EPA's Open Burning/Open Detonation Rule Revisions Fall Short in Addressing Contamination in Virginia and West Virginia

Michael Lemke[1], Alissa Ganser[1], Jane Remfert[1], Julia Davis[1], Trisha Vaidyanathan[1], Katherine Canada[1], Peter Forstner[1], Jordan Thompson[1], J. Maxwell Ebert[1]

[1]Virginia Scientist Community Interface (V-SCI), VA, USA https://virginiasci.org/
https://doi.org/10.38126/JSPG270110
Corresponding Author: lemkem0@gmail.com
Keywords: open burning/open detonation (OB/OD); thyroid cancer; Radford Army Ammunition Plant (RAAP)

Executive Summary: Open burning/open detonation (OB/OD) facilities pose a significant contamination threat to local municipalities. The OB/OD disposal method of munitions manufacturing waste is utilized by the Radford Army Ammunition Plant (RAAP) in Virginia and other locations. The OB/OD exception was originally implemented to facilitate the disposal of military explosive waste, and has continued at RAAP since the early 2000s despite safer disposal methods being developed. In accordance with its core mandate to safeguard the public and the environment, the US Environmental Protection Agency (EPA) has proposed revisions to the exemptions for OB/OD. However, based on our analysis of the disease burden within the RAAP watershed in Virginia and West Virginia, as well as the policy itself, it is evident the EPA proposal falls short of adequately safeguarding communities from the harmful effects of the OB/OD practices.

The currently proposed changes by the EPA lack the necessary vigor to protect public health and the environment from the risks associated with OB/OD. Evidence shows that OB/OD proximity to communities is highly associated with thyroid cancer in underserved regions like Virginia and West Virginia. To address these critical issues, we strongly advocate for the immediate cessation of OB/OD activities, aligning with the recommendation by the National Academies of Sciences, Engineering, and Medicine (NASEM, 2019). We propose a four-pronged solution: 1) to establish safer disposal methods, 2) stringent environmental quality monitoring by independent researchers, 3) enhanced community engagement, and 4) rigorous EPA oversight to prevent detrimental health consequences and protect the well-being of underserved communities. By addressing the contamination burden that includes funding procurement, we aim to protect against adverse OB/OD health outcomes in proximal communities by addressing policy limitations.

I. Introduction

Open burning and open detonation (OB/OD) are methods used for destroying unexploded munitions, waste explosives, and other hazardous materials, involving either burning materials in open air (open burning, OB) or causing them to explode in an unconfined environment (open detonation, OD). In 1980, the Environmental Protection Agency (EPA) banned OB/OD of hazardous waste but made exceptions for waste explosives with no safe alternative method of disposal (EPA, 1980; Figure 1). Today, sixty-four facilities in the US have OB/OD

permits, the vast majority of which are operated by the US military (EPA, 2025).

The United States Government originally built almost sixty munitions manufacturing facilities across the country during World War II (Haraburda, 2017). Many of these sites are now decommissioned, including the Cornhusker Army Ammunition Plant (Hall County, Nebraska), which was designated a Superfund National Priority List site by the EPA (ATSDR, 1989), and the Badger Army Ammunition plant (Sauk County, Wisconsin), which is legally covered by the Resource Conservation and Recovery Act (The 94th Congress, 1976). However, some munitions plants, such as the Radford Army Ammunition Plant (RAAP) in Montgomery and Pulaski Counties, Virginia, are still in operation and have been permitted to use OB/OD for decades (EPA, 2022; EPA, 2025; Figure 1). There are 64 total OB/OD permitted facilities in the U.S. (EPA, 2025). In total, the US military has approximately 400,000 tons of munitions destined for disposal, and nearly 60,000 tons are added to that stock across facilities each year (NASEM, 2019). Due to the growing public awareness of munitions waste contamination in public municipalities, environmental advocacy groups such as Citizens for Arsenal Accountability (CAA) and Citizens for Safe Water Around Badger (CSAWB) are now actively campaigning for an outright ban on the remaining OB/OD facilities.

The OB/OD process releases toxic compounds, including heavy metals, nitrates, per- and polyfluoroalkyl substances (PFAS), and perchlorates, into the air and nearby waterways, posing a significant threat to human health (Chatterjee et al. 2017; Vinti et al. 2021). To protect high-exposure populations, including military personnel and veterans, against these harmful exposures, the Biden administration signed the Promise to Address Comprehensive Toxics (PACT) Act into law in 2022 (The 117th Congress, 2022). This act gave millions of veterans access to healthcare and benefits related to military OB/OD burn pits and toxic chemical exposure (Figure 1). The government also established the Comprehensive Assessment of Respiratory and Other Military Exposures (CARE) center as part of the PACT Act, located on the Washington, DC, Veterans Affairs Medical Center campus, which provides specialized care for veterans exposed to toxic chemicals.

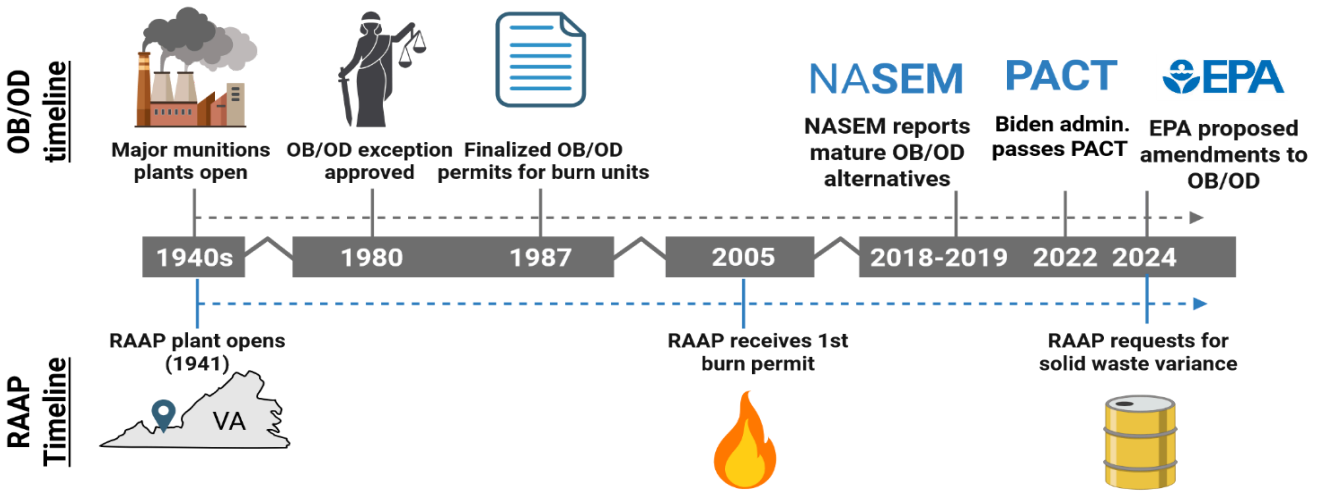

Figure 1: Timeline of (top) open burning/open detonation (OB/OD) and (bottom) the Radford Army Ammunition Plant (RAAP; Montgomery and Pulaski Counties, Virginia) over the past nine decades. Bridged lines indicate breaks in time. The graphics were generated using BioRender (Lemke, M., 2025), https://BioRender.com/6syt4d4.

In response to growing public attention, the EPA has acknowledged the potential adverse health impacts associated with OB/OD (EPA, 2024). Since 2024, acting on its primary responsibility to protect human and environmental health, the EPA has made efforts to minimize the environmental burden and human exposure to harmful heavy metals, perchlorates, PFAS, furans, and other toxic chemicals associated with upper respiratory and hormonal diseases, as well as certain forms of cancer. Numerous health conditions have been associated with exposure to these chemicals; however, further studies are needed to investigate the effects of these xenobiotic chemicals on endocrine glands, such as the thyroid (Oliveira et al., 2019). Due to the significant detrimental impacts of OB/OD, the EPA has proposed amendments to the current policy to enhance waste management by utilizing safer alternatives (NASEM, 2019; EPA, 2024; Figure 1). The proposal seeks to revise regulations for the open burning and open detonation of waste explosives by introducing stricter technical standards, requiring alternative technology evaluations, and limiting OB/OD to situations where no safer alternatives exist. The EPA included in their revision (1) a *de minimis* exemption for facilities generating small amounts of waste explosives (~15,000 pounds of net explosive weight or less annually), (2) new monitoring and operating requirements, (3) prohibitions on treating hazardous waste on-site, and (4) enhanced public notification and reporting measures (NASEM, 2019).

