PETITION TO PROHIBIT THE USE OF HYDROGEN FLUORIDE IN DOMESTIC OIL REFINING UNDER SECTIONS 21 AND 6(A) OF THE TOXIC SUBSTANCES CONTROL ACT

February 11, 2025

Via email and U.S. certified mail[a] to

Lee Zeldin
Administrator
Office of the Administrator
Environmental Protection Agency
1200 Pennsylvania Avenue NW
Washington, DC 20460-0001
Zeldin.Lee@epa.gov

Cc: Elissa Reaves
Director, Office of Pollution Prevention and Toxics
Document Control Office (7407M)
Office of Pollution Prevention and Toxics
Environmental Protection Agency
1200 Pennsylvania Ave NW
Washington, DC 20460-0001
Reaves.Elissa@epa.gov

Administrator Zeldin,

The Toxic Substances Control Act (TSCA) requires EPA to prohibit the use of hydrogen fluoride (HF) in domestic oil refining, to eliminate the extreme and unreasonable risks this use presents to public health and the environment. This petition is brought by Clean Air Council (CAC), Communities for a Better Environment (CBE), and the Natural Resources Defense Council (NRDC) pursuant to Sections 6(a) and 21 of TSCA. 15 U.S.C. §§ 2605(a) and 2620.

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[a] The Appendices, copies of all cited sources, and an index of sources are available at the following URL. Please contact Marissa Spalding (mspalding@nrdc.org) to resolve any access issues.

Petitioner CAC is a nonprofit environmental health organization with offices in Philadelphia and Pittsburgh, Pennsylvania. CAC has been working to protect everyone's right to a clean and healthy environment for over 50 years. The organization has members throughout Pennsylvania and the Mid-Atlantic region who support its mission. CAC contacted the Chemical Safety Board requesting an investigation immediately after the 2019 HF release from the Philadelphia Refinery, and has advocated to reduce toxic pollution from the HF-using refinery in Trainer, PA. CAC helped organize concerned residents near the Trainer refinery to form Marcus Hook Area Neighbors for Public Health, a group which seeks to reduce the public health impacts of the Trainer refinery and other facilities. CAC works closely with that group and others who could be exposed to a poison cloud in the event of a release from the refinery or a train delivering HF to it.

Petitioner CBE is a community-based environmental justice organization working to fight toxic pollution and environmental injustices in California. CBE has offices in California, including in the city of Wilmington. CBE organizes in the pollution-burdened communities of Richmond, East Oakland, Southeast Los Angeles, and Wilmington. Established in 1978, CBE organizes to support these communities' self-empowerment around environmental decision-making. CBE believes that people have a right to breathe clean air and drink clean water in the environments where we live, work, go to school, play, and pray, regardless of race, sexual orientation, age, culture, ability, nationality, or income. CBE is actively engaged in fighting the dangerous effects of fossil-fuel-fired power plants and building the resilient, just, renewable future envisioned by the environmental-justice communities where it organizes. CBE has advocated for state and local bans on HF use at the HF-using refineries in Torrance and Wilmington on behalf of people who could be exposed to a poison cloud in the event of a release from one of those facilities, or a vehicle delivering HF to one of them.

Petitioner NRDC is a national organization with offices across the country, including in Southern California and Chicago. Its mission is to protect the earth. NRDC has long advocated for more stringent regulation of toxic chemicals, including under TSCA. For example, NRDC joined forces with Neighbors for Environmental Justice and other organizations to challenge EPA's inadequate evaluation of the risks presented by the chemical methylene chloride—prompting more stringent regulation and a phaseout of many industrial uses. NRDC has also been a key player in advocating for the cancellation of organophosphate pesticides, which pose significant health risks to farmworkers and their families. NRDC's members include people living close enough to refineries using HF, and the rail and truck routes used to move HF to those refineries, to be exposed to and harmed by a refinery-related release.

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[b] The appendices are available athttps://nrdc1-my.sharepoint.com/:f:/g/personal/mspalding_nrdc_org/EksTWOm1bB5NtFx7cNuKZy0BK3jQYdoNLi2OKo1tEGf0GA?e=ntlryO. Please contact Marissa Spalding, mspalding@nrdc.org, to resolve any access issues.

I. Introduction

Forty-two oil refineries across the United States use HF as a catalyst for alkylation, the process used to boost fuel octane. HF is an extremely corrosive and reactive chemical that readily penetrates and destroys living tissue. It is so acutely toxic that having just a hand's worth of one's skin exposed to liquid HF can be a death sentence.

HF's low boiling point (just over 67°F) and other properties also mean that the public cannot count on it remaining in liquid form once it escapes into open air. Rather, as the U.S. government and oil industry have known for decades, HF released at normal pressures and temperatures above its boiling point tends to form a dense, ground-hugging, and toxic cloud near the source. The industry's own risk management plan (RMP) reporting to EPA shows that a release from one of the United States' more urban HF-using refineries could cause a toxic cloud to spread into neighboring communities, triggering a mass public-health catastrophe. The owner of the Torrance refinery in greater Los Angeles, for example, has estimated that an HF release could cause a toxic cloud to spread 6.2 miles from the alkylation unit. About 840,000 people live within that distance, in the threat zone. A toxic cloud released from the Wilmington refinery, just a few miles southeast, could spread 8.7 miles; about 1.1 million people live within the threat zone. A release from the Trainer refinery south of Philadelphia could cause a toxic cloud to spread 17 miles; about 1.9 million people live in the threat zone. A release from the Joliet or Lemont refineries southwest of Chicago could cause a cloud to spread 25 miles or more; more than 1.2 million people live within Joliet's threat zone, and more than 3.3 million live within Lemont's.

Although EPA's RMP reports are silent on this issue, refinery use of HF presents additional, substantial transportation-related risks. Just one U.S. plant, in Louisiana, manufactures HF for refinery use. Refineries must replenish their HF supplies to keep their alkylation process running—so HF is regularly moved to refineries along rail and highway routes that can exceed a thousand miles. This extends the risks of refinery-related HF releases to many communities located far from any HF-using refinery. For example, tanker trucks delivering HF to Los Angeles-area refineries likely pass through other major metropolitan areas including Phoenix. If a cargo truck crashed and its HF unloading valve failed at a major interchange in Phoenix, airborne HF levels in the resulting cloud could reach or exceed the potentially lethal human-exposure threshold used by EPA in a zone inhabited by more than 41,000 people. Railcars delivering HF to Trainer, Pennsylvania likely move through downtown Philadelphia, where a derailment and valve failure could similarly cause potentially lethal levels in a zone inhabited by more than 43,000 people. People living close to HF refineries must also contend with the threat of releases during the unloading of HF trucks and railcars on refinery grounds, before the chemical even reaches the alkylation unit. Because HF is hazardous to all living tissue, crops, livestock, natural areas, and wildlife could also be destroyed in a refinery-related release. The chemical is so corrosive that a major release could damage cars, buildings, and other parts of the built environment, compounding economic disruption and losses.

The chances of a catastrophic refinery-related HF release in this country are substantial and growing by the day. U.S. refineries have already experienced major HF releases and "near-miss" events that almost caused a release. Some of these events occurred at urbanized sites (like Torrance) that are still operating and using the chemical. Some refinery releases have already caused toxic HF clouds to spread past the fenceline; others, including in densely-populated Philadelphia and Los Angeles, easily could have, under slightly different circumstances. Cargo trucks have already released HF following crashes, and while unloading; HF-bearing railcars have already derailed. The risk of a further and catastrophic refinery-related HF release is mounting as our refineries, railways, and highways age and become ever more vulnerable to extreme weather.

Fortunately, these grave risks to public health and the environment can be eliminated through simple substitution. Many U.S. refineries already use safer alternative alkylation catalysts that cannot form toxic clouds. Several refineries that were designed to use HF have successfully converted or are in the process of converting to one of the safer alternatives.

U.S. refineries' use of HF presents an unreasonable risk to human health and the environment under TSCA, and TSCA requires EPA to answer this petition by "promptly commenc[ing]" a rulemaking to eliminate that unreasonable risk. *See* 15 U.S.C. § 2620(b)(3); *id*. § 2605(a).

II. Legal framework

TSCA establishes a "comprehensive program to anticipate and forestall injury to health and the environment from activities involving toxic chemical substances." *Env't Def. Fund v. Reilly*, 909 F.2d 1497, 1498 (D.C. Cir. 1990) (cleaned up) (citing 15 U.S.C. § 2601 (1988)). Congress emphasized the statute's preventive and precautionary purposes, declaring that "[t]he time has passed where human health and the environment [are] protected only after serious injury has occurred." S. Rep. No. 94-698, at 6 (1976), *as reprinted in* 1976 U.S.C.C.A.N. 4491, 4495. To that end, Congress vested EPA with "adequate authority . . . to regulate chemical substances and mixtures which present an unreasonable risk of injury to health or the environment." 15 U.S.C. § 2601(b)(2). Under Section 6 of TSCA, once EPA determines that a chemical substance or a particular use of that substance is found to present unreasonable risks to health or the environment, EPA "shall" exercise its authority to eliminate those risks. *Id.* § 2605(a); *see also id*. § 2620(b)(3)-(4) (empowering courts reviewing denials of citizen petitions to order EPA to exercise this authority).

EPA's statutory powers to limit unreasonable risk include "prohibiting or otherwise restricting the manufacturing, processing, or distribution in commerce of [a chemical] substance or mixture." *Id.* § 2605(a)(1). EPA may address one or more conditions of use when imposing regulations to eliminate the unreasonable risks from the chemical. *See id.* § 2605(a). A chemical substance's "conditions of use" include the circumstances under which it is "intended, known, or reasonably foreseen to be . . . distributed in commerce [or] used." *Id.* § 2602(5).

"[T]o protect against lax administration" of TSCA, S. Rep. No. 94–698, at 13 (1976), *as reprinted in* 1976 U.S.C.C.A.N. 4491, 4503, Congress included "unusually powerful procedures for citizens to force EPA's hand." *Trumpeter Swan Soc'y v. EPA*, 774 F.3d 1037, 1039 (D.C. Cir. 2014); *see also Env't Def. Fund*, 909 F.2d at 1503 (describing TSCA's citizen enforcement provisions as "a comprehensive as well as an unusual remedy"). Section 21 provides that "[a]ny person may petition [EPA] to initiate a proceeding for the issuance . . . of a rule under section . . . 2605" of TSCA, otherwise known as Section 6. 15 U.S.C. § 2620(a); *see id*. § 2605 (Section 6), § 2602(1) ("Administrator" in TSCA means EPA). "Such petition . . . shall set forth the facts which it is claimed establish that it is necessary to issue" such a rule. *Id.* § 2620(b)(1). Congress included Section 21 in TSCA when the statute was enacted in 1976, and preserved Section 21 with no substantive changes when updating TSCA in 2016. *Food and Water Watch, Inc. v. EPA*, 291 F. Supp. 3d 1033, 1049 (N.D. Cal. 2017) (citing S. Rep. 114-67 at 33 (2015)). Section 21 gives EPA 90 days to "either grant or deny" a Section 21 petition. 15 U.S.C. § 2620(b)(3). If EPA grants a petition, it "shall promptly commence" a rulemaking to eliminate the unreasonable risk to health and the environment. *Id.* If EPA denies the petition, or "fails to grant or deny [the] petition within the 90-day period," the petitioners may sue EPA in federal district court "to compel [EPA] to initiate a rulemaking proceeding as requested in the petition." *Id.* § 2620(b)(4)(A).

This petition sets out the facts establishing why EPA must establish a Section 6(a) rule prohibiting the use of HF in domestic oil refining to eliminate unreasonable risks to public health and the environment. TSCA requires EPA to issue such a rule because this petition identifies (1) a "chemical substance" (HF) that presents, (2) under one or more "conditions of use" (the use of HF for alkylation at U.S. refineries, and the rail and truck transportation needed to supply HF to those refineries), (3) an unreasonable risk to health or the environment. *See id.* §§ 2605(a), 2620(b)(4)(B)(ii).

III. Refinery-related HF use presents an unreasonable risk to human health

HF is a "chemical substance" under TSCA because it is an "inorganic substance of a particular molecular identity." *Id.* § 2602(2)(A). HF consists of one hydrogen (H) atom bonded to one fluorine (F) atom and has been assigned the Chemical Abstracts Service (CAS) registry number 7664-39-3.[1] The storage, use, recycling, and any mixing or blending of HF for alkylation at U.S. oil refineries are "conditions of use" of HF because they are among the "circumstances . . . under which [HF] is . . . known . . . to be . . . used."[2] *Id.* § 2602(4). The same goes for the transportation of HF, and mixes and blends incorporating HF, from manufacturing or import sites to U.S. oil refineries by rail and truck; these are "circumstances . . . under which [HF] is intended, known, or reasonably foreseen to be . . . distributed in commerce." *Id.* § 2602(4), (5) This petition uses the term "refinery-related" to encompass these interrelated conditions of use, all of which stem from some oil refiners' choice to use HF as an alkylation process chemical.

To determine whether a chemical substance or condition of use thereof presents an unreasonable risk, EPA (or a reviewing court, if EPA does not timely grant a citizen petition and the petitioner seeks judicial review under Section 21) must consider both hazard and exposure, including to "potentially exposed or susceptible subpopulations," and excluding "costs or other non-risk factors." *Id.* §§ 2605(a), 2605(b)(4)(F), 2620(b)(4)(B)(ii).

A. HF is extremely hazardous to human health

When assessing unreasonable risk under TSCA, EPA first evaluates a chemical's hazard—meaning its potential to "cause an increase in the incidence of specific adverse health or environmental effects" upon exposure.[3] Under TSCA, EPA must consider the severity of the hazard, including whether the chemical's adverse effects are reversible.[4] EPA must also evaluate hazard in light of the unique vulnerabilities of potentially exposed and susceptible subpopulations. 40 C.F.R. § 702.39(c)(4).

Congress, EPA, and other federal agencies charged with protecting public health have long recognized HF as an extremely hazardous chemical. In 1990, as part of Clean Air Act amendments establishing EPA's Risk Management Program, Congress directed EPA to include HF on a list of substances "which pose the greatest risk of causing death, injury, or serious adverse effects to human health or the environment from accidental releases." Clean Air Act, Amendments, Pub. L. 101–549, 104 Stat 2399, 2564 (1990) (codified at 42 U.S.C. § 7412(r)(3)); *see also* 40 C.F.R. § 68.130, Tbl. 1. EPA's emergency-planning regulations characterize HF as an "extremely hazardous substance."[c] The federal Occupational Safety and Health Administration (OSHA), charged with protecting refinery and other workers, has identified HF as a "highly hazardous chemical" with "a potential for a catastrophic event." 29 C.F.R. § 1910.119 app. A.

HF can take different forms, all of which are hazardous to people. Pure HF unmixed with water, or "anhydrous HF," can exist as either a colorless gas or liquid.[5] Anhydrous HF is highly soluble in water,[6] and tends to form hydrofluoric acid when it mixes with water, including water vapor present in ambient air.[7] HF and HF/acid clouds appear dense and white,[8] similar to clouds of pure steam (evaporated water).

In the context of a refinery-related release, members of the general public are most likely to be exposed to HF when they inhale HF gas or droplets, or when their skin or eyes come into contact with HF gas or droplets. Workers are likewise subject to exposure through these pathways, and

[c] 40 C.F.R. pt. 355, App. A (listing HF as an "extremely hazardous substance" under the Emergency Planning and Community Right-to-Know Act); *see also id.* § 116.4 (listing hydrofluoric acid as a "hazardous substance" under the EPA-administered Clean Water Act); *id.* § 302.4 (listing HF as a "hazardous substance" under the EPA-administered Comprehensive Environmental Response, Compensation, and Liability Act, commonly known as Superfund).

are at additional risk of being exposed to liquid HF that can splash onto their skin or eyes. People who inhale HF, or whose skin or eyes HF touches, can suffer severe and irreversible health harm.

This petition highlights three primary reasons why HF poses extreme hazards to human beings. First, HF is highly corrosive. It moves quickly through biological tissue and destroys cells by liquifying them. The resulting damage can be deadly or permanently disabling. Second, HF has the propensity to cause systemic effects by sequestering calcium and magnesium ions necessary for organ functions such as muscle contraction, nervous system signaling, and other essential metabolic processes. These effects can likewise be fatal or lead to permanent disability. Exposure to HF can cause toxicological harm across multiple organ systems, even if the initial area of exposure is limited. Third, exposure to HF, especially at low concentrations, often causes latent effects, with evidence of exposure manifesting only hours or days after exposure. This delays and complicates medical treatment, increasing the likelihood of death or irreversible damage before proper diagnosis or intervention is possible.

The severity of harm from HF exposure tends to increase with HF concentration and exposure time, and can vary with other factors.[d] However, exposure to even a small amount of the chemical can destroy living tissue, disrupt organ function, and lead to death, particularly when treatment is delayed. Young children, older adults, and people with certain preexisting health conditions are particularly susceptible to harm from HF exposure.

1. HF is highly corrosive and readily destroys human tissue

HF is so corrosive that contact with liquid or aerosolized HF destroys biological tissue by causing it to dissolve. The hydrogen and fluoride ions in the HF molecule contribute to tissue destruction through additive mechanisms, resulting in progressive damage.[9] First, the hydrogen ion can cause superficial tissue burns by attacking the bonds that hold proteins together and causing them to break down.[10] Hydrogen ions in dilute HF (<50%) generally cause limited skin damage, while hydrogen ions in concentrated HF (>50%) can lead to caustic burns.[11] Exposure to concentrated HF typically results in immediate, visible, and painful tissue damage as hydrogen ions kill surface cells.[12] Damage to surface tissue then renders the underlying soft tissue more vulnerable to exposure to HF's fluoride ion.[13]

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[d] Other factors may include, for example, the nature and route of exposure, the penetrability of the exposed tissue, the amount of body surface area exposed, the extent to which preventative or protective measures are used, and the preexisting health status of the victim. *See*, *e.g.*, Ctrs. for Disease Control & Prevention (CDC), Facts About Hydrogen Fluoride (last updated Apr. 4, 2018) [hereinafter CDC, Facts About HF] (on file with NRDC); *Hydrofluoric Acid Exposure—A Double Whammy That's Not Just Skin Deep*, Pa. Patient Safety Reporting Sys. Patient Safety Advisory, June 2006, at 1, 1 [hereinafter *Hydrofluoric Acid Exposure*], https://patientsafety.pa.gov/ADVISORIES/documents/200606_11.pdf.

The fluoride ion accounts for HF's subsequent—and more severe—tissue destruction. Fluorine is the most reactive element on the periodic table.[14] Relatedly, it is also the most electronegative, meaning it has a powerful tendency to attract electrons shared in chemical bonds.[15] Together, and particularly when the fluoride ion is combined with the hydrogen ion, these characteristics make HF highly corrosive and lipophilic, meaning that it easily dissolves in lipids (i.e., fats).[16] Because lipids are a core component of human skin,[17] the lipophilic HF molecule readily penetrates skin.[18] After HF has breached the skin, the fluoride ion dissociates from the hydrogen ion.[19] The fluoride ion is small and diffuses readily, spreading through the body.[20] The membranes that keep human cells intact are largely made of lipids.[21] The fluoride ion attacks these lipids and perforates cell membranes.[22] It thereby causes cells to rupture and release their contents, leading to liquefaction necrosis—in essence, killing cells by liquifying them.[23]

HF thus easily passes through biological tissue and penetrates deep into the body, aggressively destroying tissue far beneath the skin.[24] The highly electronegative fluoride ion also binds powerfully with positively charged calcium and magnesium ions, drawing those ions out of cells and further contributing to cell death by disrupting cellular metabolism.[25] As discussed further below, *see infra* Part III.A.3, the resulting tissue destruction can continue for days if unrecognized or left untreated,[26] causing irreversible organ damage and leading to death or permanent disability.

HF's destruction of human tissue can affect both the surface and internal organs of the body. Inhaling HF, even at low concentrations, can cause nose and respiratory tract irritation either immediately or up to 36 hours later.[27] When a person breathes air with a high concentration of HF, it destroys tissues in their nose, mouth, and throat.[28] It causes tissues in the upper respiratory system to disintegrate, a condition known as ulcerative tracheobronchitis.[29] The person's throat swells and constricts, obstructing their upper airway.[30] A tracheostomy, the surgical creation of a hole in the neck into the windpipe, may be required to prevent suffocation.[31] As HF reaches a person's lower airway and continues destroying tissue there, the tubes connecting their throat to their lungs (bronchi) constrict, and their lungs may collapse.[32] The tissue destruction also causes blood and cellular fluids to build up in their lungs (hemorrhagic pulmonary edema).[33] This can be deadly, causing people to drown in their own bodily fluids.[34] HF's destruction of lung cells can, moreover, trigger a severe inflammatory response that can itself contribute to respiratory distress and death.[35] As these life-threatening effects unfold within a person's body, outwardly visible symptoms may include coughing, chills, fever, chest tightness, choking, and bluish discoloration of the skin resulting from lack of oxygen in the blood.[36]

Skin contact with HF can likewise lead to serious tissue damage. Exposure to concentrated (>50%) HF can cause immediate corrosive burns, characterized by excruciating and persistent pain, blistering and whitish discoloration of the skin, and severe lesions.[37] "Healing often is delayed, and tissue destruction (necrotic changes) may continue to occur beneath a layer of tough coagulated tissue to produce deep penetrating ulcers."[38] In addition to liquefying flesh, HF can corrode bone.[39] Upon penetrating skin and soft tissue and reaching bone, the fluoride ion binds with calcium and magnesium ions, stripping the bone of these foundational minerals.[40] Honeywell, the sole U.S. manufacturer of HF for refinery use, has recognized that HF is "highly corrosive to tissues and bones."[41]

In addition, tissues in the eye are extremely sensitive to HF.[42] Even low concentrations of HF can completely diffuse in the cornea within minutes, causing burns and blindness if left untreated.[43] At higher exposures, HF can penetrate eye tissue and severely damage both surface and underlying structures.[44] It can denude the membranes covering the cornea and other parts of the eye, lead to cell death in the optic nerve from lack of blood flow, perforate the eyeball, and cause scar tissue and blood vessels to develop on the cornea, which is normally transparent so that light can enter the pupil.[45] These changes can permanently impair vision and lead to blindness.[46]

2. HF causes life-threatening systemic toxicity by binding with chemicals needed to regulate critical biological processes

HF is particularly dangerous because it causes systemic toxicity. Systemic toxicity refers to adverse health effects that occur when a toxicant is absorbed in one part of the body but then causes harm in other parts to which it is distributed.[47] For example, splashes of HF on the skin can lead to pulmonary effects.[48] After exposure by any route, HF is rapidly absorbed into blood and lymph; it is then carried throughout the body, including to different organs, via blood and lymph vessels.[49]

Systemic absorption of HF through the lungs or skin can cause severe harm, including death. Indeed, fatal HF exposures most commonly arise from systemic toxicity.[50] HF's fluoride ion binds strongly with calcium and magnesium, electrolytes[e] that regulate critical biological processes like heartbeat, muscle contraction, and nervous system signaling.[51] As HF spreads throughout the body, blood levels of calcium and magnesium drop, blood levels of potassium rise, and acid builds up in the blood and tissues.[52] These disruptions to the delicate and tightly-regulated balance of chemicals in the body can, in turn, disrupt the normal functioning of the cardiovascular system,[53] causing abnormal or disordered heart rhythms (arrythmia), involuntary muscle contractions, seizures, and death through cardiac arrest.[54] Reductions in blood calcium levels, in particular, weaken cardiac contractions and can lead to heart failure.[55] As the fluoride ion causes potassium to flow out of cells, this leads to changes at nerve endings that may cause extreme pain.[56] Other organ systems may also be affected. For example, those exposed to HF have reported gastrointestinal effects, such as nausea, vomiting, and gastrointestinal distress.[57]

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[e] Electrolytes are substances in the body that help regulate chemical reactions, maintain the balance between fluids inside and outside cells, support heart function, and more. Cleveland Clinic, *Electrolytes*, https://my.clevelandclinic.org/health/diagnostics/21790-electrolytes (last visited Oct. 16, 2024).

