made it into the HCP-manufacturing process, which, in turn, would impact the concentration of 2,3,7,8-TCDD on the Nuchar filter cake.

Additionally, it is not clear that, even if the two types of Nuchar filter cake accumulated at the same rate in different receptacles, all of that filter cake was placed in the exact same location in the WDA. Much more likely, the placement of a particular load of filter cake that went to the WDA rested on the whim of the person transporting that load from the HCP building. And it is also not clear that, even if both types of filter cake accumulated at the same rate, they were taken from the HCP plant at the same time. As Kittrell testified, the filter cake from the HCP-manufacturing process would have a foul odor (Trial Tr., vol. XIII, 93:6-93:9, ECF No. 395), and it is conceivable that Metro Atlantic employees would not want to leave the foul smelling Nuchar filter cake in or near the small HCP building for very long. Therefore, it is entirely possible that the two types of Nuchar filter cake, although accumulating at the same rate, were taken to the WDA at different times and placed in different places within that area or that some Nuchar

filter cake went to the WDA and some went to the dumpster, as noted above. As Locke acknowledged, such a scenario could explain the lack of a strong correlation between the HCX and the 2,3,7,8-TCDD in the WDA. (See Trial Tr., vol. IX, 118:8-118:18, 119:2-119:5, ECF No. 391.)

Even if the two types of filter cake from the HCP-manufacturing process were disposed of at the same time and in the same place, the lack of a consistent correlation between HCX and 2,3,7,8-TCDD in the WDA still does not foreclose the possibility that the filter cake was deposited there. Ensley analogized the Site data to that found at sites in Missouri that were contaminated from material taken from the site of another HCP manufacturer, Northeastern Chemical and Pharmaceutical Company ("NEPACCO").[68] (See Trial Tr., vol. XVIII, 58:24-61:24, 172:12-173:21, ECF No. 400; Ensley's Slide 37, U.S. Ex. 538; see also Trial Tr., vol. II, 100:8-100:9, ECF No. 384.) Ensley explained that, like the correlations between HCX and 2,3,7,8-TCDD found at the Site, the correlations of the same two substances at the NEPACCO-related Missouri sites varied widely.

[68] By way of background, dioxin contamination was discovered in several locations in the area of St. Louis, Missouri in the 1970s. (Trial Tr., vol. II, 99:25-100:15, ECF No. 384.) The dioxin contamination was linked to dust control materials that were sprayed in the area. (Id. at 100:3-100:5.) A component of those dust control materials was still-bottom residues from NEPACCO's HCP-manufacturing process. (Id. at 100:7-100:15.) The still-bottom residues contained both HCX and 2,3,7,8-TCDD. (Trial Tr., vol. XVIII, 58:24-59:3, ECF No. 400.)

(Trial Tr., vol. XVIII, 59:4-59:10, ECF No. 400.) In fact, Ensley opined, the divergent ratios at the Missouri sites were even more surprising than the lack of a consistent correlation at the Site because NEPACCO stored its still-bottom residues from its distillation of 2,4,5-TCP – which contained "tremendously high concentrations of 2,3,7,8-TCDD and no HCX" – and its still-bottom residues from its procedure of recrystallizing HCP – which contained high concentrations of HCX – in a single storage tank, ominously referred to as "the black tank." (Id. at 59:10-60:7, 172:24-173:1.)

Ensley explained that, contrary to what one might expect, the two still-bottom residues did not commingle into a uniform mixture when stored in the same storage tank. (Id. at 60:8-60:13, 173:2-173:16.) Instead, each withdrawal from the black tank by the waste hauler who spread the material around the NEPACCO-related Missouri sites yielded a different ratio of HCX to 2,3,7,8-TCDD; sometimes the withdrawn material would have much greater concentrations of 2,3,7,8-TCDD than concentrations of HCX, and other times the inverse was true. (Id. at 60:14-60:18, 173:16-173:20.) And this variation in the ratios of 2,3,7,8-TCDD to HCX in the black tank resulted in the wide disparities between the ratios of the two compounds at the NEPACCO-related Missouri sites. (Id. at 60:18-60:20, 173:20-173:21.)

In this case, even if the two types of filter cake were disposed of at the same place in the WDA at the same time, they were not placed in a sterile, unchanging environment. Instead, they were placed in a dump that was extensively used by both Metro Atlantic and NECC for many years, see, e.g., supra Sections I.B.1.a, I.B.3.c, expanded between 1965 and 1970, see infra Section I.C.3.b.ii.B, and frequently subject to inundation as a result of flooding of the Woonasquatucket River, which led to downstream transport of the contents of the WDA, see infra Section I.D. With all these variables, the lack of a consistent ratio between 2,3,7,8-TCDD and HCX fails to demonstrate that some amount of Nuchar filter cake from the HCP-manufacturing process was not deposited in the WDA.

Therefore, this Court finds that the presence of HCX in the WDA is indicative of releases of solid waste from the HCP-manufacturing process and provides further support for the conclusion that some amount of Nuchar filter cake was deposited in that area.

B. 2,3,7,8-TCDD in the WDA

Forrester opined that the disposal of the filter cake containing the first Nuchar addition represents "[t]he most significant release" of 2,3,7,8-TCDD associated with Metro Atlantic's HCP-manufacturing operations. (Trial Tr., vol. II, 182:22-182:24, ECF No. 384; see also id. at 209:18-210:4.)

Elevated concentrations of 2,3,7,8-TCDD were found throughout the southern portion of the peninsula (see Trial Tr., vol. IV, 178:2-178:15, 196:2-196:6, ECF No. 386; U.S. Ex. 200; Medine Slide 22, U.S. Ex. 501; Andrews Slide 6, U.S. Ex. 542), and, like the presence of HCX, these concentrations also support the conclusion that some amount of filter cake from the HCP-manufacturing process was deposited in the WDA.[69] Indeed, the highest concentration of 2,3,7,8-TCDD found on the Site – 895,000 nanograms per kilogram – was from a sample, "T1 Grab 4," taken from the WDA.[70] (2013 WDA Investigation Results 59, U.S.

[69] To be clear, this Court's conclusion that the elevated concentrations of 2,3,7,8-TCDD in the WDA support the conclusion that some amount of Nuchar filter cake was deposited in that location in no way implies that Metro Atlantic is responsible for all of the 2,3,7,8-TCDD found in the WDA. But such an all-or-nothing factual finding is simply not required in this case.

[70] In reaching this conclusion, this Court need not address whether material comprising T1 Grab 4 was in fact Nuchar filter cake. Forrester opined that material comprising T1 Grab 4 consisted of rotten filter cloth material and that, based on the concentration of 2,3,7,8-TCDD, this material was consistent with filter cake from the first use of Nuchar. (Trial Tr., vol. II, 136:5-136:19, ECF No. 384; Trial Tr., vol. IV, 109:22-110:5, 123:5-123:10, ECF No. 386; see U.S. Exs. 188-89.) However, in addition to disputing whether the concentration of 2,3,7,8-TCDD is consistent with what one would expect to find after either the first or second Nuchar use (which is discussed in more detail above), Emhart points out that the detections of HCX are far lower than what would be found on the second use of Nuchar and that the presence of other contaminants – such as octochlorodibenzo-p-dioxin and Aroclor 1254, a PCB – suggests that NECC's operations created material that comprised T1 Grab 4. (See Emhart's Post-trial Br. 118-23, ECF No. 378.) Both the Government and Emhart seem to assume that T1 Grab 4 came from either Metro Atlantic or NECC, but this Court finds that T1 Grab

Ex. 57; Trial Tr., vol. II, 140:17-141:9, ECF No. 384; Trial Tr., vol. IV, 122:21-122:23, ECF No. 386.)

Emhart disagrees that the high concentrations of 2,3,7,8-TCDD in the WDA are indicative of releases from the HCP-manufacturing process in that area, and it offers up several arguments in an attempt to exonerate itself from responsibility for the 2,3,7,8-TCDD found in that location. (See Emhart's Post-trial Br. 110-27, ECF No. 378.) Emhart first argues that the location of the elevated concentrations of 2,3,7,8-TCDD within the WDA demonstrates that Metro Atlantic was not the culprit. (See id. at 110-13.) This argument relies on the testimony of Dr. Charles Andrews, a Government expert, who testified that there was expansion of the WDA to the south and the east sometime between the April 1965 aerial photograph and the March 1970 aerial photograph.[71] (Trial Tr., vol. XX, 5:4, 11:5-11:12, 66:3-66:8, 67:20-68:2, ECF No. 402; Andrews Slide 23, U.S. Ex. 542.) Andrews noted that the sampling data within

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4 cannot be conclusively attributed to either source exclusively; rather, it is likely an amalgamation of material deposited by both entities that has commingled over the years in the WDA.

[71] Andrews was the Government's expert in surface and groundwater hydrology and in evaluating the origin, distribution, and fate and transport of contaminants in soil, surface water, and groundwater in the environment. (Trial Tr., vol. XX, 11:5-11:12, June 25, 2015, ECF No. 402.)

the area that had been disturbed[72] as of April 1965 did not contain elevated concentrations of 2,3,7,8-TCDD, while several sampling points within the area that was disturbed between April 1965 and March 1970 revealed elevated levels of 2,3,7,8-TCDD.[73] (Trial Tr., vol. XX, 66:9-66:19, 68:3-68:10, ECF No. 402; Andrews Slide 23, U.S. Ex. 542.) From this observation, Andrews opined that "2,3,7,8-TCD[D] was not contained at significant concentrations in waste materials placed in the [WDA] prior to April 5, 1965, or approximately that time frame" and that "significant releases of 2,3,7,8-TCD[D] at least in the southern part of the peninsula did not occur until at or after the mid-1960s." (Trial Tr., vol. XX, 67:6-67:10, 68:13-68:16, 151:5-151:10, 155:23-156:3, ECF No. 402.) Emhart argues that this testimony supports the notion that the Nuchar filter cake was not deposited in the WDA because: (1) the location of the 2,3,7,8-TCDD indicates that it had not been there from the time when Metro Atlantic began manufacturing HCP, which Forrester opined was soon after the ZEP List was compiled in June 1964, until April 1965, a period of approximately ten months; and (2)

[72] Andrews used the term "disturbed" to indicate "an area where waste materials were deposited." (Trial Tr., vol. XX, 135:13-135:16, ECF No. 402.)

[73] Indeed, the highest concentration of 2,3,7,8-TCDD found at the Site, which was in the T1 Grab 4 sample, was within the area that was disturbed between April 1965 and March 1970. (Trial Tr., vol. IV, 40:12-40:15, ECF No. 386.)

it is unlikely that the expansion of the WDA from April 1965 to March 1970 occurred during the remainder of 1965 – which, in Emhart's view, is when Metro Atlantic ceased manufacturing HCP – and it is more likely that the WDA expanded as a result of NECC's expansion of operations, as evidenced by the growth in the impoundment and drum-storage areas from 1965 to 1970. (Emhart's Post-trial Br. 110-13, ECF No. 378.)

The Court is not persuaded by this argument. For one thing, Andrews acknowledged that the outer limits of the extent of the WDA in April 1965 that he delineated are "fuzzy" and "approximate[ ]." (Trial Tr., vol. XX, 134:24, 157:6, ECF No. 402; see also id. at 134:20-134:24, 157:2-157:9; id. at 157:10-157:11 ("[T]here isn't a precise demarcation of the disturbed area.").) Moreover, there are several elevated concentrations that are just beyond the 1965 WDA limits that Andrews delineated. (Andrews Slide 23, U.S. Ex. 542; see also Trial Tr., vol. XX, 135:20-135:21, ECF No. 402 (acknowledging that there were some detections of 2,3,7,8-TCDD "right near the [1965] limits of the disturbed area"); id. at 157:8-157:9 ("[S]ome materials were being kind of dumped right at the edge [of the 1965 limit of the WDA]").) Therefore, given the imprecision inherent in the 1965 demarcation of the WDA, and the fact that some amount of 2,3,7,8-TCDD was deposited along the edge of that demarcation, this Court is not prepared to accept

Andrews's opinion that no significant concentration of 2,3,7,8-TCDD was deposited in the WDA prior to the April 1965 aerial photograph.

For another thing, even if this Court were to accept the proposition that Metro Atlantic did not dispose its Nuchar filter cake in the WDA before April 1965, this Court is not persuaded by Emhart's argument that it was unlikely that Metro Atlantic did so after April 1965. As an initial matter, the combined assumptions underlying this argument – that Metro Atlantic's HCP-manufacturing operations lasted less than a year (Emhart's Post-trial Br. 29, 36-39, ECF No. 378) and would not have gone on for much longer after the April 1965 aerial photograph (id. at 112-13, ECF No. 378) – are dubious. Cleary's testimony, upon which Emhart chiefly relies in contending that Metro Atlantic's HCP operation lasted less than a year, was less decisive than Emhart lets on:

> Q. Okay. Now, you also mentioned -- let me withdraw the question.
>
> Do you recall the approximate length of the time that Metro[ ]Atlantic was making [HCP] at its plant?
>
> A. Only vaguely. Probably -- less than a year.

(Cleary Dep. Tr. 53:20-53:25.) However, on March 24, 1966, a representative of Diamond Alkali spoke with Huse, a chemical engineer employed by Metro Atlantic, about a titration problem

that Metro Atlantic was having with the crude Na 2,4,5-TCP that it was receiving from Diamond Alkali. (See Emhart Ex. 83; Trial Tr., vol. II, 189:21-191:6, ECF No. 384.) This evidence indicates that, at least as of late March 1966, Metro Atlantic was still manufacturing HCP. (See Trial Tr., vol. XIX, 39:17-39:24, ECF No. 401.) Therefore, Cleary's "vague[ ]" recollection that Metro Atlantic's HCP-manufacturing operation operated only for "[p]robably -- less than a year" (Cleary Dep. Tr. 53:25) can only be correct if the HCP operation did not begin until sometime around March 1965. And, in such a scenario, the fact that there were no significant concentrations of 2,3,7,8-TCDD in the WDA as of April 5, 1965 simply does not support the inference that filter cake from the HCP-manufacturing process was not deposited in the WDA in the almost one-year period in which Metro Atlantic continued to manufacture HCP.[74] (See Trial Tr., vol. XX, 68:17-69:3, 151:11-151:14,, ECF No. 402.)

Additionally, there is no evidence from which this Court can confidently determine the time period when the WDA was

[74] In addition to Cleary's testimony, Emhart also relies on Kittrell's Gantt-chart analysis for the duration of the HCP-manufacturing operation. (See Emhart's Post-trial Br. 37, ECF No. 378.) However, if Kittrell's estimation of eight to nine months of operation (see Trial Tr., vol. XIII, 32:8-32:22, ECF No. 395) is correct, the March 24, 1966 discussion between Huse and a Diamond Alkali representative makes clear that the absence of 2,3,7,8-TCDD within the limits of the WDA of April 5, 1965 is insignificant.

expanded or the rate at which this expansion occurred (see id. at 156:22-157:1); all that can be said is that the WDA expanded sometime between April 1965 and March 1970. Because of this uncertainty, this Court cannot rule out the placement of Nuchar filter cake in the WDA after April 1965, especially when the lay-witness testimony and other site data are considered.

Emhart next asserts that the elevated concentrations of 2,3,7,8-TCDD in the WDA do not indicate releases of filter cake from the HCP-manufacturing process because the concentrations of 2,3,7,8-TCDD on the samples in that area are both (a) much too low for the first type of filter cake, which would have had the vast majority of 2,3,7,8-TCDD adsorbed to it, and (b) much too high for the second type of filter cake, which would have had elevated concentrations of HCX, but little to no 2,3,7,8-TCDD.[75] (Emhart's Post-trial Br. 118-21, ECF No. 378.) To demonstrate the first component of this argument, Kittrell calculated that the concentration of 2,3,7,8-TCDD on the filter cake from the first Nuchar use would have been approximately 1.4 billion parts per trillion (Trial Tr., vol. XIII, 46:22-47:15, ECF No. 395), which is "orders of magnitude above the 895,000 ng/kg present in

[75] This argument is focused on the highest 2,3,7,8-TCDD concentration found on Site, which was contained in T1 Grab 4, but this Court will presume that Emhart would make a similar argument with respect to each sample in the WDA containing elevated concentrations of 2,3,7,8-TCDD.

the black sludge-like material found at T1-Grab 4." (Emhart's Post-trial Br. 119, ECF No. 378.)

This Court might be persuaded by this argument if the evidence demonstrated that the 2,3,7,8-TCDD containing materials found in the southern portion of the peninsula were placed in a sterile environment, wholly isolated from fate and transport mechanisms and the effects of commingling with other substances. To the contrary, these samples were found in a former industrial dump, which consisted of a host of different waste products commingled in an area that was subject to frequent flooding and other disruption caused by weather, construction projects, and other activities on the peninsula over the course of the decades. See supra Sections I.B.1.a, I.B.3.c; infra Section I.D. Even Kittrell acknowledged that his 1.4 billion parts per trillion figure would be the concentration one would expect if the sample was taken directly from the filter cake alone and that the concentration would be lower if the sample was a mix of filter cake and other soil in the WDA. (Trial Tr., vol. XIII, 47:16-48:3, 67:6-67:19, ECF No. 395.) Although 2,3,7,8-TCDD and other dioxins are generally regarded as persistent in the environment, it is clear to this Court that not all of the 2,3,7,8-TCDD that was brought onto or generated at the peninsula in the 1960s remained on the peninsula until the soil was sampled several decades later. In addition to transport,

decomposition processes are an important consideration. (See Trial Tr., vol. XVII, 180:4-180:12, ECF No. 399 (testimony of Dr. John Paul Giesy, Jr. to the effect that: "Through space and time there's a winnowing process going on . . . . If I take these dioxin congeners and put them out in full sunlight and I put a little bit of olive oil on them, they're gone in four hours. So what's often portrayed as being super-persistent under the right conditions aren't.").) In sum, this Court is unwilling to accept Emhart's argument that the concentrations that one would expect to find on the two types of filter cake from the HCP-manufacturing process would have remained constant when the filter cake was placed in the dynamic environment of the WDA.