The proposed addendums to the regulations on OB/OD do not adequately protect against the associated dangers, particularly at high output facilities like RAAP. This analysis examines RAAP as a case study into the long-term effects of legacy OB/OD continuation, and demonstrates the policy shortcomings regarding safeguarding municipalities. We promote more rigorous oversight and immediate adoption of safer waste disposal methods to address the pervasive challenge of munitions waste in Appalachia.

II. Data Acquisition and Methodology

The historical timeline (Figure 1) was created using historical records, regulatory filings, and environmental reports compiled from the government (Federal Registry), contractors, and grassroots organizations since the time of the RAAP construction in the 1940s until the present (NASEM, 2019; Lien, 2023; Fuhrmann and Minovi, 2022). Both State Cancer Profiles and EPA Toxic Release Inventory (TRI, EPA, 1987) data are free for public use under the US government's public domain policies (17 U.S.C. § 105). Both Virginia and West Virginia cancer data were obtained from the National Cancer Institute's State Cancer Profiles (https://statecancerprofiles.cancer.gov/), and the RAAP-TRI data were obtained from the EPA environmental database website (https://enviro.epa.gov/triexplorer/tri_release.chemical). State TRI factsheets for the top five facilities, as described by waste releases in millions of pounds, and the total on- and off-site chemical waste releases in pounds were accessed via the TRI Explorer site for both Virginia and West Virginia (Figure 3 & 4). ArcGIS was used to produce maps, and BioRender to create graphics using a personal license.

Age-adjusted cancer incidence data by county for Virginia and West Virginia were downloaded from the National Cancer Institute's State Cancer Profiles database (https://statecancerprofiles.cancer. gov/), which provides publicly accessible data compiled from state cancer registries and the Centers for Disease Control and Prevention (CDC). County boundaries for Virginia and West Virginia, as well as the New River map layer, were obtained from publicly available spatial data from the ESRI ArcGIS Online Portal. Coordination points at Gauley Bridge (Fayette County, West Virginia) and the RAAP (Montgomery and Pulaski Counties, Virginia) were added as point features to ArcGIS Pro using the XY Table to Point tool, which converted the specific latitude and longitude values of both locations into point features. All mapping and spatial analysis were conducted in ArcGIS Pro Version 3.3.0. All data were symbolized, labeled, and finalized using ArcGIS Pro's layout tools, with all layers projected in WGS 1984 for consistency across Figure 2 and Figure 6.

The New River Health District in Virginia was delineated by selecting Giles, Pulaski, Montgomery, and Floyd Counties and the City of Radford from the USA Counties map layer (ESRI ArcGIS Online Portal) using the Select by Attribute tool (Figure 2). The included counties and city were determined based on the Virginia Department of Health regional definitions. The locations of Gauley Bridge (Fayette County, West Virginia) and the RAAP (Montgomery

and Pulaski Counties, Virginia) were included for reference (Figure 2).

For the cancer incidence analysis (Figure 6), the downloaded data of cancer incidence by county was joined to the county boundaries layer and classified using five categories created with the Natural Breaks (Jenks) classification in ArcGIS Pro. This method minimizes variance within groups while maximizing variance between groups, producing five classes that highlight distinct clusters across the 188 counties and cities in Virginia and West Virginia. Gray shading indicates counties with fewer than sixteen cases (Figure 6), which were excluded from mapping to avoid over-interpretation of small counts. These counties represent approximately 52.7% of all counties in the dataset. The New River map layer was added to contextualize spatial patterns in cancer incidence along the watershed (Figure 6). Gauley Bridge (Fayette County, West Virginia) and the RAAP (Montgomery and Pulaski Counties, Virginia) point features were then added to indicate potential upstream and downstream influences.

To assess the strength and direction of associations between thyroid cancer incidence in Virginia and West Virginia and the total on- and off-site release of toxic chemicals, as reported in the TRI, from the RAAP, we performed correlation analyses for each state by compound (n = 14). Spearman's rank-order correlations were performed using R version 4.4.3 (R Core Team, 2025). Cancer incidence data for Virginia and West Virginia spanned 2002-2021, and the TRI data for the RAAP covered 1994-2023. To account for thyroid cancer disease latency, we generated correlations on a one- and five-year time scale, as five years is the minimum latency period before cancer appearance following direct radiation exposure (Iglesias et al., 2017). To control the false discovery rate arising from multiple comparisons (14 chemical compounds * 2 states * 2 time windows), we applied the Benjamini-Hochberg procedure across all correlations (n = 56).

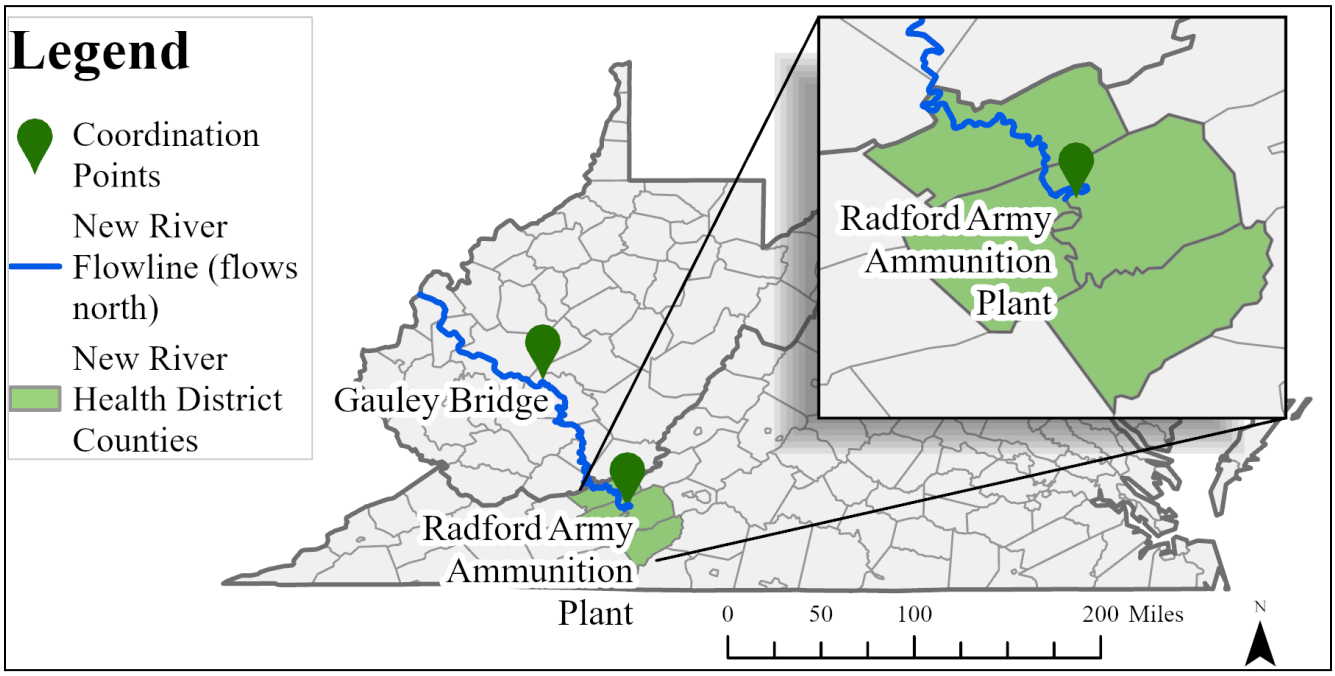

Figure 2: County-level maps of West Virginia and Virginia. The locations of Gauley Bridge (Fayette County, West Virginia) and the Radford Army Ammunition Plant (RAAP; Montgomery and Pulaski Counties, Virginia), along with the counties in the New River Health District in Virginia, are highlighted in green. The counties in the New River Health District include Giles, Pulaski, the City of Radford, Montgomery, and Floyd counties.