Contact with concentrated HF in even small amounts can cause fatal systemic effects. Exposing as little as 2.5% of one's skin—about the size of one's hand— to concentrated liquid HF is enough to kill a person through such effects.[58]

3. HF exposure can be difficult to recognize and treat, increasing the chances that those exposed will die or suffer irreversible health harm

The hazards of HF exposure are compounded by difficulties in identifying and treating its toxic effects. While correct diagnosis and timely treatment are critical, HF exposure may at first be invisible, with symptoms appearing or worsening only over time. This unusual characteristic complicates medical treatment. The delayed effects of HF exposure make timely, accurate diagnosis of HF-related injuries difficult, increasing the risk that people will die or suffer permanent harm after exposure.[f]

It is well-documented that HF exposure can have delayed effects. When a person is exposed to low concentrations of HF, the initial burn damage caused by hydrogen ions tends to be limited.[59] The subsequent, more serious damage caused by fluoride ions after HF has deeply penetrated tissue can take longer to manifest.[60] After inhalation of HF, respiratory irritation may not begin for 12 to 36 hours.[61] Symptoms such as coughing, chest tightness, rales (rattling sounds while breathing[62]), fluid buildup in the lungs, and cyanosis (skin turning blue from lack of oxygen[63]) may not appear for one to two days.[64]

Skin exposure can also produce delayed effects. Contact with dilute HF can be particularly dangerous, because the fluoride ion can begin to poison the body systemically before a person is in any pain.[65] Contact with solutions of less than 20% HF causes almost no immediate pain but may cause delayed serious injury 12 to 24 hours later.[66] Contact with solutions containing 20% to 50% HF may produce pain and swelling that may be delayed up to eight hours.[67] "[U]ntreated burns initially thought to involve only surface tissue can progress to deep tissue injury and bone destruction."[68] Even after a severe HF exposure, a person might not experience *any* symptoms for up to 36 hours.[69] This can happen when HF is rinsed off quickly, thus limiting superficial burns, but no action is taken to neutralize fluoride ions from HF molecules that have already breached the skin. The fluoride ion's destruction of nerve cells[70] can, moreover, interfere with victims' perception of pain. Even without immediate symptoms, HF exposures can lead to such serious effects as abnormal heart rhythm and acute accumulation of fluid in the lungs, both of

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[f] For example, three U.S. military personnel exposed to HF died of respiratory failure within 24 hours of exposure, "[d]espite presenting with little to no additional signs of trauma." Dustin Zierold & Matthew Chauviere, *Hydrogen Fluoride Inhalation Injury Because of a Fire Suppression System*, 177 Military Medicine 108, 108 (Jan. 2012), https://academic.oup.com/milmed/article/177/1/108/4345530. The victims died before medical personnel were able to identify HF as the cause of their injuries. *Id*. at 108-09.

which can be fatal.[71] In addition, the delayed pain caused by HF burns is characteristically excruciating when it finally manifests.[72]

The delay in symptom onset from HF exposure can confuse both exposure victims and the medical professionals trying to treat them. Early symptoms of dermal exposure to HF of less than 50% concentration may be mistaken for an allergic reaction.[73] Correct diagnosis and timely medical treatment are critical to limiting the tissue destruction, respiratory effects, and metabolic poisoning that can occur hours after HF exposure.[74] But people might not seek immediate treatment because their symptoms take longer to manifest. Delayed symptoms also increase the likelihood that first responders and other medical personnel may not connect victims' symptoms to HF exposure quickly enough to provide effective treatment. In addition, there is increased risk of secondary exposures when HF is not correctly identified as the cause of harm, thereby delaying or preventing proper decontamination. For example, medical staff risk secondary contamination from treating victims exposed to HF if they do not undertake adequate procedures to protect themselves from HF that remains on victims' skin or clothing.[75]

These problems are particularly likely to occur in the event a release causes people other than refinery-related workers to be exposed. Even when HF exposure is recognized, there is no antidote to HF toxicity.[76] Instead, immediate decontamination and medical treatment are undertaken to prevent further harm to the body.[77] The prevailing treatment involves application, injection, or other administration of chemicals that can help to neutralize the fluoride ion by binding to it; calcium gluconate is the main chemical used for this purpose, although other chemicals, such as hexafluorine, are also used.[78] Treatment may also include support of respiratory and cardiovascular functions, such as administration of aerosolized medications to widen the airways and facilitate breathing.[79]

People who survive their exposure to HF gas can go on to suffer long-term and irreversible injuries. Survivors of inhalation injury may develop chronic lung disease.[80] Burns caused by exposure to concentrated HF may result in permanent tissue death and extensive scarring.[81] Fingertip injuries are troublesome and characterized by persistent pain, bone loss, and nailbed injury.[82] Eye exposure may result in prolonged or permanent visual defects, blindness, or complete destruction of the eye.[83]

A study of individuals exposed to HF in the 1987 Texas City release (discussed at Part III.B.7.i.a) underscores how readily HF exposure can cause long-term health harm. Researchers studied more than 10,000 individuals who lived in the path of the toxic cloud the release caused.[84] As discussed below, people may have been exposed to airborne hydrofluoric acid at concentrations ranging as high as 50 parts per million (ppm) or greater.[85] The researchers' data showed that many people were still suffering symptoms two years after exposure. For the people who had had the highest exposure to HF, about one in three still reported severe throat symptoms (such as burning sensations or difficulty swallowing), half still had severe breathing problems (like persistent coughing or shortness of breath), nearly a quarter still had severe skin symptoms (like itching or rashes), and more than one in ten still had severe stomach problems (like diarrhea, nausea, or blood in stool).[86] About a quarter of those with higher exposure reported that they still had difficulty breathing and headaches bad enough to disrupt their sleep.[87] Nearly one in ten said their skin still burned.[88] Even some people with lower exposure and no preexisting conditions still reported breathing problems.[89]

4. Children, people over 65, and those with preexisting heart and lung problems are especially vulnerable to the hazards of HF

Certain subpopulations are particularly vulnerable to the hazards posed by HF exposure. TSCA defines unreasonable risk by reference to not just the general population, but also potentially exposed and susceptible subpopulations. 15 U.S.C. § 2620(b)(4)(B)(ii). "Potentially exposed or susceptible subpopulation" refers to:

> a group of individuals within the general population identified by EPA who, due to either greater susceptibility or greater exposure, may be at greater risk than the general population of adverse health effects from exposure to a chemical substance or mixture, such as infants, children, pregnant women, workers, the elderly, or overburdened communities.

40 C.F.R. § 702.33. Greater susceptibility refers to the fact that some individuals may, for reasons having to do with their genetics, age, preexisting health status, or other factors, suffer relatively greater health harm after being exposed to any given level of HF.[g, 90] Children, people over 65, and individuals with preexisting heart and lung problems are subpopulations with greater susceptibility to the hazards of HF exposure.

i. Children

Children are more likely to experience adverse health effects than healthy adults after exposure to a given concentration of HF in the ambient air. Owing to their size, physiology, behavior, and activity level, young children breathe at a faster rate than adults.[91] "[C]hildren have a higher resting metabolic rate and oxygen consumption rate" than adults given "their rapid growth and relatively larger lung surface area"; thus, although greater amounts of HF would be inhaled by adults than children breathing the same HF-contaminated air over the same time period on an absolute basis, the relative volume of air and HF passing through the children's lungs would be significantly higher.[92] Children may also be more vulnerable to corrosive agents like HF than adults because of the relatively smaller diameter of their airways.[93] And because of their relatively larger surface area to body weight ratio, children are far more vulnerable to HF exposure through the skin.[94]

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[g] Greater exposure refers to circumstances that make an individual particularly likely to be exposed to HF in the first place, as discussed in Part III.B.6.ii.

ii. People over 65

People over 65 are also more likely to experience adverse health effects than are younger adults after exposure to HF. Exposure standards tailored to working adults are particularly inappropriate for older adults, who are usually no longer in the workforce and thus unrepresented by epidemiological studies of worker health harms.[95] As people get older, changes occur in the heart and blood vessels that increase the risk of various heart conditions.[96] Older people are also more likely to have noncardiac chronic conditions, such as diabetes or arthritis; nearly 95% of adults over 65 have at least one chronic health condition, and nearly 80% have two or more.[97] These preexisting health conditions contribute to greater susceptibility among elderly people to any additional harms caused by HF exposure.

People over 65 are also less likely to respond well to treatment for HF exposure. Treatment for HF may include, among other approaches, using cardiovascular treatments that may pose risks of creating heart arrhythmias (unusually slow or fast heartbeats), especially in older patients.[98]

iii. People with underlying heart and lung conditions

Preexisting heart and lung conditions can also make people more susceptible to harm following HF exposure.[99] A study of victims of the 1987 Texas City refinery HF release discussed at Part III.A.3 found that those with preexisting pulmonary conditions, and those who smoked two or more packs of cigarettes per day, experienced more severe symptoms both immediately following the release and two years later.[100] The National Research Council has found that individuals with asthma may also have more severe responses to HF exposure.[101]

B. Millions of people across the U.S. are at risk of being exposed to HF from refinery-related releases

Under TSCA, the risk a chemical presents to people and the environment is a function of both its human and ecological hazards, discussed at Parts III.A and IV.A, and exposure—the potential that people and other vulnerable beings and parts of our natural environment will come into contact with it.[102] When determining unreasonable risk, EPA must accordingly "take into account, where relevant, the likely duration, intensity, frequency, and number of exposures under the conditions of use of the chemical substance." 15 U.S.C. § 2605(b)(4)(F). U.S. oil refineries' use of HF for alkylation, and the associated transportation of HF to refineries by train and truck, are conditions of use that threaten significant human exposures to this dangerous chemical. As this Part explains, HF's propensity to vaporize, aerosolize, and spread in a ground-level cloud means that any substantial release in a populated area is likely to result in significant, unavoidable human exposure and health harm. Once it escapes into the atmosphere and forms a cloud, the HF is impossible to fully contain, and difficult or impossible for many people in its path to evade.

1. HF boils and forms a ground-hugging cloud at common ambient temperatures

HF's normal boiling point is just 67.2 degrees Fahrenheit (19.6 degrees Celsius).[103] When HF stored under pressure (as in an alkylation unit or cargo tank) is released above its normal boiling point, at ambient pressure (i.e., at ground level), it will vaporize and, close to the release point, form a spreading, ground-hugging cloud.[104]

The federal government and oil industry have understood this for decades. In August and September 1986, Lawrence Livermore National Laboratory and Amoco Oil Company scientists conducted a series of field release experiments, codenamed Goldfish, at the U.S. Department of Energy's Nevada Test Site (now the Nevada National Security Site).[105] The experiments were designed to simulate an HF release from a refinery's HF alkylation unit.[106] The experimenters' goals included (1) understanding "the degree to which [the contained, pressurized] liquid HF would become airborne and [move] downwind when released to the environment," and (2) developing data on resulting atmospheric concentrations of HF to inform "accidental release scenarios using atmospheric dispersion models."[107]

The scientists repeatedly released liquid anhydrous HF from a pressurized 5,000-gallon (roughly semi-truck-sized) tank[h] into the open air through a discharge pipe sitting just above ground level.[108] The results established how readily HF can form a large, ground-hugging cloud that is acutely toxic to humans. In each of the three tests designed to study how HF would disperse naturally, before application of a water suppressant, the scientists found that "[a]ll of the HF liquid released . . . was transported downwind in an airborne cloud as a combination of aerosol and vapor."[109] In the first test, the scientists released HF through a 1.65-inch diameter hole for just over two minutes, causing the tank to spill about a fifth of its contents.[110] That was enough to cause HF levels of 411 ppm near ground level at the furthest sampling point, three kilometers downwind.[111] Levels exceeded 25,000 ppm at the closest sampling point, 300 meters downwind of the release point, and exceeded 3,000 ppm at the intermediate sampling point, a kilometer downwind.[112] These levels far exceeded the threshold levels for acute inhalation exposure that may lead to death, as discussed below.

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[h] The modern HF cargo tanks Petitioners used as the basis for the truck-release scenarios at Part III.B.4.ii.b of this petition hold about 5,300 gallons. *See* Appendix C, Part II.B.1.

Figure 1: Aerial view of the first Goldfish test HF release[113]

2. The Acute Exposure Level Guidelines (AEGLs) provide benchmarks that help to describe human health harms from acute inhalation exposure to HF via a toxic cloud

To support emergency planning, prevention, and response in community, workplace, transportation, and other settings, the federal government has collaborated with state agencies, academics, the chemical industry, and other private-sector organizations to develop Acute Exposure Guideline Levels (AEGLs) for releases of HF and other highly hazardous chemicals.[114] The AEGLs were developed after the 1984 Bhopal, India catastrophe—which caused a lethal, spreading toxic cloud—deepened concerns about major industrial chemical releases in this country.[115] The AEGLs "describe the human health effects from once-in-a-lifetime, or rare, exposure to airborne chemicals" and are used in emergency situations "dealing with chemical spills or other catastrophic exposures."[116] Despite several limitations, the AEGLs provide numerical, concentration-based benchmarks that help to describe threats to human health from the acute inhalation exposures associated with a refinery-related HF release.[117]

i. The AEGLs set forth the inhalation exposure levels above which people could experience adverse health effects

The AEGLs represent inhalation exposure levels for the general public that, if exceeded, could lead to different kinds of adverse health effects.[118] They apply to one-time emergency exposures ranging from 10 minutes to eight hours.[119] The AEGLs are intended for use in "various risk assessments to aid in the development of emergency preparedness and prevention plans, as well as real-time emergency response actions, for accidental chemical releases at fixed facilities and from transport carriers."[120] The AEGLs are usually paired with chemical-release and dispersion models—like the ALOHA model Petitioners used to develop the transportation release scenarios, at Part III.B.4.ii—to help characterize and predict the human health risks associated with the release of cloud-forming toxic chemicals.[121]

There are three tiers of AEGLs for each chemical (labeled AEGL-1 through AEGL-3) that correspond to increasingly severe health effects.[i] AEGL-3, corresponding to the most severe, represents "the airborne concentration . . . of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death."[122] "AEGL-2 is the airborne concentration . . . of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape."[123] "AEGL-1 is the airborne concentration . . . of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects [that are] not disabling and are transient and reversible upon cessation of exposure."[124]

As reflected in the AEGLs, the airborne concentrations of HF corresponding to different categories of potential health harms vary according to exposure timeframe, because the gravity of the effects increases the longer one is exposed.[125] Because an HF cloud resulting from a refinery-related release could form and spread relatively quickly, see Part III.B.5, the most pertinent AEGLs are those corresponding to inhalation exposures of an hour or less:

Figure 2: Acute Exposure Guideline Levels (AEGLs) for HF exposures of 10 to 60 minutes

Assumed exposure timeframe	AEGL-3 (potentially lethal)	AEGL-2 (potentially disabling)	AEGL-1 (potentially harmful but nondisabling)
10 minutes	170 ppm	95 ppm	1 ppm
30 minutes	62 ppm	34 ppm	1 ppm
60 minutes	44 ppm	24 ppm	1 ppm

[i] AEGL values are specified in terms of parts per million (ppm) or (alternatively) milligrams per cubic meter (mg/m^3) of the substance in ambient air. *See* NRC AEGLs, *infra* en.49, at 3.

See NRC AEGLs, *infra* en.49, at 127 tbl.3-1.

As discussed at Part III.B.1, above, the 1986 tests that were designed to simulate an HF release from a refinery's alkylation unit resulted in the formation of HF clouds with concentrations far exceeding even the potentially lethal AEGL-3 levels shown in Figure 2. And, as discussed in Part III.B.4, below, a refinery-related HF release that is not promptly controlled could readily result in significant human exposures exceeding the AEGL-1, AEGL-2, and AEGL-3 concentrations.

ii. The AEGLs do not capture the full range and extent of hazards to a substantial portion of the people who risk exposure to HF in a refinery-related release

Despite their utility in helping to describe the human health harms from acute inhalation of HF, the AEGLs do not account for the full range and extent of the hazards to a significant proportion of the general population who would likely be exposed to HF in the event of a refinery-related release.

First, HF exposures from a refinery-related release are likely to involve multiple exposure pathways that increase exposure and the risk of death or serious injury. People who contact HF in a dense, ground-hugging cloud may experience both skin and eye exposure from contact with HF droplets and inhalation exposure as they breathe in HF vapor and aerosols. See Parts III.A, III.B.1. While the AEGLs address acute inhalation exposure, any concurrent dermal exposure to HF droplets would add to the cumulative risk of death or serious injury from inhalation exposure. Those who are very close to an HF release from a refinery vessel, tank car, or truck may additionally be splashed or sprayed with liquid HF. Such combined exposures would exacerbate the health consequences to exposed individuals. Furthermore, emergency responders and members of the public are at risk of not only direct dermal and inhalation exposures, but also secondary exposures from pathways such as contact with contaminated clothing.[126] To the best of Petitioners' knowledge, no federal regulatory thresholds account for the cumulative health effects of being exposed to HF through more than one pathway.

Second, although the AEGLs are said to represent emergency response threshold values for the general public, the National Research Council emphasizes that individuals vary and that some people may experience health harms at lower levels of exposure than the corresponding AEGL would suggest.[127]

Third, the AEGLs cover only limited exposure timeframes. The shortest exposure timeframe that the AEGLs account for is 10 minutes. However, high-concentration exposures for even shorter durations—which are a realistic possibility in the event of a refinery-related HF release—can lead to serious health harms, including those that are fatal or permanently disabling. In addition, a refinery-related HF release could lead to harmful acute exposures that last beyond eight hours, the longest exposure timeframe encompassed by the AEGLs. As one example, this is possible for indoor exposures, given the longer time it would take for HF to dissipate from enclosed spaces. *See infra* Part III.B.6.i.

Finally, the AEGLs may not adequately account for and protect people from longer-term, chronic health effects known to follow acute HF exposures. Short-term exposures can have severe and persistent effects on the cardiovascular, respiratory, gastrointestinal, neurological, and other organs systems, any of which may seriously affect overall health and long-term quality of life for acutely exposed individuals. *See supra* Part III.A.3.

Accordingly, although Petitioners reference the AEGLs to provide context for the serious health harms that may arise from a refinery-related release, it is important to note that health harms may manifest for exposed individuals even below the AEGL levels.

3. HF is still used at many U.S. refineries, including some in major cities, and is regularly moved long distances to refineries by rail and truck

Refiners use HF for a process called "alkylation": the production of alkylate, an ingredient in a refinery's recipe for gasoline and jet fuel.[128] When alkylate is blended with other hydrocarbons to make fuel, it raises the octane rating of the finished product.[129] Octane ratings are a measure of fuel stability, with more stable fuel helping engines to run more efficiently.[130] While the exact design of alkylation units varies by refinery, all alkylation units that use HF feed anhydrous HF and blends of HF, other chemicals, and water through a series of pipes and vessels to cause a reaction with hydrocarbons generated in the refining process.

EPA knows that a substantial number of U.S. oil refineries are still using HF for alkylation, despite the chemical's extraordinary hazards. In a March 2024 Clean Air Act rulemaking preamble, for example, it "not[ed] that HF is an extremely toxic chemical used for alkylation at 27 percent of facilities in [the category of facilities that includes petroleum refineries]."[131]

To better inform themselves about these facilities, Petitioners reviewed relevant parts of the RMPs refiners submit to EPA pursuant to Clean Air Act Section 112, including the Offsite Consequences Analyses that must be reviewed in person at agency offices.[132] Section 112 aims "to prevent the accidental release and to minimize the consequences of any such release" of "extremely hazardous substance[s]"—those "which, in the case of an accidental release, are known to cause or may reasonably be anticipated to cause death, injury, or serious adverse effects to human health or the environment." 42 U.S.C. § 7412(r)(1), (r)(3).

According to the RMPs Petitioners reviewed, all 42 of the refineries whose locations are marked with red dots on the following figure use HF for alkylation.[133]

Figure 3: Map of the United States' 42 HF-using refineries

As the figure shows, a significant number of the United States' HF-using refineries are in or near large cities, including Los Angeles, Philadelphia, Chicago, Salt Lake City, and Memphis. An interactive version of this map is available on NRDC's website.[j]

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[j] *See* https://www.nrdc.org/court-battles/hydrogen-fluoride-refineries. The website also shows additional information about HF-using refineries and past incidents at those refineries.

Appendix A to this petition presents additional detail on each HF-using refinery, combining data from Petitioners' RMP file reviews with other data they compiled from public sources.[134] It includes each refinery's name; location; current owner; and the following figures the refiners reported to EPA in their most recent RMPs: the maximum amount of HF the refinery may hold onsite; the number of full-time workers onsite; the number of miles an HF cloud could extend from the release point in the event of a "worst-case" release from the refinery's alkylation unit; and the number of people living within the worst-case scenario zone (the circle described by the worst-case cloud extent).

As Appendix A shows, an average-sized HF-using refinery may hold more than 156 tons (312,000 pounds) of HF on site at any given time.[135] The six largest facilities may each hold more than twice that amount at any given time; the very largest user, the CITGO Corpus Christi Refinery East, holds over 800 tons (1.6 million pounds).[136] The average amount of HF released in refiners' worst-case scenarios exceeds 100 tons (200,000 pounds),[137] and the five largest refineries' worst-case release amounts each exceed 250 tons (500,000 pounds).[138]

Although the RMP data reveal just the HF volumes each refinery may hold onsite, typically within its alkylation unit, the cargo tanks used to deliver HF to refineries by road and rail also hold significant amounts. A single HF cargo tanker (semi-truck trailer) can carry more than 9 tons of anhydrous HF, and a single railcar can carry more than 39 tons.[139]

To help put these figures in context, consider the consequences of a 2012 explosion that led to the release of about 8 tons of anhydrous HF during cargo tanker unloading at a chemical plant in Gumi, South Korea.[140] The release killed 5 workers and injured at least another 18, including plant workers and emergency personnel.[141] It also forced the evacuation of hundreds of people from neighboring villages; led to more than 12,000 to claim compensation for injuries; and spurred a government investigation, the designation of a special disaster zone, and $33 million in compensatory payments to residents and businesses.[142]

As the RMP data and transportation release analyses discussed in the remainder of this Part illustrate, an HF cloud released from a U.S. refinery, or a truck or train delivering HF to a refinery, could be far more extensive and destructive of human health and the environment than the one formed in Gumi.

4. Millions of people across the country live close enough to an HF-using refinery or transportation route to face the risk of exposure to a toxic cloud following a refinery-related release

i. Many refineries are close enough to residential areas and use enough HF that an onsite release could cause a toxic cloud to spread through neighboring communities

EPA's RMP reporting regulations require refinery owners to conduct and present the results of a "worst-case release scenario" intended to capture the greatest distance any toxic chemical the refinery holds could spread following "an accidental release from covered processes." 40 C.F.R. § 68.25(a)(2)(i). Every one of the 42 HF-using refinery owners whose RMP Petitioners reviewed based its worst-case scenario on an HF release.[143] The RMP data (summarized in Appendix A) show that these refineries collectively employ more than 19,800 full-time workers, and that approximately 19 million[k] people live close enough to one or more of these refineries that they could be exposed to an HF cloud following a worst-case release.[144]

To help ground its discussion of human and environmental threats, the remainder of the petition focuses on the following six refineries: the Trainer refinery south of Philadelphia, the Lemont and Joliet refineries southwest of Chicago, the Garyville refinery in Louisiana, and the Torrance and Wilmington refineries in greater Los Angeles. The following table summarizes key RMP data for those refineries.

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[k] Because some HF-refineries (like those in Torrance and Wilmington, California; Joliet and Lemont, Illinois; and the Salt Lake City refineries) lie close to one another, the aggregate total—19,832,000—likely double-counts some individuals who live within the predicted worst-case release distance from more than one of those refineries. *See also* Figures 6, 8, and 9 (maps showing overlaps in the RMP worst-case release zones for California and Illinois refineries).

Figure 4: Worst-case scenario release distances and population counts for select HF-using refineries, as reported to EPA by the refiners

Refinery name	Location	Full-time workers	Pounds of HF released in a "worst-case" scenario	Miles to endpoint (HF cloud extent)[l]	Number of people living in potential worst-case release zone
Monroe Energy[m] Trainer Refinery	Trainer, Pennsylvania	515	217,472	17	1,900,000
Exxon Joliet Refinery	Channahon, Illinois	660	631,748	25	1,270,400
Lemont Refinery	Lemont, Illinois	600	302,023	22	3,370,000
Marathon Garyville Refinery	Garyville, Louisiana	920	890,000	25	400,000
Valero Wilmington Refinery	Wilmington, California	385	610,470	8.7[n]	1,100,00
PBF Torrance Refinery	Torrance, California	584	110,000	6.2	840,000

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[l] EPA directs refiners to calculate the "miles to endpoint" by describing the farthest point at which airborne HF concentrations in the cloud could exceed 0.016 milligrams per liter (mg/L). *See* 40 C.F.R. §68.22(a)(1); *Id.* pt. 68 app. A (Table of Toxic Endpoints, row marked "Hydrogen fluoride / Hydrofluoric acid (conc 50% or greater)"). That is equivalent to 19 ppm (assuming an HF molecular weight of 20.01 grams/mole, and a temperature of 20 degrees Celsius. This endpoint is well above the AEGL threshold for "potentially harmful but nondisabling" effects (1 ppm) for exposures as short as 10 minutes (the lowest interval for which an AEGL exists) and near the threshold for "potentially disabling" effects, assuming a 60-minute exposure (24 ppm). *See* Figure 2.

[m] Monroe Energy, Trainer's immediate owner and operator, is a wholly owned subsidiary of Delta Airlines. *See* Appendix A (row for Trainer refinery, col. marked "Parent Company Name").

[n] This distance may be inconsistent with the choice of dispersion modeling software the refiner reported using to develop its worst-case scenario (ALOHA); as EPA's RMP guidance notes, the version of ALOHA EPA provides "has an artificial distance cutoff of 6 miles (i.e., any scenario which would result in an endpoint distance beyond 6 miles is reported as "greater than 6 miles"). EPA, *Risk Management Program Guidance for Offsite Consequence Analysis* (Mar. 2009) at 1–2 [hereinafter EPA RMP Guidance], https://www.epa.gov/rmp/rmp-guidance-offsite-consequence-analysis (last visited Jan. 7, 2025). Petitioners have mentioned the apparent discrepancy to the EPA office that hosted their review of this RMP (Chicago Region 5).

The worst-case release zones used to develop the population counts are formed by taking the refiner's estimated worst-case release ("miles to endpoint") distance and rotating it in a circle around the refiner's assumed release point. *See* 68 C.F.R. § 68.30(a). This accounts for the fact that the release cloud (or plume) could extend in various compass directions from the release point, depending on wind direction at the time of the release.