Relatedly, Emhart asserts that, because concentrations of OCDD were greater than those of 2,3,7,8-TCDD in the samples taken from the WDA (see Trial Tr., vol. XX, 136:21-137:2, ECF No. 402; Andrews Slide 14, U.S. Ex. 542) and because OCDD is associated with combustion or incineration, the samples in the WDA show that NECC is the source of the OCDD and all of the 2,3,7,8-TCDD in that portion of the peninsula. (See Emhart's Post-trial Br. 117-18, ECF No. 378.) This argument is unconvincing. At the outset, although this Court does not quarrel with Emhart's position that the OCDD in the WDA likely came from combustion or incineration, it does not necessarily

follow that NECC's operations were the source of all of the OCDD. Forrester testified that the high concentration of OCDD in T1 Grab 4 could have been generated by combustion fires that occurred in the WDA. (Trial Tr., vol. IV, 133:6-133:25, ECF No. 386.) And there is ample evidence in the record that fires in the WDA were a common occurrence during the period in which Metro Atlantic and NECC operated on the peninsula. (See Trial Tr., vol. III, 128:13-128:14, 128:20-129:1, 130:7-130:14, 130:21-131:11, 133:5-133:21, ECF No. 385; North Providence Fire Dept. Fire Reports 1-2, 5, 8-11, 20, 52-53, U.S. Ex. 16; Tr. of Joseph Buonanno, Jr.'s Testimony in Home Insurance Case 109:21-110:6.) Moreover, as Emhart concedes (see Emhart's Post-trial Br. 118, ECF No. 378), even if NECC is responsible for the OCDD in the WDA, that circumstance does not rule out disposal of Nuchar filter cake in the WDA. As Dr. Courtney Sandau – Emhart's expert in chemistry, environmental-forensic investigations, and environmental sampling and sample data interpretation – acknowledged, where a sample reflects elevated concentrations of OCDD and 2,3,7,8-TCDD, it is impossible to definitively determine whether the source of those concentrations is combustion of a 2,3,7,8-TCDD contaminated source or a combination of a combustion source and a separate 2,3,7,8-TCDD contaminated source. (See Trial Tr. vol. X, 185:19-185:20, 198:22-199:5, ECF No. 392; Trial Tr., vol. XI,

122:21-123:23, ECF No. 393.) Therefore, the presence of elevated concentrations of OCDD does not persuade this Court that Nuchar filter cake was not deposited in the WDA.

Finally, Emhart argues that the internal-standard recoveries across the peninsula would have been much lower if the sample contained a carbon such as Nuchar; because the recoveries were higher than what Stellacci would expect to find for a sample containing Nuchar, the argument goes, none of the samples containing 2,3,7,8-TCDD in the WDA (or anywhere else on the peninsula, for that matter) came from Nuchar filter cake. (Emhart's Post-trial Br. 123-26, ECF No. 378.) An internal standard is a known quantity of a substance that is added to a sample in order to gauge the effectiveness of a sampling and analytical procedure. (See Trial Tr., vol. XVII, 46:24-47:2, ECF No. 399.) In the case of the samples taken from the peninsula, the internal standard was a known quantity of $^{13}C_{12}$-labeled 2,3,7,8-TCDD. (See EPA Testing Method 8280B 51, U.S. Ex. 80; EPA Testing Method 8290A 3, 51, U.S Ex. 81; Trial Tr., vol. XVII, 48:11-48:20, ECF No. 399.) The percentage of the $^{13}C_{12}$-labeled 2,3,7,8-TCDD that is recovered through the sampling and analytical procedure shows the internal-standard recovery rate for that testing procedure. (Trial Tr., vol. XVII, 47:3-47:9, ECF No. 399.) Stellacci opined that, if the soil in the samples from the peninsula contained Nuchar (as one would expect

if the 2,3,7,8-TCDD came from Metro Atlantic's HCP-manufacturing process), then some of the $^{13}C_{12}$-labeled 2,3,7,8-TCDD[76] would become adsorbed to the Nuchar. (Id. at 48:21-48:25.) Stellacci further opined that, because the EPA's methods "could have removed some dioxin from Nuchar but not a lot," not all of the internal-standard 2,3,7,8-TCDD that adsorbed to Nuchar would have been recovered, and the failure to recover all of the adsorbed 2,3,7,8-TCDD would affect the internal-standard recovery rate. (Id. at 48:21-49:1, 49:22-50:18, 51:3-51:6, ECF No. 399.) Stellacci deemed the internal-standard recovery rates for the samples taken at the peninsula higher than what he would expect to find if some of the internal-standard 2,3,7,8-TCDD had adsorbed to Nuchar and not been recovered; for this reason, he concluded that the 2,3,7,8-TCDD that was found on the peninsula was not 2,3,7,8-TCDD that had been adsorbed to Nuchar.[77] (See id. at 65:24-66:10.)

[76] Stellacci referred to the internal standard used in the EPA methods as "radiolabeled" 2,3,7,8-TCDD. (Trial Tr., vol. XVII, 48:11-49:1, ECF No. 399; Stellacci Slide 12, Emhart Ex. 353.) However, the EPA methods use $^{13}C_{12}$-labeled 2,3,7,8-TCDD, not radiolabeled 2,3,7,8-TCDD, as the internal standard. (See EPA Testing Method 8280B 51, U.S. Ex. 80; EPA Testing Method 8290A 3, 51, U.S Ex. 81.)

[77] Hass, one of Emhart's experts in the Home Insurance litigation, offered opinions consistent with Stellacci's on this point. (See Emhart Reply Brief in Home Insurance Case 29, U.S. Ex. 87.)

This Court is unpersuaded. For starters, Stellacci's argument concerns the validity of the EPA's methods, but he admitted that he did not know how those methods had been validated. (See id. at 85:11-85:14.) Additionally, Stellacci acknowledged that, if little to no carbon was present in the sample, the internal-standard recovery rate would typically be somewhere between 70 percent and 100 percent. (Id. at 71:9-71:23, 73:4-73:10.) He also acknowledged that there is a range of expected recovery rates for samples containing carbon: "maybe 50 percent, maybe 70 percent, maybe 80 percent, but not 100 percent." (Id. at 71:24-72:13.) Thus, this Court rejects Emhart's argument that the internal-standard recovery rates for the analysis of T1 Grab 4 "in the order of eighty percent" are necessarily inconsistent with the sample containing some amount of carbon. (Emhart's Post-trial Br. 126, ECF No. 378; see Data Review Complete Form 72, 95, Emhart Ex. 317.)

Moreover, the quantity of carbon in a sample would, in Stellacci's opinion, impact the disparity between actual and expected internal-standard recoveries; he acknowledged that the internal-standard recovery rate could be 100 percent even where a small amount of carbon was present in the sample. (Trial Tr., vol. XVII, 72:10-72:13, ECF No. 399.) The Nuchar filter cake that was deposited in the WDA could have commingled with other substances through the frequent flooding that occurred there,

such that it would be difficult to assess how much Nuchar was in any particular sample from the WDA. Indeed, Stellacci acknowledged that he could not say that none of the samples from the peninsula that detected dioxin contained carbon.[78] (Id. at 79:5-79:13.) Therefore, this Court finds that the sampling data of HCX and 2,3,7,8-TCDD in the WDA supports the conclusion that some amount of Nuchar filter cake was deposited there.

For all of these reasons, this Court finds that some amount of filter cake from the HCP-manufacturing process was deposited in the WDA and that that filter cake is the source of some of the 2,3,7,8-TCDD in that area of the peninsula.

[78] Emhart also argues that the Government's failure to test T1 Grab 4 for carbon should lead this Court to disregard Forrester's opinions relating to T1 Grab 4. (Emhart's Post-trial Br. 127-28, ECF No. 378.) The evidence shows that it is possible to test samples for carbon, although it is not done routinely. (See Trial Tr., vol. XI, 127:6-128:10, 128:22-128:24, ECF No. 393; Trial Tr., vol. XVII, 18:2-18:4, 55:7-56:3, 80:17-81:16, ECF No. 399.) However, because this Court does not address whether material comprising T1 Grab 4 is Nuchar filter cake, see supra note 70, this argument need not be tackled head on. Nonetheless, this Court notes that the Government's failure to test for carbon at the peninsula, although regrettable, does not undermine either the reliability of the sampling results for 2,3,7,8-TCDD or the conclusion that the site data supports the finding that some amount of Nuchar filter cake was deposited in the WDA.

4. Soil in Vicinity of HCP Building Footprint

Elevated concentrations of 2,3,7,8-TCDD were found underneath the footprint of the HCP building.[79] (Trial Tr., vol. IV, 178:2-179:2, 196:2-196:6, ECF No. 386; U.S. Ex. 200; Medine Slide 22, U.S. Ex. 501.) The parties disagree on the source of 2,3,7,8-TCDD in this location.

a. Leaks and Spills

Forrester opined that leaks from the pipes underneath the HCP building were the cause of the 2,3,7,8-TCDD concentrations found there. (Trial Tr., vol. IV, 99:15-99:18, 99:22-99:23, 99:25-100:12, 102:3-102:20, ECF No. 386.) Emhart disagrees that the elevated concentrations of 2,3,7,8-TCDD under the HCP building footprint are attributable to leaks and spills from the discharge pipe. (Emhart's Post-trial Br. 90-94, ECF No. 378.) First, Emhart argues that, because the pipes for the HCP building were put in place during the construction of the HCP building and, therefore, were new, it was unlikely that they

[79] To be precise, the parties agree that, after the HCP building was torn down, approximately four to five feet of fill was deposited in the area when the parking lot for the Brook Village housing complex was constructed. (See Trial Tr., vol. VIII, 107:4-107:7, ECF No. 390; Trial Tr., vol. XV, 64:9-64:22, June 11, 2015, ECF No. 397; Trial Tr., vol. XX, 34:1-34:13, ECF No. 402; Emhart's Post-trial Br. 137 n.651, ECF No. 378; Gov't's PFOF ¶ 561, ECF No. 379.) Therefore, the discussion of contaminants found underneath the HCP building footprint refers to contaminants found at or below a depth of approximately five to six feet.

leaked. (Id. at 90-91; see also Trial Tr., vol. III, 216:2-216:11, ECF No. 385.) Second, Emhart notes that Forrester testified that, even when a pipe leaks, the majority of the liquid flowing through a drain pipe is discharged at the end of the pipe and not where the pipe leaks. (Emhart Post-trial Br. 90 & n.462, ECF No. 378; Trial Tr., vol. IV, 126:8-126:15, ECF No. 386.) Finally, Emhart argues that, even if there were leaks from the discharge pipe from the HCP building, any leakage could not account for the concentration of 2,3,7,8-TCDD found under the HCP building footprint because the liquid waste streams generated by the HCP-manufacturing process contained only small concentrations of 2,3,7,8-TCDD. (Emhart's Post-trial Br. 91-94, ECF No. 378.) The Court will address this last argument first.

It is not clear that all of the liquid wastes that were directed to the drain that led to the Woonasquatucket River contained only small concentrations of 2,3,7,8-TCDD. First, there would have been a significant quantity of 2,3,7,8-TCDD in the salts that settled in the crude Na 2,4,5-TCP outdoor storage tanks that would have been flushed into a drain and to the Woonasquatucket River. See supra Section I.C.1. Indeed, Emhart does not dispute this possibility; its effort on this liquid waste stream is to demonstrate that the quantity of 2,3,7,8-TCDD in any salts that may have leaked from the drain when flushed from the storage tanks could not alone account for the

concentrations of 2,3,7,8-TCDD that were found underneath the HCP building footprint. (See Emhart's Post-trial Br. 91-93 & n.476, ECF No. 378.) Second, as explained above, see supra Section I.C.3.a, there is at least one other potential waste stream from the HCP-manufacturing process that has not received much attention from the parties: residue from the filter that was not shoveled into drums and was instead rinsed into the floor drains. Thus, if there were leaks from the discharge pipe, at least some of those leaks could have contained substantial concentrations of 2,3,7,8-TCDD.

Evidence concerning the likelihood of leaks from the discharge pipe or of the quantities of 2,3,7,8-TCDD that might have been released if such leaks occurred is virtually nonexistent,[80] and Emhart's arguments about the unlikelihood of leaks and the minimal amount of liquid that would spill from those leaks are not without some persuasive force. However, the combination of three established facts supports Forrester's opinion that at least some amount of the 2,3,7,8-TCDD underneath the HCP building footprint is attributable to leaky pipes. First, it is undisputed that Metro Atlantic brought 2,3,7,8-TCDD

[80] Although Emhart attempted to quantify the amount of 2,3,7,8-TCDD that might have leaked out of the pipe underneath the HCP building footprint (see Emhart's Post-trial Br. 93 n.476, ECF No. 378), that effort overlooked the filter residue that was washed down the trench drains, and the filter residue from the first use of Nuchar contained significant quantities of 2,3,7,8-TCDD.

onto the peninsula when it obtained crude Na 2,4,5-TCP from Diamond Alkali. (NIOSH Report for Diamond Alkali 45, U.S. Ex. 48; Trial Tr., vol. II, 188:14-189:1, ECF No. 384; Trial Tr., vol. III, 37:2-37:6, ECF No. 385; Trial Tr., vol. XII, 44:19-44:25, EFC No. 394; Trial Tr., vol. XIII, 35:18-35:20, 76:5-76:7, ECF No. 395; Cleary Dep. Tr. 80:9-80:13, 90:11-90:16, 91:13-91:19.) Second, it is similarly undisputed that elevated concentrations of 2,3,7,8-TCDD were found underneath the footprint of the HCP building. (See Trial Tr., vol. XI, 31:14-31:15, 31:18-31:21, 32:5-32:6, ECF No. 393; Trial Tr., vol. XX, 15:21-15:23, ECF No. 402; Sandau Slide 21, Emhart Ex. 348; Andrews Slide 6, U.S. Ex. 542.) Third, it is undisputed that the predominance of 2,3,7,8-TCDD over OCDD in the samples taken from the footprint of the HCP building demonstrates that the source of the 2,3,7,8-TCDD contamination in that area was not a combustion source. (See Trial Tr., vol. XI, 32:11-32:13, 33:11-33:18, ECF No. 393; Trial Tr., vol. XX, 45:22-46:15, 47:8-48:7, 48:17-48:24, 49:12-49:17, 98:8-100:2, ECF No. 402; Sandau Slide 21, Emhart Ex. 348; Andrews Slide 14, U.S. Ex. 542.) The confluence of these undisputed facts suggests that the most likely source of at least some, and likely most, of the 2,3,7,8-TCDD was leakage from the operation that indisputably occurred at, and brought crude Na 2,4,5-TCP that contained 2,3,7,8-TCDD to, that location.

b. Presence of Other Substances

In an effort to blunt the force of this evidence, Emhart points to NECC's practice of storing drums along the western side of the peninsula and the contaminants found underneath the HCP building footprint that were undeniably not associated with the manufacture of either trifluralin or HCP. (See Emhart's Post-trial Br. 136-39, ECF No. 378.) These facts, Emhart insists, demonstrate that NECC is likely the source of all of the contaminants under the HCP building footprint, including the elevated concentrations of 2,3,7,8-TCDD found there. (See id. at 136-37, 139, ECF No. 378.)

Although this Court cannot, and specifically does not, rule out the possibility that NECC is responsible for some of the contaminants found beneath the HCP building footprint, the Court remains convinced that the most likely source of the majority of the 2,3,7,8-TCDD found in that area is Metro Atlantic's HCP-manufacturing operation. While evidence demonstrates that drums were stored in the vicinity of the HCP building by NECC through the years (see Emhart Exs. 330A, 332-33, 340; Locke Slides 80, 82-83, Emhart Ex. 342; U.S. Exs. 241, 243; Trial Tr., vol. I, 147:6-147:11, 151:8-151:11, ECF No. 383; Trial Tr., vol. VII, 69:2-69:8, 71:14-71:20, 91:14-91:16, ECF No. 389),[81] this Court

[81] In addition to the aerial photographs and lay-witness testimony, crushed drums, drum lids, and other debris were

agrees with Andrews that drum storage in this specific area – as opposed to drum storage on the western portion of the peninsula generally (see Emhart's Post-trial Br. 22-27, ECF No. 378) – was not significant. (Trial Tr., vol. XX, 81:15-82:1, 83:5-83:8, 84:6-84:9, ECF No. 402; see also Trial Tr., vol. I, 147:6-147:11, ECF No. 383.) Additionally, although several contaminants not associated with Metro Atlantic's manufacture of HCP were found underneath the HCP building footprint at depths where 2,3,7,8-TCDD was found (see Trial Tr., vol. VIII, 108:15-113:15, ECF No. 390; Locke Slides 90-96, Emhart Ex. 342), the concentrations of several of these contaminants were not above cleanup levels and were consistent with background concentrations (which, in turn, indicates that there was not a release of those contaminants by either Metro Atlantic or NECC) (see Trial Tr., vol. XX, 35:8-35:15, 37:3-37:10, ECF No. 402). In any event, the contaminants underneath the footprint of the HCP building cut both ways; several contaminants associated with Metro Atlantic's HCP-manufacturing operations, including 2,3,7,8-TCDD, 2,4,5-TCP, HCP, HCX, PCE, and degradation products of PCE,[82] were also found in this area. (Trial Tr., vol. IV,

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uncovered during the 2009 excavation of the soils in the area where the HCP building once stood. (See Trial Tr., vol. I, 207:24-207:25, 226:10-226:16, ECF No. 383.)

[82] This Court acknowledges Emhart's argument that the elevated concentrations of PCE under the footprint of the HCP

190:18-192:13, 197:19-198:4, ECF No. 386; Trial Tr., vol. XX, 33:3-33:11, 35:16-35:21, 36:4-37:2, ECF No. 402; Medine Slides 21, 23, U.S. Ex. 501; Andrews Slide 10, U.S. Ex. 542; see also Trial Tr., vol. VIII, 107:22-108:14, ECF No. 390.) Therefore, it appears most likely that both NECC and Metro Atlantic released the contaminants found underneath the former Metro Atlantic HCP building. (See Trial Tr., vol. XX, 34:17-34:22, ECF No. 402.)

c. NECC as the Source of 2,3,7,8-TCDD in This Area

Emhart launches a two-pronged explanation for the elevated concentrations of 2,3,7,8-TCDD underneath the HCP building footprint with the objective of laying responsibility at NECC's feet. Emhart first claims that the dioxin-congener profile in

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building could not have come from leaks from the discharge pipe that carried the liquid waste generated in the HCP building to the Woonasquatucket River. (See Emhart's Post-trial Br. 93-94 & n.480, ECF No. 378.) However, contrary to Emhart's contention that all "aqueous waste streams in the HCP process . . . contain[ed] little, if any, PCE" (id. at 94), Forrester opined that Metro Atlantic's re-distillation and recovery of PCE would have generated a PCE still bottom that periodically would have been discharged to the trench drain and then to the Woonasquatucket River (Trial Tr., vol. III, 8:16-8:20, ECF No. 385). If the liquid waste stream containing the PCE still bottom leaked from the discharge pipe, that could account for at least some of the elevated concentrations of PCE found underneath the HCP building footprint. Moreover, even if leakage of the PCE still bottom from the discharge pipe were not enough to alone account for the elevated concentrations of PCE in that location, the conclusion that some amount of PCE was released from the HCP process is not incompatible with additional releases of PCE by NECC in that vicinity.

that area is inconsistent with a release of crude Na 2,4,5-TCP and is instead consistent with a release of a purified source of 2,4,5-TCP. (See Emhart's Post-trial Br. 31-34, 94-99, ECF No. 378.) And, at least before trial, Emhart identified a likely source of the purified TCP: drums containing herbicides that NECC purchased from two military bases. (See Emhart's Pretrial Mem. 63-67, ECF No. 360; see generally Emhart's Opp'n to the DOD's Mot. for Partial Summ. J., ECF No. 340.)[83] Each argument is discussed in turn.

i. Dioxin-Congener Profile

In addition to 2,3,7,8-TCDD, which all parties agree was contained in the crude Na 2,4,5-TCP brought onto the peninsula by Diamond Alkali, Emhart asserts that other dioxins, as well as

[83] At trial, Emhart was less specific. It noted that sampling in that area revealed the presence of 2,4,5-T, a compound made from 2,4,5-TCP that, like 2,4,5-TCP itself, contained 2,3,7,8-TCDD, and Emhart's experts identified entities that possessed 2,4,5-TCP or 2,4,5-T and also supplied drums to NECC. (See Trial Tr., vol. VIII, 55:18-55:22, 110:8-111:2, 112:11-112:21, ECF No. 390; Trial Tr., vol. XIII, 57:7-57:10, 58:15-58:23, 60:11-60:19, ECF No. 395; Locke Slides 69, 92, Emhart Ex. 342; Kittrell Slides 51-52, Emhart Ex. 350.)