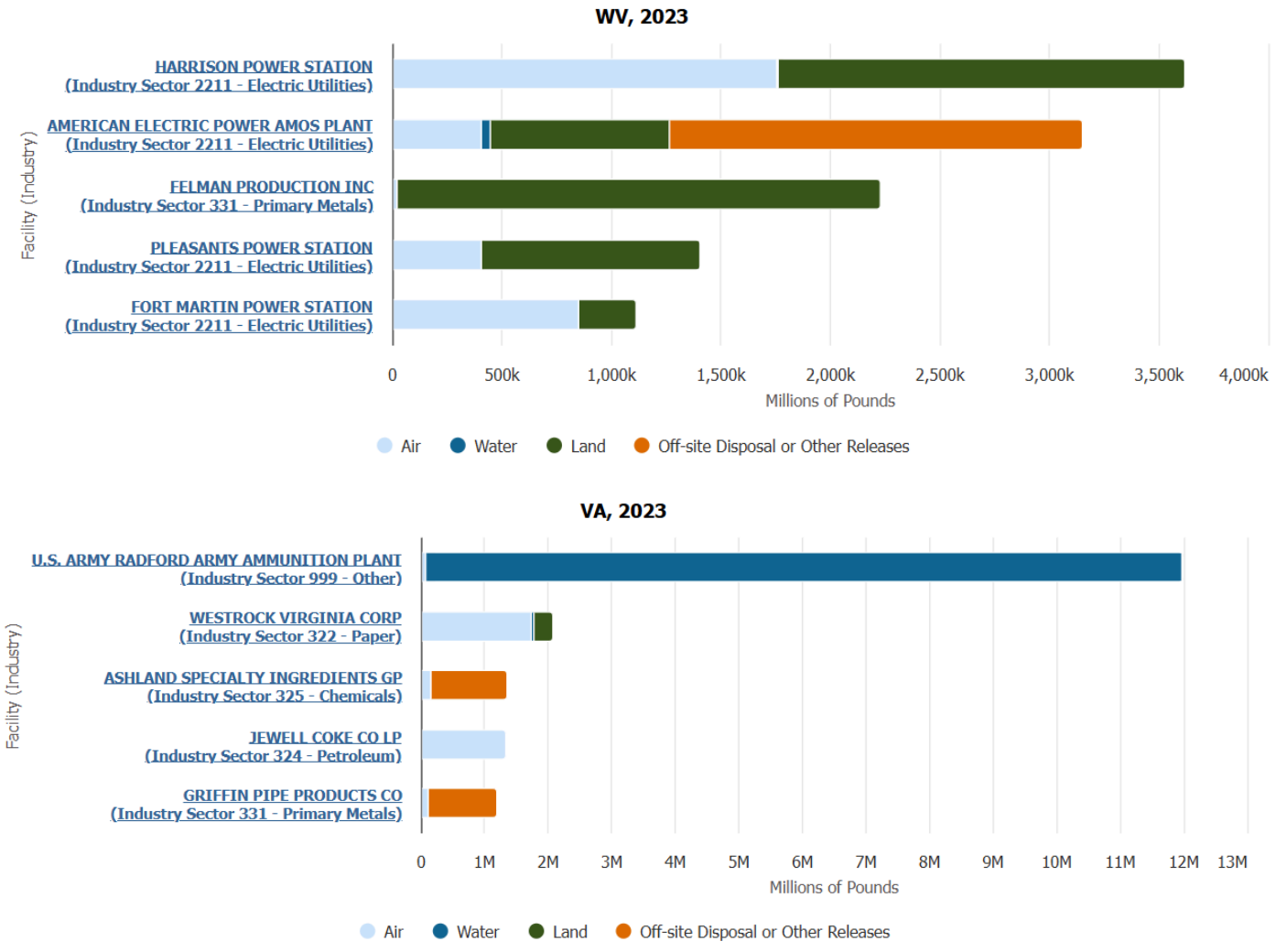

Figure 3: Radford Army Ammunition Plant (RAAP; Montgomery and Pulaski Counties, Virginia) Toxic Release Inventory outline (TRI). The top five facilities, as described by waste releases in millions of pounds, for West Virginia (WV) and Virginia (VA).

III. Case Study: The Radford Army Ammunition Plant

i. The Radford Army Ammunition Plant is a significant waste contributor in Virginia.

Here, we use the RAAP as a localized case study to investigate how operational OB/OD near human populations could impart severe public health consequences (Figure 2). The RAAP is in the New River Health District between Pulaski and Montgomery counties in Virginia and currently functions as one of the major domestic suppliers of propellants and explosives used in American field, naval, and aircraft artillery. The RAAP is operated by BAE Systems under contract to the US Army Joint Munitions Command, and is located directly along the bank of the New River in Radford, Virginia, about ten miles southwest of Virginia Tech (Figure 2). The New River begins in North Carolina and flows north and northwest through the southwestern portion of Virginia and the southeastern portion of West Virginia. In West Virginia, the New River converges with the Gauley River in the town of Gauley Bridge, where it forms the Kanawha River and eventually meets the Ohio River.

The RAAP disposes of millions of pounds of waste annually, and, despite significant exemptions, has

violated EPA regulations on incinerator waste management and groundwater disposal at least fifty times over the past thirty-seven years (Fuhrmann and Minovi 2022). Additionally, excessive flooding from Hurricane Helene in September 2024 resulted in a release of 225 gallons of dibutyl phthalate, a known endocrine disruptor, into the New River (DEQ, 2024), as well as the release of calcium sulfate and petroleum into the waterway when the facility flooded and storage containers were washed away (Beyer & Verrelli, 2024). This flooding event occurred when RAAP was already requesting an exemption from the Virginia Department of Environmental Quality to accept and recycle excess waste. This exemption request, or variance, was granted, and allowed RAAP to increase the amount of waste accepted at the facility above their original permits (VWMB, 2024). This formal application, to temporarily exempt specific water use restrictions or conservation measures (VAC, 2024; Figure 1), likely exacerbated the release of dibutyl phthalate and other chemicals linked to reproductive and organ toxicity (Ahern et al., 2019; VDEQ, 2024). These chemicals can accumulate in riverbeds and in aquatic life, thereby affecting the food chain in the New River locality and causing fish kills, oxygen depletion, bioaccumulation of toxins, and serious health risks to humans. Unfortunately, long-term monitoring of the health impacts of exposure to New River contamination is severely limited by the high turnover of residents in the area, largely due to the hyper-transient Virginia Tech student population. In 2023, approximately 35,000 students were enrolled, most of whom lived in the community for less than five years.

By law, the Radford Army Ammunition Plant submits detailed reports on its releases and pollution prevention efforts to the EPA annually. Since 2001, RAAP has consistently deposited over 10 million pounds of waste chemicals on- and off-site (Figure 3). In 2021, the RAAP disposed of over 10 million pounds of chemical waste, mostly nitrate compounds, that were deposited on- and off-site as water waste in the New River (Figure 4). Nitrate-containing compounds, being highly water soluble, can contaminate water ecosystems by promoting eutrophication and harming aquatic life, while downstream water treatment plants struggle to remove nitrates from potable water alongside other chemicals that are currently not fully eliminated (Knobleman, 2017). As of 2023, RAAP is the top facility in Virginia for total waste releases, reporting close to 12 million pounds of waste, which is 3.5 times higher than the highest reported facility in West Virginia (Figure 3). This collectively identifies RAAP as a significant source of pollution to the New River and the state of Virginia for the past twenty years.

ii. Thyroid Cancer has increased in Virginia and West Virginia since the early 2000s.