The following figures, prepared by Petitioners, overlay the zones on area maps. As the figures show, many Illinois and California residents live within more than one refinery's reported worst-case release zone—heightening their risks of HF exposure and harm.

Figure 5: Trainer, Pennsylvania refinery worst-case release zone

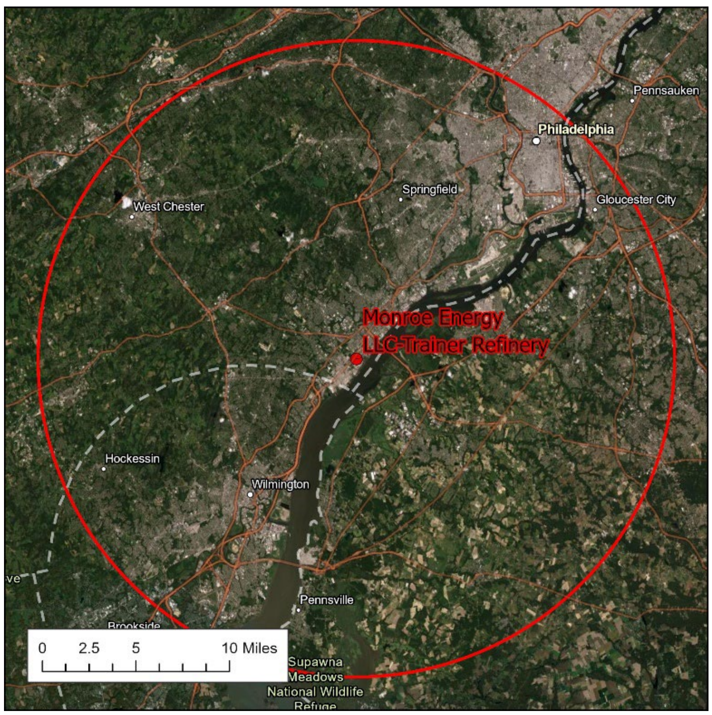


Figure 6: Lemont and Joliet, Illinois refinery worst-case release zones

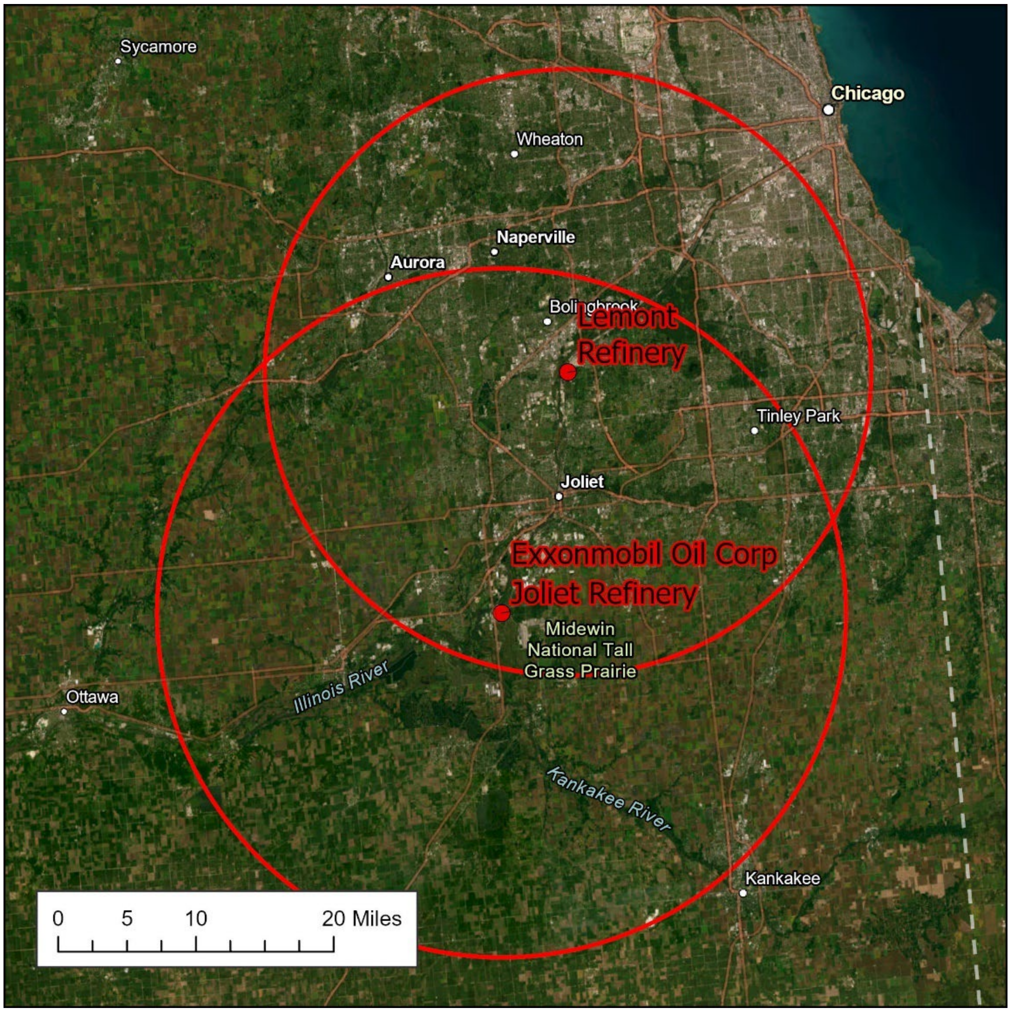


Figure 7: Garyville, Louisiana refinery worst-case release zone

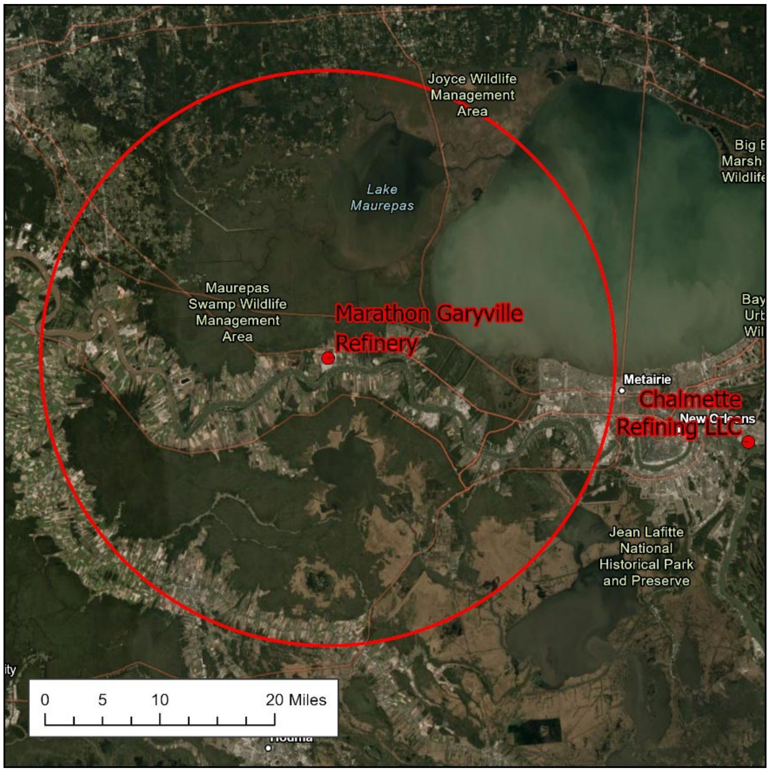
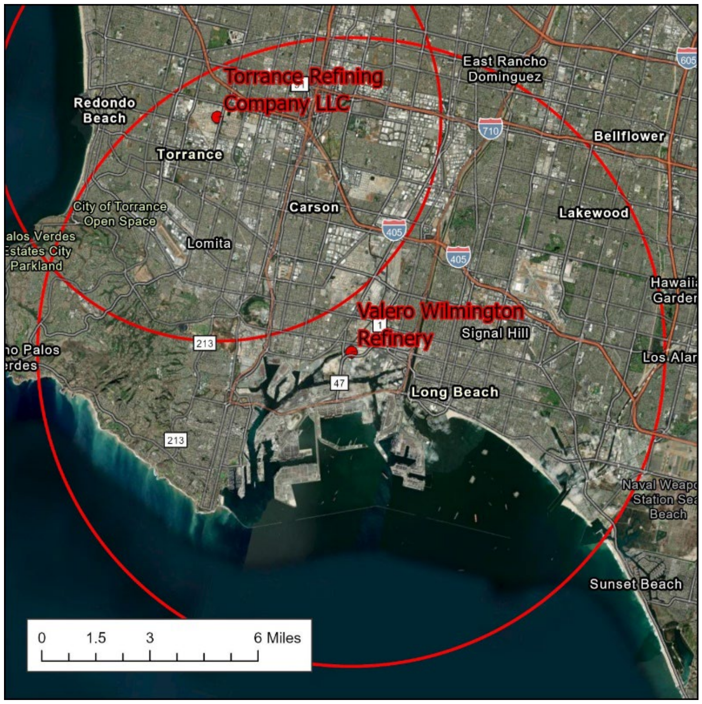


Figure 8: Torrance, California refinery worst-case release zone

Figure 9: Wilmington, California refinery worst-case release zone



In short, refiners' own federal reporting shows that their choice to continue using HF—and EPA's ongoing failure to prohibit that use—is causing tens of thousands of workers, and millions of people in communities across our country, to live under the threat of a toxic cloud.

ii. The ongoing transportation of HF to refineries by railcar and truck could also cause a toxic cloud to spread through communities—including some far from the refineries themselves

EPA's RMP reporting requirements address possible HF releases on refinery property. They do not require refiners to address the public-health and environmental implications of moving HF to refineries—an important facet of the overall risk refineries' HF use presents to public health and the environment. Although most HF within refinery alkylation systems is recirculated and reused, some is lost through chemical reactions and air pollution control.[145] On information and belief, operators of HF-based alkylation systems must replenish their supplies of fresh anhydrous HF, and they buy and import HF from third-party chemical producers rather than making it onsite. Petitioners have identified just one U.S. plant—Honeywell's Geismar, Louisiana facility—that still makes anhydrous HF for refinery use.[146]

As a consequence, at least some (and likely many) U.S. refineries are relying on regular, long-distance railcar[147] or tanker truck[148] shipments of anhydrous HF to continue producing alkylated fuel. As the following scenarios help illustrate, this transportation threatens many people who live outside "worst-case" release zones EPA requires refiners to describe in their RMP reports and adds to the cumulative risks faced by people within those zones. Appendix C includes additional graphics and detail on Petitioners' methodology.

a. Railcar release scenarios

1. Routes

Petitioners used commercial rail-routing software to determine practical routes for trains hauling anhydrous HF from Geismar, Louisiana to refineries in Trainer, Pennsylvania (south of Philadelphia) and Joliet and Lemont, Illinois (southwest of Chicago).[149] The recommended route to Joliet is 942 miles long, and the recommended route to Lemont is 980 miles long; both pass through Memphis, Tennessee and central Chicago.[150] The recommended route to Trainer, Pennsylvania is 1,401 miles long and passes through major cities including New Orleans, Louisiana; Knoxville, Tennessee; and Philadelphia, Pennsylvania.[151]

2. Release during railcar unloading (Trainer, Pennsylvania)

Petitioners' first railcar-release scenario describes what could happen if the outlet valve on an HF railcar failed during unloading at the Trainer refinery and HF were released for 10 minutes—the same timeframe EPA directs refiners to use in their RMP "worst-case" scenarios for onsite HF releases.[o] They used ALOHA (Areal Locations of Hazardous Atmospheres), EPA-provided software that may be used to develop RMP "worst-case" scenarios,[p] to predict the extent of the HF cloud that would form in the first hour following the start of the release, and within a 10-kilometer radius of the release point.[q]

Petitioners directed ALOHA to map contours specifying the distances from the release point at which HF concentrations in the cloud (plume) would exceed each 10-minute AEGL presented in Figure 2.[152] Petitioners applied the 10-minute AEGL values because that exposure timeframe

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[o] *See* 40 C.F.R. § 68.25(c)(1).

[p] *See* EPA, *ALOHA Software*, https://www.epa.gov/cameo/aloha-software (last visited Jan. 31, 2025); EPA RMP Guidance, *supra* fn. n, at 1–2.

[q] Appendix C, Part III. These time and distance cutoffs are built into the EPA-provided ALOHA software. *Id*. For this transportation scenario and most others described in this petition, this cutoff resulted in a truncated AEGL-1 plume. *Id.*, Figures 16, 18-20 (ALOHA plume graphs for Trainer railcar unloading; Torrance truck unloading; and Phoenix and Baton Rouge truck crash scenarios). This means that the actual zone in which people could be exposed at or above AEGL-1 is larger than the one shown on Petitioners' threat-zone maps, and that the actual numbers of potentially exposed people almost certainly exceed those shown in Petitioners' tables.

corresponds most closely to the timeframe during which ALOHA predicted HF concentrations would peak at a point along the plume's centerline, one kilometer from the release point.[r]

Petitioners then used additional EPA-provided and ArcGIS software to rotate the plume 360 degrees, in order to describe the full area within 10 kilometers of the release point in which HF concentrations could exceed each AEGL, depending on wind direction during the release.[s] Finally, Petitioners used GIS software and Census data to estimate the total number of people, and people in certain sensitive subgroups, living within that threat zone.[t] The next figure shows the results.

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[r] Appendix C, Part III, Figure 16 (ALOHA computational outputs for Trainer, Pennsylvania unloading scenario, chart marked "Concentration at Point").

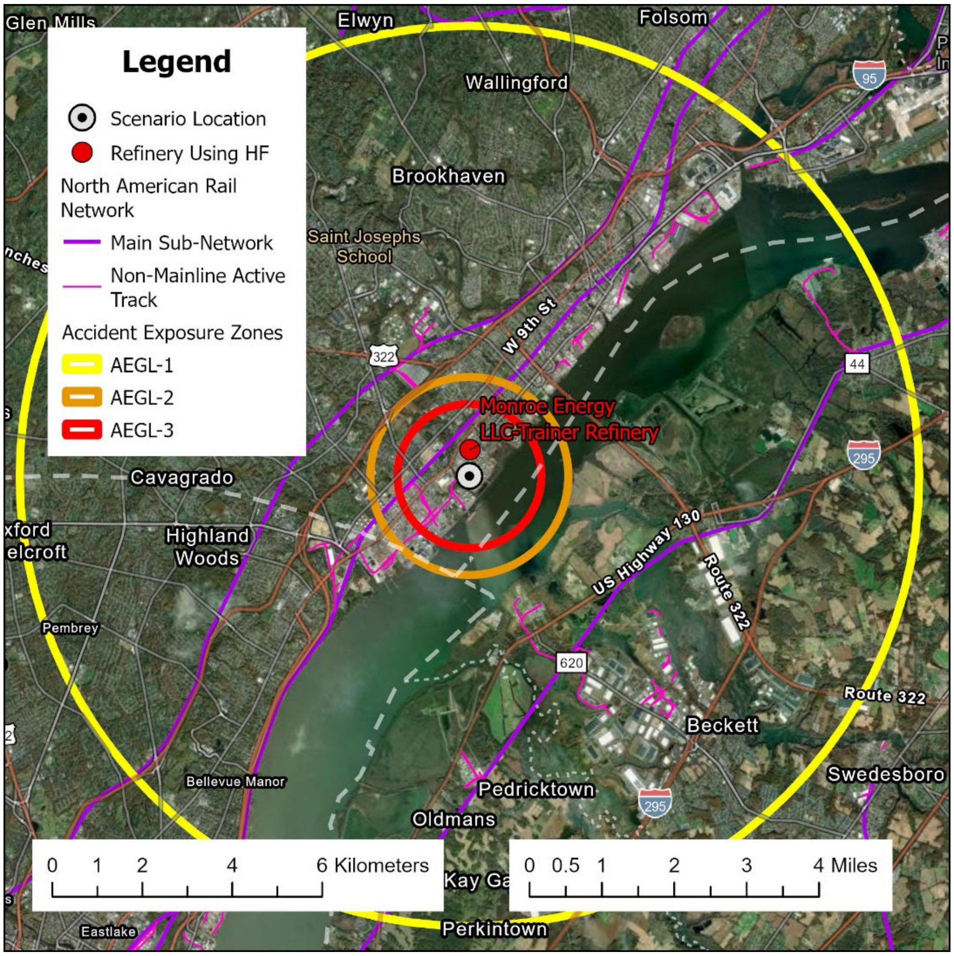
[s] The plumes ALOHA generates, predicting the extent of the plume that would form in this and Petitioners' other release scenarios, cover roughly 10% of the land area within the corresponding circle. *See generally* Appendix C, Part III, Figures 16-20 (plume graphics from ALOHA runs). The cloud may capture more than 10% of the population within the circle, or less, depending on the relative population densities within the given threat zone.

All of the modeled plumes point straight east from the release point because ALOHA assumes the wind would be blowing from west to east at the time of release.

EPA's RMP regulations direct refiners to use the same basic rotation approach to describe the threat ("offsite impact") zones for their worst-case scenarios. *See* 40 C.F.R. § 68.30 (Defining offsite impacts—population), subsection (a) ("The owner or operator shall estimate in the RMP the population within a circle with its center at the point of the release and a radius determined by the distance to the [toxic] endpoint defined in § 68.22(a)).

[t] EPA's RMP Guidance directs refiners to "use the most recent Census data or any other source of data that you believe is more accurate," to estimate the residential population within their modeled worst-case release zones. EPA RMP Guidance, *supra* fn. m, at 11–1. The regulations do not require refiners to present breakouts for any sensitive subpopulations, *see* 40 C.F.R. § 68.30, and no RMP Petitioners reviewed included breakouts.

Figure 10: Threat zone for Trainer, Pennsylvania HF railcar unloading release



	People in areas with HF levels at or above AEGL-3 (red zone)	People in areas with HF levels at or above AEGL-2, but below AEGL-3 (orange zone)	People in areas with HF levels at or above AEGL-1, but below AEGL-2 (yellow zone)
Total residential population	4,212	5,207	204,884
Young children (less than 5 years old)	193	255	11,166
People 65+ years old	646	689	37,539
People with asthma	592	688	22,105
People with coronary heart disease	351	405	13,587
People with chronic obstructive	466	530	14,234

pulmonary disease (COPD)			
People in poverty[u]	811	1,192	20,207
People 5 and older living in linguistically isolated households[v]	43	118	3,005

3. Release following derailment (Philadelphia)

The following scenario describes what could happen if the outlet valve on an HF railcar failed during a derailment in central Philadelphia, enroute to the Trainer refinery.[w] No refinery-based emergency-shutoff or rapid-drainage equipment would be available to first responders in the event of an offsite release, and it would be extremely dangerous and contrary to protocol for a person to approach an active HF release.[x] Petitioners did not assume the release would be stopped 10 minutes after it started.[y] This resulted in a longer peak-exposure timeframe, so Petitioners applied the 60-minute AEGLs (again using the AEGL timeframe that corresponded most closely to the timeframe during which ALOHA predicted HF levels one kilometer from the source would peak). The following figure shows the resulting threat zones and population counts:

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[u] People in poverty are those living below the Federal poverty level, based on their income over the past year. Appendix C, Part IV.

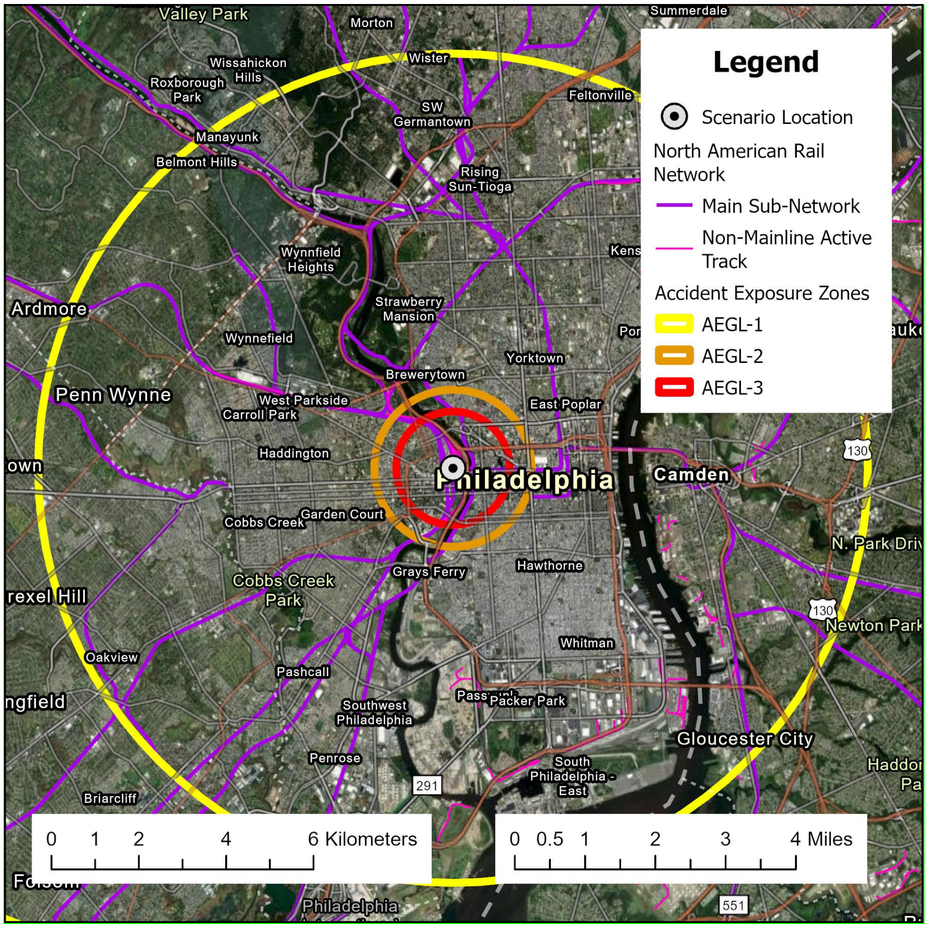
[v] Linguistically isolated households are those in which, according to Census data, no one 14 or older (1) speaks English only, or (2) speaks a language other than English at home and speaks English very well. Appendix C, Part IV.

[w] Petitioners assumed the railcar would derail where the route passes Walnut Street, along the Schuylkill River. Appendix C, Part I.C & Figure 8.

[x] The *Emergency Response Guidebook*, prepared for first responders by the U.S. Department of Transportation and its Canadian and Mexican counterparts, specifies minimum initial isolation distances of 1,500 feet in all directions in the event of a large anhydrous HF release from a rail tank car, and 700 feet in all directions for a large release from a highway tank truck or trailer. U.S Dept. of Transp. *2024 Emergency Response Guidebook*, 343 (last visited Jan. 31, 2025) https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/2024-04/ERG2024-Eng-Web-a.pdf.

[y] The release parameters Petitioners developed for this scenario show that the railcar would continue emptying for more than 11 hours (until the fill level dropped below 50%). Appendix C, Part II.A.3, Figure 13. Due to cutoffs built into the ALOHA software Petitioners used, *see supra* note q, the maps and population counts presented here account for just cloud formation during the first hour following the release, and within a 10-kilometer radius of the release point.

Figure 11: Threat zone for Philadelphia, Pennsylvania HF railcar derailment release



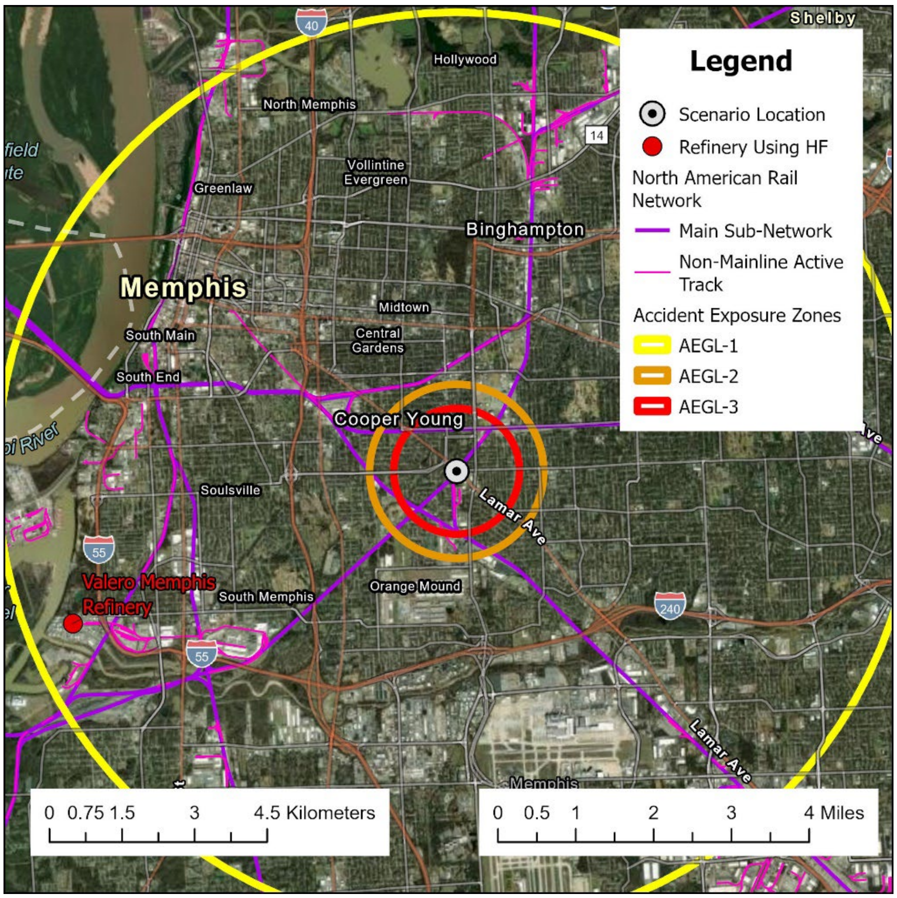
	People in areas with HF levels at or above AEGL-3 (red zone)	People in areas with HF levels at or above AEGL-2, but below AEGL-3 (orange)	People in areas with HF levels at or above AEGL-1, but below AEGL-2 (yellow)
Total residential population	43,062	45,059	1,095,660
Young children (less than 5 years old)	759	1,623	65,323
People 65+ years old	5,887	5,831	142,964
People with asthma	4,776	4,802	129,967
People with coronary heart disease	1,926	1,917	72,815
People with chronic obstructive pulmonary disease (COPD)	1,888	1,842	83,387
People in poverty	6,994	7,063	253,270

People 5 and older living in linguistically isolated households	1,506	691	65,036

4. Release following derailment (Memphis)

The following figures and table, prepared using the same methodology described for the Philadelphia scenario, show what could happen (again, in the first hour following the release and within a ten-kilometer radius of the release point) if a railcar delivering HF to the Joliet or Lemont, Illinois refineries derailed while moving through Memphis, Tennessee.[z]

Figure 12: Threat zones for Memphis, Tennessee HF railcar derailment release



	People in areas with HF levels at or above AEGL-3 (red zone)	People in areas with HF levels at or above	People in areas with HF levels at or above

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[z] Petitioners assumed the release would occur where the rail line intersects with Lamar Avenue. Appendix C, Part I.C & Figure 9.