As mentioned above, the 2,3,7,8-TCDD concentrations found underneath the footprint of the HCP building are not from a combustion source. (See Trial Tr., vol. XI, 32:11-32:13, 33:11-33:18, ECF No. 393; Trial Tr., vol. XX, 45:22-46:15, 47:8-48:7, 48:17-48:24, 49:12-49:17, 98:8-100:2, ECF No. 402; Sandau Slide 21, Emhart Ex. 348; Andrews Slide 14, U.S. Ex. 542.) Therefore, in order for NECC to be the source of the 2,3,7,8-TCDD in that location, there needed to be leaks from drums containing 2,3,7,8-TCDD that were stored in the vicinity of the HCP building.

furans, including 2,3,7,8-tetrachlorodibenzo-p-furan ("2,3,7,8-TCDF"), also would have been created during Diamond Alkali's manufacture of Na 2,4,5-TCP. (See Emhart's Post-trial Br. 31-34, 94-99, ECF No. 378; see also Trial Tr., vol. XII, 42:24-43:11, 64:3-64:4, ECF No. 394.) This assertion is the foundational premise of one of Emhart's explanations for why it is not responsible for the dioxin contamination on the Site: that the 2,3,7,8-congener profile of the dioxins and furans found in the vicinity of the HCP building footprint is inconsistent with that of the crude Na 2,4,5-TCP delivered to Metro Atlantic by Diamond Alkali.[84] (See Emhart's Post-trial Br. 94-99, ECF No. 378.) There are two discrete components of this foundational premise. The first relates to the likelihood that

[84] There are eight different chlorinated dioxin homologs, or groups of dioxins with the same number of chlorine atoms. (See Trial Tr., vol. X, 205:12-205:14, ECF No. 392.) For example, tetrachlorodibenzo-p-dioxins all have four chlorine atoms. There are several different isomers of most of the homologs; isomers of a particular homolog are distinguished by the positions of the chlorine atoms on the dioxin structure. (See id. at 205:15-205:23.) For instance, 2,3,7,8-TCDD is an isomer in the tetracholorodibenzo-p-dioxin homolog group where the chlorine atoms are situated on the 2, 3, 7, and 8 positions. (See Trial Tr., vol. XII, 17:15-17:18, ECF No. 394.) Analogously, there are eight homologs of chlorinated dibenzofurans. Finally, dioxins and furans that have a particular arrangement of chlorines in common – 2,3,7,8, for example – are referred to as congeners. There are seventeen 2,3,7,8 dioxin and furan congeners (regardless of the total number of chlorines in the molecule), and those are the dioxins and furans that encompass the 2,3,7,8-congener profile at the heart of this issue. (See Trial Tr., vol. X, 206:22-206:24, ECF No. 392.)

2,3,7,8-TCDF was formed during Diamond Alkali's synthesis of crude Na 2,4,5-TCP. The second is concerned with whether other dioxins and furans were formed in this process. Each component is briefly discussed in turn.

The starting material for Diamond Alkali's synthesis of its crude Na 2,4,5-TCP was 1,2,4,5-tetrachlorobenzene ("1,2,4,5-TCB"). (Trial Tr., vol. XI, 37:21-37:24, ECF No. 393; see also Trial Tr., vol. III, 107:1-107:3, ECF No. 385.) Fu opined that Diamond Alkali's method for synthesizing crude Na 2,4,5-TCP from 1,2,4,5-TCB was more conducive to the formation of 2,3,7,8-TCDF than the processes of other 2,4,5-TCP manufacturers. (Trial Tr., vol. XII, 46:24-47:5, 47:9-47:13, 52:18-52:24, ECF No. 394.) The specifics of that process need not be recited in painstaking detail. It suffices to say that the combination of (1) Diamond Alkali's order of addition, which involved the gradual addition of methanol and caustic (to produce sodium methylate in methanol, (see NIOSH Report for Diamond Alkali 4, U.S. Ex. 48)) to 1,2,4,5-TCB (Trial Tr., vol. XII, 47:17-48:1, 50:21-51:3, 75:4-75:16, ECF No. 394); (2) the length of time over which this was added, which ranged from thirty minutes to two hours (id. at 48:1-48:11, 75:10-75:16); and (3) the temperature (approximately 170° C) and pressure (ranging from 350 to 375 psig) in the reaction vessel (id. at 49:8-49:12, 53:7-53:11) led Fu to conclude that 2,3,7,8-TCDF could have been

produced under Diamond Alkali's reaction conditions. (Id. at 64:3-64:4.) Sandau similarly concluded that Diamond Alkali's synthesis conditions would lead to the formation of 2,3,7,8-TCDF. (Trial Tr., vol. XI, 38:1-38:4, 38:6-38:10, 42:3-44:1, 49:6-49:20, 96:22-96:24, ECF No. 393.) Both Fu and Sandau opined that the formation of 2,3,7,8-TCDF would likely have occurred in the early stages of Diamond Alkali's synthesis of crude Na 2,4,5-TCP when one molecule of 1,2,4,5-TCB reacted with one molecule of 2,4,5-TCP.[85] (Id. at 41:19-41:22, 43:2-43:3, 43:19-44:1; Trial Tr., vol. XII, 45:15-45:20, 50:24-52:14, 73:20-74:1, 74:7-74:10, 76:9-76:12, 79:16-80:8, ECF No. 394.) Fu outlined two possible pathways by which 2,3,7,8-TCDF could form during Diamond Alkali's synthesis of crude Na 2,4,5-TCP. (Fu Slides 22-23, Emhart Ex. 349; Trial Tr., vol. XII, 55:8-56:2, 57:2-57:7, 57:15-57:20, 58:5-59:18, 60:12-61:10, 61:21-62:24, 63:23-64:4, 65:9-66:13, ECF No. 394.)

In addition to the formation of 2,3,7,8-TCDF, Emhart insists that Diamond Alkali's manufacture of crude Na 2,4,5-TCP produced dioxins and furans other than 2,3,7,8-TCDD and 2,3,7,8-TCDF. (See Emhart's Post-trial Br. 33, ECF No. 378.) This assertion stems from impurities contained in the 1,2,4,5-TCB

[85] By contrast, 2,3,7,8-TCDD is more likely to form in the latter stages of the crude Na 2,4,5-TCP synthesis. (Trial Tr., vol. XI, 43:8-43:17, ECF No. 393; Trial Tr., vol. XII, 75:17-76:16, ECF No. 394.)

feedstock used by Diamond Alkali. (See Trial Tr., vol. XI, 38:24-39:2, 39:10-39:17, 40:3-40:8, ECF No. 393; Trial Tr., vol. XII, 19:2-19:19, 20:7-21:11, 24:15-24:19, 25:3-25:5, ECF No. 394.) Diamond Alkali obtained the 1,2,4,5-TCB that it used to synthesize its crude Na 2,4,5-TCP from Hooker Chemical Company ("Hooker"). (Trial Tr., vol. XII, 26:13-26:24, ECF No. 394.) Fu opined that the Hooker synthesis of 1,2,4,5-TCB would produce other isomers of tetrachlorobenzene, as well as under-chlorinated and over-chlorinated benzene compounds. (Fu Slide 6, Emhart Ex. 349; Trial Tr., vol. XII, 19:2-19:19, 20:7-21:11, 24:15-24:19, 25:3-25:5, ECF No. 394.) Documents reflecting the composition of Hooker's 1,2,4,5-TCB and Diamond Alkali's crude Na 2,4,5-TCP for the years 1967 and 1968 showed the presence of impurities – including different isomers of tetrachlorobenzene and under-chlorinated and over-chlorinated benzene compounds – in Hooker's 1,2,4,5-TCB during that period.[86] (Emhart Exs. 250-51; NIOSH Report for Diamond Alkali 48, U.S. Ex. 48; Sandau Slide 23, Emhart Ex. 348; Trial Tr., vol. XI, 39:10-39:17, ECF

[86] The documents did not reflect the composition of Hooker's 1,2,4,5-TCB during the 1964-65 timeframe when Metro Atlantic manufactured HCP on the peninsula. (Trial Tr., vol. XII, 140:19-141:7, 143:15-143:23, ECF No. 394.) However, experts in this case have relied on these documents, despite this deficiency and the technical level at which the data were obtained, because there is no indication that Hooker changed its operations between the early 1960s and the late 1960s. (Trial Tr., vol. XVIII, 19:20-19:25, ECF No. 400.)

No. 393; Trial Tr., vol. XII, 25:21-26:12, 29:3-29:10, 33:6-33:16, 34:14-34:19, 35:1-36:1, 38:11-39:5, 40:1-40:6, 40:11-42:1, 42:5-43:4, ECF No. 394.) Fu and Sandau both opined that the presence of these impurities in the 1,2,4,5-TCB feedstock used by Diamond Alkali would result in the formation of dioxins and furans other than 2,3,7,8-TCDD and 2,3,7,8-TCDF during Diamond Alkali's synthesis of crude Na 2,4,5-TCP.[87] (Trial Tr., vol. XI, 40:3-40:8, 116:11-116:18, ECF No. 393; Trial Tr., vol. XII, 43:5-43:11, ECF No. 394.)

Building on these conclusions, Sandau opined that the 2,3,7,8-congener profile of Diamond Alkali's crude Na 2,4,5-TCP would have contained 2,3,7,8-TCDD, 2,3,7,8-TCDF, and other 2,3,7,8-substituted dioxins and furans. (Trial Tr., vol. X, 200:7-200:12, ECF No. 392; Trial Tr., vol. XI, 32:14-32:17, 33:4-33:10, 35:5-35:9, 36:1-36:5, 36:13-36:17, 62:9-62:12, 117:7-117:9, 117:13-117:20, 124:4-124:12, ECF No. 393.) In contrast to what he would expect to find in the vicinity of the

[87] In contrast to these other dioxins and furans, no impurities in the 1,2,4,5-TCB are necessary for the formation of 2,3,7,8-TCDD and 2,3,7,8-TCDF. (Trial Tr., vol. XII, 45:7-45:10, 46:15-46:19, ECF No. 394; Trial Tr., vol. XVIII, 81:12-81:18, 81:25-82:6, ECF No. 400; cf. Trial Tr., vol. XVII, 92:20-92:21, 111:16-111:23, 125:22-126:14, 127:16-127:19, ECF No. 399 (testimony of Dr. John Paul Giesy, Jr., a Government expert, that, although impurities in 1,2,4,5-TCB could theoretically lead to the formation of 2,3,7,8-TCDF, none of the impurities identified in Hooker's 1,2,4,5-TCB is expected to lead directly to 2,3,7,8-TCDF).)

HCP building footprint if leaks of the crude Na 2,4,5-TCP were the culprit for the dioxin contamination in that area, Sandau noted that the only dioxin or furan found in that area with concentrations above background levels was 2,3,7,8-TCDD.[88] (Trial Tr., vol. X, 199:25-200:2, ECF No. 392; Trial Tr., vol. XI, 32:5-32:6, 52:23-53:17, 54:1-54:13, 61:18-62:6, 62:18-63:1, 124:13-124:17, ECF No. 393.) Because of the dominance of 2,3,7,8-TCDD and the fact that 2,3,7,8-TCDF and other dioxins and furans do not have concentrations above background levels, Sandau opined that the 2,3,7,8-TCDD must have come from a purified source of 2,4,5-TCP.[89] (Trial Tr., vol. X, 200:3-200:4, ECF No. 392; Trial Tr., vol. XI, 33:25-34:14, 35:10-35:15, 35:21-35:24, 125:11-125:16, ECF No. 393.)

Ultimately, this Court is unpersuaded that the 2,3,7,8-congener profile for samples in the vicinity of the HCP building footprint is inconsistent with that of the crude Na 2,4,5-TCP that Diamond Alkali delivered to Metro Atlantic. Critically, as Sandau acknowledged, the composition of the crude Na 2,4,5-TCP

[88] 2,3,7,8-TCDF was found in these areas, but only in concentrations consistent with background levels. (Trial Tr., vol. XI, 62:18-63:1, ECF No. 393.) Determining background levels is important because dioxins and furans are ubiquitous at low levels in the environment. (Id. at 14:10-14:16.) The background levels established by Sandau refer to the 2,3,7,8-congener profile of dioxins and furans at locations upstream from the peninsula. (Id.)

[89] Diamond Alkali did not purify its crude Na 2,4,5-TCP. (Trial Tr., vol. XI, 51:8-51:14, ECF No. 393.)

that was delivered to Metro Atlantic was and is unknown. (Trial Tr., vol. XI, 116:24-117:2, ECF No. 393; see also id. at 93:9-93:14.) Similarly, Kittrell and Dr. John Paul Giesy, Jr. – a Government expert in environmental forensics and chemistry – confirmed that there is no data showing the congener profile of the crude Na 2,4,5-TCP manufactured by Diamond Alkali. (Trial Tr., vol. XIII, 165:8-165:13, ECF No. 395; Trial Tr., vol. XVII, 92:20-92:21, 111:16-111:23, 149:9-150:1, ECF No. 399.) And there are several other areas of uncertainty on this score.

With regard to the presence of 2,3,7,8-TCDF in the crude Na 2,4,5-TCP, Sandau acknowledged that no data from any manufacturer of 2,4,5-TCP, including Diamond Alkali, indicated the presence of 2,3,7,8-TCDF in 2,4,5-TCP. (Trial Tr., vol. XI, 94:7-94:11, 94:24-95:3, ECF No. 393.) Fu similarly acknowledged that the NIOSH report for Diamond Alkali does not show 2,3,7,8-TCDF as a byproduct of its 2,4,5-TCP synthesis. (Trial Tr., vol. XII, 121:2-121:5, ECF No. 394.) Additionally, although Ensley agreed that Fu had identified theoretically possible mechanisms for the formation of furans in Diamond Alkali's synthesis of crude Na 2,4,5-TCP, he opined that Diamond Alkali's reaction conditions did not provide enough energy for a measurable quantity of 2,3,7,8-TCDF to form.[90] (Trial Tr., vol.

[90] The amount of a chemical product that is produced in a reaction depends on how much starting material is present, how

XVIII, 23:19-23:20, 26:15-26:19, 26:22-26:23, 28:9, 28:14-29:16, 36:23-36:25, 95:10-95:16, 115:12-115:15, 126:10-126:15, ECF No. 400.) Sandau acknowledged that furans are typically formed at high temperatures. (Trial Tr., vol. XI, 96:8-96:12, ECF No. 393.) And Fu acknowledged that 2,3,7,8-TCDF does not always accompany 2,3,7,8-TCDD. (Trial Tr., vol. XII, 141:25-142:11, 143:1-143:10, ECF No. 394.)

In any event, even if Diamond Alkali's process for synthesizing its crude Na 2,4,5-TCP did result in the formation of 2,3,7,8-TCDF, Sandau acknowledged that none of the methods for purifying 2,4,5-TCP would have changed the ratio of 2,3,7,8-

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quickly the reaction occurs ("the reaction rate"), and the length of time of the reaction. See generally Raymond Chang, Chemistry 510-16, 532, 542 (7th ed. 2002). The reaction rate depends on the concentration of the chemical compounds and the rate constant. See id. at 513, 516. The rate constant, in turn, depends on the reaction temperature and the threshold level of energy that must be reached in order for the reactants to form the product; this energy threshold, referred to as "activation energy," functions as a barrier, sometimes thought of as a hill, that the reactants must get over to turn into products. See id. at 513, 532. As the temperature increases, an increasing fraction of the reactants can make it over the hill. See id. at 532.

In this case, the experts have somewhat differing views on whether the energy threshold is too high for many molecules of the product, 2,3,7,8-TCDF, to be formed under Diamond Alkali's reaction conditions. Government experts opine that only "very, very small amounts" of 2,3,7,8-TCDF would have been formed (Trial Tr., vol. XVIII, 125:2, ECF No. 400; see also id. at 125:1-125:14, 126:10-126:15; Trial Tr., vol. XVII, 158:23-158:25, 160:22-161:13, 162:5-162:18, 162:25-163:16, ECF No. 399), while Emhart's experts opine that a measurable quantity of 2,3,7,8-TCDF would have been produced (see Trial Tr., vol. XI, 43:19-44:1, ECF No. 393; Trial Tr., vol. XII, 64:3-64:4, ECF No. 394).

TCDD to 2,3,7,8-TCDF in a batch of 2,4,5-TCP. (Trial Tr., vol. XI, 100:3-100:12, ECF No. 393.) Ensley and Giesy agreed with Sandau on this point, and Ensley expressed confusion as to how Sandau could nonetheless identify the source of the dioxin under the HCP building footprint as a purified source of 2,4,5-TCP and rule out Diamond Alkali's crude Na 2,4,5-TCP. (Trial Tr., vol. XVII, 150:3-150:6, 153:23-156:2, 168:17-169:5, 186:22-188:23, ECF No. 399; Trial Tr., vol. XVIII, 37:3-37:9, 37:24-38:2, 39:1-39:5, ECF No. 400.)

Concerning the presence of other dioxins and furans in the crude Na 2,4,5-TCP that Metro Atlantic received from Diamond Alkali, Ensley explained that the only dioxins tested for at the Site were 2,3,7,8-substituted congeners; consequently, any other dioxins or furans that may have been created because of impurities in Hooker's 1,2,4,5-TCB would not have been detected on the Site. (Trial Tr., vol. XVIII, 20:25-21:23, 22:4-22:20, 47:6-47:10, 88:3-88:6, ECF No. 400.) Ensley further noted that there is no data indicating that pentachlorobenzene or hexachlorobenze – two benzene molecules more highly chlorinated than 1,2,4,5-TCB – were contained in the purified 1,2,4,5-TCB that was sent to Diamond Alkali (id. at 22:21-23:14), and none of Fu's testimony expressly contradicts this observation. The absence of these higher chlorinated benzenes, Ensley opined, would forestall the creation of higher chlorinated dioxins and

furans. (Id. at 23:5-23:9; 24:3-24:5, 157:17-157:20.) Ultimately, Sandau acknowledged that 2,3,7,8-TCDD would have comprised 95% or more of the 2,3,7,8-congener profile in Diamond Alkali's crude Na 2,4,5-TCP. (Trial Tr., vol. XI, 92:17-93:8, ECF No. 393.)