Thyroid cancer incidence has been rising significantly, presenting unique challenges in regions like Appalachia that face disparities in healthcare access and outcomes (Wilson, 2016). The thyroid gland is located in the neck and produces hormones necessary for human metabolism and development. Thyroid Cancer refers to abnormal cell growth in thyroid tissue and has significantly risen globally, with rates tripling in the US over the last three decades (Davies and Welch, 2014). This rise is partly attributable to increased detection and diagnosis, especially of small, asymptomatic cancers. This is the case for papillary thyroid cancer, which is the most common type and most receptive to treatment (Davies and Welch, 2014). While thyroid cancer is often treatable and typically has a high survival rate compared to other metastatic cancers, the Appalachian region, including West Virginia and parts of Virginia, faces broader challenges in cancer care. Disparities in socioeconomic status, healthcare access, and historical occupational risks in Appalachia contribute to significant variation in cancer outcomes, with certain counties experiencing disproportionately higher incidence and mortality rates, complicating thyroid cancer care and survival in the region (Burus et al. 2023).

Thyroid cancer data is made publicly available through the National Cancer Institute's (NCI) Surveillance, Epidemiology, and End Results Program (SEER*Stat) Database (HHS, CDC) and indexed by state through the State Cancer Profiles interactive map website (Hankey et al., 1999). When considering thyroid cancer cases in Virginia and West Virginia, the incidence has consistently risen since the early 2000s (Figure 5). This aligns with the dramatic increases in munitions production at RAAP until the 2010s (Figure 4). Increases in cancer incidence plateaued around that time and slightly decreased in the latter portion of the last decade

(Figure 5). From 2017 to 2021, there were approximately 11.3 and 16.3 diagnoses of thyroid cancer per 100,000 people in Virginia and West Virginia, respectively. During the period 2018-2022, there were 0.5 and 0.4 deaths per 100,000 people in Virginia and West Virginia, respectively (NCI and CDC, 2025). The rate of mortality is still climbing in Virginia over the most recent five-year rate change analysis (2018-2022, Figure 5). West Virginia thyroid cancer mortality rates could not be calculated due to insufficient counts in the SEER database (Figure 5).

We hypothesized that cancer rates in West Virginia and parts of Virginia might be higher in closer proximity to RAAP. Specifically, due to RAAP's dominant water waste disposal practices (Figures 3 and 4), the cancer incidence by county in Virginia's New River Health District and southwest-central West Virginia would be higher along the New River. Overlaying the incidence of thyroid cancer data in West Virginia and Virginia counties shows that the incidence is generally higher in West Virginia (Figure 6).

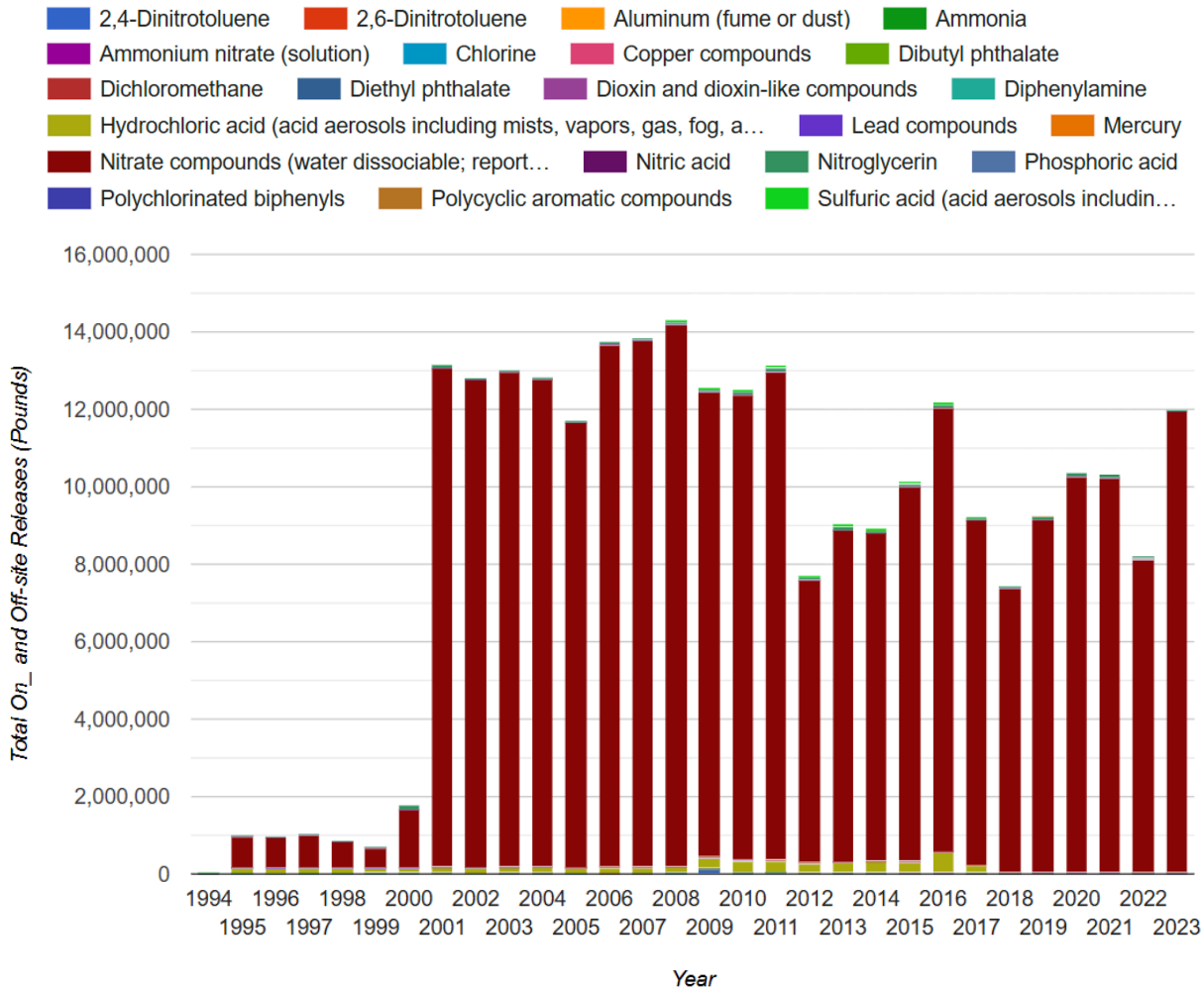

Figure 4: The Radford Army Ammunition Plant (RAAP; Montgomery and Pulaski Counties, Virginia) Toxic Release Inventory outline (TRI) total on- and off-site chemical waste releases in pounds from 1994 to 2023. All data is publicly available via the EPA-TRI explorer site. Total annual waste stacked in years; color indicates chemical compound. Updated October 2024.