		AEGL-2, but below AEGL-3 (orange)	AEGL-1, but below AEGL-2 (yellow)
Total residential population	6,599	5,751	266,106
Young children (less than 5 years old)	438	350	19,360
People 65+ years old	1,065	910	39,264
People with asthma	965	843	35,169
People with coronary heart disease	596	515	20,728
People with chronic obstructive pulmonary disease (COPD)	847	744	28,944
People in poverty	1,600	1,398	69,368
People 5 and older living in linguistically isolated households	13	7	8,531

b. Truck release scenarios

On information and belief, some of the United States' HF-using refineries, including the Torrance and Wilmington refineries in greater Los Angeles, rely on truck deliveries of HF from Honeywell. The following scenarios help illustrate the implications of this traffic.

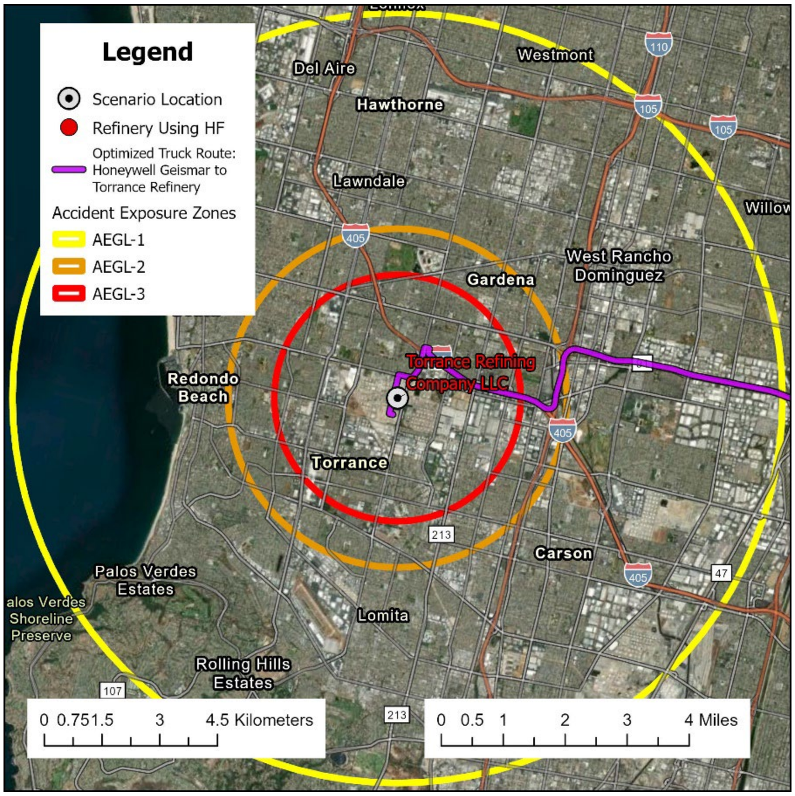
1. Routes

Petitioners used commercial truck-routing software to determine practical routes for a cargo truck carrying HF from Geismar, Louisiana to the Torrance and Wilmington refineries.[153] The recommended Torrance route is 1,890 miles long, requires an estimated 28 hours of driving time, and passes through Baton Rouge, Alexandria, and Shreveport, Louisiana; Dallas, Abilene, and El Paso, Texas; Las Cruces, New Mexico; Tucson and Phoenix, Arizona; and Riverside and Anaheim, California.[154] The recommended Wilmington route is similar in length (1,888 miles, 27 hours' driving time) and passes through the same cities.[155]

2. Release during truck unloading (Torrance)

The following figures show what could happen if an HF truck tanker's outlet valve failed during unloading at the Torrance refinery alkylation unit. Petitioners applied the 10-minute AEGLs, because they corresponded most closely to the timeframe during which ALOHA predicted outdoor HF concentrations would peak a kilometer downwind from the source.[aa]

Figure 13: Threat zone for Torrance, California HF truck unloading release



	People in areas with HF levels at or above AEGL-3 (red zone)	People in areas with HF levels at or above AEGL-2, but below AEGL-3 (orange)	People in areas with HF levels at or above AEGL-1, but below AEGL-2 (yellow)
Total residential population	83,099	104,159	628,579
Young children (less than 5 years old)	4,170	6,065	35,292
People 65+ years old	13,551	17,154	93,523
People with asthma	7,079	9,236	62,356
People with coronary heart disease	4,184	5,619	35,016

[aa] See Appendix C, Part III, Figure 18 (ALOHA modeling results for Torrance unloading scenario, "Concentration at Point" chart).

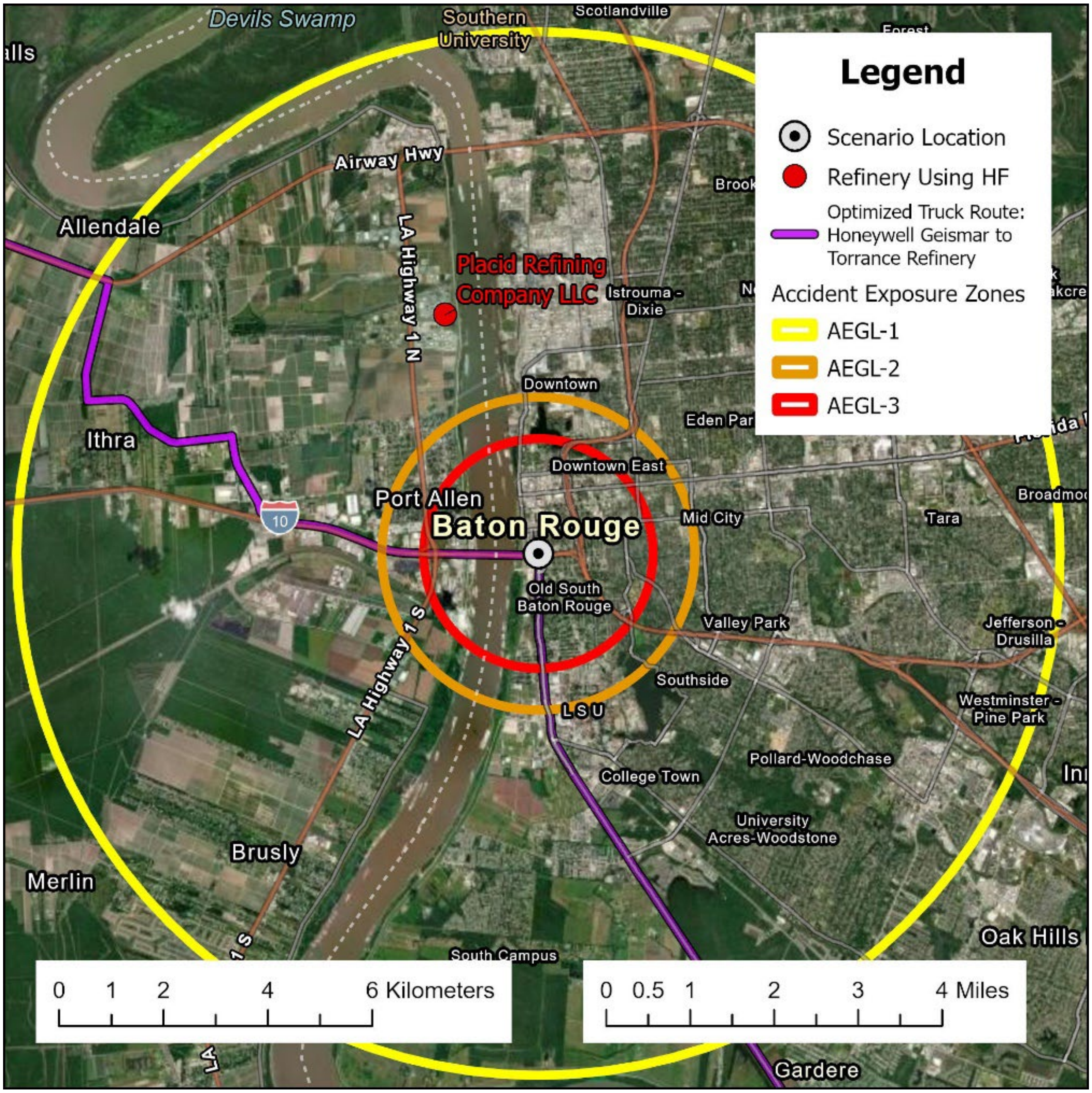
People with chronic obstructive pulmonary disease (COPD)	3,567	4,878	32,840
People in poverty	7,282	9,122	68,387
People 5 and older living in linguistically isolated households	7,991	9,569	45,430

3. Release following truck crash (Baton Rouge)

The following figures show what could happen if the outlet valve on an HF tanker truck failed while moving through Baton Rouge, Louisiana or Phoenix, Arizona, on its way to the Torrance or Wilmington refineries. As in the Philadelphia and Memphis derailment scenarios, Petitioners applied the 60-minute AEGLs, because those correspond most closely to the peak-outdoor-concentration timeframe shown in ALOHA.[bb]

[bb] Appendix C, Part III, Figures 19-20 (ALOHA modeling results for Baton Rouge and Phoenix truck crash scenarios, "Concentration at Point" tables).

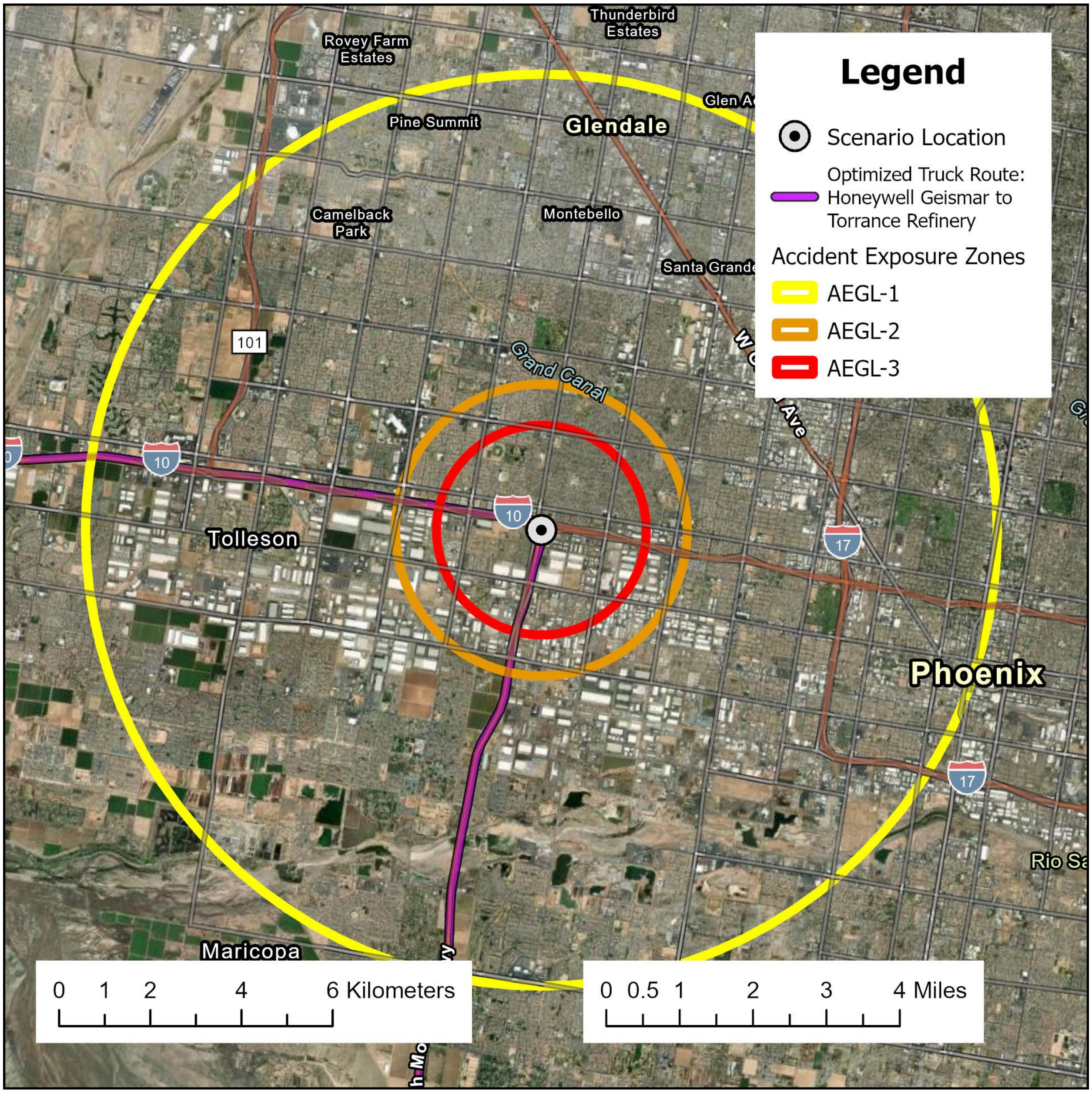
Figure 14: Threat zone for Baton Rouge, Louisiana HF truck crash release



	People in areas with HF levels at or above AEGL-3 (red zone)	People in areas with HF levels at or above AEGL-2, but below AEGL-3 (orange)	People in areas with HF levels at or above AEGL-1, but below AEGL-2 (yellow)
Total residential population	12,785	11,566	153,935
Young children (less than 5 years old)	509	555	9,246

People 65+ years old	1,788	1,476	21,985
People with asthma	1,549	1,353	17,140
People with coronary heart disease	902	640	10,041
People with chronic obstructive pulmonary disease (COPD)	1,127	781	12,134
People in poverty	3,801	2,264	38,358
People 5 and older living in linguistically isolated households	265	188	2,923

Figure 15: Threat zone (Phoenix, AZ HF truck crash release)



	People in areas with HF levels at or above AEGL-3 (red zone)	People in areas with HF levels at or above AEGL-2, but below AEGL-3 (orange)	People in areas with HF levels at or above AEGL-1, but below AEGL-2 (yellow)
Total residential population	41,739	33,695	509,053
Young children (less than 5 years old)	3,084	2,274	37,293

People 65+ years old	2,985	2,455	39,476
People with asthma	4,245	3,737	55,594
People with coronary heart disease	2,186	2,092	28,841
People with chronic obstructive pulmonary disease (COPD)	2,497	2,407	33,668
People in poverty	7,308	8,599	99,637
People 5 and older living in linguistically isolated households	3,760	3,177	35,154

The closest refineries to Phoenix are in southern California (Wilmington and Torrance) and southeastern New Mexico (Artesia, between Carlsbad and Roswell). [cc] This release scenario underscores how the U.S. refineries' use of HF threatens even some people living thousands of miles away from any HF-using refinery. The other scenarios highlight how the transportation of HF compounds the exposure and health risks faced by those living in or near the "worst-case" threat zones EPA requires refiners to estimate for onsite HF releases.

5. HF clouds can spread rapidly

EPA's RMP regulations do not require refiners to say how quickly the HF clouds modeled for their worst-case release scenarios would spread. In the typical daytime conditions on which Petitioners' transportation release scenarios are based, the cloud would travel and HF concentrations at ground level would reach AEGL-3 (the highest threshold, for potentially fatal health effects) at close to the modeled wind speed of 3 meters per second (m/s), at rates of 5.8-6.3 miles per hour.[dd] Those are moderate running speeds for a healthy adult with no mobility impairment.

[cc] *See supra* at 3 (Figure 3 "Map of the United States' 42 HF-using refineries"); *see also* Appendix A (calculating affected population under worst case scenarios from these refineries).

[dd] Appendix C, Part III, introductory text and table showing distance, time, and speed metrics. Petitioners also directed ALOHA to assume an atmospheric stability rating of D. EPA has characterized a 3 meter per second wind speed and a stability rating of D "as conditions likely to be applicable to many sites" in the RMP program. EPA RMP Guidance, *supra* fn. n, at 7–1.

6. Many communities would face significant challenges in responding to a major HF release

i. There are multiple, substantial barriers to organizing an effective emergency response

In the event of a major HF release, emergency responders would need to quickly establish evacuation zones and issue shelter-in-place orders. They would also need to carry out decontamination procedures and rescue operations for those injured or exposed. High population density, linguistic diversity, and other characteristics of many communities bordering refineries, railroads, and highways pose substantial barriers to organizing an effective emergency response.

As recent wildfires and hurricanes have demonstrated, it can be extremely challenging to mount an effective emergency response to a mass catastrophe. Evacuation orders in metropolitan areas often cause traffic jams even when there is plenty of advance warning of the emergency,[156] trapping people in harm's way. Particularly if a release disrupted public transportation, it could become impossible for people without immediate access to private vehicles to escape or reach shelter before the HF cloud overtook them. If an HF release were caused by natural disaster, *see* Part III.B.7.iv, or the HF cloud itself damaged vehicles and buildings in its path, *see* Part IV.C, that would further complicate evacuations, shelter-in-place orders, deployment of medical personnel and chemical-control experts, and other emergency responses.

Another challenge is that some of the communities surrounding U.S. refineries are very language diverse. For example, about 40% of students in Torrance's public school system and 41% of all Torrance residents speak a language other than English at home.[157] Any emergency-response messages with a reasonable expectation of reaching all residents would need to be communicated in multiple languages, including Arabic, Mandarin, Spanish, Japanese, Portuguese, and Korean. Most residents of Wilmington, California speak Spanish at home,[158] making Spanish-language emergency communication a necessity. Some members of petitioners' organizations do not recall receiving emergency messages following release and near-miss events at local refineries—much less messages in languages other than English.

Shelter-in-place orders could ameliorate some of the challenges associated with evacuations, but (even assuming shelter-in-place protocols are widely understood, practiced, and obeyed) they are no guarantee against harmful HF exposure. A spreading cloud from a major release would cause HF concentrations to build indoors as well as outdoors. Although sheltering indoors is likely to reduce one's initial exposure relative to staying outdoors, adequate shelter-in-place procedures can be complex to implement, and the level of protection can vary radically depending on building architecture and purpose. All else being equal, the leakier a building is, the more readily outside air will penetrate it, and the more quickly HF levels will build inside. The following chart, derived from a 2001 technical manual prepared for Department of Defense emergency planning use, illustrates how levels of air infiltration (described in terms of air changes per hour, or ACH) can vary according to the type of structure someone is sheltering in.[159] The higher the air exchange rate, the leakier and less protective the building is.[160]

Figure 16: Estimated air infiltration rates for different types of structures

Type of Structure	Air changes per hour (ACH)
Modern residences with energy-conserving features, where occupants never feel drafts from outdoors	0.30
Single family, unoccupied new (4-year-old) house with closed doors and windows	0.38 to 0.53
Modern residences 10-50 years old, where occupants can feel some drafts on windy days	0.75
Older residences, where drapes move due to drafts	1.2
Mobile homes with doors and windows closed and air conditioning/heating systems turned off	1.98
Schools and theaters	3.0
Clubs and restaurants	5.0
Factories, warehouses, and transportation facilities	10.0

The air dispersion modeling Petitioners conducted to prepare their transportation scenarios shows that HF levels inside even relatively modern, airtight homes would eventually exceed the AEGL thresholds for potentially lethal or disabling health effects. In the Philadelphia derailment scenario, HF levels in a 0.75-ACH home located a kilometer downwind of the release point, would exceed the AEGL-2 (potentially disabling) threshold about 40 minutes after the start of the release, and continue rising through the end of the one-hour period modeled in ALOHA.[ee] In the Baton Rouge truck crash scenario, HF levels inside a comparable home would build to above the AEGL-3 threshold about 30 minutes following the start of the release, and remain above the AEGL-3 threshold at the end of the hour.[ff]

As Figure 16 indicates, people trying to shelter in homes, schools, and commercial and industrial structures with more air changes per hour may experience much *higher* rates of HF intrusion and indoor exposure.

[ee] Appendix C, Part III, Figure 17 (ALOHA computational outputs for Philadelphia derailment scenario, "Concentration at Point" chart, blue dashed line denoting indoor air concentration); *see also* Figure 2, *supra*.

[ff] Appendix C, Part III, Figure 19 (ALOHA computational outputs for Baton Rouge cargo truck crash scenario, "Concentration at Point" chart, blue dashed line denoting indoor air concentration); *see also* Figure 2, *supra*.

ii. Certain population subgroups are particularly vulnerable to exposure and harm following a refinery-related HF release

TSCA provides that, in determining whether a given chemical substance and condition of use presents an unreasonable risk of injury to health or the environment, EPA (or a reviewing court) must consider not only subgroups of people who are particularly susceptible to injury following exposure, but also subgroups of people who are particularly likely to be exposed in the first place. 15 U.S.C. §§ 2605(a), 2620(b)(4)(B)(ii) ("an unreasonable risk of injury to health or the environment" "includ[es] an unreasonable risk to a potentially exposed or susceptible subpopulation"); *id*. §2602(12).

a. Refinery-related workers are particularly vulnerable

Because they are likely to be closest to the release point, refinery-related workers are most likely to be exposed to—and killed or seriously harmed by—an HF release. Susceptible workers include on-site refinery staff, in the event of a release from an alkylation unit; and train and truck operators, in the event of a release from an HF-delivering train or truck. In addition, first responders and medical personnel would be at risk of secondary contamination during rescue operations, adding to the confusion and complexity of the response. One reason for increased risk to those groups is that as an HF cloud expands, the concentrations of HF within it tend to drop. Another is that, in the event of a smaller release, workers may be the only ones exposed.

Workers close enough to a failed HF pipe, refinery vessel, railcar, or tanker car also face the risk that *liquid* HF will be spilled or sprayed directly onto their skin or into their eyes.[gg] Such concentrated exposures are particularly likely to cause death or disability, as documented in prior industrial releases of HF.[161] Vulnerable workers include not only those who are normally based onsite at the refinery, but also temporary contract workers (like construction workers) brought in to help repair, inspect, and/or rebuild equipment during major scheduled maintenance shutdowns known as "turnarounds."[162]

b. Low-income people and people of color are particularly vulnerable

In many parts of the country, including areas around refineries profiled in this petition, low-income people and people of color face a disproportionate threat of exposure to a toxic HF cloud. Due to the legacy of institutional racism in the U.S., people of color are more likely to live in poverty than their white peers.[163] And regardless of income, heavy industry like refining is more likely to be located in neighborhoods that are disproportionately Black or Latine.[164] This leaves

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[gg] Very close to the release point, where the HF first escapes containment and enters the atmosphere, the chemical could move considerably more quickly than wind speed, and far too fast for even the fittest worker or emergency responder to outrun. *See, e.g.*, Appendix C, Figures 12-15, meters/second figures in rows marked "Two-phase jet velocity."

many communities of color and lower-income communities especially vulnerable to the risks of a release from an HF-using refinery.[165]

Similarly, low-income people and people of color are more likely to occupy older homes and apartments that are less airtight.[166] This makes them more likely, all else being equal, to be exposed to higher indoor air concentrations of HF following a release.

Low-income people and people of color may also be less equipped to take precautions and procure prompt—or any—medical help in the event of a release. They may struggle to access transportation to medical facilities,[167] lack health insurance,[168] or be unable to take time off of work to seek treatment.[169] Latine Americans, Asian Americans, and Indigenous Americans are also more likely than white or Black Americans to speak a first language other than English,[170] making it potentially harder for those groups to understand broadcasts alerting people to an HF release and advising them to shelter in place and/or seek medical attention for exposure symptoms.