For these reasons, this Court concludes that there is too much uncertainty to accept the position that the 2,3,7,8-congener profile for samples in the vicinity of the HCP building footprint eliminates discharges from Metro Atlantic's HCP-manufacturing process as a source of the 2,3,7,8-TCDD found in that location. (See Trial Tr., vol. XVII, 114:8-114:15, 147:12-148:15, 148:24-149:1, ECF No. 399.)

ii. DOD Drums

Prior to trial, the centerpiece of Emhart's argument that NECC is responsible for the elevated concentrations of 2,3,7,8-TCDD found underneath and in the vicinity of the footprint of the HCP building was 4,800 drums that were purchased by NECC from the DOD; Emhart insisted that some of these drums contained residues of tactical herbicides (or perhaps ordinary commercial herbicides) that contained 2,4,5-T and, by extension, 2,3,7,8-TCDD.[91] (See generally Emhart's Opp'n to the DOD's Mot. for

[91] "A tactical herbicide is one [that has] been researched specifically by the military for use in a conflict zone in a tactical environment." (Trial Tr., vol. VI, 13:14-13:16, May 28, 2015, ECF No. 388.)

Partial Summ. J., ECF No. 340; see also Emhart' Pretrial Mem. 63-67, ECF No. 360.) At trial, however, Emhart's reliance on this theory seemed to fade to black.[92] Indeed, in its post-trial brief, Emhart has not even addressed the issue of the contents of the DOD drums that NECC purchased, opting instead to rest on its briefing in connection with the DOD's summary judgment motion and Rule 52(c) motion.[93] (See Trial Tr., vol. XXI, 10:5-10:13, July 22, 2015, ECF No. 403; see also Emhart's Opp'n to the DOD's Rule 52(c) Motion 2, ECF No. 374.)

Sometime between February 1962 and September 1963,[94] NECC purchased 2,400 55-gallon drums from Otis Air Force Base ("Otis") and another 2,400 drums from Naval Air Station Quonset

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[92] Unsurprisingly, this shift spurred the DOD to move, during trial, for judgment on partial findings under Rule 52(c) of the Federal Rules of Civil Procedure. (ECF No. 372.) This Court reserved ruling on that motion and addresses it in this decision. See infra Section II.C.

[93] Several of the statements of fact in Emhart's opposition to the DOD's summary judgment motion are based (not inappropriately for that context) on hearsay, including passages from expert reports. (See, e.g., Emhart's Resp. to the DOD's Statement of Undisputed Facts ("Emhart's SOF") ¶¶ 67, 84, 87-94, 105, 107, ECF No. 341.) Of course, this Court's findings of fact with respect to the DOD drums must be grounded in evidence that was admitted at trial.

[94] The parties agree on this timeframe. (See Gov't's PFOF ¶ 777, ECF No. 379; Emhart's SOF ¶¶ 80, 82, ECF No. 341.)

Point ("Quonset").[95] (See R. Nadeau 9/10/08 Dep. Tr. 34:11-34:18, 35:20-36:6.) The parties dispute what residues, if any, were inside the drums NECC purchased from Otis and Quonset.[96] This Court finds that the drums once held turbine oil; therefore, the residues in the drums would have likely consisted only of turbine oil. Raymond Nadeau picked up all of the drums from Otis and Quonset. (See R. Nadeau 9/10/08 Dep. Tr. 34:11-36:6; see also Trial Tr., vol. XIII, 169:17-169:21, ECF No. 395.) He testified that the tops of the drums were labeled

[95] In its statement of facts, Emhart asserts that NECC may have purchased more drums from Otis and Quonset than the 4,800 that were purchased in the 1962-63 timeframe. (See Emhart's SOF ¶¶ 95-99, ECF No. 341.) Emhart bases this assertion on Vincent J. Buonanno's deposition testimony that "from time to time through the years, [NECC] bid on empty containers generated by the Navy or the Army" and "got them." (Tr. of Oct. 22, 2008 Deposition of Vincent J. Buonanno ("V. Buonanno 10/22/08 Dep. Tr.") 82:18-83:5.) Because Buonanno worked for NECC during the summers of 1961, 1962, and perhaps 1963 and did not become a full-time NECC employee until 1967 and because NECC had other truck drivers besides Raymond Nadeau (see Tr. of May 15, 2013 Deposition of Vincent J. Buonanno ("V. Buonanno 5/15/13 Dep. Tr.") 204:2-204:4, 207:17-207:24; V. Buonanno 10/22/08 Dep. Tr. 7:18-7:19, 8:19-9:9; Tr. of March 25, 2003 Deposition of Vincent J. Buonanno ("V. Buonanno 3/25/03 Dep. Tr.") 8:20-9:1), Emhart argues that other purchases of DOD drums were possible "through the years." (Emhart's Opp'n to the DOD's Mot. for Partial Summ. J. 14-16, ECF No. 340.) This Court rejects this argument. There is simply no persuasive evidence that any additional DOD drum purchases were made by NECC. Moreover, as explained below, even if such additional purchases occurred, there is no credible evidence that any drums from Otis or Quonset that were purchased by NECC contained 2,3,7,8-TCDD.

[96] According to Raymond Nadeau, who picked up the drums from Otis and Quonset, the drums were "empty," but "they all had a coating in them." (R. Nadeau 6/12/13 Dep. Tr. 46:3-46:7.)

"turbine oil."[97] (R. Nadeau 6/12/13 Dep. Tr. 47:23-48:5, 48:8-48:14, 48:19-48:21, 48:25-49:6.) Kittrell acknowledged that there is no evidence other than Nadeau's testimony regarding the contents of the DOD drums. (Trial Tr., vol. XIII, 171:13-171:18, ECF No. 395.)

Emhart relies on NECC's Supplemental 104(e) Disclosure (U.S. Ex. 408), and certain inferences that can arguably be drawn therefrom, to contend that that the DOD drums contained something other than turbine oil residue. (See Emhart's Resp. to the DOD's Statement of Undisputed Facts ("Emhart's SOF") ¶¶ 103-04, ECF No. 341.) In its Supplemental Disclosure, NECC states that the residual content in the drums it purchased from Quonset consisted of "[t]urbine oil residues" and "[o]il/jet fuel."[98] (Attach. A to NECC's Aug. 22, 2002 Supp. 104(e)

[97] In its statement of facts (Emhart's SOF ¶ 100, ECF No. 341), Emhart seizes on Nadeau's testimony that he could not "swear to it" that all of the drums were marked with a "turbine oil" label and that "[t]here could have been anything [in the drums]. I don't know." (R. Nadeau 6/12/13 Dep. Tr. 48:5-48:6, 48:15-48:18; see also id. at 48:23-48:24 ("I didn't go read every [drum] I picked up.").) This testimony does not appreciably impact this Court's determination that the DOD drums were nearly empty turbine oil drums; the fact that Nadeau did not read the top and "swear to" the contents of each of the 4,800 drums that he picked up from Otis and Quonset is unsurprising. Additionally, Nadeau testified that "[t]he only part I remember about [the drums] is the turbine oil." (R. Nadeau 6/12/13 Dep. Tr. 48:13-48:14.)

[98] The Supplemental Disclosure listed only "[t]urbine[-]oil residues" under the space for residual content in the drums it

Disclosure 10, U.S. Ex. 408.) Because the information disclosed in the Supplemental Disclosure was obtained from discussions with Nadeau and Thomas Lussier and because Lussier did not work for NECC on the peninsula (NECC's Aug. 22, 2002 Supp. 104(e) Disclosure 1, U.S. Ex. 408), Emhart argues that Nadeau must have told NECC that the Quonset drums contained oil/jet fuel. (Emhart's SOF ¶¶ 102-04, ECF No. 341.)

This Court is unpersuaded that the Supplemental Disclosure's indication that oil/jet fuel was in the Quonset drums is significant. If Emhart is correct that Nadeau informed NECC in 2002 that oil/jet fuel was in the drums, he has not indicated so since then. Nadeau testified at his most recent deposition in this case that "[t]he only part I remember about [the drums] is the turbine oil." (R. Nadeau 6/12/13 Dep. Tr. 48:13-48:14.) Moreover, even if the drums contained residues of jet fuel, there is no evidence in this record that links jet fuel to tactical herbicides.[99]

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purchased from Otis. (Attach. A to NECC's Aug. 22, 2002 Supp. 104(e) Disclosure 9, U.S. Ex. 408.)

[99] To be sure, Emhart attempted to create this link in its statement of facts in the summary judgment briefing. (See Emhart's SOF ¶¶ 105-11, ECF No. 341.) However, several components of this link relied on hearsay that has not been admitted into evidence at this trial. (See id. at ¶¶ 105, 107, 109.) If there is evidence in this voluminous record to support this link, Emhart, by electing to rest on its summary judgment papers, has abdicated its responsibility to bring this evidence to the Court's attention.

Emhart's other effort to overcome Raymond Nadeau's identification of the DOD drums as turbine oil drums is equally unconvincing. It notes that an elevated concentration of 2,4,5-T was found on the peninsula in the vicinity of the HCP building footprint.[100] (Emhart's Post-trial Br. 137, ECF No. 378; see Trial Tr., vol. VIII, 110:8-110:13, ECF No. 390; Trial Tr., vol. XI, 33:19-33:22, ECF No. 393; Locke Slide 92, Emhart Ex. 342.) Additionally, 2,4-dichlorophenol ("2,4-DCP"), a degradation product of 2,4-D, was also found in this location.[101] (See Trial Tr., vol. XI, 64:23-64:24, ECF No. 393; Locke Slide 92, Emhart Ex. 342; Sandau Slide 42, Emhart Ex. 348.) Similarly, 2,4,5-T and 2,4-DCP were detected in the soils at Joint Base Cape Cod, the military installation where Otis was located, and inventories indicate that 2,4,5-T and 2,4-D were used at

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[100] There was only one detection of 2,4,5-T at the Site. (Trial Tr., vol. XI, 98:22-99:15, ECF No. 393.)

[101] Sandau testified that "2,4,5-dichlorophenol is a breakdown product of 2,4-D." (Trial Tr., vol. XI, 64:23-64:24, ECF No. 393.) However, there is no evidence that "2,4,5-dichlorophenol" was found in the vicinity of the HCP building footprint. Moreover, the slide to which Sandau was referring when he gave this testimony does not contain "2,4,5-dichlorophenol," but it does contain 2,4-dichlorophenol. (See Sandau Slide 42, Emhart Ex. 348; Trial Tr., vol. XI, 63:2-64:25, ECF No. 393.) Thus, it appears that Sandau meant to say "2-4-dichlorophenol is a breakdown product of 2,4-D."

Quonset.[102] (See Dept. of Navy 104(e) Resp. 14, Emhart Ex. 266; Initial Assessment Study of Naval Constr. Battalion Ctr. Davisville, Rhode Island 5-2, U.S. Ex. 162; MMR Decision Doc. 95, Emhart Ex. 272; MMR Monthly Progress Report #13 2-3, Emhart Ex. 268; MMR Monthly Progress Report #14 2, Emhart Ex. 269; MMR Monthly Progress Report #43 3, Emhart Ex. 270.) 2,4,5-T – a product that was made from 2,4,5-TCP (and, therefore, contained 2,3,7,8-TCDD) and that can degrade in the environment to 2,4,5-TCP (Trial Tr., vol. VIII, 110:20-111:2, 111:21-111:22, ECF No. 390) – and 2,4-D are key components in tactical, and several commercial, herbicides. (See Trial Tr., vol. VI, 29:10-30:1, 30:21-31:8, 32:22-33:2, 102:17-102:20, May 28, 2015, ECF No. 388; Trial Tr., vol. XI, 64:19-64:25, ECF No. 393.) Because of the presence of 2,4,5-T and either 2,4-D or 2,4-DCP on the Site, Otis, and Quonset, Emhart argues that one can reasonably infer that some of the DOD drums that NECC purchased contained residues of herbicides, whether tactical or commercial. (See Trial Tr., vol. XXI, 11:12-11:19, 13:11-13:15, ECF No. 403;

[102] Although the Court acknowledges Emhart's argument about the incompleteness of Quonset's pesticides records from 1951 to 1971 (see Emhart's Opp'n to the DOD's Mot. for Partial Summ. J. 25-26, ECF No. 340-1), the Department of the Navy's 104(e) disclosure lists quantities of 2,4,5-T at Quonset in only 1967 and 1971 and quantities of 2,4-D in 1971 (see Dept. of Navy 104(e) Resp. 14, Emhart Ex. 266), well after the timeframe that NECC purchased the drums from Quonset.

Emhart's Opp'n to the DOD's Mot. for Partial Summ. J. 23, ECF No. 340-1.)

But this is sheer speculation, plain and simple. First, as to tactical herbicides, Dr. David Biggs – a Government expert in history, with a specific expertise relating to the U.S. military's procurement, shipment, and handling of tactical herbicides in the 1960s (Trial Tr., vol. VI, 3:12, 14:4-14:12, ECF No. 388) – opined that there was no evidence that Otis or Quonset possessed tactical herbicides. (Id. at 70:4-70:22.) Similarly, Randal Curtis – a Government expert in the field of federal and public records archival research as it relates to the research, testing, possession, and disposal of chemical and hazardous substances at domestic U.S. military bases (Trial Tr., vol. XVI, 20:1, 41:7-41:15, June 15, 2015, ECF No. 398) – opined that tactical herbicides were never present at Otis or Quonset for the purposes of research, development, testing, or evaluation, or for the purpose of shipment of tactical herbicides. (Id. at 46:15-46:21, 69:4-69:17.) Biggs explained that the Government has compiled a list of every known site where any amount of tactical herbicides was tested in the period from 1943 to 1970 and that neither Otis nor Quonset was listed. (Trial Tr., vol. VI, 28:10-29:7, ECF No. 388; see U.S. Exs. 124, 163; see also Trial Tr., vol. XVI, 46:7-46:21, ECF No. 398.) Additionally, the evidence demonstrates that it is highly

unlikely that Otis or Quonset received empty tactical-herbicide drums following their use in Southeast Asia because it was cost-prohibitive to ship empty drums back to the United States. (See Trial Tr., vol. VI, 63:17-64:9, ECF No. 388.)

In response, Emhart can only note that the procurement records for tactical herbicides during the 1962-63 timeframe were incomplete and that, for much of this time period, there was no prohibition on a military base's use of tactical herbicides for ordinary grounds maintenance. (See Trial Tr., vol. XXI, 13:11-13:15, ECF No. 403; Emhart's Opp'n to the DOD's Rule 52(c) Mot. 6-7, ECF No. 374; Emhart's Opp'n to the DOD's Mot. for Partial Summ. J. 7-8, 26-31, ECF No. 340-1; see also Trial Tr., vol. VI, 131:5-131:15, 131:20-132:7, ECF No. 388.) From these observations, Emhart argues that tactical herbicides might have been used for grounds maintenance at Otis and Quonset and that some of the herbicides used might have been stored in the drums that NECC purchased from those two bases. (See Emhart's Opp'n to the DOD's Mot. for Partial Summ. J. 26-29, ECF No. 340-1.) This argument applies equally to commercial herbicides. (See id. at 23.)

This Court rejects this argument because the evidence demonstrates that, although Otis and Quonset used a small quantity of herbicides for ordinary grounds maintenance, drums that contained herbicides were not sold by either base, and,

more importantly, there is simply no persuasive evidence that herbicides were stored in any of the DOD drums that NECC purchased. As an initial matter, because a large portion of the area of both bases was either paved or bare, both bases likely possessed only a small quantity of herbicides at any one time. (See Trial Tr., vol. VI, 78:18-79:18, ECF No. 388.) Indeed, Curtis opined that "[t]here is no way" that Otis or Quonset possessed anything approaching the ballpark of 2,400 drums of herbicides (Trial Tr., vol. XVI, 47:21, ECF No. 398; see also id. at 47:11-47:25). For example, Curtis estimated that Otis might use, at most, approximately eight drums of herbicides (applied at a rate on the high side of the recommended-application rate) to maintain power-line rights of way and fire breaks on the entire Joint Base Cape Cod, of which Otis was only a part.[103] (See id. at 56:12-57:19, 58:14-58:19, 60:24-61:3, 61:23-62:14, 65:3-65:9; U.S. Exs. 294-97; see also Trial Tr., vol. XVI, 7:7-7:13, ECF No. 398; Jan. 1983 Phase I Records Search: Otis Air Nat'l Guard Base ("1983 Records Search") 4-9, U.S. Ex. 148 ("Herbicides and pesticides have been used on the Base in limited quantities . . . . Small quantities of herbicide

[103] Curtis further opined that, even under the unlikely scenario that herbicides were applied to the rights of way at Joint Base Cape Cod at the experimental testing rate instead of the recommended-application rate, a maximum of only 49 drums of herbicides would have been used. (Trial Tr., vol. XVI, 62:15-63:6, June 15, 2015, ECF No. 398.)

residual may have entered the environment at the former Pavement and Grounds clean-up/storage area, but the amounts would not have been significantly different from the amounts applied during normal herbicide applications in designated areas.").) Curtis also noted that Quonset is only a sixth of the size of Joint Base Cape Cod and is not forested, so the use of herbicides at Quonset would be even less than at Joint Base Cape Cod. (Trial Tr., vol. XVI, 65:15-65:21, ECF No. 398.)

In addition to the small quantities of herbicides used at Otis and Quonset for routine grounds maintenance, there is no evidence to suggest that Otis or Quonset sold their empty herbicide drums as surplus property. Otis disposed of its herbicide drums in the on-site landfill at Joint Base Cape Cod. (See 1983 Records Search 4-9, U.S. Ex. 148 ("Herbicide wastes [at Otis] reportedly went to the landfill."); id. at Table 4-1 (indicating that herbicide drums were sent to the sanitary landfill from 1940 to approximately 1980).) Similarly, Quonset triple rinsed its pesticide and herbicide containers and then disposed of them in the on-site landfill until 1972; Quonset also transferred its old or banned pesticides to the State of Rhode Island Pesticide Coordinator at the University of Rhode Island. (See Trial Tr., vol. VI, 94:9-95:12, ECF No. 388; Initial Assessment Study of Naval Constr. Battalion Ctr. Davisville, Rhode Island 5-2, U.S. Ex. 162.)