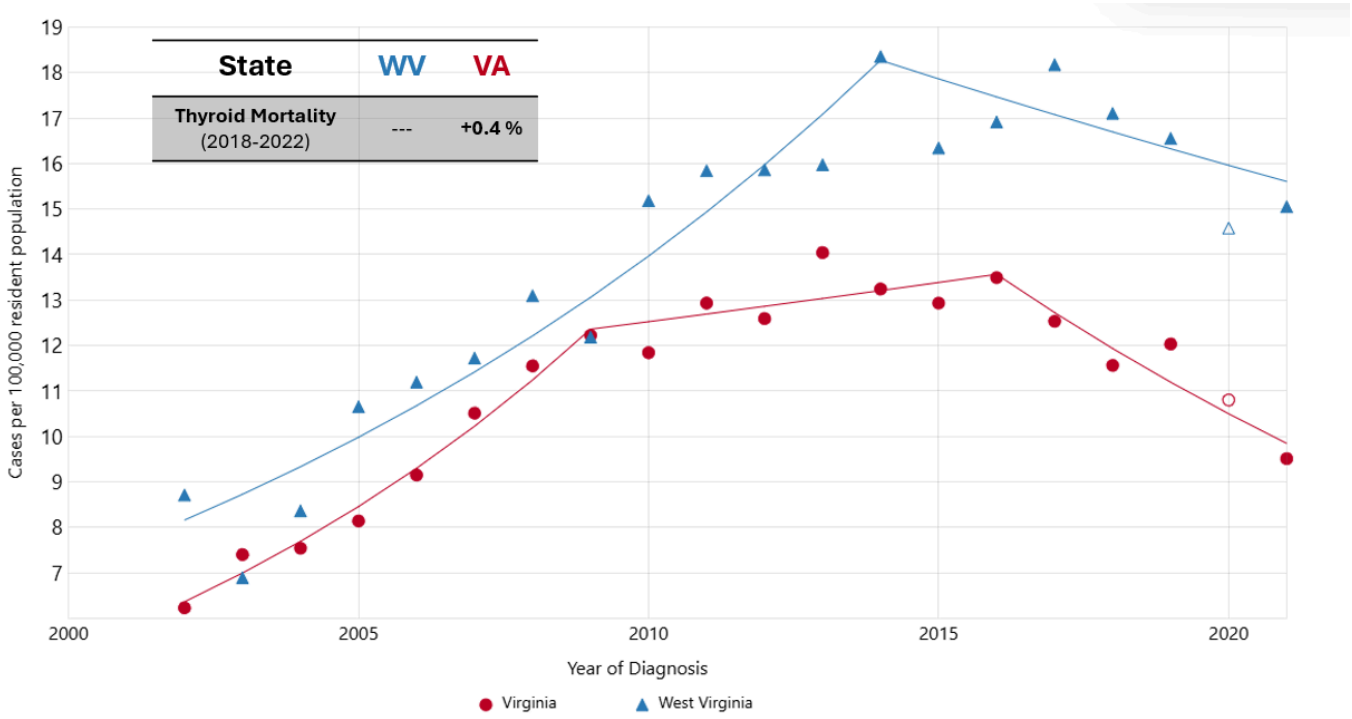

Figure 5: Thyroid cancer yearly incidence and five-year mortality rate change in Virginia (VA) and West Virginia (WV). Incidence data provided by the National Program of Cancer Registries. SEER*Stat Database - United States Department of Health and Human Services (HHS), Centers for Disease Control and Prevention (CDC). Graph created by statecancerprofiles.cancer.gov on 05/19/2025 12:16 pm. Regression lines calculated using the Joinpoint Regression Program (Version 5.1). The 2020 incidence rate (open circle and triangle) is displayed but not used in the fit of the trend line(s) due to inaccurate reporting during the initial year of the COVID-19 pandemic. (Top Left insert) Mortality data provided by the National Vital Statistics System public use data file—death rates calculated by the National Cancer Institute using SEER*Stat. Mortality rates (deaths per 100,000 population per year) are age-adjusted to the 2000 US standard population. No calculation of annual percent change due to insufficient counts is indicated by "- - -" (SEER*Stat). Population counts for denominators are based on Census populations as modified by NCI. The US Population Data File is used with mortality data.

The counties adjacent to Radford City and RAAP are Montgomery and Pulaski, which run north to south, and have a moderate incidence relative to other counties in the state. However, as the New River flows north into West Virginia, the highest incidence of thyroid cancer primarily localizes within one or two counties away from Fayette County, West Virginia, where the New River and Gauley River form the Kanawha in the southwestern West Virginia watershed (Figure 6). Although the counties nearest to RAAP experience the highest immediate exposure risk, long-term contamination is expected to travel downstream following the river flow northward into the West Virginia watershed.

To test this hypothesis, we proposed that the toxic release inventory data would correlate with the incidence of thyroid cancer in the states of Virginia and West Virginia. We then performed correlations between both state cancer incidence rates and the release data separated by chemical compound.

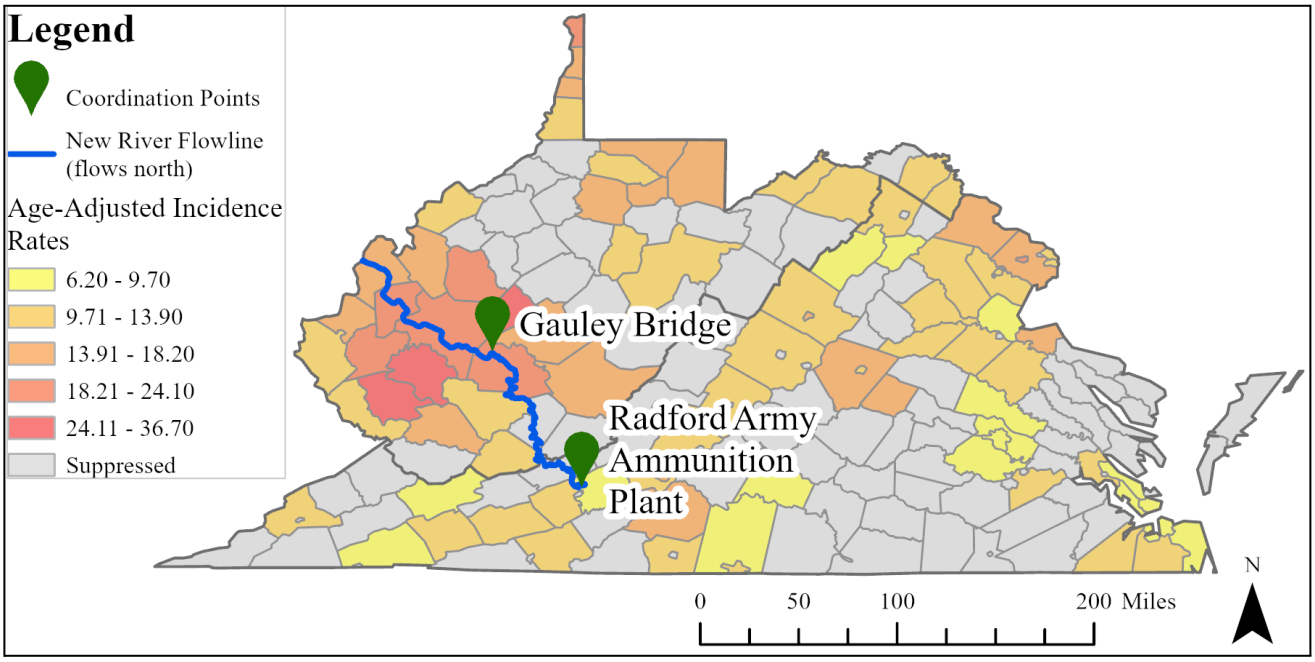

Figure 6: Age-adjusted cancer incidence rates by counties in Virginia and West Virginia. Data are sourced from the National Cancer Institute's State Cancer Profiles (https://statecancerprofiles.cancer.gov) and mapped in ArcGIS Pro. Age-adjusted incidence rates (cases per 100,000 population) are classified into five categories and displayed by county. Gray-shaded counties represent areas where data have been suppressed to protect confidentiality and ensure stability of rate estimates; specifically, data are suppressed when fewer than 16 cases were reported in a specific area-sex-race category. The New River flowline (blue), which flows north, is included to show that counties along or near the river tend to exhibit higher cancer incidence rates. The locations of Gauley Bridge (Fayette County, West Virginia) and the Radford Army Ammunition Plant (RAAP; Montgomery and Pulaski Counties, Virginia) are marked to contextualize potential chemical exposure sources within the watershed.

While some chemical releases were inversely associated with cancer incidence in West Virginia and Virginia, diphenylamine, HCl, and sulfuric acid all had positive correlations with cancer incidence (Figure 7). As well, each of the four chemical correlation strengths increased when releases were averaged over the minimum thyroid cancer latency period. In the case of diphenylamine, interpretation should be made with caution due to the relatively small sample size (n = 10, one-year; n = 7, five-year).