7. The likelihood of a catastrophic refinery-related HF release in the United States is substantial and growing

As EPA has acknowledged, a history of chemical releases at a specific facility often reveals "a failure to properly address circumstances leading to subsequent accidents."[171] EPA has also noted that when a facility is in an industrial category (such as oil refineries or chemical plants) that has experienced a particularly high rate of RMP-reportable incidents, that is a reason to regulate facilities that category more tightly, in an effort to prevent more incidents in the future.[172]

As discussed below, the U.S. refinery sector has a long record of HF releases and so-called "near miss" incidents that nearly caused releases. U.S. refineries have a particularly poor overall safety record relative to both refineries elsewhere in the world and most other major industrial facilities in the United States. Our country's HF-using refineries are also aging and increasingly prone to extreme weather-related disruptions. Each of these factors increases the likelihood of further releases, including catastrophic ones.

i. HF has been released repeatedly from U.S. refineries, and several refineries have narrowly avoided catastrophic releases

Since the late 1980s, HF has been released from alkylation units at U.S. oil refineries at least 79 times. The documented releases killed one worker and injured more than 100.[173] In addition, refineries have experienced fires, explosions, and other failures that nearly led to large HF releases. Several of these incidents are described below; additional incidents and details are included in **Appendix B**.

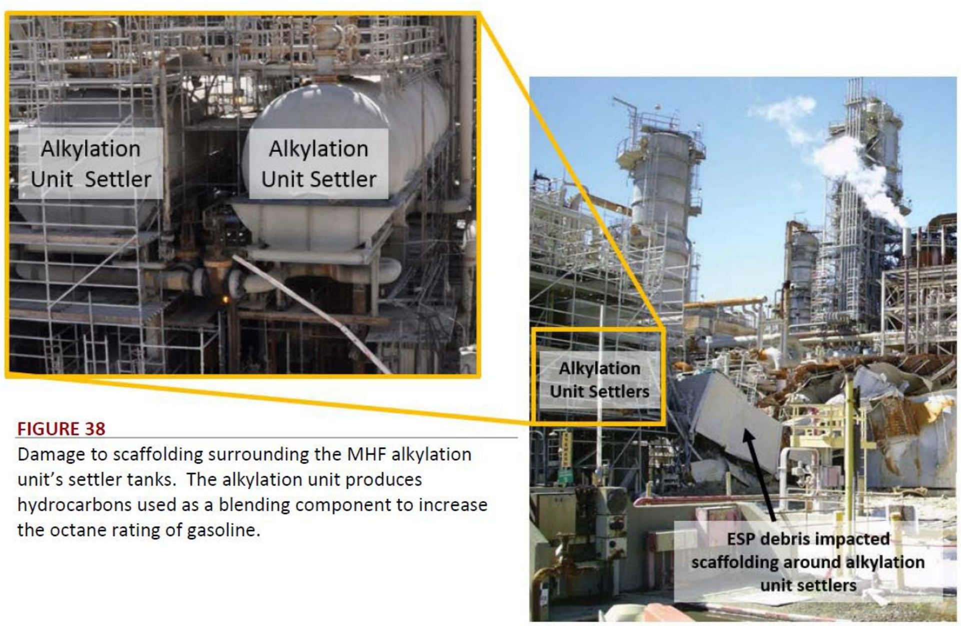
a. The 1987 Texas City release and evacuation

In 1987, a crane dropped a large piece of equipment onto an HF tank within the alkylation unit at the Marathon refinery in Texas City, shearing two HF lines leading to the top of the tank.[174] The sheared lines released an estimated 30,000 to 53,000 pounds of HF.[175] Mitigation systems meant to contain the release and warn nearby people failed.[176] More than 1,000 people sought hospital treatment,[177] and hospitals admitted 95 people.[178] An epidemiological study found a strong relationship between people's HF exposure during the incident and continued breathing and eye problems,[179] with some people still suffering from severe breathing problems, headaches, and nausea two years later.[180] The U.S. Chemical Safety and Hazard Investigation Board (also known as the Chemical Safety Board, or CSB) observed that the release killed wildlife and vegetation along a three-mile-long, half-mile-wide path from the refinery.[181] The refinery is still operating, and still using HF.

b. The 2015 Torrance, California, near-release

In 2015, the electrostatic precipitator (ESP)—a pollution control device—at the Torrance, California, refinery exploded during maintenance.[182] A 40-ton piece of debris from the electrostatic precipitator struck scaffolding surrounding an HF tank in the alkylation unit, coming within a few feet of the tank itself.[183]

Figure 17: CSB report graphic on the Torrance refinery explosion, showing how close debris from the electrostatic precipitator (ESP) came to HF tanks in the alkylation unit.[184]



In its investigation, the CSB found that then-owner ExxonMobil had not analyzed the risks of the proximity of the HF unit to the ESP, because Exxon believed the ESP was too far from the HF unit to pose a risk.[185] A subsequent EPA inspection found that Torrance's management structure for implementing the RMP was "superficial"; that systems and equipment within the alkylation unit—"even those identified as safeguards"—routinely did not work; and that some would go unrepaired "for multiple weeks."[186] EPA also found that Torrance's calculations of its worst-case scenario analysis were inaccurate, possibly underestimating potential offsite consequences of a release.[187] After the disaster, Exxon sold the refinery to its current owner, PBF Energy.[188] Following an abandoned regional ban effort, the refinery is still using HF for alkylation.[189]

c. The 2019 Philadelphia release

In 2019, the former Philadelphia Energy Solutions refinery just outside downtown Philadelphia released more than 5,200 pounds of HF (along with propane and other hydrocarbons) when a fifty-year-old pipe ruptured, causing a series of large explosions powerful enough to hurl a 19-ton projectile across the Schuylkill River.[190]

Figure 18: Video still of one of the 2019 Philadelphia refinery explosions, showing a 19-ton projectile (labeled "Portion of V-1") that flew more than 2,000 feet[191]

Fortunately, a heroic worker was able to divert 339,000 pounds of HF—most of the refinery's inventory—to its rapid acid deinventory system, preventing a far larger HF release and formation of a larger cloud. [192] However, the refinery's water pumps, meant to feed a water mitigation system to suppress an HF cloud, did not turn on because the explosion cut off the communication link to those pumps; the backup "uninterruptible" power supply system failed nine seconds later.[193] It took forty minutes for a worker to enter the area wearing firefighting gear and turn on the water pumps manually.[194] The refinery's owner estimated that less than half of the HF released was contained by the spray system.[195] Five refinery workers and a first responder were injured,[196] and property damage was so extensive that the refinery never reopened and has been dismantled.[197] The CSB investigation revealed that the incident could have been much worse. The explosions propelled wreckage as far as 2,100 feet,[198] while tanks holding large amounts of HF were between 140 feet and 200 feet away from the explosion site;[199] had those tanks been punctured, the results could have been catastrophic.

d. Additional incidents involving HF releases; other releases of toxic chemicals; and fires and explosions at the 42 U.S. refineries still using HF for alkylation

Appendix B summarizes the records Petitioners have compiled on HF and other toxic releases, fires, and explosions at the 42 U.S. refineries still using HF for alkylation.[hh] It shows that since 1987:

- At least 26 refineries have had a documented HF or hydrofluoric acid leak.
- At least 32 refineries have experienced at least one explosion or fire, and many have had multiple fires or explosions.
- At least 21 refineries have had a gas leak, explosion, fire, or other incident severe enough to cause documented off-site consequences (such as shelter-in-place or evacuation orders).

More than 500 workers have been injured, and more than 40 have been killed, in a range of incidents at these refineries.

ii. The U.S. refineries still using HF for alkylation are old

All of the U.S. refineries still using HF for alkylation are at least 40 years old, and some are more than a century old.[ii] All were built and running by the time of the Goldfish field release tests.[200] On information and belief, most or all of the United States' still-operating HF alkylation units were designed and developed at a time when regulators and industry representatives may have believed that HF would remain in an easier-to-contain liquid pool if released.

Older refineries, particularly those that have not been updated to meet modern process safety standards, are more failure- and release-prone in general because they were designed without the benefit of the newest safety and operating knowledge. Their equipment (if it has not been replaced recently) is also more likely to have deteriorated in ways that compromise its structural integrity and reliability. For example, the CSB found that the pipe that ruptured and triggered

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[hh] Petitioners compiled this information from sources including EPA's RMP data, OSHA data, U.S. Coast Guard release data, media reports, and databases assembled by fellow nonprofits. Their figures exclude incidents at the 20 or so HF-using refineries that have closed since 1987. They may also understate the actual incident rates and associated deaths and injuries at the 42 still-operating HF refineries. To the best of Petitioners' knowledge, there is no federal requirement to track all toxic release or near-miss incidents at refineries (as opposed to releases above a certain threshold volume, as with EPA's Toxics Release Inventory database, or incidents associated with an onsite worker's death or serious injury). Deaths or injuries that occur offsite, or well after the incident, also may not find their way into the incident data.

[ii] *See* Appendix A, "Year built" and "Age" columns. The Torrance refinery is about 96 years old; the Wilmington refinery is about 46; the Joliet refinery is about 53; the Lemont refinery is about 99; the Garyville refinery is about 49; and the Trainer refinery is 100 years old. *Id*.

massive explosions at the former Philadelphia Energy Solutions refinery in 2019 was installed around 1973.[201] Over time, that pipe had corroded from 0.322 inches at installation to only 0.011 inch thick—about half the thickness of a credit card[202]—less than 7% of the thickness level at which the refinery typically retires piping.[203]

iii. U.S. refineries have a particularly poor industrial-safety record

U.S. refineries' safety record is poor, relative to both other U.S. industrial sectors and refineries internationally, and this poor general safety record speaks to the inability of refineries to handle HF safely. EPA has found that the accident rate for the oil refining and coal manufacturing sectors is more than seven times higher than the total rate for all facilities it regulates under the RMP program, which also includes chemical wholesalers and oil and gas extraction.[204]

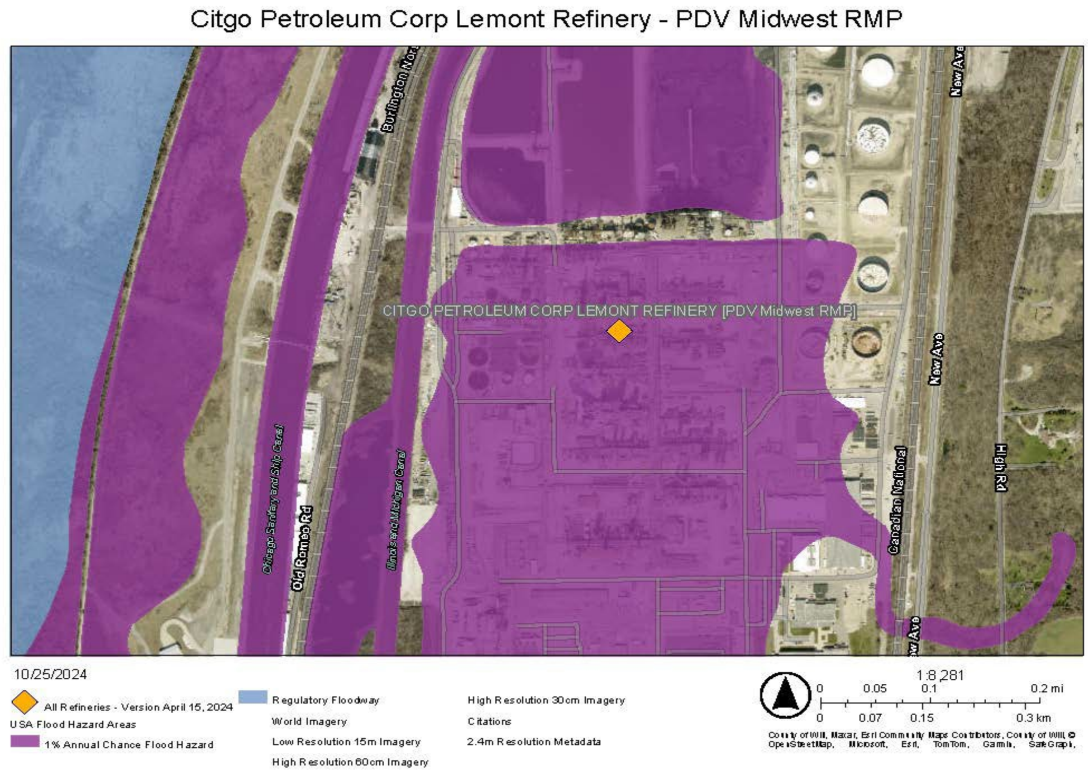
A 2016 report by the international insurance giant Swiss Re[205] found that, controlling for capacity, refineries in the United States (plus Canada, the U.K., and Australia, the so-called "USA cluster") are more dangerous than refineries in the former Soviet Union, Southwest Asia/North Africa, and Asia.[206] Swiss Re found that multiple factors—including USA cluster refineries' culture of "pushing the operating envelope," limited maintenance, plant complexity, variable inspection practices, and pressure to keep staffing levels at a minimum—contribute to this heightened danger.[207]

iv. U.S. refineries are increasingly vulnerable to extreme weather, a common cause of chemical releases

Extreme weather events fueled by climate change also increase the chances of a catastrophic refinery-related HF release.[208] Climate change is driving increases in extreme weather around the U.S., including heavy rainfall events;[209] longer, more intense heatwaves;[210] and more flooding from hurricanes.[211] Flooding, heat waves, deep freezes, high winds, and other extreme weather patterns at industrial facilities can damage equipment and trigger losses of power and water to critical warning and containment systems.[212] In summer 2024, the CSB warned the public that hurricanes may trigger additional disasters at facilities using hazardous chemicals.[213] In 2024 alone, severe weather damaged or disrupted operations in at least two of the refineries that are still operating and using HF. The Joliet refinery in Illinois lost power due to a tornado outbreak,[214] and severe weather triggered a fire at the Wynnewood refinery in Oklahoma.[215] As these examples show, extreme weather can stress and potentially damage refinery equipment, increasing the risk of releases and making any such release harder to mitigate.

Federal Emergency Management Agency (FEMA) data show that some of our country's HF-using refineries are especially vulnerable to flooding. For example, most of the Lemont refinery southwest of Chicago sits within a 100-year floodplain, as shown on the following map.

Figure 19: Lemont, Illinois refinery overlaid with (in purple) FEMA-designated 100-year floodplain[216]



Five other HF-using refineries also lie substantially within FEMA floodplains, and two more would be in floodplains but for the protection of levees.[217] Because FEMA's maps likely understate the true flood risks in many parts of the country after accounting for consequences of climate change, like sea-level rise and increased precipitation,[218] many more refineries could be at risk of flooding—or more frequent and severe flooding—than the maps suggest.[219] Flooding at an HF-using refinery could compromise the sensitive systems meant to prevent or mitigate a potential release.

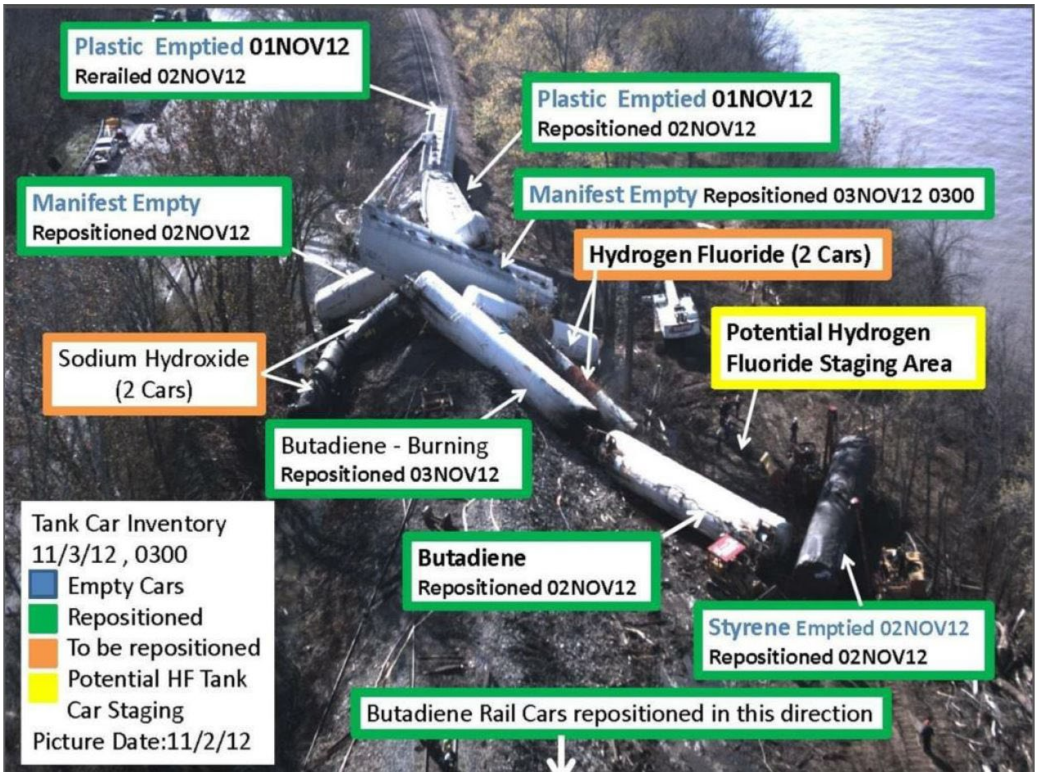
v. HF has escaped from railcars and trucks, and HF railcars have derailed, in the United States

In 1997, 150 people were evacuated from a half-mile zone around a Memphis, Tennessee, railyard due to an HF leak from a railcar.[220] The car had been repaired and returned to service.[221] It was part of the U.S. Department of Transportation 112 class, one of several classes still used for HF transportation.[222]

HF-bearing railcars have also derailed before. In October 2012, a train carrying HF tank cars, along with cars holding other chemicals, derailed south of Louisville, Kentucky.[223] The derailment resulted in the breach of two tank cars carrying styrene monomer and butadiene.[224]

Fearing an HF release, authorities issued shelter-in-place orders, and a mandatory evacuation of surrounding homes.[225]

Figure 20: Kentucky railcar derailment scene showing overturned HF tank cars[226]



Disasters involving other chemicals hint at the devastation that further rail releases of HF could cause. In 2005, two trains in Graniteville, South Carolina, collided and derailed.[227] The collision punctured a tank car carrying chlorine, forming a gas cloud that expanded at least 2,500 feet north and 900 feet south from the collision site.[228] Nine people died from chlorine gas inhalation, including the train engineer and eight people who worked or lived nearby.[229] More than 550 people were treated at hospitals, and 5,400 people were evacuated.[230]

Trucks carrying HF have also had dangerous mishaps. In 2009, a truck carrying sixteen tons of hydrofluoric acid overturned in rural Wind Gap, Pennsylvania, and developed a drip leak.[231] First responders evacuated people within a mile of the scene; 5,000 people from more than 900 households, plus farm animals, were evacuated.[232] It took about nine hours to stop the HF release.[233]

Figure 21: HF cargo tanker crashed and overturned in Wind Gap, Pennsylvania[234]

In 2011, in St. Clair, Missouri, an HF cargo tanker overturned and leaked, injuring the truck driver and shutting down Interstate 44.[235] And in 2018, HF leaked during transfer from a truck at the Torrance, California, refinery.[236]

Since 2021, at least 32 trains carrying hazardous materials have derailed, leaked, spilled, or exploded (including the one that derailed and released vinyl chloride in East Palestine, Ohio).[237] At least 48 trucks have crashed, leaked, exploded, or otherwise released chemicals.[238] Many of these incidents hurt people, and some were deadly, including a 2023 truck release of anhydrous ammonia (like HF, a cloud-forming chemical) that killed three adults and two children.[239]

IV. Refinery-related HF use also presents unreasonable risks to the environment

A. HF is extremely hazardous to living organisms other than humans

As discussed in Part II, EPA regulates "chemical substances and mixtures which present an unreasonable risk of injury to health or the environment." 15 U.S.C. § 2601(b)(2). As discussed in this Part, HF also poses unreasonable risks to the environment, including air, water, soil, plants, animals, and ecosystems. HF's extreme corrosivity and propensity to cause systemic damage, *see* Parts III.A.1-2, make it very hazardous to a wide range of organisms in addition to humans. HF has the potential to kill, injure, or harm animals and plants.[240] Airborne HF can burn animals' skin.[241] Livestock that drink water or eat plants contaminated with HF can suffer a variety of health effects, such as lameness, bone overgrowth, dental lesions, loss of appetite, decreased milk production, and reproductive harm.[242] Airborne HF can kill leaves and (at higher concentrations) inhibit plant growth and reproduction, and HF does not biodegrade in soil.[243] HF also dissolves easily in water, so it may contaminate aquatic environments and harm the fish and other organisms that inhabit them.[244]

B. A refinery-related HF release could cause severe harm to the natural environment, crops, livestock, and pets

U.S. refineries' HF use exposes not only humans but also the broader environment—including the wildlife, livestock, crops, and pets that inhabit that environment—to unreasonable risks of death and permanent injury.

The 2012 Gumi, South Korea release discussed at Part III.B.3 provides one example of an HF release with significant ecological impacts. The release killed or injured almost 4,000 agricultural animals and damaged roughly a square mile (212 hectares) of farmland.[245] Fields were posted with placards warning people that the crops were "[n]ot edible" and "[c]ontaminated by the hydrofluoric acid leak."[246] The release also had a long-term impact on the soil and crops. A 2014 study found that the release "significantly affected" the concentration of soluble fluorine in the soil.[247] This in turn affected the fluorine content in rice crops.[248] The study highlighted that further monitoring was "urgently required relating to [the fluorine's] mobility in soil and bioavailability to crops such as rice."[249] The government ultimately burned more than nine thousand tons of crops and trees killed by the release, leaving a barren landscape and causing residents to analogize their trauma to that suffered in the wake of the Fukushima nuclear release.[250] All of these harms stemmed from the release of 8 tons of HF from a single truck—considerably less than what a single railcar can hold, and a small fraction of what could be released in a single refinery incident.[251]

HF releases have likewise already harmed animal and plant life in the United States. The 1987 Texas City release discussed at Part III.B.7.i.a killed wildlife and vegetation along a three-mile-long, half-mile-wide path from the refinery.[252]

There is a substantial risk that another large HF release would cause extensive environmental damage. Some of the United States' HF refineries are located near places particularly vulnerable to environmental harm. For example, the Joliet refinery south of Chicago sits on the banks of the Des Plaines River, about two miles from the Des Plaines State Fish and Wildlife Area. The Area attracts more than 350,000 people annually to enjoy hiking, fishing, and kayaking in its "setting [of] flowing rivers and natural prairie land . . . [with an] abundance of wildlife."[253] The refinery is just over a mile from the Four Rivers Environmental Education Center, where visitors can learn about the bald eagles, American white pelicans, and numerous fish that live in the surrounding ecosystem,[254] and just north of the Midewin National Tallgrass Prairie, where buffalo have been reintroduced.[255] An HF release from Joliet could produce an HF cloud that damages these special ecosystems, killing or otherwise harming sensitive plants and animals.

A release from the Trainer Refinery, on the Delaware River south of Philadelphia, could harm aquatic ecosystems that serve as critical habitat for threatened species such as the Atlantic sturgeon.[256] This area includes sensitive plants like Indian wild rice and waterhemp ragweed, and nesting and hunting habitat for birds including ospreys and peregrine falcons.[257]

The HF-using refinery in Garyville, Louisiana, sits on the banks of the Mississippi and about two miles from the Maurepas Swamp Wildlife Management Area, together home to species Louisiana recognizes as imperiled, including West Indian manatees, alligator snapping turtles, and the western chicken turtle.[258] The Swamp is a popular destination for people interested in seeing these and other rare animals and birds.[259] In 2017, Louisiana received $14 million for engineering projects to restore the Swamp's health after decades of water channeling, logging, and saltwater penetration.[260] An HF release could damage this already-fragile ecosystem, setting back its recovery and harming both wildlife and human visitors.

Even refineries that lie within or close to dense urban areas may have valuable natural resources nearby that could be damaged or destroyed by a toxic cloud following an HF release. For example, a release from the Torrance or Wilmington refineries in Southern California could harm delicate coastal wetlands and ocean habitats.[261]

The Lemont refinery, closer to central Chicago than Joliet, borders recreational lands and waters including the Des Plaines River, the Centennial Trail, the Keepataw Preserve, and the Romeo Prairie Nature Preserve. As shown in Figure 22 a substantial amount of the land within a mile of the refinery's boundary (approximated by the red circle on the following maps) is designated critical habitat for the Hine's Emerald dragonfly, a federally listed endangered species.[262] As shown in Figure 23 much of the land within a mile of the refinery's border remains undeveloped or not intensively developed, encompassing a variety of habitats such as grasslands, wetlands, and deciduous forest. Some of the land within the one-mile radius has also been devoted to agricultural uses, such as cultivation of crops, pasture, and hay. And as shown in Figure 24a significant proportion of the land within the one-mile radius is protected to maintain its natural land cover or primarily natural state.