For these reasons, this Court fully agrees with Biggs that the DOD drums sold to NECC did not contain herbicide residues. (See Trial Tr., vol. VI, 26:2-26:11, 70:9-70:22, 96:24-97:9, ECF No. 388.) The evidence demonstrates that the small quantity of herbicides that Otis and Quonset possessed were disposed of at the on-site landfills on those bases, and that the DOD drums that NECC purchased were empty turbine oil drums. Although there is some evidence that herbicide components were found at the Site (Trial Tr., vol. XI, 64:19-64:25, ECF No. 393), these concentrations likely came from another entity that supplied drums to NECC; as commercial herbicides were widely available and used during the 1960s (see Trial Tr., vol. VI, 97:23-98:12, ECF No. 388), this scenario is highly plausible. Emhart has not proven by a preponderance of the evidence that the DOD drums purchased by NECC contained herbicide residues.[104]

[104] For similar reasons, this Court reaches the same conclusion with respect to Emhart's allegation that the DOD drums contained the commercial herbicides Silvex or MCPP. (See Second Am. Compl. ¶¶ 33, 38-40, ECF No. 69.) Based on the dearth of evidence on this issue (see Trial Tr., vol. XVI, 13:21-14:10, ECF No. 398 (indicating that MCPP and Silvex were found at Otis, but were not contaminants of concern)), this Court cannot find by a preponderance of the evidence that this allegation is true. Similarly, apart from noting the evidence that suggests that solvents, VOCs, PCBs, and metals were found at Otis and Quonset (see Emhart's Opp'n to the DOD's Rule 52(c) Mot. 4-5 n.2, ECF No. 374; see also Trial Tr., vol. VI, 89:25-90:11, 126:12-126:19, 126:25-127:3, ECF No. 388; Trial Tr., vol. XVI, 18:13-19:5, ECF No. 398), Emhart has made no attempt to link these substances to the DOD drums that NECC purchased. Therefore, this Court is constrained to find that Emhart has not

Before leaving this subject, a final word on the empty turbine oil drums is in order. Lynn Nelson, the DOD's Rule 30(b)(6) designee and a chemical engineer in the mechanical-systems branch of the Air Force who works on turbine oils, testified that she was informed by a chemist that PAHs "could have been present in one of [the DOD's] turbine engine oils," known as "Mill 06081." (Tr. of Deposition of Lynn Nelson ("Nelson Dep. Tr.") 4:24-4:25, 5:8-5:13, 5:18, 6:9-6:14, 16:20-16:23; see also id. at 16:22-16:24 ("Mill 06081 . . . could have contained some [PAHs]."). Emhart seizes on this testimony (see Emhart's Opp'n to the DOD's Rule 52(c) Mot. 5 n.2, ECF No. 374) because, although unconnected to the 2,3,7,8-TCDD contamination, PAHs are a contaminant of concern at the Site (see Trial Tr., vol. I, 95:15-95:19, ECF No. 383). However, there is no evidence that Mill 06081 was ever present at Otis or Quonset, let alone in the DOD drums that NECC purchased. (See Nelson Dep. Tr. 17:3-17:8, 18:8-18:12.) Thus, there is simply no persuasive evidence in this case that the DOD drums contained a hazardous substance.

Moreover, in addition to this fatal absence of evidence, Nelson testified that, after a review of turbine engine oil specifications in the historical records, neither her office nor

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proven by a preponderance of the evidence that these substances were contained in the DOD drums NECC purchased.

a sister office found anything "in any of the turbine engine oils that would have been qualified at the time that would have included any of the hazardous items that are being questioned in this case." (Id. at 20:7-20:11; see also id. at 20:5-20:23.) From this review, Nelson concluded that "no turbine engine oil [purchased by the DOD] has any of these hazardous components that are in question." (Id. at 21:1-21:3; see also id. at 21:4-21:6.) Emhart seeks to discount Nelson's conclusions as perhaps referring to the absence of dioxins from the DOD's turbine oils. (See Trial Tr., vol. XXI, 10:21-11:7, ECF No. 403.) But this Court finds that Nelson testified that, contrary to what she was told by a chemist, her review of historical records led her to conclude that the DOD's turbine oils did not contain any hazardous substance identified at the Site. In any event, because there is no evidence that the one turbine oil that "could have" (Nelson Dep. Tr. 16:20-16:24) contained PAHs was present at Otis or Quonset, this Court finds that Emhart has not proved by a preponderance of the evidence that empty turbine oil drums that NECC purchased contained PAHs or any other hazardous substances.

d. Metro Atlantic is Responsible for 2,3,7,8-TCDD in the Area of the HCP Plant

In sum, Emhart's attempt to pin the blame on NECC for bringing 2,4,5-TCP or 2,4,5-T onto the Site is wholly

speculative because of a critical evidentiary flaw: no evidence has been presented that any of the drums from the drum suppliers who possessed 2,4,5-TCP or 2,4,5-T on their premises actually contained those substances. Indeed, as Kittrell acknowledged, "[t]here's really no information that any particular company had a particular contaminant in a particular [drum] [that was] delivered to [NECC] for reconditioning. (Trial Tr., vol. XIII, 64:20-64:23, ECF No. 395; see also id. at 169:10-169:15.) While it is certainly possible that some of the 2,3,7,8-TCDD found in the area of the former HCP plant came from barrels stored by NECC on or near that same area, cf. supra Section I.B.3.a (finding of fact related to elevated concentrations of 2,3,7,8-TCDD in areas south of HCP building footprint), this Court is unwilling to take the leap of faith that Emhart urges when a far more plausible explanation for the 2,3,7,8-TCDD contamination under the HCP building footprint is firmly rooted in the evidentiary record. Therefore, for these reasons, the Court finds that some amount of the liquid waste streams generated by the HCP-manufacturing process – at least two of which contained significant concentrations of 2,3,7,8-TCDD – leaked from the discharge pipe and contaminated the soil in this area.

5. Radiometric Dating of Pond Sediments

The final component of Emhart's effort to show that NECC is responsible for the 2,3,7,8-TCDD at the Site focuses not on the peninsula itself but on Allendale Pond, a portion of the Site that is downstream from the peninsula. As explained below, see infra Section I.D, contaminants deposited on the peninsula, including 2,3,7,8-TCDD, were transported from the peninsula to downstream portions of the Site, such as Allendale Pond, the Oxbow Area, and Lyman Mill Pond, through various fate-and-transport pathways. As a result, elevated concentrations of 2,3,7,8-TCDD are found in these downstream areas, including in pond sediments in Allendale Pond. (See U.S. Exs. 204-05; Medine Slide 29, U.S. Ex. 501.)

Emhart argues that analysis of radiometric data from pond sediments in Allendale Pond indicates that 2,3,7,8-TCDD was released before and after Metro Atlantic manufactured HCP in the mid-1960s. (Emhart Post-trial Br. 131, ECF No. 378.) Emhart insists that only NECC could have released 2,3,7,8-TCDD at these times. (Id. at 131-33.) Although this Court agrees that the presented radiometric data indicates that NECC is responsible for some of the 2,3,7,8-TCDD in downstream sediments, the data are not as clarifying as Emhart suggests.

The evidence introduced at trial related to Cesium-137, which is an isotope that was generated as a product of above-

ground testing and explosions of nuclear weapons, was transported around the world through the atmosphere, and deposited on the earth. (See Trial Tr., vol. VIII, 74:1-74:3, 77:21-77:23, 78:10-78:21, ECF No. 390.) Locke testified that the time of Cesium-137 deposition and the deposition of closely surrounding soil in pond silt would be the same, so that Cesium-137 can be used as a temporal marker. (See id. at 74:19-75:5, 78:18-78:21.) Thus, the deepest silt containing Cesium-137 would have been from the earliest tests and would serve to date that stratum, while the last stratum with a significant level of Cesium 137 would have been from what Locke identified as the peak of nuclear-weapons testing. (See id. at 78:21-79:14.) Any 2,3,7,8-TCDD found in one of these strata would be assumed to have been deposited at the same time as the Cesium-137 in that stratum. (See id. at 83:19-84:9; Locke Slide 74, Emhart Ex. 342.) Locke testified that the first appearance of Cesium-137 occurred in approximately 1954, and the last stratum with a significant level of Cesium-137 occurred in approximately 1963.[105] (See Trial Tr., vol. VIII, 78:21-79:14, 82:10-82:24, ECF No. 390.)

[105] These dates are approximations based on the dates of nuclear-weapons tests and the time lapse between the testing date and the time at which the isotope byproducts like Cesium 137 were deposited. (See Trial Tr., vol. VIII, 78:18-79:14, ECF No. 390.)

With respect to the analyzed sediment core samples in this case, the rate of sediment deposition in Allendale Pond was between 0.5 cm and just under 0.1 cm per year, which translates into a time span of 19-30 years represented by six inches of sediment. (Id. at 80:5-80:12.) Locke focused on six sediment core samples from Allendale Pond and concluded that each of these samples revealed a similar pattern for 2,3,7,8-TCDD deposition: 2,3,7,8-TCDD was deposited in Allendale Pond sediments from at least the early 1950s until well after the mid- to late-1960s, with the largest releases occurring after the mid-1960s.[106] (Id. at 81:6-81:8, 81:22-82:2, 82:10-82:24, 83:19-84:9, 87:7-87:21, 88:4-89:13; see Locke Slides 74-75, Emhart Ex. 342.) Locke opined that the 2,3,7,8-TCDD deposition dates closely correspond with NECC's drum-reconditioning operations and that depositions of 2,3,7,8-TCDD before 1963 and after the mid-1960s are not consistent with direct releases from Metro Atlantic's HCP-manufacturing operations. (See Trial Tr., vol. VIII, 90:1-90:23, ECF No. 390.)

Andrews agreed with Locke that most of the 2,3,7,8-TCDD in downstream sediment was deposited in approximately the mid-1960s and later. (Trial Tr., vol. XX, 17:18-17:20, 59:10-59:14,

[106] Locke selected these six core samples because they appeared to follow the "classic pattern" of a Cesium-137 peak in approximately 1963 with a steady decline in Cesium-137 levels as the depth of the core sample increased, with a first appearance of Cesium-137 in approximately 1954. (Id. at 81:11-81:15.)

60:16-60:24, 173:13-173:16, 174:5-174:14, ECF No. 402.) He also agreed that NECC was likely responsible for the deposition of 2,3,7,8-TCDD that occurred before the mid-1960s and that NECC could also be responsible for some of the 2,3,7,8-TCDD that was released in the mid-1960s and after. (Id. at 61:14-62:1, 132:19-133:1, 133:10-133:18, 174:20-175:14.) However, Andrews disagreed with Locke's opinion that deposition of 2,3,7,8-TCDD after the mid-1960s was inconsistent with a release from Metro Atlantic's HCP-manufacturing operations. (Id. at 62:17-62:20.) Andrews opined that 2,3,7,8-TCDD that was released during Metro Atlantic's HCP-manufacturing operations was transported to Allendale Pond "well after [HCP] operations had ceased as the result of erosion and transport of sediment by surface waters running off the peninsula and by redistribution of sediment by flood waters." (Id. at 63:1-63:4; see also id. at 63:5-63:24.) Indeed, Locke acknowledged that the increase in 2,3,7,8-TCDD concentrations in sediment after 1963 is "consistent with a release of 2,3,7,8-TCDD to peninsula soils that then migrates gradually into the river over time." (Trial Tr., vol. IX, 113:4-113:8, ECF No. 391.)

This Court finds that the evidence on radiometric dating cannot exonerate Emhart's responsibility for some of the 2,3,7,8-TCDD that was found in Allendale Pond. To be sure, the evidence demonstrates that NECC is likely responsible for some

of the 2,3,7,8-TCDD that was deposited in sediments in Allendale Pond, such as the depositions that occurred before the mid-1960s. However, the Court agrees with Andrews that the depositions of 2,3,7,8-TCDD that occurred after the mid-1960s can be explained, at least in part, by fate and transport mechanisms that transported 2,3,7,8-TCDD from the WDA and the vicinity of the HCP building footprint (including the area underneath that footprint) downstream. See infra Section I.D.

This conclusion is reinforced by the imprecision inherent in the radiometric-dating evidence that was admitted into evidence. As Locke acknowledged, sedimentation rates can vary depending on a host of environmental or engineering factors, and "the sedimentation rates [for Allendale Pond] are somewhat uncertain." (Trial Tr., vol. VIII, 80:25, ECF No. 390; see also id. at 75:12-75:19, 76:1-76:10, 80:22-80:25.) Additionally, where, as here, samples are not collected continuously though a vertical profile of sediments, gaps in the data will render it difficult to precisely pinpoint the peak Cesium-137 concentration and the first detectable occurrence; in turn, these uncertainties impact the identification of the 1963 and 1954 time periods. (See id. at vol. VIII, 75:20-76:10, 82:3-82:8, 84:16-85:5.) Thus, it is difficult to determine with any degree of accuracy precisely when a contaminant was deposited; approximation in this area appears to be the best one can hope

for, and approximation is not Emhart's friend. This Court is unwilling to accept the inference that Emhart draws from this approximation, especially when downstream transport of 2,3,7,8-TCDD released from Metro Atlantic's HCP-manufacturing operations is consistent with the radiometric data for depositions of 2,3,7,8-TCDD during the mid-1960s and after.

D. Fate & Transport

In general, the place where a contaminant was discharged on the peninsula was not always its final resting place. Instead, there are several fate-and-transport pathways by which contaminants could have moved from one place to another, including downstream transport in the Woonasquatucket River, flooding, erosive transport through surface-water runoff, runoff from the tailrace during high-precipitation events, and migration with the groundwater. (See Trial Tr., vol. IV, 205:5-205:8, 205:17-205:23, 206:2-206:5, ECF No. 386; Trial Tr., vol. XV, 28:4-28:20, ECF No. 397.) As a general matter, the Woonasquatucket River flowed in a north-south direction, and groundwater flow and surface-water runoff transported contaminants into the river or the downstream ponds. (Trial Tr., vol. IV, 205:13-205:16, 205:23-206:1, 206:5-206:11, ECF No. 386; U.S. Ex. 199; see also Trial Tr., vol. IV, 189:24-190:13, ECF No. 386.) The three broad categories of releases of 2,3,7,8-TCDD on the peninsula by Metro Atlantic – the direct

discharge of liquid waste streams into the Woonasquatucket River; the disposal of Nuchar filter cake in the WDA; and leaks and spills of 2,3,7,8-TCDD in the vicinity of and underneath the HCP building footprint – were subject to different fate and transport pathways. The likely pathways for each category of release are discussed in turn.

Metro Atlantic discharged the liquid waste generated in the HCP-manufacturing process into the Woonasquatucket River. At least two of these liquid waste streams – the water containing salts that settled in the outdoor crude Na 2,4,5-TCP storage tanks and were flushed down a drain, and the residual filter cake from the first use of Nuchar that was not shoveled into drums but was instead washed into the trench drain – contained significant concentrations of 2,3,7,8-TCDD. Dr. Allen Medine, a Government expert in the analysis of contaminant fate and transport testified that, once a contaminant reached the Woonasquatucket River, it "migrate[d] unimpeded into downstream environments." (Trial Tr., vol. IV, 205:13-205:16, ECF No. 386; see also id. at 134:15, 152:7-152:14; see also ROD, Part 2, at 33, U.S. Ex. 68.) John Kastrinos, Emhart's expert in hydrology and fate and transport of contaminants, similarly opined that, because the Woonasquatucket River has a very fast current, it represented "a classic erosional river channel" and that "whatever reaches the river channel . . . should not stay there

very long but instead be picked up by erosion within the river itself, something . . . call[ed] scour, and transported further downstream ultimately settling in the quiet waters of Allendale Pond." (Trial Tr., vol. XV, 33:25-34:7, ECF No. 397; see also id. at 3:12-3:13, 8:11-8:16, 146:4-146:10). Therefore, the 2,3,7,8-TCDD contained in the liquid waste streams that Metro Atlantic discharged directly to the Woonasquatucket River migrated downstream once it reached the river.

The Nuchar filter cake that was deposited in the WDA was also subject to downstream transport. The Woonasquatucket River frequently flooded the WDA from approximately 1950 until the soils in the vicinity of the WDA were capped in the 1999-2000 Time Critical Removal Action ("TCRA"). (See id. at 22:3-22:9, 51:6-51:8, 157:6-157:10; RIR 1-5 to 1-6, Figure 1-3, U.S. Ex. 43; see also Trial Tr., vol. III, 125:13-125:15, 137:14-137:17, 138:7-138:17, ECF No. 385.) Medine opined that flooding, as well as surface-water runoff, transported Nuchar filter cake from the WDA to downstream areas. (Trial Tr., vol. V, 89:5-89:23, May 22, 2015, ECF No. 387.) Kastrinos agreed that flooding and surface-water runoff transported dioxins from the surficial soils in the southern half of the peninsula, including the WDA, downstream. (Trial Tr., vol. XV, 12:20-13:5, 22:3-22:9, 51:6-51:13, ECF No. 397.) Andrews opined that the elevated concentrations of 2,3,7,8-TCDD in the forested-wetland

area were deposited there from the WDA during flood events. (Trial Tr., vol. XX, 39:18-42:7, ECF No. 402; Andrews Slide 12, U.S. Ex. 542.) This Court therefore finds that 2,3,7,8-TCDD that was adsorbed to the Nuchar filter cake in the WDA was transported to the forested wetland and to downstream areas through flooding and surface-water runoff.[107]

Some of the 2,3,7,8-TCDD originally contained in the soil where elevated concentrations of 2,3,7,8-TCDD were found in the vicinity of and underneath the HCP building footprint was also transported into the Woonasquatucket River and then to downstream areas. Putting aside for the moment the 2,3,7,8-TCDD underneath the HCP building footprint, there were elevated concentrations of 2,3,7,8-TCDD in the surface soils in the vicinity of the HCP building footprint, at least prior to the placement of fill in that area in connection with the

[107] This conclusion does not mean, however, that all of the 2,3,7,8-TCDD found in the forested wetland and downstream areas came from Nuchar filter cake that was disposed of in the WDA. As Locke testified (and as Andrews acknowledged), 2,3,7,8-TCDD could have been released to the impoundment through NECC's closed-head drum washing operation and the 2,3,7,8-TCDD in the impoundment could have flowed into the forested wetland (or the tailrace and then to the forested wetland) and downstream areas through surface-water runoff and flooding. (See Trial Tr., vol. VIII, 132:4-133:3, ECF No. 390; Trial Tr., vol. XX, 127:10-127:17, 149:5-149:18, ECF No. 402.) Because of the data gap created by the 1981 soil removal in the approximate vicinity of the impoundment, see supra Section I.B.3.b.ii, there is no way to rule out NECC as a source of 2,3,7,8-TCDD on the Site. Similarly, as mentioned above, see supra note 69, this Court does not conclude that all of the 2,3,7,8-TCDD in the WDA came from Metro Atlantic.

construction of the parking lot for the Brook Village housing complex. (See Trial Tr., vol. XX, 42:19-43:20, 44:16-44:23, ECF No. 402; Andrews Slide 13, U.S. Ex. 542.) The 2,3,7,8-TCDD in this area, including concentrations on top of the concrete pad on which the HCP building once sat, were susceptible to transport to the Woonasquatucket River by surface-water runoff. (See Trial Tr., vol. XX, 38:18-39:17, 43:21-44:12, ECF No. 402; Andrews Slide 12, U.S. Ex. 542; see also Trial Tr., vol. XV, 150:25-151:7, 153:3-153:16, 228:17-229:14, ECF No. 397.) Additionally, the river bank adjacent to the HCP building was subject to erosion during high-flow events, and concentrations of 2,3,7,8-TCDD near the river could have eroded along with the river bank into the Woonasquatucket River. (Trial Tr., vol. XX, 79:14-79:20, ECF No. 402.) Finally, at least two floods reached the elevation of the HCP building, and those floods likely transported concentrations of 2,3,7,8-TCDD in the surface soils in that area downstream. (See Trial Tr., vol. XV, 65:21-66:2, 68:21-68:24, 160:21-161:8, ECF No. 397; Trial Tr., vol. XX, 64:6-65:8, 181:2-181:9, ECF No. 402.)