One potential explanation as to why some chemicals showed an inverse correlation while others showed a positive correlation to cancer incidence is the carcinogenic classification of different chemicals. Dibutyl phthalate, a plasticizer in propellants, is a known endocrine disruptor and has been previously linked to several types of breast cancer (Ahern et al., 2019). The International Agency for Research on Cancer (IARC) groups chemicals depending on how well the evidence points to that chemical being carcinogenic, with the groupings as follows: not classifiable (group 3), possibly carcinogenic (group 2B), probably carcinogenic (group 2A), and definitive carcinogens (group 1). Sulfuric acid exposure is strongly associated with throat and lung cancers (Soskolne et al., 1992) and is classified as IARC group 1. Diphenylamine is a group 2B IARC carcinogen due to significant concerns about some of its associated impurities and breakdown products, such as 4-aminobiphenyl (Feng et al., 2002), a group 1 chemical (IARC, 2012). Hydrochloric acid (HCl) is IARC group 3, and IARC has not classified nitroglycerine.

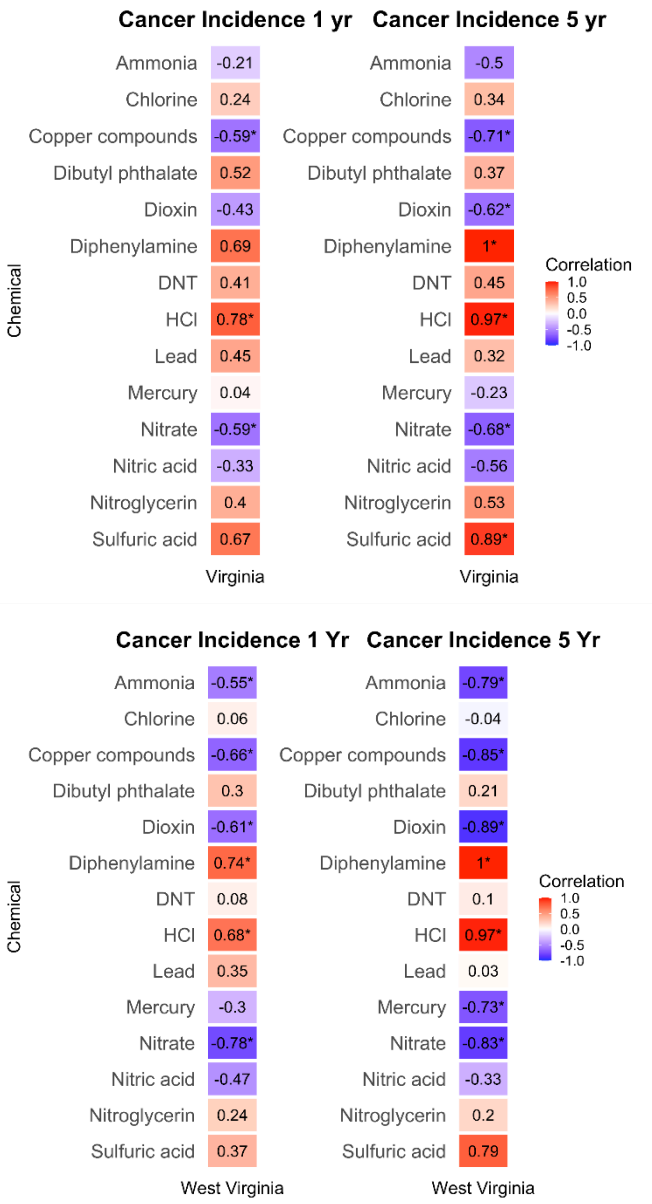

Figure 7: Correlation of Virginia (top) and West Virginia (bottom) thyroid cancer incidence and chemical waste release. Associations between National Cancer Institute Virginia and West Virginia State Cancer Profile Incidence rates (summarized in Figure 5) and Toxic Release Inventory outline release data parsed by chemical compound (summarized in Figure 4) were assessed using Spearman correlation analyses. Multiple testing corrections were applied using the Benjamini-Hochberg procedure (n = 56 tests). Significance level is represented by asterisk:
*P≤0.050.

iii. Ecosystem concerns compounded by RAAP OB/OD associated chemical release.

While we have thus far focused on the relationship between RAAP emissions and cancer rates in Virginia and West Virginia, it is also worth noting other significant concerns associated with environmental contamination. Each chemical identified here is indicative of different steps along the munitions production pipeline. Nitrate-containing compounds are used to manufacture propellants, whereas the acids are used at secondary processing stages (USDOI, 1984). Yearly emissions from RAAP include tens of millions of pounds of largely nitrate-water-soluble compounds (Figure 4). Nitrate and acid can be damaging to freshwater ecosystems, potentially causing soil acidification, eutrophication, and other harm to aquatic life (Yang et al., 2008). The remaining harmful chemicals such as dibutyl phthalate, diphenylamine, lead, and nitroglycerine also bioaccumulate as toxins that pose a severe risk to proximal wildlife and humans (USAMBRDL, 1978; Mirecki, Porter, and Weiss, 2006).

Currently, Virginia has fish consumption advisories for fish caught from the New River. These advisories are in place due to high levels of polychlorinated biphenyls (PCBs), and include catfish and other larger fish species, which are advised to be eaten less than twice per month, and carp, which are advised never to be consumed from sixty-eight miles of the New River between Claytor Lake (upstream of RAAP; Pulaski County, Virginia) and the West Virginia state line (VDH, 2025). Chemicals like PCBs are known to become concentrated in the mud at the bottom of rivers, causing bottom-feeder fish, like catfish and carp, to be exposed to PCBs frequently. Therefore, contamination of these popular game fish species poses a significant threat to both fishing and recreational industries as well as public health (Turyk et al., 2012). PCBs can bioaccumulate in the food web, and animals that consume these fish have been shown to have higher concentrations of PCBs (Sheffield, 1997). Although we are presenting limited data from only one potentially affected geographic area, catfish, smallmouth bass, and carp are all widely distributed across the United States. However, fish consumption warnings and the reasons behind these warnings are often not well broadcast along the New River. Word-of-mouth in local communities, online forums, and state websites

appears to be the primary means of disseminating this information, and individuals who lack access to these communities and online resources may inadvertently consume fish and interact with these waterways despite the warnings (VDH, 2025).

IV. Policy shortcomings

The EPA's proposed revision to implement safer OB/OD alternatives acknowledges a critical gap in regulations that allows the open burning or open detonation of waste explosives under the Resource Conservation and Recovery Act (RCRA, The 94th Congress, 1976) to cause devastating harm to health (NASEM, 2019; EPA, 2024). At the same time, the proposed rule also falls short of having a meaningful impact. Given the dire health consequences faced by communities local to OB/OD facilities (Section III), we strongly advocate that the EPA and Virginia Department of Environmental Quality (DEQ) address these shortcomings based on our comments below.

i. The proposed rule relies on self-reporting and lacks adequate details on enforcement.

The current proposed rule relies entirely on self-reporting by OB/OD facilities. Implementing new, safer technologies will involve significant financial, technical, and logistical challenges. These facilities are under immense financial and political pressure, and as such, there is not always an adequate incentive for OB/OD facilities to properly implement new guidelines. The reliance on self-reporting for regulatory compliance has historically led to underreporting and a lack of accountability for environmental violations (EPA, 2022). For example, according to a report by Earthjustice (Fuhrmann and Minovi, 2022), RAAP has been out of compliance with Clean Air Act requirements for seven out of the past twelve quarters and with Clean Water Act requirements for six out of the past twelve quarters from 2021 to 2024. Despite continued violations, RAAP has not altered its actions and continues to violate environmental regulations, mainly due to a lack of meaningful consequences for noncompliance. As per the RCRA, Virginia's DEQ issues and routinely inspects RAAP's operating permits for wastewater discharge and hazardous waste management. Ultimately, however, it is the EPA that holds the authority to take direct enforcement action against a facility like RAAP, particularly in cases of significant violations or if the EPA determines that the state's response is inadequate.