Figure 22: Critical habitat within a mile of the Lemont refinery boundary[263]

Figure 23: Land uses within a mile of the Lemont refinery boundary[264]

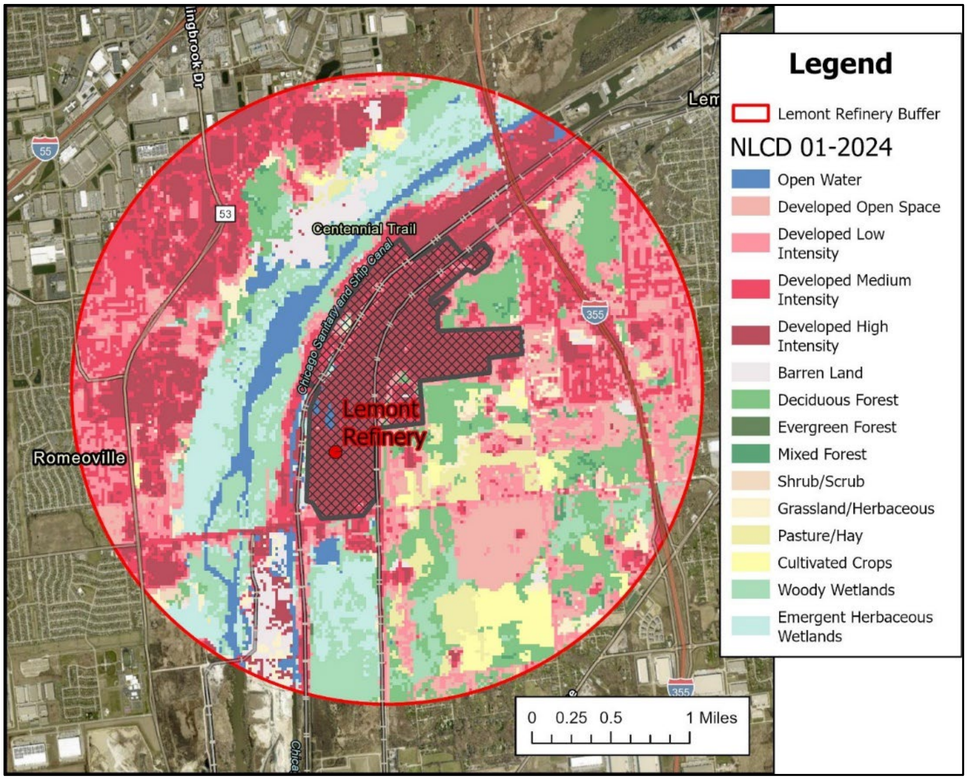
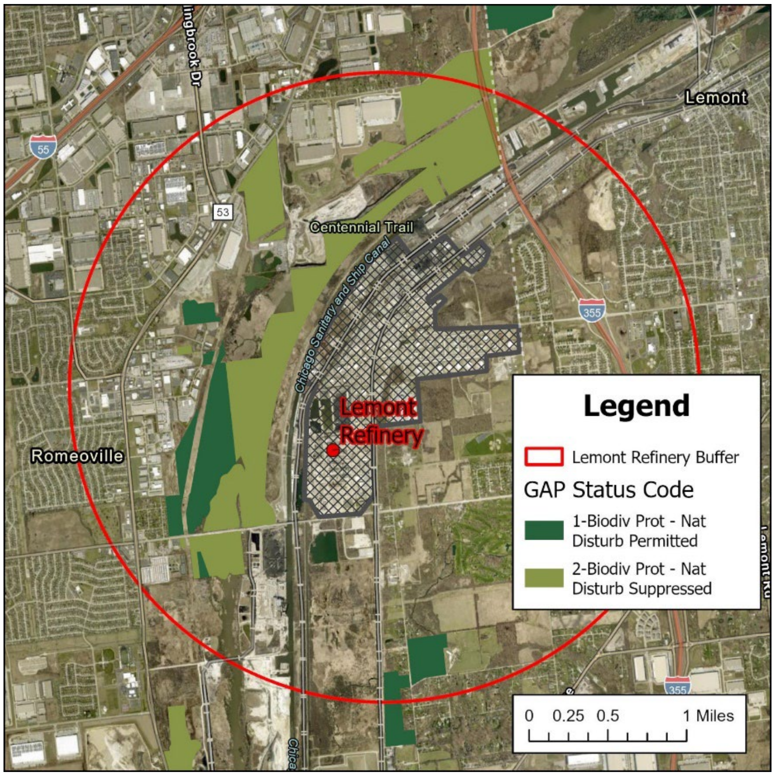


Figure 24: Protected natural areas within a mile of the Lemont refinery boundary[265]



C. A refinery-related HF release could damage the built environment

HF is so exceptionally corrosive that refinery alkylation units must be specially designed to avoid the use of glass, other silica-based materials, and some common metallic materials including aluminum, because they are so readily attacked and damaged by liquid HF.[266] On information and belief, even HF that is spreading through the environment in gaseous rather than liquid form could remain corrosive enough, close to the release point, to damage the built environment. Toxic clouds formed by the release of chlorine gas in the Graniteville train derailment contaminated and destroyed emergency-response vehicles parked nearby.[267] In the event of a major HF release, the spreading cloud's corrosive effects on the built environment could compound harms to human health and the natural environment by making it even more difficult for people to evacuate or find effective shelter—and for emergency responders to help.

V. Existing federal regulation and voluntary industry guidance cannot eliminate the unreasonable risks that refineries' use of HF presents to health and the environment

Existing government and industry initiatives have fallen far short of eliminating the unreasonable risks that refinery use of HF presents to public health and the environment. Major release and near-miss incidents have continued notwithstanding the adoption of various federal reporting requirements, occupational and transportation standards for HF, and the development of and periodic updates to voluntary industry guidance on operation of HF alkylation units.[268] Refiners continue to store hundreds of tons of HF in densely populated areas and near fragile ecosystems across the country, to and cause the regular train and truck transportation of HF through other populated and ecologically sensitive areas.

A. Federal regulation

As EPA has acknowledged, an "assumption that risk will—or could be—managed in the future cannot be used to satisfy [EPA's] statutory obligations to evaluate existing chemical substances under TSCA and manage identified risks." 88 Fed. Reg. 74,292, 74,300 (Oct. 30, 2023).

In March 2024, EPA adopted updates to its RMP regulations that may eventually require HF-using refiners to consider safer alternative catalysts and take additional steps to mitigate release risks. *See* 89 Fed. Reg. 17,622, 17,646-47. But "[n]othing in [the new regulations] forces the adoption or abandonment of any technology or design." *Id*. at 17,652. The compliance deadlines are years away.[jj] And there is reason to question whether the most meaningful updates will ever take effect; oil and chemical industry representatives have already sued in response to and asked EPA to administratively reconsider the forthcoming safer-alternatives analyses and mitigation mandates.[kk]

On information and belief, there is no guaranteed mitigation measure in place at any U.S. HF-using refinery today that could prevent or fully suppress formation of an HF cloud once HF escapes into the ambient air. At best, systems such as water-spray curtains have the potential to reduce the size and extent of the cloud. As the CSB found when it investigated incidents discussed at Part III.B.7.i and in Appendix B, HF has been released repeatedly from U.S. refineries, several refineries have narrowly avoided catastrophic releases, and refinery mitigation systems do not always work. Mitigation systems failed in the 1987 Texas City Release,[269] were absent or nonfunctional during the 2015 Torrance near-miss,[270] failed during the 2009 Corpus Christi release,[271] and failed during the Philadelphia release.[272]

B. Voluntary industry guidance

Because there is so little federal regulation bearing on HF use in refinery alkylation, the most detailed national standards available come in voluntary, industry-developed guidance documents like the American Petroleum Institute's Recommended Practice 751 on "Safe Operation of HF

[jj] *See* 40 C.F.R. § 68.10(g) (giving refiners until May 2027 to comply with referenced mandates); *see also id*. § 68.10(i) (giving refiners until May 2028 to comply with updated planning provisions).

[kk] *See* Joint Mot. for Abeyance at 1-3, *Oklahoma v. EPA*, No. 24-1125 (D.C. Cir. July 29, 2024); *id*. Exhibit A (reconsideration petition) at 1 (listing the American Petroleum Institute and American Fuel & Petrochemical Industry), 3-5 (challenging study and mitigation mandates for facilities including those "with [HF alkylation] processes"); *see also* Order at 1, *Oklahoma v. EPA*, No. 24-1125 (D.C. Cir. July 30, 2024) (granting abeyance to allow EPA time to potentially act on reconsideration).

Alkylation Units" (API 751), first released in 1992.[273] The RMP records Petitioners compiled for this petition[ll] underscore the limitations of relying on voluntary industry guidance to protect the public and environment. According to the RMPs, many of our nation's 42 HF-using refineries have yet to adopt the mitigation measures recognized as best practice in the latest (2021) edition of API 751.[274] Less than a third (12) report having installed the rapid acid de-inventory systems that (if properly designed and maintained) may allow operators to isolate much of a refinery's HF inventory in ground tanks.[mm] Another 12 refineries, with a collective total of more than five-and-a-half million people living in their estimated worst-case release zones, did not report having any water-based system for mitigating HF releases.

VI. EPA could eliminate the unreasonable risks this petition describes by requiring HF-using refiners to convert to one of the safer alternatives already in commercial use

TSCA requires unreasonable risk to be determined "without reference to costs or other nonrisk factors," whether that finding comes from EPA or by a court in a *de novo* Section 21 proceeding. 15 U.S.C. §§ 2605(a), 2605(b)(4)(A), 2620(b)(4)(B)(ii). But when EPA formulates Section 6(a) risk-management rules that would "substantially prevent[] a specific condition of use of a chemical substance or mixture" in order to eliminate unreasonable risk, EPA considers "whether technically and economically feasible alternatives that benefit health or the environment . . . will be reasonably available as a substitute." 15 U.S.C. § 2605(a), (c)(2)(C); *see also* 15 U.S.C. § 2605(c)(2)(A)(iv), (c)(2)(B) (Section 6(a) rulemakings "shall factor in, to the extent practicable," "reasonably ascertainable economic consequences"). In anticipation of rulemaking, this Part discusses technically and economically feasible alternatives.

A. Most U.S. refineries already use safer chemicals for alkylation

There are 132 operating oil refineries in the United States,[275] about 90% of which have alkylation units,[276] and only 42 of which still use HF for alkylation.[277] EPA has acknowledged that "there are recognized potentially safer chemical alternatives available for HF alkylation that have been successfully implemented by refineries, such as sulfuric acid alkylation, ionic liquid alkylation, or solid acid catalyst alkylation."[278]

Sulfuric acid, the most traditional and established alternative catalyst, has a boiling point above 500 degrees Fahrenheit and is thus much less prone to form a cloud when released—making it far easier to contain (for example, within a berm at a refinery site).[279] Newer industry-developed alkylation catalysts, now in use at commercial scale, remain liquids or solids at ambient temperatures and are believed to be nontoxic to humans.[280]

[ll] *See generally* Appendix A.

[mm] As discussed at Part III.B.7.i.c, had a heroic worker not manually activated a rapid acid de-inventory (i.e., drainage) system at the former Philadelphia Energy Solutions refinery in 2019, far more HF could have been released during that incident.

B. Several former HF-using refineries are converting or have successfully converted to using safer alternatives

At least three U.S. refineries have made or started the switch from HF to newer, safer catalysts.

In 2021, Chevron's Salt Lake City refinery completed the conversion of its HF alkylation unit to ISOALKY technology, a new alkylation process that uses an ionic liquid catalyst.[281] Also in 2021, after EPA imposed more than $300,000 in fines for its mismanagement of HF, Big West Oil Refinery in Utah entered into a contract to revamp its alkylation unit to switch from HF alkylation to the alternative catalyst ISOALKY.[282] ISOALKY does not vaporize at normal ambient air temperatures and has relatively low toxicity and corrosivity.[283] Honeywell (the sole U.S. manufacturer of the anhydrous HF used for refinery alkylation) and Chevron have described ISOALKY as safer for people than HF, as well as "commercially viable" and a "compelling economic solution."[284]

In 2023, the owner of the Wynnewood Refinery in Oklahoma announced it was revamping its HF alkylation unit to use an alternative solid acid alkylation technology called K-SAAT.[285] According to a study commissioned by California's South Coast Air Quality Management District, K-SAAT is non-volatile, will not form a vapor or aerosol, and can be safely handled by workers with only minimal personal protective equipment.[286]

VII. Conclusion

Petitioners urge EPA to grant this petition and promptly begin a TSCA Section 6(a) rulemaking to ban refinery-related HF use and eliminate the grave and unreasonable risks it presents to public health and the environment. Each day of regulatory delay leaves millions of people ever more vulnerable to the threat of death, disability, and catastrophe. The status quo is dangerous and unnecessary, and TSCA requires EPA to change it.

Sincerely,

Selena Kyle
Margaret Hsieh
Lauren P. Phillips
Chantel Jathan
Natural Resources Defense Council
20 North Wacker Drive
Suite 1600
Chicago, IL 60606
Counsel for Petitioners Natural Resources Defense Council, Clean Air Council, and Communities for a Better Environment

Lawrence Hafetz
Annie Fox*
Clean Air Council
Suite 1130
1617 JFK Boulevard
Philadelphia, PA, 19103
Counsel for Petitioner Clean Air Council
**JD; pending admission to the Pennsylvania Bar*

Shana Lazerow
Jay Parepally*
Communities for a Better Environment
113 E. Anaheim Street
Wilmington, CA 90744
Counsel for Petitioner Communities for a Better Environment
**JD; pending admission to the California Bar*

VIII. Endnotes

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[1] CAS number 7664-39-3 covers both "hydrogen fluoride" and "hydrofluoric acid." *See CAS Common Chemistry*, https://commonchemistry.cas.org/ (last visited February 4, 2025) (search for "hydrogen fluoride"). As used in the CAS Registry, the term "hydrogen fluoride" refers to pure molecular HF, which is also known as "anhydrous HF." In contrast, "hydrofluoric acid" refers to anhydrous HF that has dissolved in water to form an aqueous solution. As discussed at Parts III.A and IV.A.1, refinery alkylation units use anhydrous HF, but once anhydrous HF escapes into the air, it mixes with water vapor and begins to form hydrofluoric acid.

[2] The refineries in Torrance and Wilmington, California purportedly use a blend of anhydrous HF and another chemical or chemicals, generally referred to as "modified HF" or "MHF" as their alkylation catalyst. *See* S. Coast Air Quality Mgmt. Dist., *Staff Presentation to Governing Board: Status Update on PR 1410 – Hydrogen Fluoride Storage and Use at Petroleum Refineries*, slides 14, 23-24 (Feb. 1, 2019), https://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2019/2019-feb1-025.pdf?sfvrsn=6. The refineries' owners do not appear to have publicized the formulation they now use, and Torrance's owner resisted the U.S. Chemical Safety Board's effort to obtain further information in the wake of the 2015 explosion at that refinery. *See* Chem. Safety Bd., ExxonMobil Torrance Refinery Explosion Final Report No. 2015-02-I-CA, 6-7 & n.2, 23 (May 3, 2017) [hereinafter CSB Torrance Report], https://www.csb.gov/exxonmobil-torrance-refinery-explosion-/.

On information and belief, the modified HF formulation used at the California refineries today is chemically similar to pure anhydrous HF and poses substantially the same unreasonable risks to health and the environment. On information and belief, the modifying chemical's ability to suppress an HF vapor cloud is proportional to how much of it is mixed with HF. On information and belief, the modified HF used by at least Torrance today is overwhelmingly anhydrous HF by volume; the modifier accounts for less than ten percent of the mixture by weight, and perhaps well less than five percent.

This petition accordingly requests a Section 6(a) rulemaking to eliminate the unreasonable risks posed by U.S. refineries' use of modified HF, as well pure anhydrous HF, for alkylation. *See* 15 U.S.C. § 2605(a) (requiring regulation of unreasonable risks posed by "a chemical substance or mixture," or certain conditions of use thereof); *id.* § 2602(10) (defining "mixture").

[3] Office of Chem. Safety and Pollution Prevention, EPA, 740-R17-001, Guidance to Assist Interested Persons in Developing and Submitting Draft Risk Evaluations Under the Toxic Substances Control Act 18 (2017), https://www.epa.gov/sites/default/files/2017-06/documents/tsca_ra_guidance_final.pdf.

[4] *Id.* at 18, 22; Procedures for Chemical Risk Evaluation Under the Toxic Substances Control Act (TSCA), 89 Fed. Reg. 37,028, 37,037 (May 3, 2024).

[5] Agency for Toxic Substances & Disease Registry, Medical Management Guide for Hydrogen Fluoride 1 (2014) [hereinafter ATSDR MMG] (on file with NRDC). This document is

a page-numbered PDF that was previously available on ATSDR's website in 2024. The current web version has minor differences and does not contain page numbers.

[6] Sommerville et. al., U.S. Dep't of Homeland Sec., Chem. Sec. Analysis Ctr., Review and Assessment of Hydrogen Fluoride Mammalian Lethality Data and Development of a Human Estimate, CSAC 11-024, at 2-1 (Nov. 10, 2011) [hereinafter Sommerville].

[7] *Id.*; Nat'l Institute for Occupational Safety and Health (NIOSH), CDC, Hydrogen Fluoride/Hydrofluoric Acid: Systemic Agent (last updated May 12, 2011) [hereinafter NIOSH, HF: Systemic Agent], https://www.cdc.gov/niosh/ershdb/emergencyresponsecard_29750030.html.

[8] Am. Chemistry Council, Emergency Preparedness and Response Guidelines for Anhydrous Hydrogen Fluoride (AHF) and Hydrofluoric Acid (HF) (Oct. 2018) at 6, https://www.americanchemistry.com/content/download/5432/file/Emergency-Preparedness-and-Response-Guidelines-for-Anhydrous-Hydrogen-Fluoride-AHF-and-Hydrofluoric-Acid-HF.pdf.

[9] Agency for Toxic Substances & Disease Registry, Toxicological Profile for Fluorides, Hydrogen Fluoride, and Fluorine 166 (Sept. 2023) [hereinafter ATSDR Tox Profile], https://www.ncbi.nlm.nih.gov/books/NBK597862/pdf/Bookshelf_NBK597862.pdf; Daniel McKee et al., *A Review of Hydrofluoric Acid Burn Management*, 22 Plastic Surgery 95, 95 (2014), https://pmc.ncbi.nlm.nih.gov/articles/PMC4116323/pdf/ps-22-95.pdf.

[10] Ricardo Jorge Dinis-Oliveira, et al., *Clinical and Forensic Signs Related to Chemical Burns: A Mechanistic Approach*, 41 Burns 658, 660 (2015), https://pubmed.ncbi.nlm.nih.gov/25280586/; *see* ATSDR Tox Profile, *supra* note 9, at 166; Nat'l Ctr. for Biotech. Info., Nat'l Insts. of Health (NIH), PubChem Compound Summary for CID 14917, Hydrogen Fluoride, §§ 8.4, 12.1.1 [hereinafter NIH PubChem], https://pubchem.ncbi.nlm.nih.gov/compound/Hydrofluoric-Acid (last updated Feb. 2, 2025); McKee, *supra* note 9, at 95; Sommerville, *supra* note 6, at 3-2.

[11] Dinis-Oliveira, *supra* note 10, at 662; *see* ATSDR Tox Profile, *supra* note 9, at 166; NIH PubChem, *supra* note 10, §§ 8.4, 12.1.1; McKee, *supra* note 9, at 95; Sommerville, *supra* note 6, at 3-2.

[12] McKee, *supra* note 9, at 95; *see* ATSDR Tox Profile, *supra* note 9, at 166; Michael I. Greenburg & David Vearrier, *Hydrofluoric Acid Exposure*, Merck Manual Professional Version (May 2002) (on file with NRDC).

[13] *See* F. Burgher et al., Key Parameters of Hydrofluoric Acid Skin Contamination and First Aid Measures: Human Occupational Accidents and Experimental Data 2 (unpublished manuscript), https://www.prevor.com/app/uploads/sites/3/2020/09/medichem2010-hall-hf-plenerypresentation.pdf; Sommerville, *supra* note 6, at 3-2 (explaining that HF's penetration of skin is facilitated by prior damage to skin).

[14] Los Alamos Nat'l Labs., Periodic Table of Elements: Fluorine, https://periodic.lanl.gov/9.shtml (last visited Jan. 16, 2025).

[15] *Id.*; *Merriam Webster Dictionary* (online ed.), https://www.merriam-webster.com/dictionary/electronegative (last visited Jan. 16, 2025).

[16] *See* Katherine Atley & Edward Ridyard, *Treatment of Hydrofluoric Acid Exposure to the Eye*, 8 Int'l J. Opthalmology 157, 157 (Feb. 2015), https://pmc.ncbi.nlm.nih.gov/articles/PMC4325260/pdf/ijo-08-01-157.pdf; Emilija Bajraktarova-Valjakova et al., *Hydrofluoric Acid: Burns and Systemic Toxicity, Protective Measures,*

Immediate and Hospital Medical Treatment, 6 Open Access Macedonian J. Med. Sci. 2257, 2259 (Nov. 2018), https://pmc.ncbi.nlm.nih.gov/articles/PMC6290397/pdf/OAMJMS-6-2257.pdf; McKee, *supra* note 9, at 95; Daniel L. Schwerin & Jason D. Hatcher, *Hydrofluoric Acid Burns* (July 17, 2023), https://www.ncbi.nlm.nih.gov/books/NBK441829/ (see section on Pathophysiology).

[17] Apostolos Pappas, *Epidermal Surface Lipids*, 1 Dermato-Endocrinology 72, 72 (2009), https://pmc.ncbi.nlm.nih.gov/articles/PMC2835894/pdf/de0102_0072.pdf.

[18] Schwerin, *supra* note 16 (see section on Pathophysiology).

[19] Atley, *supra* note 16, at 157; Burgher, *supra* note 13, at 5; McKee, *supra* note 9, at 95.

[20] *See* ATSDR MMG, *supra* note 5, at 5; Sommerville, *supra* note 6, at 3-2.

[21] Nat'l Human Genome Rsch. Inst., NIH, Talking Glossary of Genomic and Genetic Terms: Cell Membrane (Plasma Membrane), https://www.genome.gov/genetics-glossary/Cell-Membrane (last updated Feb. 3, 2025).

[22] Int'l Programme on Chem. Safety, World Health Org. (WHO), INCHEM: Hydrogen Fluoride § 7.1 [hereinafter INCHEM], https://www.inchem.org/documents/pims/chemical/hydfluor.htm (last visited Feb. 3, 2025).

[23] *See* ATSDR Tox Profile, *supra* note 9, at 166; INCHEM, *supra* note 22, at § 7.1; Schwerin, *supra* note 16 (see Introduction and section on Pathophysiology); Sommerville, *supra* note 6, at 3-2.

[24] ATSDR MMG, *supra* note 5, at 1.

[25] ATSDR Tox Profile, *supra* note 9, at 168; Sommerville, *supra* note 6, at 3-2; Siyu Wang & Gengwu Dai, *Hydrofluoric Acid Burn*, 191 Canadian Med. Ass'n J. E314, E314 (2019), https://pmc.ncbi.nlm.nih.gov/articles/PMC6422780/pdf/191e314.pdf ("The fluoride ions in hydrofluoric acid are strong scavengers of bivalent cations, such as calcium and magnesium . . . ."); Felicia N. Williams & Jong O. Lee, *Chemical Burns*, *in Total Burn Care* 408, 411 (David N. Herdon, ed., 5th ed. 2018).

[26] Honeywell, Recommended Medical Treatment for Hydrofluoric Acid Exposure 2 (2012), https://www.drs.illinois.edu/site-documents/HFMedicalTreatmentGuide.pdf.

[27] EPA, Hydrogen Fluoride Study, Final Report: Report to Congress, Section 112(n)(6), Clean Air Act as Amended 9 (1993) [hereinafter EPA HF Report], https://tinyurl.com/y9smtr54; Cal. Dep't of Indus. Rel., Protecting Workers Exposed to Hydrogen Fluoride (HF) 1 (2002), https://www.dir.ca.gov/dosh/dosh_publications/Hydrogen-Flouride-fs.pdf.

[28] EPA HF Report, *supra* note 27, at 9; Sommerville, *supra* note 6, at 3-2.

[29] EPA HF Report, *supra* note 27, at 9.

[30] ATSDR MMG, *supra* note 5, at 5.

[31] *See* Honeywell, *supra* note 26, at 4.

[32] ATSDR MMG, *supra* note 5, at 5.

[33] CDC, Facts About HF, *supra* fn.d; EPA HF Report, *supra* note 27, at 9; Sommerville, *supra* note 6, at 3-2.

[34] *See* Sommerville, *supra* note 6, at 3-2.

[35] *See* Mark McVey et al., *Inflammasome Activation in Acute Lung Injury*, 320 Am. J. Physiology: Lung & Molecular Physiology L165, L167-69 (2021).

[36] EPA HF Report, *supra* note 27, at 9.

[37] ATSDR MMG, *supra* note 5, at 6; EPA HF Report, *supra* note 27, at 11; Sommerville, *supra* note 6, at 3-2.

[38] EPA HF Report, *supra* note 27, at 11.

[39] *Id*.

[40] ATSDR MMG, *supra* note 5, at 5; INCHEM, *supra* note 22, at § 7.1; Janna H. Villano & Binh T. Ly, *Hydrogen Fluoride and Hydrofluoric Acid*, *in Poisoning & Drug Overdose* 269, 269 (Kent R. Olson, ed., 7th ed. 2018).

[41] Hye-Kyung Timken, et al., for Honeywell, Chevron and UOP, A New Era For Alkylation: Ionic Liquid Alkylation – Isoalky™ Process Technology 12 (2020) https://uop.honeywell.com/content/dam/uop/en-us/documents/industry-solutions/refining/gasoline/ISOALKY_Whitepaper.pdf.