With respect to the migration of 2,3,7,8-TCDD underneath the HCP building footprint, the concrete pad on which the HCP building once stood isolated the 2,3,7,8-TCDD underneath it from fate and transport by flooding and surface-water runoff. (See Trial Tr., vol. XV, 61:23-62:6, 64:15-64:18, 66:16-66:24, 68:25-

69:3, ECF No. 397; Trial Tr., vol. XX, 129:21-130:5, 132:7-132:14, ECF No. 402.) The concrete pad remained in place until the parking lot for the Brook Village housing complex was constructed in 1978. (Trail Tr., vol. XV, 62:7-62:9, 63:3-63:9, 64:1-64:2, ECF No. 397; Kastrinos Slide 31, Emhart Ex. 352.) Clean fill was then brought in to raise the elevation of the area, and a paved parking lot was constructed on top of this clean fill. (Trial Tr., vol. XV, 64:9-64:12, 113:25-114:5, ECF No. 397; Kastrinos Slide 31, Emhart Ex. 352.) Like the concrete pad before it, the clean fill and pavement likely isolated the 2,3,7,8-TCDD underneath the footprint of the HCP building from the migratory effects of surface-water runoff. (See Trial Tr., vol. XV, 64:13-65:1, 113:25-114:7, ECF No. 397.) Therefore, this Court finds that surface-water runoff and some occasional flooding transported some 2,3,7,8-TCDD in the vicinity of the HCP building (including any on top of the concrete pad) to the Woonasquatucket River, but 2,3,7,8-TCDD underneath the HCP building footprint was not amenable to those fate-and-transport pathways.

Notwithstanding this conclusion, the 2,3,7,8-TCDD underneath the HCP building footprint was amenable to groundwater flow and facilitated transport. Andrews opined that 2,3,7,8-TCDD underneath the footprint of the HCP building migrated with the groundwater to the Woonasquatucket River

before the 2009 TCRA by a process called colloidal transport. (Trial Tr., vol. XX, 73:9-73:13, 77:12-77:22, ECF No. 402.) In broad strokes, colloidal transport occurs when a low-solubility contaminant, such as 2,3,7,8-TCDD, forms colloidal particles or adsorbs to other particles to form colloidal particles, which are extremely small particles that move through the groundwater within the pore spaces between grains of sand and gravel. (See Trial Tr., vol. XV, 82:8-83:4, ECF No. 397; Trial Tr., vol. XX, 73:16-74:11, 74:18-74:24, ECF No. 402; Kastrinos Slide 47, Emhart Ex. 352.) It can also occur when a low-solubility contaminant migrates in the groundwater with dissolved organic compounds, such as fluvic and humic acids. (Trial Tr., vol. XX, 77:12-77:22, ECF No. 402.) Andrews emphasized that colloidal transport would only have to occur for a relatively short distance before 2,3,7,8-TCDD was released to the Woonasquatucket River through this process. (Id. at 74:12-74:17; see also Trial Tr., vol. XV, 191:11-191:15, ECF No. 397.) Although there were flaws in the EPA's efforts to measure the significance of colloidal transport at the Site (see Trial Tr., vol. XV, 80:11-81:24, 83:11-83:18, 84:16-85:16, ECF No. 397; Trial Tr., vol. XX, 75:12-75:23, 138:15-138:22, ECF No. 402), Andrews emphatically opined that colloidal transport was "clearly a process that did occur" for the contaminants underneath the HCP

building footprint.[108] (Trial Tr., vol. XX, 75:3, ECF No. 402; see id. at 77:20-77:22 (process "undoubtedly did occur at this site"); id. at 140:17-140:21 (expressing the opinion to "a high degree of scientific certainty that that process [i.e. transport with dissolved organic compounds] did occur and was an important process in the migration of 2,3,7,8-TCD[D] in groundwater at the [S]ite prior to the [2009] Time Critical Removal Action"); see also id. at 75:8-75:11, 76:13-76:16.) Therefore, this Court finds that, although the 2,3,7,8-TCDD underneath the footprint of the HCP building was not amenable to transport through flooding or surface-water runoff, it was amenable to facilitated transport to the Woonasquatucket River through colloidal transport.

For these reasons, the Court finds that 2,3,7,8-TCDD from Metro Atlantic's HCP operations was transported to downstream areas. Specifically, liquid waste generated in the HCP building – some of which contained significant concentrations of 2,3,7,8-

[108] Kastrinos opined that the data do not support the conclusion that colloidal transport of 2,3,7,8-TCDD occurred underneath the HCP building footprint. (Trial Tr., vol. XV, 80:11-81:24, 83:11-83:18, 84:16-85:16, 114:14-114:21, 193:3-193:19, ECF No. 397.) Andrews acknowledged the concerns voiced by Kastrinos (see Trial Tr., vol. XX, 75:12-75:23, 138:15-138:22, ECF No. 402), but nonetheless concluded, based on his prior work on sites where colloidal transport occurred (see id. at 75:24-76:16), that it was "clearly a process that did occur" at this Site. (Id. at 75:3.) This Court credits the opinion of Andrews, who has experience with colloidal transport, on this score.

TCDD – was discharged directly into the Woonasquatucket River; 2,3,7,8-TCDD in surface soils in the vicinity of the HCP building footprint was transported into the river by surface-water runoff and the occasional flood; and 2,3,7,8-TCDD underneath the HCP building footprint migrated to the river through colloidal transport. Once in the Woonasquatucket River, 2,3,7,8-TCDD was transported downstream. This conclusion is supported by the data from the sediment core samples from Allendale Pond that indicate that 2,3,7,8-TCDD was transported downstream from the vicinity of the HCP building. (Id. at 51:23-56:16, 85:3-85:17, 179:2-182:22, 183:4-183:22; Andrews Slides 16-18, U.S. Ex. 542.) Additionally, 2,3,7,8-TCDD adsorbed to Nuchar filter cake particles in the WDA was transported to the forested-wetland area and downstream by flooding and surface-water runoff. The upshot of this downstream transport is that elevated concentrations of 2,3,7,8-TCDD are found throughout the Site, including in downstream areas, and the 2,3,7,8-TCDD found throughout the Site is mixed with a host of other contaminants. (Trial Tr., vol. XIV, 96:5-96:22, ECF No. 396.)

E. Incurrence of Response Costs

The EPA has incurred "significant costs" as a result of the dioxin contamination at the Site.[109] (Trial Tr., vol. I, 93:4-93:8, ECF No. 383.) In connection with its investigation, the EPA took extensive sampling of the soils and sediment at the Site. (See id. at 73:4-73:6, 200:23-201:3; RIR 1-4 to 1-5, 2-1 to 2-10, U.S. Ex. 43; ROD, Part 2, at 5-7, 20-26, U.S. Ex. 68.) Additionally, several short-term response efforts, or removal actions, were performed throughout the peninsula and downstream areas. (See Trial Tr., vol. I, 63:7-63:11, 87:7-87:10, ECF No. 383.) In broad strokes, these removal actions involved: construction of an interim protective cap ("Cap Area #1") in the southern portion of the peninsula where the WDA was located; construction of another interim cap ("Cap Area #2") along the western side of the peninsula where it abuts the Woonasquatucket River, encompassing the area where the HCP building was located; construction of a third interim cap ("Cap Area #3") along the tailrace; reconstruction of the Allendale Dam and restoration of Allendale Pond to prevent further downstream migration of contaminants; excavation and removal of one hundred cubic yards of soil from eleven areas along Allendale and Lyman Mill Ponds;

[109] Those costs need not be exhaustively chronicled at this juncture because the issue of the EPA's costs has been deferred to the second phase of this trial. (8th Rev. Case Mgmt. Order 2, ECF No. 295.)

and erection of fences along the residential properties adjacent to the Site in order to prevent access to the contamination.[110] (See RIR 1-5 to 1-7, U.S. Ex. 43; ROD, Part 2, at 5-6, U.S. Ex. 68; Trial Tr., vol. I, 86:23-87:1, 87:13-87:15, 201:9-201:18, ECF No. 383.)

In 2009, the EPA and Emhart entered into an Administrative Order on Consent, pursuant to which Emhart implemented and financed the 2009 excavation, which consisted of removal of contaminated soil in an area that encompassed the HCP building footprint and the installation of a Resource Conservation and Recovery Act ("RCRA") hazardous-waste cap. (See ROD, Part 2, at 9, 12, U.S. Ex. 68; Trial Tr., vol. I, 205:1-205:3, ECF No. 383; Trial Tr., vol. XIV, 81:14-81:16, ECF No. 396; Feb. 2010 Completion of Work Rep. 6-2, U.S. Ex. 53.) The EPA has accepted this RCRA cap as the final remedy for the area in the vicinity of the HCP building footprint; "[n]o further action is required in that area . . . ." (Trial Tr., vol. XIV, 94:14-94:15, ECF No. 396; see id. at 94:9-94:16; see also Apr. 2010 Addendum No. 1 to Completion of Work Rep. A.5-1, U.S. Ex. 61.)

[110] To "varying degrees" (Emhart's Post-trial Br. 70, ECF No. 378), Emhart participated in (and paid for some of the cost of) each of these removal actions. (See Trial Tr., vol. XIV, 76:4-76:10, 80:4-80:6, 81:6-81:8 87:4-87:12, ECF No. 396; ROD, Part 2, at 11, U.S. Ex. 68; Sept. 2, 2010 Completion of Work Letter 1-2, Emhart Ex. 167; Aug. 2000 Completion of Work Rep. 4-1, Emhart Ex. 156; Nov. 2004 Completion of Work Rep. 7-1, Emhart Ex. 164.)

Because the Site remains polluted (Trial Tr., vol. I, 94:8-94:11, ECF No. 383), there are also future costs associated with the Site. The EPA issued its Record of Decision ("ROD") in September 2012. (ROD, U.S. Ex. 68; Trial Tr., vol. I, 86:16-86:17, ECF No. 383.) The ROD identifies the EPA's selected remedy for the Site. (Trial Tr., vol. I, 86:16-86:19, ECF No. 383.) In general terms, the selected remedy requires removal of buried waste from the peninsula; installation of a hazardous-waste cap over contamination in the peninsula; excavation of the contaminated sediment in the Woonasquatucket River and Allendale and Lyman Mill ponds, along with contaminated floodplain soil in those areas, and placement of that material in an upland confined disposal facility, which would need to be constructed; placement of a soil cover over the contamination in the Oxbow Area; and long-term monitoring and maintenance.[111] (ROD, Part 1, at 3, U.S. Ex. 68.) According to the EPA, implementing the selected remedy will cost approximately $104,600,000 in addition to the amounts already expended in removal actions at the Site. (ROD, Part 2, at 203, U.S. Ex. 68.)

[111] The specifics of the EPA's selected remedy need not be addressed here because, like the issue of the EPA's costs, the issue of whether the selected remedy is consistent with CERCLA and the National Contingency Plan will be addressed in the second phase of this trial. (8th Rev. Case Mgmt. Order 2, ECF No. 295.)

II. Conclusions of Law

"In passing CERCLA, Congress 'intended that those responsible for problems caused by the disposal of chemical poisons bear the costs and responsibility for remedying the harmful conditions they created.'" United States v. Gen. Elec. Co., 670 F.3d 377, 382 (1st Cir. 2012) (quoting Dedham Water Co. v. Cumberland Farms Dairy, Inc., 805 F.2d 1074, 1081 (1st Cir. 1986)); see also United States v. Domenic Lombardi Realty, Inc., 204 F. Supp. 2d 318, 330 (D.R.I. 2002) ("DLR") ("[CERCLA's] primary purpose is to encourage voluntary cleanup . . . ."). To this end, liability under CERCLA is generally joint and several. See O'Neil v. Picillo, 883 F.2d 176, 178-79 (1st Cir. 1989). This is so even where "the 'cleanup must be paid for by those least responsible because those who are most responsible lack funds or cannot be found.'" DLR, 204 F. Supp. 2d at 330 (quoting Lincoln Props., Ltd. v. Higgins, 823 F. Supp. 1528, 1537 (E.D. Cal. 1992)). To escape joint and several liability, a party found liable under CERCLA bears the burden to prove that the environmental harm is divisible. See Burlington N. & Santa Fe Ry. Co. v. United States, 556 U.S. 599, 614 (2009). "Divisibility is the exception, however, not the rule." United States v. Capital Tax Corp., 545 F.3d 525, 535 (7th Cir. 2008).

For the reasons explained below, Emhart is liable under § 107(a) of CERCLA as a past operator and Emhart has not proven

by a preponderance of the evidence that the harm at the Site is divisible. Therefore, the Court concludes that Emhart is jointly and severally liable under § 107(a) of CERCLA. Additionally, the Court concludes that Emhart has not proven by a preponderance of the evidence that the DOD drums contained a hazardous substance; consequently, its claims against the DOD must fail.

A. Emhart is Liable as a Past Operator under § 9607(a)

The EPA has brought a cost recovery action under 42 U.S.C. § 9607(a) against Emhart. See United States v. Davis, 261 F.3d 1, 15 (1st Cir. 2001). In order to prevail, the EPA must establish four elements by a preponderance of the evidence: that (1) a release or threatened release[112] of a hazardous substance occurred (2) at a facility;[113] (3) the release caused the EPA to incur response costs;[114] and (4) Emhart qualifies as one of the

[112] CERCLA defines the term "release" as "any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant)." 42 U.S.C. § 9601(22).

[113] "[T]he term 'facility' enjoys a broad and detailed definition," United States v. Bestfoods, 524 U.S. 51, 56 (1998), and "any building, structure, installation, equipment, pipe," or "any site or area where a hazardous substance has . . . come to be located," 42 U.S.C. § 9601(9), falls within its scope.

[114] To be recoverable under 42 U.S.C. § 9607(a), EPA's response costs must be "not inconsistent with the national

four types of responsible parties identified in § 9607(a). See 42 U.S.C. § 9607(a); DLR, 204 F. Supp. 2d at 329; see also Dedham Water, 889 F.2d at 1150.

Emhart is liable under § 107(a) of CERCLA as a past operator. Although CERCLA provides only a tautological definition of the phrase "owner or operator," see 42 U.S.C. § 9601(20)(A)(ii), the Supreme Court has clarified that, under CERCLA, "an operator must manage, direct, or conduct operations specifically related to pollution, that is, operations having to do with the leakage or disposal of hazardous waste, or decisions about compliance with environmental regulations." United States v. Bestfoods, 524 U.S. 51, 66-67 (1998); see also Am. Cyanamid Co. v. Capuano, 381 F.3d 6, 22-23 (1st Cir. 2004).

In this case, Metro Atlantic – and, by extension, Emhart – discharged a hazardous substance, 2,3,7,8-TCDD, see 40 C.F.R. § 302.4, to the Site. Liquid waste was discharged into the Woonasquatucket River, and some amount of Nuchar filter cake was deposited in the WDA. See supra Section I.C.3. Additionally, 2,3,7,8-TCDD was spilled in the vicinity of the HCP building, and 2,3,7,8-TCDD leaked into the ground underneath the HCP building footprint from pipes. See supra Sections I.C.1,

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contingency plan." 42 U.S.C. § 9607(a)(4)(A). In this case, this issue will be addressed in the second phase of the trial. (See 8th Rev. Case Mgmt. Order 2, ECF No. 295.) Consequently, the issue was not addressed in this phase, and it will not be discussed in this decision.

I.C.4.a, I.C.4.d. In response to the release of dioxin on the Site, the EPA has incurred costs and will incur future costs. See supra Section I.E. Thus, Emhart "conduct[ed] operations . . . having to do with the leakage or disposal of hazardous waste," Bestfoods, 524 U.S. at 66-67, released a hazardous substance from a facility,[115] and the release caused the EPA to incur response costs.

In reaching the conclusion that Emhart is liable as a past operator, this Court necessarily rejects Emhart's third-party defense, which is based on the mistaken premise that NECC is responsible for all of the 2,3,7,8-TCDD on the Site. (See Emhart's Post-trial Br. 162 n.712, ECF No. 378; see generally id. at 129-41.) In order to successfully mount this defense, Emhart bears the burden of proving by a preponderance of the evidence that, among other things, the release of the hazardous substance, and the damage flowing from the release, were caused solely by a third party. See 42 U.S.C. § 9607(b)(3); DLR, 204 F. Supp. 2d at 331. Because this Court finds that Metro

[115] Because of the "broad and detailed definition" of the term "facility" under CERCLA, Bestfoods, 524 U.S. at 56, this Court need not attempt to characterize the precise facility from which the release occurred. The facility could be construed as the discharge pipe to the Woonasquatucket River, the HCP building, or the Site as a whole. See 42 U.S.C. § 9601(9). (Cf. Emhart's 2d Am. Compl. ¶ 43, ECF No. 69 (alleging that "the Site constitutes a 'facility' or 'facilities' within the meaning of 42 U.S.C. § 9601(9)").)

Atlantic released 2,3,7,8-TCDD to the Site, this defense must fail.

For these reasons, Emhart is liable as a past operator under § 107(a) of CERCLA.[116]

B. Emhart Has Not Proven that the Harm at the Site is Divisible

In addition to the limited defenses set forth in § 9607(b), CERCLA also permits divisibility or apportionment "when 'there is a reasonable basis for determining the contribution of'" a defendant's actions to the environmental harm at the site. Burlington, 556 U.S. at 614 (quoting Restatement (Second) of Torts § 433A(1)(b), at 434 (1963-64)). Emhart bears the burden of proving by a preponderance of the evidence that the harm at the Site is divisible. See id.; United States v. Hercules, Inc., 247 F.3d 706, 717 (8th Cir. 2001); see also Davis, 261 F.3d at 44; O'Neil, 883 F.2d at 179. In order to shoulder this burden, Emhart must demonstrate that (1) the harm at the Site is "theoretically capable of apportionment" and (2) there is sufficient evidence to establish a reasonable basis for apportionment under the circumstances. Burlington, 556 U.S. at 615; see also id. at 614; Padgett Bros. LLC v. A.L. Ross & Sons, Inc., No. 1:10-cv-00858-RLY-DML, 2014 WL 3547353, at *8 (S.D.

[116] Because this Court reaches this conclusion, it need not consider the Government's alternative argument that Emhart can be held liable under CERCLA as an arranger. (See Gov't's Proposed Conclusions of Law 24-28, ECF No. 379-1.)

Ind. July 17, 2014). "By its nature, apportionment necessarily requires a fact-intensive, site-specific analysis." PCS Nitrogen Inc. v. Ashley II of Charleston LLC, 714 F.3d 161, 182 (4th Cir. 2013).

"[A]pportionment is proper only when the evidence supports the divisibility of the damages"; equitable considerations are irrelevant. Burlington, 556 U.S. at 615 n.9. Moreover, "[e]vidence supporting divisibility must be concrete and specific." Hercules, 247 F.3d at 718. Thus,

> [w]here causation is unclear, divisibility is not an opportunity for courts to "split the difference" in an attempt to achieve equity. Rather, "[i]f they are in doubt, district courts should not settle on a compromise amount that they think best approximates the relative responsibility of the parties." In such circumstances, courts lacking a reasonable basis for dividing causation should avoid apportionment altogether by imposing joint and several liability.