For the current proposed rule, the DEQ and EPA must establish robust, direct monitoring mechanisms and strict sanctions to ensure adherence to new OB/OD regulations at facilities like RAAP. This could operate via established "polluter pays" principles established by the European Union, where those that produce pollution, are made to bear high-multiple financial penalties that strongly incentivize investment in prevention and control measures by manufacturers (OECD, 2008). Unlike the EU, which can impose high-multiple fines based on a percentage of a company's global turnover for serious environmental crimes, the US relies on a patchwork of federal and state penalties that are fiscally limited in comparison, and enforcement is often case-specific (de Sadeleer 2012; Campa, 2023). Direct inspections by DEQ officials are crucial for accurately assessing compliance, detecting violations, and enforcing regulations effectively. This will not only enhance the credibility and efficacy of the regulatory framework by DEQ/EPA officials but also safeguard public health and the environment from the adverse impacts of OB/OD.

ii. The EPA exemptions create loopholes.

In reviewing EPA's proposed rule on the OB/OD of waste explosives, several loopholes can be identified that facilities might exploit under different provisions. The *de minimis* exemption, which allows facilities to avoid comprehensive alternative technology evaluations if they demonstrate negligible contamination and exposure, is one such loophole. This exemption could be leveraged by facilities to bypass stricter regulations by splitting waste generation across multiple sites, thereby avoiding the evaluation process intended to identify safer alternatives. In addition, the *de minimis* exemption relies on self-reporting by the facilities, which raises concerns about the accuracy and reliability of the self-reported data. Without stringent and regular inspections by regulatory authorities or third-party independent contractors, facilities could potentially underreport their waste generation, resulting in treatment volumes falling under the exemption threshold.

Second, the emergency response exemption from the RCRA allows facilities to bypass substantive regulatory requirements under immediate threat

scenarios. Facilities can exploit this by declaring routine situations as emergencies. Such scenarios raise concerns about subjective assessments and inconsistent oversight by monitors, resulting from overreliance on an explosives or munitions emergency response specialist. The proposed 90-day extension for emergency permits, with a one-year maximum if alternative technologies are procured, may be misused to prolong OB/OD activities under less stringent conditions, thereby increasing environmental and health risks to communities.

Lastly, temporary authorizations under §270.42 (e) allow for increased OB/OD capacity during alternative technology downtimes, which could be exploited to extend OB/OD operations indefinitely under the guise of unanticipated downtime or national emergencies. The lack of sufficient oversight in determining the necessity and duration of these authorizations could result in multiple unnecessary extensions, effectively turning temporary measures into long-term practices. These potential loopholes underscore the need for more stringent and clearly defined criteria to prevent exploitation of the proposed regulations, ensuring OB/OD is a last resort, and prioritizing human health and safety.

iii. The EPA fails to identify how facilities will obtain adequate funding for researching and implementing necessary changes.

The EPA's proposed rule lacks an adequately detailed plan for implementing safer alternative technologies, particularly in terms of funding and timing. Without a robust implementation strategy, the rule will fail to provide meaningful protection from pollution. The EPA estimates that the proposed rule would cost between $6.3 million and $28 million. However, this estimate (see Regulatory Impact Analysis) only considers the increased costs associated with assessment and monitoring. It does not include any estimates regarding the Mobile Treatment Units or the implementation of other alternative technologies. Indeed, the most considerable financial burden will come from implementing new technologies. Key difficulties include operational disruptions from transitioning to new treatment methods, costly infrastructure overhauls, technical complexities of handling diverse waste types, supply chain delays for new equipment, regulatory compliance hurdles, financial constraints for technological investment, risks associated with new treatment failures, workforce training needs, and political pressure to maintain production levels for defense needs (NASEM, 2019).

NASEM emphasizes the significant challenge of cost and throughput in their report, *"...without a clear directive and sufficient and stable funding from Congress, it will be impossible for the U.S. Army to implement a full-scale deployment of alternative technologies to replace OB/OD*" (NASEM, 2018). The report finds that previous budgets for both the DOD and the Army suggest that they have placed a low priority on funding demilitarization or alternative technologies. Further, NASEM reports that they were unable to obtain an accurate estimate of costs for implementing alternative technologies. Without a plan for funding alternative technologies, the EPA's proposed rule proves to be largely theoretical, unable to create a real-world impact.

In short, the EPA acknowledges the significant health risks of OB/OD and the dire need for safer alternatives and has proposed revisions to the policy. However, we find the current EPA's proposed rule falls short. First, relying on self-reporting will invariably lead to non-compliance, and the EPA currently lacks an adequate plan to accurately assess compliance, detect violations, and enforce regulations effectively. Second, the proposed rule lists several exemptions that will lead to harmful loopholes and continued pollution. Last, the EPA fails to provide sufficient plans for funding the implementation of safer alternatives, nor a robust method to ensure timely transitions. Without addressing these shortcomings, the EPA will not succeed in its goal of protecting communities exposed to OB/OD.

V. Proposed policy solutions

The EPA currently proposes that each facility develop its own implementation schedule, with the option to amend it as needed. We find that this approach lacks sufficient detail, and we suggest that concrete deadlines are necessary to incentivize timely transitions to safer alternatives. How will the EPA determine whether the implementation schedule is adequate? Without robust deadlines, we find it unlikely that OB/OD facilities will prioritize the timely transition required by the urgent health risks faced by local communities and workers. To ensure a swift transition to safer methods, we strongly urge the EPA to establish strict compliance

dates for implementing alternative technologies, focusing first on high-risk facilities. This approach mirrors the successful environmental strategies used in other nations. In Finland, for example, stringent nutrient discharge limits for municipal wastewater treatment plants, combined with a robust 'polluter pays' enforcement model, have led to rapid technological upgrades (OECD, 2008). These measures have been credited with significantly reducing the nutrient load flowing into the Baltic Sea, thereby contributing substantially to the long-term effort to restore its ecological health (HELCOM, 2018). By setting firm, enforceable deadlines and steeper monetary penalties, the EPA can replicate this success and ensure that American communities are not left waiting for protections that are already standard practice in other countries. Furthermore, the weaknesses in the federal proposal create a critical opportunity for state leadership. Under the framework of the Resource Conservation and Recovery Act (RCRA), states with authorized hazardous waste programs have the authority to enact regulations that are faster-acting and potentially more stringent than federal rules. This proposal should be seen as a federal floor, not a ceiling. We urge state environmental agencies to seize this opportunity to mandate their own clear compliance deadlines and funding mechanisms. Doing so would not only accelerate the transition away from OB/OD but also enable the implementation of strategies tailored to the unique industrial, environmental, and political landscapes of each state, providing a more immediate and robust layer of protection for their residents.

*i. Prioritization of the development of alternative technologies***.**

The 2019 NASEM report on alternatives to open burning/open detonation (OB/OD) for demilitarization of conventional munitions identifies funding as the primary barrier to the full-scale deployment of alternative, safer technologies. The Department of Defense (DoD) is the principal federal entity responsible for demilitarization activities, particularly through its Demilitarization (DEMIL) program. Congressional mandates or appropriations to the DoD or the EPA could federally fund such an effort. Otherwise, state agencies, such as the Virginia Department of Health (VDH) or the Department of Environmental Quality (DEQ) in Virginia, and the Departments of Environmental Protection (DEP) and Health (DH) in West Virginia, could provide the necessary funds.

ii. Increase third-party data monitoring in areas near existing OB/OD plants.

While accumulating evidence suggests a negative impact of OB/OD on surrounding communities, the lack of available data continues to be a significant challenge for research aimed at understanding the extent of the relationship between OB/OD and thyroid disease. This point is compounded by false assurances from stationary air monitors, rather than effective drone technology. We suggest conducting long-term, frequent water and air quality monitoring by an independent third party within 5 miles of OB/OD facilities (Tenailleau, 2024). That data would have to be made publicly available for transparency and community consideration. Not only will accurately monitoring changes in air and water quality allow scientists to assess the impact of OB/OD, but it will also enable the distribution of appropriate environmental warnings to the public regarding health and safety concerns associated with OB/OD. Alerts and warnings about environmental hazards from OB/OD operations are typically issued by state and local health departments, environmental agencies such as the EPA, the Department of Defense (when military sites are involved), and facility operators themselves. These authorities coordinate to provide timely notifications to the public through various dissemination methods, including emergency alert systems, local media, social media, and direct communications.

iii. Improve public awareness, engagement, and transparency.