[42] NIH PubChem, *supra* note 10, at § 12.1.8.

[43] ATSDR MMG, *supra* note 5, at 7; *Hydrofluoric Acid*, Princeton Univ. Env't Health & Safety, https://ehs.princeton.edu/laboratory-research/chemical-safety/chemical-specific-protocols/hydrofluoric-acid (last visited Jan. 17, 2025); Schwerin, *supra* note 16 (see section on History and Physical [Assessment]).

[44] NIH PubChem, *supra* note 10, at § 11.1.9.

[45] ATSDR MMG, *supra* note 5, at 6; Atley, *supra* note 16, at 158; NIH PubChem, *supra* note 10, at § 12.1.8.

[46] Atley, *supra* note 16, at 158.

[47] EPA, Integrated Risk Information System (IRIS) Glossary, https://sor.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do?details=&vocabName=IRIS%20Glossary (last visited Nov. 13, 2024) (defining "systemic effects"); NIOSH, Effects of Skin Contact with Chemicals: Guidance for Occupational Health Professionals and Employers 6 (2011), https://www.cdc.gov/niosh/docs/2011-200/pdfs/2011-200.pdf.

[48] ATSDR Tox Profile, *supra* note 9, at 9.

[49] ATSDR Tox Profile, *supra* note 9, at 6, 130; Bajraktarova-Valjakova, *supra* note 16, at 2258; Nat'l Cancer Inst. (NCI), NIH, NCI Dictionary of Cancer Terms (defining "lymph" and "lymph vessels"), https://www.cancer.gov/publications/dictionaries/cancer-terms/search/lymph/?searchMode=Begins; Subcomm. on Acute Exposure Guideline Levels, Nat'l Rsch. Council (NRC), 4 Acute Exposure Guideline Levels for Selected Airborne Chemicals 159 (2004) [hereinafter NRC AEGLs], https://www.epa.gov/sites/default/files/2014-11/documents/tsd53.pdf; Sommerville, *supra* note 6, at 3-2.

[50] Williams, *supra* note 2518, at 411.

[51] NIH, Calcium: Fact Sheet for Professionals, https://ods.od.nih.gov/factsheets/Calcium-HealthProfessional/ (last visited Nov. 13, 2024); NIH, Magnesium: Fact Sheet for Professionals, https://ods.od.nih.gov/factsheets/Magnesium-HealthProfessional/ (last visited Nov. 13, 2024).

[52] NIOSH, HF: Systemic Agent, *supra* note 7.

[53] Bajraktarova-Valjakova, *supra* note 16, at 2261-62.

[54] ATSDR Tox Profile, *supra* note 9, at 33, 127; Bajraktarova-Valjakova, *supra* note 16, at 2262; NIOSH, HF: Systemic Agent, *supra* note 7.

[55] *See, e.g.*, ATSDR MMG, *supra* note 5, at 5.

[56] *See* Williams, *supra* note 2518, at 411.

[57] ATSDR Tox Profile, *supra* note 9, at 21.

[58] Sommerville, *supra* note 6, at 3-2; *see also Hydrofluoric Acid Exposure*, *supra* fn.d, at 1 (stating that exposure to HF at concentrations of 50% or higher to just one percent of the body, which is the size of the sole of a foot, can lead to death; and that exposure to any concentration of HF to five percent of the body can be fatal).

[59] *See supra* Part III.A.1.

[60] *See* ATSDR MMG, *supra* note 5, at 1; Burgher, *supra* note 13, at 5.

[61] NIOSH, HF: Systemic Agent, *supra* note 7.

[62] Nat'l Library of Med., Medline Plus: Breath Sounds, https://medlineplus.gov/ency/article/007535.htm (last visited Nov. 14, 2024).

[63] Cleveland Clinic, Cyanosis, https://my.clevelandclinic.org/health/diseases/24297-cyanosis (last visited Nov. 14, 2024).

[64] Robert H. Dreisbach & William O. Robertson, *Handbook of Poisoning: Prevention, Diagnosis, and Treatment* 217. (12th ed. 1987).

[65] *See* John C. Bertolini, *Hydrofluoric Acid: A Review of Toxicity*, 10 J. Emergency Med. 163, 163 (1992); Sommerville, *supra* note 6, at 3-2.

[66] ATSDR MMG, *supra* note 5, at 6.

[67] *Id*.

[68] William M. Bracken et al., *Comparative Effectiveness of Topical Treatments for Hydrofluoric Acid Burns*, 27 J. Occupational Med., 733, 733 (1985).

[69] ATSDR MMG, *supra* note 5, at 23.

[70] *See* Schwerin, *supra* note 16 (see section on Pathophysiology).

[71] *See* ATSDR MMG, *supra* note 5, at 5; Dreisbach, *supra* note 64, at 217; Parts III.A.1, III.A.2; *see also* J. Braun, H. Stoss, & A. Zober, *Intoxication Following the Inhalation of Hydrogen Fluoride*, 56 Archives Toxicology 50, 50-52 (1984); J.A. Kroes et al., *Delayed Cardiac Arrest After Hydrofluoric Acid Ingestion*, 62 Clinical Toxicology 205, 205 (2024), https://www.tandfonline.com/doi/epdf/10.1080/15563650.2024.2328348.

[72] Bertolini, *supra* note 6565, at 164.

[73] Wang, *supra* note 25, at E314.

[74] *See* Bajraktarova-Valjakova, *supra* note 16, at 2262; Honeywell, *supra* note 26, at 3-4; Schwerin, *supra* note 16 (see section on Etiology); Wang, *supra* note 25, at E314; *see generally* Fed. Emergency Mgmt. Admin. (FEMA), Key Planning Factors and Considerations for Response to and Recovery from a Chemical Incident, § 3.2 (Human Decontamination), https://www.fema.gov/cbrn-tools/key-planning-factors-chemical-incident/kpf4/3/3-2 (last updated June 6, 2023) ("If decontamination does not interfere with essential treatment, it should be performed as quickly as possible, as the most important and effective chemical decontamination procedures are those done within minutes.").

[75] ATSDR MMG, *supra* note 5, at 11.

[76] NIOSH, HF: Systemic Agent, *supra* note 7.

[77] *See* ATSDR MMG, *supra* note 5, at 10, 13.

[78] ATSDR MMG, *supra* note 5, at 17-18; Bracken, *supra* note 68, at 733; Greenburg, *supra* note 12; Schwerin, *supra* note 16 (see section on Treatment / Management); Atley, *supra* note 16, at 157; Williams, *supra* note 2518, at 411.

[79] ATSDR MMG, *supra* note 5, at 16.

[80] *Id.* at 7; NIOSH, HF: Systemic Agent, *supra* note 7; *see, e.g.*, Braun, *supra* note 7171, at 52.

[81] ATSDR MMG, *supra* note 5, at 7; Wang, *supra* note 25, at E314.

[82] ATSDR MMG, *supra* note 5, at 7.

[83] *Id.*

[84] Hari H. Dayal et al., *A Community-Based Epidemiologic Study of Health Sequelae of Exposure to Hydrofluoric Acid*, 2 Annals Epidemiology 213, 213 (May 1992), https://pubmed.ncbi.nlm.nih.gov/1342272/ (on file with Petitioner NRDC).

[85] Ron Koopman, HF Dispersion—Model Development, Field Experiments, and Real-World Application 14-15 (Oct. 27-28, 2016) (unpublished PowerPoint slides) (on file with NRDC).

[86] Dayal, *supra* note 8484, at 219, 221.

[87] *Id.* at 227.

[88] *Id.* at 219.

[89] *Id.* at 221 tbl.4.

[90] Risk Assessment Forum, EPA, Guidelines for Human Exposure Assessment, 42-43 (2019), https://www.epa.gov/sites/default/files/2020-01/documents/guidelines_for_human_exposure_assessment_final2019.pdf.

[91] EPA, Exposure Factors Handbook 6-1 (2011), https://www.epa.gov/sites/default/files/2015-09/documents/efh-chapter06.pdf.

[92] *See id.*

[93] ATSDR MMG, *supra* note 5, at 17.

[94] *Id.*

[95] *See* NIOSH, CDC, *Derivation of Immediately Dangerous to Life or Health (IDLH) Values*, 66 Current Intelligence Bulletin xviii (Nov. 2013), https://www.cdc.gov/niosh/docs/2014-100/pdfs/2014-100.pdf (describing the "healthy worker effect" as the "[e]pidemiological phenomenon" where "workers usually exhibit lower overall disease and death rates than the general population, due to the fact that elderly individuals and those with significant pre-existing illness are less likely to be active in the workforce than healthy adults").

[96] *See* Nat'l Inst. on Aging, NIH, *Heart Health and Aging*, https://www.nia.nih.gov/health/heart-health/heart-health-and-aging (last updated July 22, 2024).

[97] Nat'l Council on Aging, *Get the Facts on Healthy Aging* (Aug. 16, 2024), https://www.ncoa.org/article/get-the-facts-on-healthy-aging/.

[98] ATSDR MMG, *supra* note 5, at 12.

[99] *See* Sommerville, *supra* note 6, at 3-2 (noting that people with "underlying cardiopulmonary disease," i.e., heart and lung conditions, may be more vulnerable to HF).

[100] Dayal, *supra* note 844, at 219-21.

[101] NRC AEGLs, *supra* note 49, at 3.

[102] *See, e.g.*, 15 U.S.C. § 2605(b)(1)(B)(i) (EPA shall designate as high priority for risk evaluation "a chemical substance that . . . may present an unreasonable risk of injury to health or the environment because of a potential hazard and a potential route of exposure under the conditions of use . . . .").

[103] ATSDR MMG, *supra* note 5, at 3.

[104] *See infra* notes 105-113 & accompanying petition text.

[105] *See* R. Koopman, R.L. Baskett, and M.B. Dillon, *Goldfish Hydrogen Fluoride Spill Experiment Technical Report*, Lawrence Livermore National Laboratory report number LLNL-TR-781457 (Oct. 22, 2021 draft) [hereinafter Goldfish Report], at 1-2. The scientists named the series after goldfish they found in an old well near the test site. City of Torrance, recording of Sept. 22, 2018, South Coast Air Quality Management District Community Meeting, at 1:33 https://www.youtube.com/watch?v=qwo08BtEQuM&t=5108s (visited Oct. 15, 2024) (comments of Goldfish test co-Principal Investigator Koopman).

[106] Goldfish Report at 1.

[107] *Id.* at 6.

[108] *Id.* at 9-14; *see also id*. at 34 (showing HF-sensing towers).

[109] *Id.* at 58; *id.* at 2 (explaining that the first three tests were conducted to collect atmospheric dispersion information and "assess the potential consequences of . . . accidental release," without the use of a water spray mitigation system).

[110] *Id.* at 13 (HF tank capacity of 18.927 liters, equivalent to 5,000 gallons), 53 (Table 5-1b, Test 1, Orifice Diameter (1.65 inches)), and 54 (Table 5-2, Test 1, Duration (2.08 minutes) and HF Spill Amount (3,698 liters)).

[111] *Id.* at 71 (Table 7-1, Maximum Downwind Concentration); *id*. at 76 (Table 7-2c) (showing this level was recorded by the HF sensor mounted just one meter above ground level (AGL)), 13 (defining AGL).

[112] *Id.* at 71 (Table 7-1, Maximum Downwind Concentration); *see also id*. at 74-75 (Tables 7-2a and 7-2b) (showing these levels were recorded by the HF sensors mounted one meter above ground level).

[113] Photograph reproduced from Goldfish Report, *supra* note 105105, at 11 (Figure 3-3). This was taken from a helicopter that stayed upwind of the release. *Id*. at 37.

[114] NRC AEGLs, *supra* note 49, at xi-xii, 2-3.

[115] *See* Subcomm. on Acute Exposure Guideline Levels, NRC, Standard Operating Procedures for Developing Acute Exposure Guideline Levels for Hazardous Chemicals 1, 19 (2001) [hereinafter NRC, Procedures for Developing AEGLs].

[116] EPA, Acute Exposure Guideline Levels for Airborne Chemicals, https://www.epa.gov/aegl (last updated Jan. 29, 2025).

[117] Although there are several additional regulatory thresholds for HF exposure, most apply only in workplace settings, or in certain states. *See* ATSDR Tox Profile, *supra* note 9, at 256-63 (listing various regulatory thresholds for HF).

[118] NRC AEGLs, *supra* note 49, at 3.

[119] *Id*. at 2-3.

[120] NRC, Procedures for Developing AEGLs, *supra* note 115, at 31-32.

[121] *See id.* at 32.

[122] NRC AEGLs, *supra* note 49, at 3; *see also* NRC, Procedures for Developing AEGLs, *supra* note 115, at 33 fig.1-1.

[123] NRC AEGLs, *supra* note 49, at 3.

[124] *Id.*

[125] *See id.* at 173 tbl.3-9, 175 tbl.3-10.

[126] *See* ATSDR MMG, *supra* note 5, at 15.

[127] NRC AEGLs, *supra* note 49, at 3.

[128] Chemical Safety Board, Philadelphia Energy Solutions (PES) Refinery Fire and Explosions Final Report No. 2019-04-I-PA, 11 (Oct. 11, 2022) [hereinafter CSB PES Report], *available for download at* https://www.csb.gov/philadelphia-energy-solutions-pes-refinery-fire-and-explosions-/; *see also* American Fuel and Petrochemical Manufacturers, *Alkylate: Understanding a Key Component of Cleaner Gasoline* (Aug. 6, 2021) https://www.afpm.org/newsroom/blog/alkylate-understanding-key-component-cleaner-gasoline.

[129] *See* CSB PES Report, *supra* note 128, at 11.

[130] *See id.*

[131] *See* Accidental Release Prevention Requirements: Risk Management Programs Under the Clean Air Act; Safer Communities by Chemical Accident Prevention, 89 Fed. Reg. 17,622, 17,646 (Mar. 11, 2024) (final rule); EPA, Petroleum Sector (NAICS 324), https://www.epa.gov/regulatory-information-sector/petroleum-sector-naics-324 (last visited Jan. 31, 2025). EPA described NAICS 324 as including 45 facilities that use HF for alkylation—a slightly larger number than its RMP records identify as oil refineries. The difference is likely attributable to the fact that NAICS 324 includes some non-oil refineries that also use HF for alkylation, such as petroleum coke refineries.

[132] Petitioners compiled this data by reviewing the Offsite Consequences Analyses and other relevant portions of the RMPs, inclusive of scheduled 5-year updates through the end of calendar 2024, at EPA offices. EPA prevents members of the public from photographing RMPs and caps the number an individual may review in a single visit. Some of the RMPs Petitioners reviewed were missing information or included internally inconsistent information. Petitioners may have inadvertently erred in compiling some of their notes, and some RMPs may have been revised since Petitioners last reviewed them. *See* 40 C.F.R. §§ 68.190(b), 68.195.

[133] Petitioners are aware of a 2021 EPA chart that listed 45 U.S. refineries with HF alkylation units. *See* EPA, Technical Background Document for Notice of Proposed Rulemaking: Risk Management Programs Under the Clean Air Act, Section 112(r)(7) Safer Communities by Chemical Accident Prevention, RMP Accidents 2004-2020 (Appendix A), EPA-HQ-OLEM-2022-0174-0065. Since then, one refinery has converted away from HF, one has closed its alkylation unit, and one has converted to a terminal. One additional refinery—the Pasadena Refinery, in greater Houston— was registered as an HF-using refinery as of its latest RMP submission. In 2023, however, the refinery stopped reporting the amount of HF on site to the federal Toxics Release Inventory database. EPA, *TRI Explorer* (2022 Dataset (released Oct. 2023)) [Internet database], https://enviro.epa.gov/triexplorer/tri_release.chemical? (last visited Jan. 31, 2025) (in query form, select "2022" for year, enter zip code 77506, select "hydrogen fluoride" as chemical, industry code "324"). This petition assumes that Pasadena remains an HF-using refinery.

[134] In addition to the HF-related information presented in the RMPs, the table presents information on each refinery's parent company, age, mitigation system, union presence, number of full-time employees, and other characteristics.

[135] Appendix A, col. marked Total HF volume (lbs), row marked "average." The figures in this paragraph exclude the Galveston Bay Refinery in averages, because that refinery had conflicting volume information in its RMP.

[136] *Id.*, col. marked "Total HF volume (lbs)"; then sort column by largest volume. The figures in this paragraph exclude the Galveston Bay Refinery in averages, because that refinery had conflicting volume information in its RMP.

[137] *Id.*, col. marked "HF volume for worst case release scenario (lbs)", row marked "average." The figures in this paragraph exclude the Galveston Bay Refinery in averages, because that refinery had conflicting volume information in its RMP.

[138] *Id.*, col. marked "HF volume for worst case release scenario (lbs)"; then sort column by largest volume. The figures in this paragraph exclude the Galveston Bay Refinery in averages, because that refinery had conflicting volume information in its RMP.

[139] *See* Appendix C, Parts II.A.1 (railcar) and II.B.1 (cargo truck). Petitioners use short tons, equivalent to 2,000 kilograms.

[140] *South Korea designates chemical leak area 'disaster zone'*, BBC News, (Oct. 8, 2012), https://www.bbc.com/news/world-asia-19867454; Hyun-Sul Lim and Kwan Lee, *Health Care Plan for Hydrogen Fluoride Spill, Gumi, Korea* (Editorial), 27 J. of Korean Med. Sci. 1283, 1283 (Oct. 30, 2012), https://jkms.org/pdf/10.3346/jkms.2012.27.11.1283.

[141] Soo Bin Park, *Alert over South Korea toxic leaks*, 494 Nature 15, 15 (Feb. 6, 2013), https://www.nature.com/articles/494015a.

[142] *South Korea designates chemical leak area 'disaster zone'*, *supra* note 140; Lim and Lee, *supra* note 140, at 1283; CSB PES Report, *supra* note 128, at 57.

[143] *See generally* Appendix A, col. marked "HF volume for worst case release scenario (lbs)."

[144] *See id.*, columns marked "Population in the worst case release zone per RMP," "# of full time employees at refinery," row marked "Totals."

[145] *See* Wietlisbach et al., S&P Global Commodity Insights, Chemical Economics Handbook: *Fluorspar, Fluorosilicic Acid (FSA), Hydrofluoric Acid (HF) and Inorganic Fluorine Compounds*, 121 (July 2023), available for purchase from S&P Global.

[146] *See id.* at 116, 119, 124-25. While there are other producers of HF in the United States, to the best of Petitioners' knowledge, only this plant makes HF for refinery use.

[147] Thomas Stare, *Hydrogen Fluoride Emergency Response*, HazmatNation (Sept. 12, 2017), https://www.hazmatnation.com/hydrogen-fluoride-emergency-response/ ("90% of all [anhydrous HF is] transported by rail").

[148] The U.S. Department of Transportation has forbidden the transportation of HF by aircraft. *See* table at 49 C.F.R. § 172.101, row marked "Hydrogen fluoride, anhydrous," col. 9 entries. It is possible that some refiners are importing HF from Canada or Mexico by rail or truck, and/or using boat transportation. Because many of the United States' HF-using refineries lie far from our coastlines and land borders, importation and/or boat transportation would also necessitate moving HF long distances, including through populated and ecologically sensitive areas.

[149] Petitioners used software from PC*Miler, which defines "practical" rail routes as those that "simulate the most likely routes of general merchandise train traffic."

[150] Appendix C, Part I.A and Figures 1-3.

[151] Appendix C, Part I.A and Figures 4-5.

[152] Appendix C, Part II.C. Petitioners applied the AEGLs for the exposure timeframes that corresponded most closely to those predicted by ALOHA. For releases from vehicles being

unloaded at refineries, which they assumed would last no longer than 10 minutes, they applied the 10-minute AEGLs; for other releases, they used the 60-minute AEGLs.

[153] Petitioners used software from PC*Miler, which defines "practical" rail routes as those that "simulate the most likely movement of general merchandise train traffic." Appendix C, Part IA.

[154] Appendix C, Part I.B and Figures 6-7.

[155] Appendix C, Part I.B and Figures 6-7.

[156] *See, e.g.*, Fla. Div. of Emergency Mgmt., *Make an Evacuation Plan*, FloridaDisaster.org, https://www.floridadisaster.org/planprepare/make-an-evacuation-plan/ (last visited Jan. 31, 2025) (guidance from Florida's Division of Emergency Management regarding hurricane evacuations); Shreya Vuttaluru et al., *Tampa Bay traffic jams as thousands evacuate before Hurricane Milton*, Tampa Bay Times (Oct. 7, 2024), https://www.tampabay.com/hurricane/2024/10/07/tampa-bay-traffic-jams-thousands-evacuate-before-hurricane-milton/ (discussing traffic jams stemming from evacuation days ahead of the landfall of Hurricane Milton).

[157] *See Torrance Unified School District*, Ed-Data.org, https://www.ed-data.org/district/los-angeles/torrance-unified (last visited Jan. 31, 2025) (chart notes of table named, "Languages of English Learners"); U.S. Census Bureau, *American Community Survey: QuickFacts Torrance city, California*, https://www.census.gov/quickfacts/fact/table/torrancecitycalifornia/PST045224 (last visited Jan. 31, 2025).

[158] City of Los Angeles Dep't of City Plan., Wilmington - Harbor City Demographic Profile 2 (2017), https://planning.lacity.gov/odocument/0c42be14-c7ef-4780-a469-fa00045e96ca/2017_demo_profile_wilmington.pdf.

[159] Innovative Emergency Mgmt., D2-Puff Model Version 4.0 Technical Manual, IEM/TEC01-089 (Sept. 4, 2001), at i (describing preparer and purposes), 142-43 (chart).

[160] *See id*. at 143.

[161] On October 21, 2021, an employee at the Honeywell Geismar facility, which makes anhydrous HF for refinery use, *see* Part III.B.4.ii, died after a piece of equipment sprayed HF onto him. U.S Dept. of Labor, Occupational Safety and Health Admin., *Accident Report Detail, Accident Summary Nr: 140416.015 - Employee is killed when sprayed by hydrogen fluoride*, https://www.osha.gov/ords/imis/accidentsearch.accident_detail?id=140416.015 (last visited Jan. 31, 2025); U.S Dept. of Labor, Occupational Safety and Health Admin., *Inspection Detail, Inspection: 1559538.015 - Honeywell International Inc.*, https://www.osha.gov/ords/imis/establishment.inspection_detail?id=1559538.015 (last visited Jan. 31, 2025). In 2020, a worker died after partially falling into a tub of paint remover mixture that included hydrofluoric acid and methylene chloride, leaving him with severe chemical burns. U.S Dept. of Labor, Occupational Safety and Health Admin., *Accident Report Detail, Accident Summary Nr: 126160.015 - Employee dies after falling into industrial paint remover*, https://www.osha.gov/ords/imis/accidentsearch.accident_detail?id=126160.015 (last visited Jan. 31, 2025). And in 2012, a worker at the Memphis Refinery died after an equipment failure sprayed his face with a hydrogen fluoride and propane mixture. U.S Dept. of Labor, Occupational Safety and Health Admin., *Inspection Detail, Inspection: 316875640 - Valero Refining Company-Tennessee LLC,*

https://www.osha.gov/ords/imis/establishment.inspection_detail?id=316875640 (last visited Jan. 31, 2025); *Valero worker dies in chemical exposure incident at Memphis refinery*, Hydrocarbon Processing (Dec. 4, 2012), https://www.hydrocarbonprocessing.com/news/2012/12/valero-worker-dies-in-chemical-exposure-incident-at-memphis-refinery.

[162] Am. Petroleum Inst. (API), Safe Operation of Hydrofluoric Acid Alkylation Units, API Recommended Practice 751, at 11 (5th ed. 2021), available for purchase at https://tinyurl.com/2sxtrwny, (defining "turnaround") (purchased copy included as Appendix D) [hereinafter API 751 Appendix D]; *see also* Am. Fuel and Petrochemical Mfrs., *Refinery turnarounds 101: What are turnarounds and why do we need them?* (Oct. 17, 2023) https://www.afpm.org/newsroom/blog/refinery-turnarounds-101-what-are-turnarounds-and-why-do-we-need-them.

The Chemical Safety Board has found that shutting down refinery equipment, as happens during turnarounds, "introduces unique and potentially hazardous conditions" and "may require a different set of safe operating limits compared with normal operation." Chem. Safety Bd., *FCC Unit Explosion and Asphalt Fire at Husky Superior Refinery, Investigation Report, No. 2018-02-I-WI*, 60, 173 (Dec. 23, 2022), *available for download at* https://www.csb.gov/husky-energy-superior-refinery-explosion-and-fire/.

The Texas City and Torrance refinery incidents described in Part III.B.7 occurred during turnarounds. All fifteen people killed in the 2005 Texas City explosion, and most of the people who were seriously injured, were contract workers who were there to support the turnaround; the refinery had brought in 800 contractors on top of its 1,800 regular employees. Chem. Safety Bd., *Investigation Report, Refinery Explosion and Fire (15 Killed, 180 Injured), No. 2005-04-I-TX,* 31, 68 (Mar. 20, 2007) [hereinafter Chem. Safety Bd., Texas City report], *available for download at* https://www.csb.gov/bp-america-texas-city-refinery-explosion/.