Id. at 718-19 (quoting United States v. Twp. of Brighton, 153 F.3d 307, 319 (6th Cir. 1998)) (internal citations and footnote omitted); see also O'Neil, 883 F.2d at 178-79 ("The practical effect of placing the burden on defendants has been that responsible parties rarely escape joint and several liability, courts regularly finding that where wastes of varying (and unknown) degrees of toxicity and migratory potential commingle, it simply is impossible to determine the amount of environmental harm caused by each party."). When a reasonable basis for apportionment is lacking, "courts have refused to make an

arbitrary apportionment for its own sake." Burlington, 556 U.S. at 614-15 (quoting Restatement (Second) of Torts § 433A, cmt. i, at 440 (1963-64)); see PCS Nitrogen, 714 F.3d at 183 (affirming district court's refusal to make an arbitrary apportionment); O'Neil, 883 F.2d at 183 n.11 (remarking, in the course of affirming district court's refusal to apportion the harm, that apportionment in that case "would necessarily be arbitrary").

In an attempt to carry its burden, Emhart has provided this Court with four divisibility options. (See Emhart's Post-trial Br. 171-77, ECF No. 378.) Under Divisibility Option 1, Emhart argues that, because any incidental amounts of 2,3,7,8-TCDD that were released during the HCP-manufacturing process through spills and leaks were localized in the vicinity of the HCP building footprint and because Emhart already remediated this area in the 2009-10 TCRA, its divisible share of the remaining harm should be zero. (See id. at 171-72.) Alternatively, under Divisibility Option 2, Emhart argues that, even if the 2,3,7,8-TCDD contamination in the vicinity of the HCP building from leaks and spills migrated from that area, Emhart's divisible share of the remaining harm should still be zero on the basis of volumetric divisibility because the amount Emhart spent in the 2009-10 TCRA in relation to the total cost of the proposed remedy far exceeds the percentage of volumetric contribution of 2,3,7,8-TCDD from leaks and spills to the total concentration of

2,3,7,8-TCDD contamination on the Site. (See id. at 173-74.) Emhart argues under Divisibility Option 3 that, if Metro Atlantic discharged its liquid waste from the HCP-manufacturing process into the Woonasquatucket River, volumetric divisibility is still available because the liquid wastes contained a known quantity of 2,3,7,8-TCDD: namely, the 20 percent that settled in the outdoor storage tanks. (See id. at 174-175.) Finally, Emhart argues under Divisibility Option 4 that, even if this Court cannot apportion the harm on the basis of volume, considerations of geography, time, and the type of contaminant provide a basis upon which to apportion the harm. (See id. at 175-77.)

This Court assumes, without deciding, that Emhart is correct that the harm at the Site is at least theoretically capable of apportionment (Emhart's Post-trial Br. 165-167, ECF No. 378). See Burlington, 556 U.S. at 616-19 (affirming district court's apportionment based on considerations of geography, volume, duration of operations, and type of contaminant); Hercules, 247 F.3d at 719 ("[I]t is . . . possible to prove divisibility of single harms based on volumetric, chronological, or other types of evidence.") Nonetheless, Emhart has failed to prove by a preponderance of the evidence that there is a reasonable basis for apportionment of the harm on this evidentiary record.

For starters, all of Emhart's divisibility options depend, at least in part, on the conclusion that Metro Atlantic disposed of all of its Nuchar filter cake in dumpsters that were hauled offsite. (See Emhart' Post-trial Br. 167, 170, 171-77, ECF No. 378; Trial Tr., vol. XXI, 138:15-139:21, ECF No. 403.) The first three divisibility options expressly do so. (See Emhart's Post-trial Br. 171, ECF No. 378 (stating that Divisibility Option 1 "assumes that the Court finds, by a preponderance of the evidence, that the HCP plant Nuchar waste was disposed of in Metro[ ]Atlantic's onsite dumpster and hauled offsite"); id. at 173 (stating that Divisibility Option 2 "assumes that the Court finds, by a preponderance of the evidence, that the only possible contamination from the HCP plant would come from incidental spills from tanker hook-ups and leaks from sewer pipes"); id. at 174 (stating that Divisibility Option 3 "assumes that the Court rejects Mr. Forrester's assumption that Nuchar from the HCP operation was disposed of in the southern disposal area, finding, instead, that plant waste was disposed of in the nearby dumpster.").) Even Divisibility Option 4, which is an amalgam of geographic divisibility, temporal divisibility, and contaminant-based divisibility, relies in part on a finding that the Nuchar filter cake was not deposited in the WDA. The geographic-divisibility component of Divisibility Option 4 is based solely on the acreage of the HCP building in relation to

the acreage of the peninsula. (See id. at 170, 177.) And Divisibility Option 4 assumes that, "at most, . . . Metro[ ]Atlantic may be responsible for incidental spills from tanker hook-ups during raw materials deliveries and leaks from sewer pipes" and that, therefore, "any contamination potentially attributable to [Metro Atlantic] is localized." (Id. at 176.) Thus, at least the geographical-divisibility component of Divisibility Option 4 assumes that Nuchar filter cake was not sent to the WDA.

However, this Court has found that some amount of Nuchar filter cake was in fact deposited in the WDA. Therefore, a critical assumption underlying Divisibility Options 1-3 and a component of Divisibility Option 4 is not supported by the evidence in this record. Moreover, there are other reasons why there is no basis in the record for geographic divisibility in this case. Not only was some amount of Nuchar filter cake deposited in the WDA, but 2,3,7,8-TCDD was also directly discharged in the Woonasquatucket River in the liquid waste streams from the HCP-manufacturing process. Both the 2,3,7,8-TCDD in the WDA and the 2,3,7,8-TCDD deposited in the Woonasquatucket River were transported downstream through various fate-and-transport pathways. Additionally, Emhart's assertion that the 2,3,7,8-TCDD from spills during transfers of the crude Na 2,4,5-TCP and from leaks of liquid waste streams

from the pipes remained localized in the vicinity of the HCP building footprint is unsupported by the record. This Court has found that the 2,3,7,8-TCDD in the vicinity of (but not underneath) the HCP building footprint was transported to the Woonasquatucket River by surface-water runoff and the occasional flood, while the 2,3,7,8-TCDD underneath the HCP building footprint was subject to colloidal transport to the Woonasquatucket River. In sum, 2,3,7,8-TCDD from Metro Atlantic's HCP-manufacturing process did not remain in the vicinity of the HCP building footprint, but instead exists in numerous areas across the Site: in the vicinity of the HCP building footprint; in the WDA; and in downstream areas. Therefore, there is simply no reasonable basis in this evidentiary record to apportion the harm by geography. See Capital Tax, 545 F.3d at 535-36 (finding no basis for geographic divisibility because of the migration of hazardous substances across site).

Emhart's volumetric-divisibility arguments similarly depend on the triumph of hope over reason. Relying on Medine's "back-of-the-napkin" (Trial Tr., vol. V, 96:2, ECF No. 387) calculations of the total amount of 2,3,7,8-TCDD, Emhart purports to pinpoint the amount of 2,3,7,8-TCDD that could have been released to the peninsula through leaks and spills and discharges of liquid waste to the Woonasquatucket River. (See

Emhart's Post-trial Br. 168-69, 173-75, ECF No. 378.) Putting aside the overly approximate nature of Medine's total 2,3,7,8-TCDD calculations, there are numerous uncertainties that doom Emhart's attempt to demonstrate volumetric divisibility. As an initial matter, each of Emhart's volumetric calculations assumes that Nuchar filter cake was not deposited in the WDA, and there is simply no basis in this record to estimate the total amount of 2,3,7,8-TCDD that accompanied the unknown amount of Nuchar filter cake that this Court finds was deposited in the WDA. Additionally, Emhart's calculation of the volume of 2,3,7,8-TCDD in liquid waste streams from the HCP-manufacturing process does not include the residual filter waste that was not shoveled into a trash receptacle but was instead washed into the trench drain. And filter waste from the first use of Nuchar would have contained very high concentrations of 2,3,7,8-TCDD. Finally, Emhart's calculations on the amount of 2,3,7,8-TCDD that would have been discharged from spills during the transfers of crude Na 2,4,5-TCP to the storage tanks and from leaks from pipes of the liquid waste that flushed out the settled material in the storage tanks depends on assumptions about the duration of Metro Atlantic's HCP-manufacturing process and the frequency with which Metro Atlantic manufactured a batch of HCP. However, as explained above, see supra Section I.C.2, there is simply too much uncertainty for this Court to make findings of fact

consistent with either assumption. For all of these reasons, the various uncertainties associated with Emhart's volumetric-divisibility arguments make clear that there is no reasonable basis in this record to apportion the harm by volume.

With geographic and volumetric divisibility out the window, not much remains of Emhart's divisibility efforts. In Divisibility Option 4, Emhart seeks to apportion the harm based, in part, on the type of contaminant. (See Emhart's Post-trial Br. 175, 177, ECF No. 378.) Emhart notes that there are six contaminants of concern at the Site – dioxins, PCBs, VOCs, SVOCs, pesticides, and metals – and that Metro Atlantic's HCP operation is associated with only two contaminants – 2,3,7,8-TCDD, a dioxin, and PCE, a VOC. (See id. at 169.) Therefore, the argument goes, Emhart is only associated with 33 percent of the contaminants of concern. (See id. at 170.)

For several reasons, this Court is unwilling to travel with Emhart down this divisibility path. For starters, this "calculation" seems wholly arbitrary. Although there may be six categories of contaminants of concern at the Site, it is unclear to this Court why all should be treated equally, particularly because all parties agree that 2,3,7,8-TCDD is the most toxic substance found at the Site. (See id. at 2-3.) Indeed, even Emhart acknowledges that "2,3,7,8-TCDD is the contaminant driving the remediation at the Site and, therefore, the

contaminant that should drive the apportionment analysis." (Id. at 172 n.720.) Attributing equal weight to each category of contaminant hardly comports with the reality that not all hazardous substances are, or should be, treated equally.

Additionally, Emhart has not identified any case where the harm at a CERCLA site was apportioned on the basis of the type of contaminant where, as here, the record did not provide a reasonable basis to apportion the harm by either geography or volume. Although the district court in Burlington appeared to factor in the type of contaminants associated with the defendants' operations in its divisibility determination, the evidentiary support for geographic and volumetric divisibility was present in that case and is not present here. See Burlington, 556 U.S. at 616 ("The District Court calculated the [defendants'] liability based on three figures. First, the court noted that the [defendants'] parcel constituted only 19% of the surface area of the Arvin site. Second, the court observed that the [defendants] had leased their parcel to B&B for 13 years, which was only 45% of the time B&B operated the Arvin facility. Finally, the court found that the volume of hazardous-substance-releasing activities on the B&B property was at least 10 times greater than the releases that occurred on the [defendants'] parcel, and it concluded that only spills of two chemicals . . . substantially contributed to the contamination

that had originated on the [defendants'] parcel and that those two chemicals had contributed to two-thirds of the overall site contamination requiring remediation."). Indeed, in upholding the district court's divisibility determination, the Supreme Court in Burlington emphasized the geographic- and volumetric-divisibility aspects of the case. See id. at 617 ("The District Court's detailed findings make it abundantly clear that the primary pollution at the Arvin facility was contained in an [area] . . . of the facility most distant from the [defendants'] parcel and that the spills of hazardous chemicals that occurred on the [defendants'] parcel contributed to no more than 10% of the total site contamination, some of which did not require remediation. With those background facts in mind, we are persuaded that it was reasonable for the court to use the size of the leased parcel and the duration of the lease as the starting point for its analysis." (citation omitted)). In this case, where there is no reasonable basis in the evidentiary record to apportion the harm on the basis of geography or volume, this Court is not persuaded that Emhart's dubious contaminant-based calculation provides a reasonable basis for apportionment.

The final arrow in Emhart's divisibility quiver is temporal divisibility. (See Emhart's Post-trial Br. 170, 175-77, ECF No. 378.) Emhart argues that, because Emhart's HCP-manufacturing

operations lasted for less than a year (in comparison to NECC's 23 years on the peninsula) and because "there is no evidence to conclude that Metro[ ]Atlantic was responsible for a disproportionate volumetric contribution to the Site during the time of its operations," temporal divisibility should be a consideration under Divisibility Option 4. (Id. at 175-76; see also id. at 170, 177.) Each underlying premise of Emhart's temporal-divisibility argument is flawed. Initially, as discussed above, see supra Section I.C.2, the duration of Metro Atlantic's HCP-manufacturing operations is unclear. More importantly, even if this Court could resolve the question of the duration of the HCP-manufacturing operation, it is far from clear that Metro Atlantic is not responsible for a disproportionate volumetric contribution of 2,3,7,8-TCDD to the Site. To the contrary, this Court has found that Metro Atlantic released 2,3,7,8-TCDD directly to the Woonasquatucket River and the WDA and that this 2,3,7,8-TCDD was transported downstream. Although this Court cannot quantify Metro Atlantic's volumetric contribution to the total 2,3,7,8-TCDD, this uncertainty redounds to Emhart's detriment. As Emhart acknowledges (see Emhart's Post-trial Br. 176 n.723, ECF No. 378), courts have refused to apportion harm on the basis of temporal considerations where, as here, the evidence on the defendant's volumetric contribution in relation to that of other PRPs is too

uncertain. See, e.g., Bd. of Cnty. Comm'rs of Cnty. of La Plata v. Brown Grp. Retail, Inc., 768 F. Supp. 2d 1092, 1118-19 (D. Colo. 2011); 3000 E. Imperial, LLC v. Robertshaw Controls Co., No. CV 08-3985 PA(ex)., 2010 WL 5464296, at *10-11 (C.D. Cal. Dec. 29, 2010). Therefore, this Court concludes that the relatively short duration of the HCP-manufacturing operation does not bear a reasonable relationship to the amount of environmental harm caused by that operation. Accordingly, the evidence in this record does not provide a reasonable basis to apportion the harm by temporal consideration.

For these reasons, this Court concludes that Emhart has not proven by a preponderance of the evidence that there is a reasonable basis in this evidentiary record to apportion the harm by geography, volume, type of contaminant, or time.[117] In reaching this conclusion, this Court remains mindful that NECC

[117] During closing argument, Emhart expressed its hope that, if this Court was unpersuaded by the four divisibility options suggested by Emhart, this Court would conceive of its own scheme for apportioning the harm. (See Trial Tr., vol. XXI, 139:22-140:23, ECF No. 403.) Assuming, without deciding, that Emhart can carry its burden to show a reasonable basis for apportionment if this Court is left with the task of conceiving a basis on which to apportion the harm, cf. Burlington N. & Sante Fe Ry. Co. v. United States, 556 U.S. 599, 615-16 (2009) (district court, acting sua sponte, apportioned the harm without assistance from the defendant "in linking the evidence supporting apportionment to the proper allocation of liability"); see also id. at 622 (Ginsburg, J., dissenting) ("[I]t is questionable whether the court should have pursued the [divisibility] matter sua sponte."), this Court is unable to conjure a non-equity (and, therefore, non-arbitrary) basis on which to divide the harm at the Site.

is responsible for releasing a litany of hazardous substances, and that this "dioxin manufacturing machine" (Trial Tr., vol. XVIII, 161:18, ECF No. 400) may well have released a substantial portion of the 2,3,7,8-TCDD that is found on the Site. However, given this evidentiary record and the Court's inability to allow equitable considerations to enter the mix in the divisibility inquiry, see Burlington, 556 U.S. at 615 n.9, any apportionment of the environmental harm at the Site "would necessarily be arbitrary," O'Neil, 883 F.2d at 183 n.11, and this Court will not "make an arbitrary apportionment for its own sake," Burlington, 556 U.S. at 614 (quoting Restatement (Second) of Torts § 433A, cmt. i, at 440). Therefore, this Court concludes that the harm at the Site is not divisible and that Emhart is jointly and severally liable under § 107(a) of CERCLA.

C. The DOD's Rule 52(c) Motion

During trial, the DOD moved for judgment on partial findings under Rule 52(c), arguing that, on this evidentiary record, it cannot be held liable for arranging the disposal of any hazardous substance, including tactical and commercial herbicides, at the Site.[118] (DOD's Rule 52(c) Mot. 2, ECF No.

[118] Rule 52(c) of the Federal Rules of Civil Procedure provides that:

> If a party has been fully heard on an issue during a nonjury trial and the court finds against the party on that issue, the court may enter judgment against the party on a claim or defense that, under the

372.) Emhart opposed this motion. (ECF No. 374.) As permitted under Rule 52(c), this Court deferred ruling until the close of the evidence.

Before addressing the merits of the DOD's motion, a procedural wrinkle must be ironed out. The operative case management order in this case provides that: "[D]uring this [first] phase, the evidence [pertaining to the DOD's liability] will be used solely to determine the liability of Emhart . . . and whether this liability (if proven) is divisible . . . . The Court will not rule on the liability of the [DOD], or its amount in contribution, if any, until the third phase when it considers the contribution of the Third-Party Defendants." (8th Rev. Case Mgmt. Order 3, ECF No. 295; see also id. at 2 ("A third phase . . . will be held at a later date and address the liability and contribution of the Third-Party Defendants and the [DOD].").) Emhart construes this language "as requiring the presentation of evidence concerning [the DOD's] liability to the extent '[the DOD's] liability [is] tied to [Emhart's] . . . defenses,' i.e., defenses to any liability for the dioxin contamination on the

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controlling law, can be maintained or defeated only with a favorable finding on that issue. The court may, however, decline to render any judgment until the close of the evidence. A judgment on partial findings must be supported by findings of fact and conclusions of law as required by Rule 52(a).

Site." (Emhart's Opp'n to the DOD's Rule 52(c) Mot. 3, ECF No. 374.)

However, the case management order unambiguously declares that "[a]ll evidence pertaining to the [DOD's] liability for contamination of the Site will be presented during the first phase (the liability phase) of the trial." (8th Rev. Case Mgmt. Order 3, ECF No. 295, (emphasis added).) Therefore, all evidence relating to the DOD's liability, and not just evidence relating to the DOD's liability for dioxin, needed to be put forward in this phase. The case management order was prepared based upon representations by Emhart at that time as to what the evidence would be against the DOD. The evidence turned out to be dramatically different than promised. Rule 52(c) provides that judgment may be entered against a party on a claim after the "party has been fully heard on [that] issue," and, because the first-phase trial has concluded, Emhart has now been fully heard on its claims against the DOD. Notwithstanding the case management order's statement that the DOD's liability will be decided in the third phase, this Court, after hearing Emhart's evidence against the DOD, sees no reason to force the DOD to remain in this case until the third phase. See Morales Feliciano v. Rullan, 378 F.3d 42, 59 (1st Cir. 2004) ("When a party has finished presenting evidence and that evidence is deemed by the trier insufficient to sustain the party's

position, the court need not waste time, but, rather, may call a halt to the proceedings and enter judgment accordingly.").

Notably, Emhart has not claimed that it would suffer any prejudice in the event that this Court adjudicates the DOD's CERCLA liability now instead of during the third phase.[119] Indeed, in its opposition, Emhart chronicled the "substantial evidence relating to the [DOD's] potential liability" (Emhart's Opp'n to the DOD's Rule 52(c) Mot. 4 n.2, ECF No. 374) for hazardous substances other than tactical herbicides (see id. at 4-5 and n.2). Therefore, this Court does not deem the case management order to preclude an immediate adjudication of the DOD's CERCLA liability.

Turning to the merits, Emhart's claims against the DOD are premised on arranger liability. (See Emhart's Opp'n to the DOD's Mot. for Partial Summ. J. 3, 16-17, ECF No. 340-1.) Under CERCLA, arranger liability extends to "any person who . . .

[119] To be sure, Emhart notes that "the adjudication of the NECC customer group liability in the third phase will take place against a legal background starkly different from the backdrop present in this first phase" because the allocation of responsibility among liable parties "will require the Court to consider a number of equitable factors in reaching a decision." (Emhart's Opp'n to the DOD's Rule 52(c) Mot. 3-4, ECF No. 374.) However, before the question of allocation in a contribution action is addressed, it must first be determined whether the defendant is liable under CERCLA. See 42 U.S.C. § 9613(f)(1); Goodrich Corp. v. Town of Middlebury, 311 F.3d 154, 168 (2d Cir. 2002) ("[Section 113(f) of CERCLA] envisions a two-part inquiry: First, the court must determine whether the defendant is 'liable' under CERCLA § 107(a); Second, the court must allocate response costs among liable parties in an equitable manner.").

arranged for disposal . . . of hazardous substances . . . at any facility . . . containing such hazardous substances." 42 U.S.C. § 9607(a)(3). In order to prevail on its claims that the DOD is liable as an arranger, Emhart must show that: (1) the DOD arranged for a hazardous substance to be transported to or disposed of at the Site; (2) there was a release (or threatened release) of that kind of hazardous substance; and (3) the release caused the incurrence of response costs. See United States v. Davis, 31 F. Supp. 2d 45, 61 (D.R.I. 1998). "[T]he question whether [arranger] liability attaches is fact intensive and case specific . . . ." Burlington, 556 U.S. at 610. Emhart has failed to prove by a preponderance of the evidence that the DOD drums purchased by NECC contained a hazardous substance, and, therefore, it cannot prevail on its claims against the DOD. See Dana Corp. v. Am. Standard, Inc., 866 F. Supp. 1481, 1497 (N.D. Ind. 1994) ("[T]he plaintiffs first must present some evidence that each defendant's waste hauled to the Site contained hazardous substances.")

As explained above, see supra Section I.C.4.c.ii, this Court has found that the DOD drums did not contain herbicide residues. Although herbicide components were found at Otis and Quonset, the evidence demonstrates that the practice of both bases was to dispose of herbicide containers in the on-site landfill at each base. This Court has found that the residues

in the drums were turbine oil residues. Turbine oil is not a CERCLA hazardous substance. Although there is some evidence that one particular turbine oil "could have" contained PAHs (Nelson Dep. Tr. 16:22-16:24), there is no evidence that this particular turbine oil was present at Otis or Quonset. Additionally, Nelson testified that her review of historical records led her to conclude that none of the turbine-engine oils that were qualified for use by the DOD during the relevant time period contained any hazardous substances (id. at 20:5-21:6). Therefore, Emhart has failed to prove by a preponderance of the evidence that the DOD drums that NECC purchased contained a hazardous substance. Cf. Dana Corp., 866 F. Supp. at 1503-06, 1508-09, 1518-21, 1527-28, (granting summary judgment to several putative arranger defendants whose waste indisputably went to the site because there was no evidence that the defendants' waste that went to the site contained hazardous substances).

In reaching this conclusion, this Court is not forcing Emhart to trace the DOD's hazardous waste from Otis and Quonset to the incurrence of response costs at the Site – a difficult task that CERCLA undeniably does not impose on plaintiffs. See id. at 886 F. Supp. at 1497 ("[T]he plaintiffs need not present eyewitness testimony providing a complete chain of custody of hazardous waste from a defendant to a [site]."); see also Hercules, 247 F.3d at 716. Indeed, had Emhart shown that the

DOD "generated a predictable and relatively consistent waste stream that included hazardous waste of a sort ultimately found at the [S]ite, and that [the DOD's] waste was regularly taken to the [S]ite," Dana Corp., 886 F. Supp. at 1497, this Court's conclusion on the DOD's arranger liability might well have been different because, in that scenario, "an inference that the [hazardous] waste found at the [S]ite came from [the DOD] is permissible," id., and might, depending on the circumstances, be drawn by this Court. See also id. at 1530. However, Emhart's evidence with respect to the DOD drums depends on the inference that, because similar hazardous substances were found at Otis, Quonset, and the Site, the DOD drums contained those substances. Regardless of whether such "anything's possible" evidence is sufficient to withstand summary judgment, Dana Corp., 886 F. Supp. at 1498, it has not persuaded this Court that the DOD drums contained a hazardous substance. Cf. id. at 1511 (granting summary judgment to a putative arranger defendant who disposed of empty drums at the site because "[t]he plaintiffs have not presented any admissible evidence that [the defendant's] drums contained hazardous substances" and "[m]ere disposal of drums at the Site is not sufficient to establish liability under CERCLA").

For these reasons, this Court concludes that Emhart has not proven by a preponderance of the evidence that the DOD drums

contained a hazardous substance; therefore, its claims that the DOD is liable as an arranger under CERCLA must fail.[120]

III. Conclusion

For the reasons set forth above, this Court concludes that Emhart is jointly and severally liable under § 107(a) of CERCLA and that Emhart failed to prove by a preponderance of the evidence that the DOD is liable as an arranger. Accordingly, this Court finds for the Government on Emhart's claims against the DOD.[121] (ECF Nos. 69, 367.) With respect to the Government's CERCLA cost recovery claim against Emhart ("Count Two") (ECF Nos. 357-58), this Court finds that Emhart is liable as an operator under CERCLA and that the harm at the Site is not divisible. However, the Government is not yet entitled to judgment in its favor on this claim because the issues of costs and whether the remedy selected by the EPA is consistent with CERCLA first need to be litigated in the second phase of this

[120] In light of this conclusion, the DOD's motion for summary judgment (ECF No. 332) is denied as moot.

[121] As mentioned above, see supra note 8, Emhart's Second Amended Complaint purports to assert additional claims. However, for the reasons stated above, see supra note 8, the Government is entitled to judgment in its favor on these additional claims. Additionally, because the Court finds that the DOD is not liable under CERCLA, it denies as moot the DOD's CERCLA contribution claim against Emhart ("Count One"). (ECF Nos. 357-58.) The denial is without prejudice, such that the DOD may reassert its claim against Emhart in the event that it is found liable on an as-yet unasserted CERCLA contribution claim brought by a third party in this case.

trial. (See 8th Rev. Case Mgmt. Order 2, ECF No. 295.) Additionally, the Government's claim that Emhart failed to comply with a CERCLA cleanup order ("Count Three") (ECF Nos. 357-58) will also be addressed in phase two; Emhart's third-party claims will be addressed in phase three.[122]

Inasmuch as this opinion is rendered at the conclusion of the first phase of a trifurcated trial, the orders entered in pursuance thereof will not ripen automatically into final judgments and will not be immediately appealable as of right. Final judgment will not enter until all aspects of all claims are adjudicated.

IT IS SO ORDERED.

William E. Smith
Chief Judge
Date: September 17, 2015

[122] From the Court's review of the docket in C.A. Nos. 06-218 and 11-23, it appears as though only the Government and NECC have asserted claims against third parties (see ECF Nos. 80, 112; C.A. No. 06-218, ECF No. 261) – although NECC's claims were waived in the Consent Decree (see Consent Decree ¶ 20, ECF No. 375). By contrast, Emhart has not yet filed contribution claims against any of the third parties currently in this case. The Court will hold a status conference soon after the date of this order in which the scope of phases two and three will be discussed.

APPENDIX A

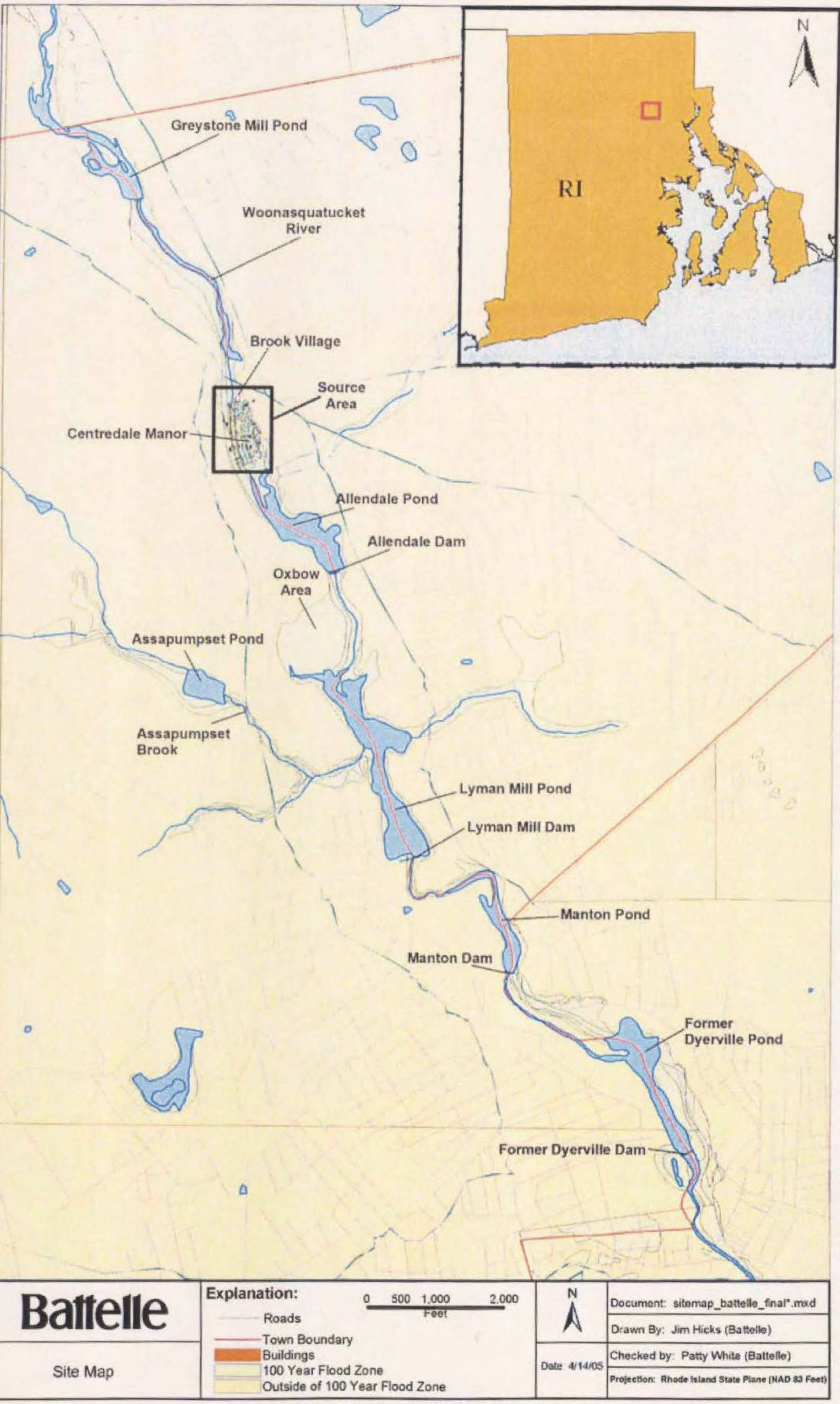


Figure 1-1. Site Map

APPENDIX B

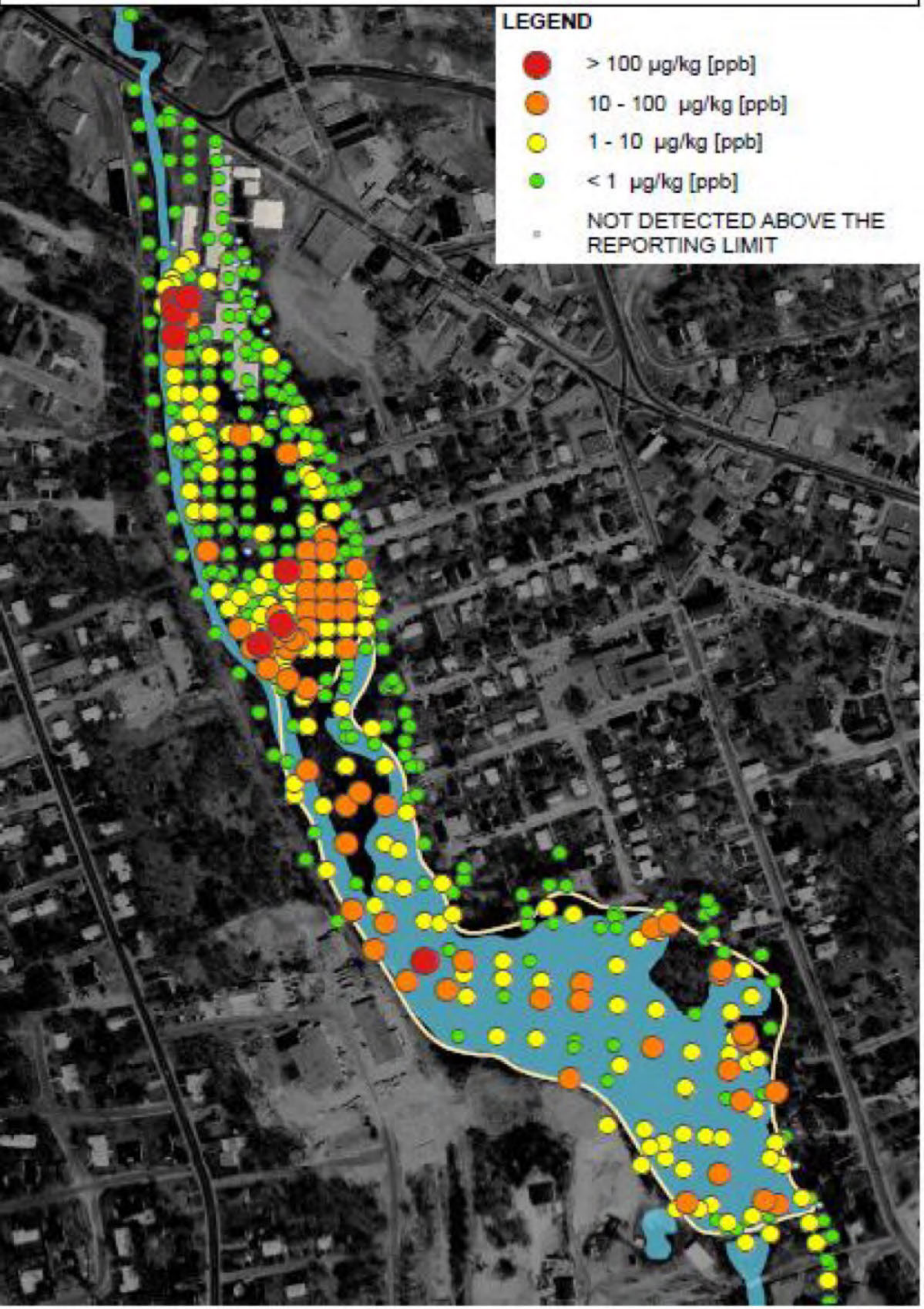
APPENDIX C

2,3,7,8-TCDD


LEGEND
> 100 µg/kg [ppb]
10 - 100 µg/kg [ppb]
1 - 10 µg/kg [ppb]
< 1 µg/kg [ppb]
NOT DETECTED ABOVE THE REPORTING LIMIT
N
0
100
200
SCALE IN FEET

APPENDIX D

2,3,7,8-TCDD


LEGEND
> 100 µg/kg [ppb]
10 - 100 µg/kg [ppb]
1 - 10 µg/kg [ppb]
< 1 µg/kg [ppb]
NOT DETECTED ABOVE THE REPORTING LIMIT

Centredale Manor Superfund Site
North Providence, RI

Dioxin 2,3,7,8-TCDD Concentration in Surface Soil Source Area

Legend

2,3,7,8-TCDD Concentration in Surface Soil Sample (ng/kg dry):

- <17
- 17–500
- 500–1,000
- 1,000–2,000
- 2,000–5,000
- 5,000–10,000
- >10,000

2,3,7,8-TCDD Concentration in Surface Soil (ng/kg dry):

- <17
- 17–500
- 500–1,000
- 1,000–2,000
- 2,000–5,000
- 5,000–10,000
- >10,000

Former Source Area Buildings (1965)

Estimated Excavation Area (5-Foot Buffer around Building Footprint)

Source Area

Notes:

Sample concentrations are based on average of all results within surface 0–1 foot interval, excluding field duplicates and QC duplicates.

Contouring method is inverse distance weighted interpolation using ArcGIS Spatial Analyst.

Labeled locations have one or more detections exceeding Cleanup Level of 17 ng/kg.

ng/kg dry=nanograms per kilogram of dry sediment/soil

M-A HCP Manufacturing Building

Southern Disposal Area

N

50 100 200

Feet

Figure 5. The 2,3,7,8-TCDD concentration in surface soils at the Source Area.

Centredale Manor Superfund Site, North Providence, RI

Dioxin 2,3,7,8-TCDD Concentration in Surface Sediment Allendale Pond

Legend

2,3,7,8-TCDD Concentration in Surface Sediment/Soil Sample (ng/kg dry):

- <17
- 17–500
- 500–1,000
- 1,000–2,000
- 2,000–5,000
- 5,000–10,000
- >10,000

2,3,7,8-TCDD Concentration in Surface Sediment/Soil (ng/kg dry):

- <17
- 17–500
- 500–1,000
- 1,000–2,000
- 2,000–5,000
- 5,000–10,000
- >10,000

Allendale Pond

100–Year Floodplain

Notes:
Sample concentrations are based on average of all results within surface 0–1 foot interval, excluding field duplicates and QC duplicates..
Contouring method is inverse distance weighted interpolation using ArcGIS Spatial Analyst.

ng/kg dry=nanograms per kilogram of dry sediment/soil

N

80 160 320
Feet

ure 14. Concentration contours for 2,3,7,8-TCDD in the Allendale Pond sediments. Sample locations are shown along with th range in concentrations.

Dioxin 2,3,7,8-TCDD Concentration in Surface Sediment Lyman Mill Pond and Oxbow Area

Legend

2,3,7,8-TCDD Concentration in Surface Sediment/Soil Sample (ng/kg dry):

- <17
- 17–500
- 500–1,000
- 1,000–2,000
- 2,000–5,000
- 5,000–10,000
- >10,000

2,3,7,8-TCDD Concentration in Surface Sediment/Soil (ng/kg dry):

- <17
- 17–500
- 500–1,000
- 1,000–2,000
- 2,000–5,000
- 5,000–10,000
- >10,000

Lyman Mill Pond

100–Year Floodplain

Oxbow Area

Notes:
Sample concentrations are based on average of all results within surface 0–1 foot interval, excluding field duplicates and QC duplicates.
Contouring method is inverse distance weighted interpolation using ArcGIS Spatial Analyst.

ng/kg dry= nanograms per kilogram of dry sediment/soil

N

0 240 480 960

Feet

Figure 15. Concentration contours for 2,3,7,8-TCDD in the Oxbow Area floodplain soils (below the Allendale Dam) and in th Lyman Mill Pond surface sediments. Sample locations are shown along with the range in concentrations.

APPENDIX E


EMHART
EXHIBITS
184
C.A. No. 11-023 S
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APPENDIX F

HCX:2,3,7,8 TCDD Ratio