[163] *See, e.g.*, Bettina M. Beech et. al, *Poverty, Racism, and the Public Health Crisis in America*, 9 Frontiers Pub. Health 1, 1-3 (2021), https://pmc.ncbi.nlm.nih.gov/articles/PMC8450438/pdf/fpubh-09-699049.pdf.

[164] *See generally* Liam Downey & Brian Hawkins, *Race, Income, and Environmental Inequality in the United States*, 51 J. Socio. Persps. 759 (2008), https://pmc.ncbi.nlm.nih.gov/articles/PMC2705126/.

[165] *See* Envt'l Just. & Health All. for Chemical Pol'y Reform, *Who's in Danger? Race, Poverty, and Chemical Disasters* 1-3, 27-35 (May 2014), https://comingcleaninc.org/assets/media/images/Reports/Who%27s%20in%20Danger%20Report%20FINAL.pdf (study showing there are higher rates of people of color and people living in poverty near RMP facilities, including refineries using HF, than further from RMP facilities).

[166] James Krieger & Donna L. Higgins., *Housing and Health: Time Again for Public Health Action*, 92 Am. J. Pub. Health 758, 760 (May 2002), https://pmc.ncbi.nlm.nih.gov/articles/PMC1447157/pdf/0920758.pdf.

[167] *See, e.g.*, Jackie Powder, *For Blacks and Other Minorities, Transportation Inequities Often Keep Opportunities Out of Reach*, Hopkins Bloomberg Pub. Health (Sept. 8, 2020) https://magazine.publichealth.jhu.edu/2020/blacks-and-other-minorities-transportation-inequities-often-keep-opportunities-out-reach.

[168] *See* Latoya Hill et al., *Health Coverage by Race and Ethnicity, 2010-2022*, KFF (Jan. 11, 2024) https://www.kff.org/racial-equity-and-health-policy/issue-brief/health-coverage-by-

race-and-ethnicity/#:~:text=While%20overall%20uninsured%20rates%20continued,%2C%20respectively%2C%20as%20of%202022.

169 *See generally* Chantel Boyens et al., *Access to Paid Leave Is Lowest among Workers with the Greatest Needs*, Urb. Inst. (July 2022), https://www.urban.org/sites/default/files/2022-07/Access%20to%20Paid%20Leave%20Is%20Lowest%20among%20Workers%20with%20the%20Greatest%20Needs.pdf.

170 *See, e.g.*¸Tallese D. Johnson et al., People Who Spoke a Language Other Than English at Home by Hispanic Origin and Race: 2009, U.S. Census Bureau (Oct. 2010), https://www2.census.gov/library/publications/2010/acs/acsbr09-19.pdf.

171 89 Fed. Reg. at 17,655.

172 *See, e.g.*, *id.* at 17,633.

173 *See* Appendix B (which also discusses the methodology behind the analysis). Of course, it is possible that the actual numbers are higher than these, due to underreporting, missing records, or the possibility that HF was a contributing factor to a death or injury also caused by other elements of a refinery incident.

174 *See* EPA HF Report, *supra* note 27, at 113.

175 CSB PES Report, *supra* note 128, at 52.

176 *Id.* at 53.

177 EPA HF Report, *supra* note 27, at 113.

178 Dayal et al., *supra* note 84, at 214.

179 *Id.* at 213.

180 *Id.* at 219.

181 CSB PES Report, *supra* note 128, at 53. The Marathon Refinery has had a lengthy list of serious safety problems since then, including a 2005 explosion (under BP's ownership) that killed 15 workers. The CSB report on the 2005 explosion described chronic problems with the refinery's safety culture, including its cost-cutting, failure to invest in safety, and "run to failure" approach to equipment. *See* Chem. Safety Bd., Texas City report, *supra* note 162, at 25. Thirty-five workers were killed there between 1980 and 2015. *See* Leo W. Gerard, *The Words of Dead Workers*, United Steelworkers Blog (Apr. 28, 2015), https://www.usw.org/blog/2015/the-words-of-dead-workers.

182 *See* CSB Torrance Report, *supra* note 2, at 6.

183 *Id.* at 49.

184 *Id.*

185 *Id.* at 50.

186 EPA Region IX, Notice of Inspection Findings and Request for Information Pursuant to Clean Air Act Section 114 for Torrance Refining Company 3, 7 (Mar. 27, 2017) (on file).

187 *Id.* at 4-5.

188 Nick Green, *ExxonMobil exits Torrance as PBF Energy assumes ownership and operation of refinery*, Daily Breeze (Sept. 6, 2017), https://www.dailybreeze.com/2016/07/01/exxonmobil-exits-torrance-as-pbf-energy-assumes-ownership-and-operation-of-refinery/.

189 In 2017, officials at California's South Coast Air Quality Management District, which includes the Torrance and Wilmington refineries, began considering a rule that would have

phased out use of HF at both the Torrance and nearby Wilmington refineries. *See generally* S. Coast Air Quality Mgmt. Dist., *Former Proposed Rule 1410*, https://www.aqmd.gov/home/rules-compliance/rules/scaqmd-rule-book/proposed-rules/rule-1410 (last visited Oct. 11, 2024). The effort was abandoned in 2019, after the refineries' owners pledged additional mitigation. S. Coast Air Quality Mgmt. Dist. Governing Bd.*, Resolution No. 19-19* (Sept. 6, 2019), https://www.aqmd.gov/docs/default-source/rule-book/Proposed-Rules/1410/1410-comment-letters/resolution-signed.pdf?sfvrsn=6.

[190] *See* CSB PES Report, *supra* note 128, at 6.

[191] *Id.* at 21, 24.

[192] *Id.* at 6.

[193] CSB PES Report, *supra* note 128, at 27-28.

[194] *Id.* at 21-23.

[195] *Id.* at 6.

[196] *Id.*

[197] Sophia Schmidt, *'This is how I'm gonna die': Former employees remember the PES refinery explosion, 5 years later*, WHYY PBS (June 21, 2024), https://whyy.org/articles/pes-refinery-explosion-five-years-former-employees/.

[198] CSB PES Report, *supra* note 128, at 24.

[199] *Id.*

[200] *See* Appendix A, col. marked "Year built."

[201] CSB PES Report, *supra* note 128, at 25.

[202] Dr. Chirstina Simeone, *An Unrefined Ending: Lessons Learned from the Creation and Closure of the Philadelphia Energy Solutions Refinery* 20, Union of Concerned Scientists (Mar. 2023), https://www.ucsusa.org/sites/default/files/2023-03/unrefined-ending-pa-energy-solutions-refinery.pdf.

[203] CSB PES Report, *supra* note 128, at 33.

[204] Accidental Release Prevention Requirements: Risk Management Programs Under the Clean Air Act, *supra* note 171, at 17,632.

[205] Swiss Re is a Swiss reinsurance company that is "one of the world's leading providers of reinsurance, insurance, and other forms of insurance-based risk transfer." Swiss Re, *About Us* https://www.swissre.com/about-us.html (last visited Jan. 31, 2025).

[206] Ernst Zirngast, *Selective U/W in Oil – Petro Segment* 3 ("Swiss Re Report") (June 16, 2016) (unpublished technical report) (on file with Petitioner NRDC).

[207] *Id.*; Ernst Zirngast, *Oil and petrochemical industry Regional Differences* 23, 36-41 (Jan 28, 2008) (unpublished presentation) (on file with Petitioner NRDC).

[208] *See* Ctr. for Progressive Reform et al., *Preventing "Double Disasters"* 3 (July 2021), https://cpr-assets.s3.amazonaws.com/documents/preventing-double-disasters-final.pdf; *see also* Letter from Chemical Safety Board to Federal Energy Regulatory Commission 1-2 (July 13, 2023), https://www.csb.gov/assets/1/6/csb_ltr_to_ferc_(7-13-2023).pdf.

[209] EPA, Climate Change Indicators: Weather and Climate (last updated June 27, 2024), https://www.epa.gov/climate-indicators/weather-climate.

[210] *Id.*

[211] Nat'l Oceanic & Atmospheric Admin. (NOAA), State of the Science FACT SHEET, *Atlantic Hurricanes and Climate Change* (May 2023), https://sciencecouncil.noaa.gov/wp-

content/uploads/2023/05/1.1_SOS_Atlantic_Hurricanes_Climate.pdf ("[I]nundation levels during hurricane surge events will increase due to sea level rise," and "[r]ainfall rates within tropical storms and hurricanes are projected to increase by about 15%.").

[212] *See, e.g.*, CSB, News Release, *U.S. Chemical Safety Board Urges Chemical Companies to Prepare for Harsh Hurricane Season* (July 3, 2024), https://www.csb.gov/us-chemical-safety-board-urges-chemical-companies-to-prepare-for-harsh-hurricane-season/ (noting that heavy flooding from 2017's Hurricane Harvey caused equipment failures and fire at the Arkema chemical facility in Texas, leading to human exposures and an evacuation of nearby residents, and that extreme winds and flooding from 2020's Hurricane Laura damaged buildings, caused a power outage, and disabled mitigation equipment, leading to the release of "large plumes of hazardous gases… into the air," a 28-hour closure of Interstate 10, and a shelter-in-place order).

[213] *Id.*

[214] *Exxon's Joliet, Illinois, refinery still without power after tornado*, Reuters, July 18, 2024, https://www.cnbc.com/2024/07/18/exxons-joliet-illinois-refinery-still-without-power-after-tornado.html.

[215] *Crews battle refinery fire overnight*, Garvin County News Star, Apr. 28, 2024, https://www.gcnewsstar.com/news/crews-battle-refinery-fire-overnight.

[216] This graphic was prepared using ArcGIS software and FEMA data.

[217] *See* Appendix A, col. labeled "Flood Risk."

[218] *See, e.g.*, William Rabb, Update: FEMA *Flood Maps are Misleading, Blocking Insurance Uptake, Report Shows*, Insurance J. (Nov. 6, 2022), https://www.insurancejournal.com/news/national/2022/11/03/693006.htm#:~:text=And%20NC%20State%20researchers%20earlier,by%20about%20790%2C000%20square%20miles; Christopher Flavelle et al., *New Data Reveals Hidden Flood Risk Across America*, N.Y. Times, June 29, 2020, https://web.archive.org/web/20240404084407/https://www.nytimes.com/interactive/2020/06/29/climate/hidden-flood-risk-maps.html.

[219] Potential discrepancy between the floodplain maps and current conditions is apparent from a brief review of the precipitation data that FEMA uses. FEMA guidance points to precipitation data from NOAA National Weather Service's precipitation depth-duration-frequency maps compiled in several Atlases and Technical Papers. *See* FEMA, Guidance for Flood Risk Analysis and Mapping 2 (Feb. 2019), https://www.fema.gov/sites/default/files/2020-02/Hydrologic_Rainfall_Runoff_Analysis_Feb_2019.pdf. However, most volumes of NOAA's precipitation Atlas are outdated. *See* NOAA, *Current NWS Precipitation Frequency (PF) Documents*, https://www.weather.gov/owp/hdsc_currentpf (last visited Feb. 2, 2025) (listing, for example, the last-updated date for Illinois, housed in Volume 2, as 2006).

[220] Nat'l Transp. Safety Bd., *Hazardous Materials Accident Brief: Accident Number DCA-97-SZ-001* 1 (Nov. 1998), https://www.ntsb.gov/investigations/AccidentReports/Reports/HZB9804.pdf.

[221] *Id.*

[222] U.S. Dep't of Transp., Bureau of Transp. Stat., Tank Car Specifications & Terms (Apr. 18, 2018), https://www.bts.gov/surveys/annual-tank-car-facility-survey/tank-car-specifications-terms; 49 C.F.R. §§ 179.100–179.103; 49 C.F.R. § 173.244(a)(2) (2024) (narrowing HF carrier classes to cars in the 105 and 112 classes starting in 2028).

[223] Fed. R.R. Admin., Off. of Safety, Headquarters Assigned, *Accident Investigation Report HQ-2012-33: Paducah & Louisville Railway Company (PAL) Louisville, KY October 29, 2012* 5-7 https://railroads.dot.gov/sites/fra.dot.gov/files/fra_net/3559/HQ-2012-33.pdf.

[224] *Id.* at 6.

[225] Bruce Schreinerdylan Lovan, *Fire erupts at Ky. chemical train derailment site*, Spokesman-Rev., Oct 31, 2012, https://www.spokesman.com/stories/2012/oct/31/fire-erupts-at-ky-chemical-train-derailment-site/; Mark Vanderhoff, *Report revealing cause of 2012 West Point train derailment released*, WLKY, Mar. 12, 2014, https://www.wlky.com/article/report-revealing-cause-of-2012-west-point-train-derailment-released/3748437#:~:text=According%20to%20the%20report%2C%20a,torch%20ignited%20a%20leaking%20chemical; Patrick T. Sullivan, $*3.1 million settlement reached in 2012 derailment*, The Courier J., Apr. 22, 2014, https://www.courier-journal.com/story/news/local/2014/04/02/million-settlement-reached-derailment/7225445/.

[226] Michael J. Magda, Livonia Fire & Rescue, Western Wayne County HMRT, *Louisville Train Derailment Case Study* 21 (July 24, 2014), https://www.slideserve.com/faith/louisville-train-derailment-case-study (please note that this presentation contains graphic images of injuries).

[227] Nat'l Transp. Safety Bd., *Railroad Accident Report: Collision of Norfolk Southern Freight Train 192 With Standing Norfolk Southern Local Train P22 With Subsequent Hazardous Materials Release at Graniteville, South Carolina* [hereinafter Graniteville Report] v (Jan. 6, 2005), https://www.ntsb.gov/investigations/AccidentReports/Reports/RAR0504.pdf.

[228] *Id.* at 11.

[229] *Id.* at 17.

[230] *Id*. at v.

[231] Sally Hayati, *Hydrofluoric Acid Incidents in Torrance & Elsewhere* 6 (Oct. 7, 2015), https://traatest.wordpress.com/wp-content/uploads/2015/11/hf-incidents-partial-history.pdf.

[232] *Id.*; *see also Spill Forces Evacuation **Thousands leave homes after tanker truck with toxic chemical overturns on Rt. 33 in Wind Gap*, The Morning Call (last updated Oct. 5, 2021), https://www.mcall.com/2009/03/22/spill-forces-evacuation-thousands-leave-homes-after-tanker-truck-with-toxic-chemical-overturns-on-rt-33-in-wind-gap/.

[233] Ken Shigley, *Hazmat truck of hydrofluoric acid overturns, prompts evacuation*, Ga. Truck Accident Attorney Blog, Mar. 22, 2009, https://www.georgiatruckaccidentattorneyblog.com/hazmat_truck_of_hydrofluoric_a_1/.

[234] Torrance Refinery Action Alliance, *HF Truck Accident*, Facebook (May 11, 2017), https://www.facebook.com/TorranceRefineryActionAlliance/videos/476625769335859/.

[235] Sally Hayati, *Hydrofluoric Acid Incidents, supra,* note 231.

[236] Sharon McNary, *AQMD reviewing new toxic chemical leak at Torrance Refinery*, LAist, Dec. 27, 2018, https://laist.com/news/kpcc-archive/aqmd-reviewing-new-toxic-chemical-leak-at-torrance.

[237] Coalition to Prevent Chemical Disasters, Chemical Incident Tracker (last visited Feb. 4, 2025), https://preventchemicaldisasters.org/chemical-incident-tracker/incidents#searchform (search results for "Rail incident involving hazardous materials").

[238] *Id.* (search results for "Road incident involving hazardous materials").

[239] Keith Allen et al., *Illinois father and his 2 children are among those killed by ammonia release from semi-truck crash, coroner says*, CNN, Oct. 1, 2023, https://www.cnn.com/2023/10/01/us/truck-crash-illinois-anhydrous-ammonia/index.html.

[240] EPA HF Report, *supra* note 27, at 12.

[241] *Id.*

[242] *Id.*

[243] *Id.*

[244] *Id.*

[245] Kyujin Jung, 2017-2-6 *Critical Assessment of the 2012 Gumi Chemical Spill: An Adaptive Governance Approach*, Korea Institute of Public Administration Case Study Series at 2, 9.

[246] *Id.*; *see also* Soo Bin Park, *supra* note 141, at 15.

[247] Jinsung et al., *Fluorine distribution in soil in the vicinity of an accidental spillage of hydrofluoric acid in Korea*, 119 Chemosphere 577, 577 (2015).

[248] *Id*. at 577, 580, 582 (2015).

[249] *Id*. at 577, 582 (2015).

[250] Soo Bin Park, *supra* note 141, at 16.

[251] Kyujin Jung, *supra* note 246, at 3; Part III.B.4.ii & Appendix A (column labeled "HF volume for worst case release scenario").

[252] CSB PES Report, *supra* note 128, at 53.

[253] Illinois Department of Natural Resources, Des Plaines State Fish and Wildlife Area, https://dnr.illinois.gov/parks/park.desplaines.html (last visited Jan. 31, 2025).

[254] Forest Preserve District Will County, Four Rivers Environmental Education Center, https://www.reconnectwithnature.org/preserves-trails/visitor-centers/four-rivers-environmental-education-center/ (last visited Jan. 31, 2025).

[255] *See, e.g*., Midewin National Tallgrass Prairie: The Bison Project-Homepage, U.S. Forest Serv., https://www.fs.usda.gov/detail/midewin/landmanagement/resourcemanagement/?cid=FSEPRD533279 (last visited Jan. 31, 2025).

[256] Monroe Energy, History and Today, https://www.monroe-energy.com/history-today/ (last visited Dec. 12, 2024); *see also* NOAA, Atlantic Sturgeon Critical Habitat Map and GIS Data, https://www.fisheries.noaa.gov/resource/map/atlantic-sturgeon-critical-habitat-map-and-gis-data (last visited Feb. 3, 2025).

[257] Pennsylvania Natural Heritage Program, Western Pennsylvania Conservancy, *A Natural Heritage Inventory of Delaware County, Pennsylvania – Update 2011* 209-210 (June 2011), https://www.naturalheritage.state.pa.us/CNAI_PDFs/Delaware_CNHI_Update_2011_WEB.pdf (last visited Feb. 6, 2025).

[258] Louisiana Department of Wildlife & Fisheries, *Diversity: Rare Species and Natural Communities by Parish,* https://www.wlf.louisiana.gov/page/rare-species-and-natural-communities-by-parish (last visited Oct. 15, 2024) (search results for St. John the Baptist Parish, the parish that includes Marathon Garyville, the adjacent portion of the Mississippi River, and Lake Maurepas).

[259] *See, e.g.*, NOLA Adventures, *Beyond the Bayou Swamp Tour*, https://nolaadventures.com/adventures/beyond-the-bayou-swamp-tour/ (last visited Oct. 15, 2024).

[260] Della Hasselle, The Lens, *Louisiana plans to restore the dying Maurepas Swamp with water diverted from the Mississippi* (Sept. 29, 2017), https://thelensnola.org/2017/09/29/louisiana-plans-to-restore-the-dying-maurepas-swamp-with-water-diverted-from-the-mississippi/.

[261] *See* Christian MilNeil, Along the LA River, New Signs of Life in an Industrial Wasteland (Aug. 2, 2012), https://grist.org/cities/along-the-l-a-river-new-signs-of-life-in-an-industrial-wasteland/ (noting that the Torrance refinery is adjacent to a wetland); *see also* Valero, Wilmington Refinery, https://www.valero.com/about/locations/wilmington-refinery (last visited Dec 12, 2024) (noting that the refinery is adjacent to the ports of Long Beach and Los Angeles).

[262] U.S. Fish & Wildlife Service, *Hine's Emerald*, https://www.fws.gov/species/hines-emerald-somatochlora-hineana (last visited Jan. 17, 2025).

[263] This graphic was prepared using ArcGIS software. For the base map, Petitioners created a circular zone (approximately 12.6 square miles, or 8,000 acres) capturing the area within approximately one mile of the refinery boundary. They used the ArcGIS Pro tool Select Features by Location, https://pro.arcgis.com/en/pro-app/latest/help/mapping/navigation/select-features-by-location.htm (last visited Jan. 17, 2025); and the *Endangered Species Critical Habitat Areas* database (Aug 1, 2022), at https://www.arcgis.com/home/item.html?id=d46156cc921d4b41923c70c280b82458, to identify the critical habitat.

[264] The base map for this figure was prepared as described in note 263, above. The land-use data is drawn from the *USA NLCD Land Cover* database (last updated Nov. 15, 2023), at https://www.arcgis.com/home/item.html?id=3ccf118ed80748909eb85c6d262b426f.

[265] The base map for this figure was prepared as described in note 263, above. The protected land use data comes from the *PAD-US Protection Status by GAP Status Code* database (last updated Jun. 12, 2024), at https://www.arcgis.com/home/item.html?id=b7a09e6c95a846fe82970c70195a2739. The areas marked GAP 1 and 2 are classified as "managed primarily for biodiversity." *Id*.

[266] *See, e.g.*, API 751 Appendix D, *supra* note 162, at §§ 6.2.3.4, 6.2.4.1, 6.2.4.4.

[267] *See* Graniteville Report, *supra* note 227, at 20-21 (noting that "two pumper trucks, one medical unit vehicle, and one service truck" parked at a local fire station during a chlorine gas release from a derailed train were "destroyed or damaged beyond economical repair as a result of chlorine gas contamination."); Part III.B.7.v (also discussing the Graniteville release).

[268] *See* Part III.B.7 & Appendix B (summarizing incident history).

[269] *See* Part III.B.7.i.a.

[270] *See* Part III.B.7.i.b.

[271] *See* Appendix B at page 4, ¶ 38.

[272] CSB PES Report, *supra* note 128, at 6, 28.

[273] *See* https://www.apiwebstore.org/standards/751 (link to first edition).

[274] *See* API 751 Appendix D, *supra* note 162, §§ 9.5, 9.6.3 (recommending that refiners install water spray and rapid acid transfer/rapid acid deinventory systems).

[275] Energy Information Administration, *Number and Capacity of Petroleum Refineries*, https://www.eia.gov/dnav/pet/pet_pnp_cap1_dcu_nus_a.htm (last visited Oct. 10, 2024).

[276] American Fuel & Petrochemical Manufacturers, *Alkylation Safety* https://www.afpm.org/issues/safety-health/alkylation-safety (last visited Oct. 10, 2024).

[277] *See supra* note 133 and Appendix A.

[278] EPA, Accidental Release Prevention Requirements: Risk Management Programs Under the Clean Air Act, *supra* note 171, at 17,647.

[279] *See, e.g,* National Library of Medicine, PubChem: *Sulfuric Acid* https://pubchem.ncbi.nlm.nih.gov/compound/Sulfuric-Acid (listing the boiling point of sulfuric acid as 554 degrees Fahrenheit) (last visited Sept. 30, 2024). In 1991, oil company scientists conducted tests similar to the 1986 Goldfish tests discussed at Part III.B.1 to assess the consequences of a sulfuric acid release from a refinery alkylation unit—and found that the vast majority of the released sulfuric acid (97% on average) fell to the ground as a liquid. *See* David W. Johnson, *Sulfuric Acid Release Report*, Presented At 1994 National Petroleum Refiners Association Annual Meeting San Antonio, Texas March 20-22, 1994, https://www.questconsult.com/papers/sulfuric-acid-release-report/ (last visited Oct. 15, 2024).

[280] *See generally* Hye-Kyung Timken, et al., *supra* note 41, at 12; S. Zhang, et al. for Norton Engineering, *Alkylation Technology Study Final Report for the South Coast Air Quality Management District*, at 27 (Sept. 9, 2016) https://www.aqmd.gov/docs/default-source/permitting/alkylation-technology-study-final-report.pdf.

[281] Robert Brelsford, *Chevron's Salt Lake City refinery starts up ISOALKY unit*, Oil & Gas Journal (Apr. 13, 2021) https://www.ogj.com/refining-processing/refining/article/14201279/chevrons-salt-lake-city-refinery-starts-up-isoalky-unit.

[282] EPA, *Big West Oil, LLC resolves chemical risk management violations at North Salt Lake facility* (Jan. 14, 2021) https://www.epa.gov/newsreleases/big-west-oil-llc-resolves-chemical-risk-management-violations-north-salt-lake-facility; Callum O'Reilly, *Big West Oil selects Honeywell UOP technology*, Hydrocarbon Engineering (Nov. 12, 2021) https://www.hydrocarbonengineering.com/refining/12112021/big-west-oil-selects-honeywell-uop-technology/; Robert Brelsford, *Big West Oil lets contract for unit revamp at Utah refinery*, Oil & Gas Journal (Nov. 11, 2021) https://www.ogj.com/refining-processing/refining/optimization/article/14213854/big-west-oil-lets-contract-for-unit-revamp-at-utah-refinery. In the settlement consent decree, Big West had committed to installing technology to better detect HF leaks, estimated to cost $253,000; conversion will save Big West this cost. *See* Consent Decree ¶ 118(a), *United States v. Big West Oil*, No. 1:13-CV-00121 BCW (D. Utah filed Aug. 23, 2013), https://www.epa.gov/sites/default/files/2013-08/documents/bigwestoil-cd.pdf.

[283] Hye-Kyung Timken, et al., *supra* note 41, at 11-12.

[284] *Id.* at 15.

[285] Journal Record Staff, *Wynnewood refinery upgrade may lead to industry changes*, The Journal Record (Mar. 20, 2023), https://journalrecord.com/2023/03/wynnewood-refinery-upgrade-may-lead-to-industry-changes/.

[286] S. Zhang, et al., *supra* note 41280, at 27.