Despite the federal government's recognition of the municipal danger of OB/OD pits, there remains a disturbing lack of sufficient community outreach to inform the public about the environmental and health threats posed by these facilities. Ensuring public health and safety is a fundamental government responsibility—one that requires transparent communication and independent oversight, rather than placing the burden on the community. Effective educational and outreach programs, ideally conducted by independent third parties with strong oversight, would significantly advance public health protections in the surrounding regions. This could include regular community meetings, both in-person and virtual, publicly

accessible environmental updates, and dedicated communication channels such as websites and social media for timely information sharing. Additionally, establishing a Restoration Advisory Board (RAB) with local stakeholders would foster ongoing dialogue, transparency, and community involvement in environmental cleanup and health risk management efforts.

iv. Implement EPA inspections to ensure the accuracy of reports and correct non-compliance.

Finally, we advocate for close, direct monitoring of ammunition plant waste production by state or federal representatives to investigate policy infractions. Currently, OB/OD plants, such as RAAP, are allowed to self-report data with little oversight from the state or federal government. There are few to no audits on the reported data, meaning that relevant information regarding pollution is never verified. Instead, we suggest direct and regular monitoring by an EPA representative, with sufficient allocated resources to test water quality and air pollution in the plant and its surrounding community, thereby allowing for rapid identification and response deployment in the event of non-compliance issues. Findings should be made publicly available and outlined to State officials with sufficient time to enact proper cleaning protocols when necessary.

Our proposed solutions share several common advantages and challenges (Figure 8). Prioritizing safer alternative technologies and monitoring to protect municipal health requires significant funding allocations and faces potential resistance from defense contractors operating the plants, facility employees concerned about job security, various federal and state agencies, and local community members apprehensive about negative economic impacts to the area. Similarly, improving public awareness and implementing third party environmental monitoring inspections strengthen accountability and community engagement but demand sustained manpower, effective communication, and political support. Implementation plans for all options as described above involve multi-level coordination among federal and state agencies, independent oversight, and clear regulatory frameworks. As mentioned, the main barriers include limited funding, bureaucratic and technical policy hurdles, and the need for consistent enforcement mechanisms. Addressing these will firm-up deadlines and direct resources to protect vulnerable communities and align the U.S. with proven international environmental standards.

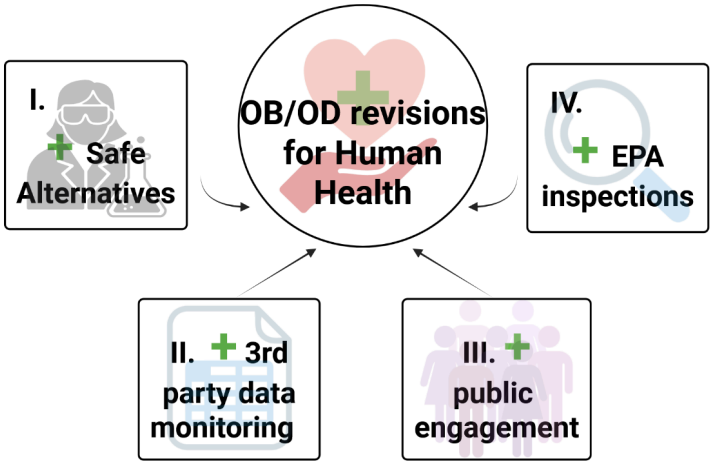

Figure 8: Graphical representation of the four proposed solutions in the open burn/open detonation (OB/OD) policy that protects human health. The graphic was generated in BioRender (Lemke, M., 2025), https://BioRender.com/6syt4d4.

It is clear that the best way to ensure feasibility and impact is to secure sufficient and sustained funding and regulatory support. Implementation of alternative technologies is proposed to be mandated federally, where funds could be appropriated to the DoD, EPA, and dispersed to state-level programs to develop scalable technologies. From these funds, state agencies or independent environmental consulting firms could be contracted to establish online data access of real-time data. The EPA/state DEQ would then subsidize funds for expanded inspection teams for audit and on-site inspections along with the current self-report format. The state would then notify the community of the results using community liaisons and reporting platforms such as local news stations, online forums, social media, and in-person advisory boards. Despite the financial limitations, securing the funding for these changes must come from an evidence-based appeal geared toward lawmakers like the one presented here. While not the focus of our article, and a very nuanced issue in itself, there are economic co-benefits associated with safer alternatives beyond the initial overhead cost (NASEM, 2018; 2019). The most effective method would integrate local voters, community advocacy groups, scientists, and legislators in the discussion of policy around issues like OB/OD.

VI. Conclusion

In conclusion, the EPA's proposed rule to revise policy on OB/OD falls short of adequately safeguarding communities near waste sites from ammunition plant production. The exemptions and loopholes within the policy pose a significant risk of continued exposure to toxic waste in local communities, leading to heightened health risks such as thyroid cancer in regions like Virginia and West Virginia. To address these critical issues, we strongly advocate for the immediate cessation of OB/OD activities, or, alternatively, cessation of the OB/OD exemption to make the facilities accountable for the contamination. This best aligns with the recommendation by the National Academies of Sciences, Engineering, and Medicine (NASEM). Additionally, we propose stringent environmental quality monitoring by independent researchers, enhanced community engagement, and rigorous EPA oversight to prevent detrimental health consequences and protect the well-being of underserved communities.

References

Ahern, Thomas P., Anne Broe, Timothy L. Lash, Deirdre P. Cronin-Fenton, Sinna Pilgaard Ulrichsen, Peer M. Christiansen, Bernard F. Cole, Rulla M. Tamimi, Henrik Toft Sørensen, and Per Damkier. 2019. "Phthalate Exposure and Breast Cancer Incidence: A Danish Nationwide Cohort Study." *Journal of Clinical Oncology* 37, no. 21: 1800–1809. https://doi.org/10.1200/JCO.18.0220.

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. *Public Health Assessment for Cornhusker Army Ammunition Plant, Grand Island, Nebraska, Region 7. CERCLIS No. NE2213820234*. Preliminary Report PB-90-112202/XAB. Atlanta: U.S. Department of Health and Human Services. Accessed on October 3rd, 2025. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB93113231.xhtml.

Beyer, Elisabeth and Samantha Verelli. 2024."'Ammunition plant didn't notify the public of toxic chemicals released into the New River for over a month, residents say.' *Cardinal News*. November 13, 2024. Accessed on October 3rd, 2025. https://cardinalnews.org/2024/11/13/ammunition-plant-state-agencies-didnt-notify-the-public-of-toxic-chemicals-released-into-the-new-river-for-over-a-month-residents-say/."

Burus, Todd, Pamela C. Hull, Krystle A. Lang Kuhs, Tianyan Gao, Christine F. Brainson, and B. Mark Evers. 2023. "Examining Geographic Disparity: Variation in Cancer Outcomes within Appalachia." *Journal of the American College of Surgeons* 237, no. 6: 1090–97. DOI: 10.1097/XCS.0000000000001273.

Campa, Pamela, and Giulian Etingin-Frati. 2023. "Environmental Enforcement in the EU: Insights from Administrative Cases in the US." Policy Brief, Stockholm Institute of Transition Economics, May 23. Accessed on October 3rd, 2025. https://freepolicybriefs.org/2023/05/23/environmental-enforcement-european-union/.

Chatterjee, Soumya, Utsab Deb, Sibnarayan Datta, Clemens Walther, and Dharmendra K. Gupta. 2017. "Common Explosives (TNT, RDX, HMX) and Their Fate in the Environment: Emphasizing Bioremediation." *Chemosphere* 184 (October): 438–51. https://doi.org/10.1016/j.chemosphere.2017.06.008.

Davies, Louise, and H. Gilbert Welch. 2014. "Current Thyroid Cancer Trends in the United States." *JAMA Otolaryngology–Head & Neck Surgery* 140, no. 4: 317–22. DOI: 10.1001/jamaoto.2014.1

Department of the Interior (U.S.). 1984. *Historic Properties Report. Radford Army Ammunition Plant (RAAP)*. ADA175875. Defense Technical Information Center. Accessed on October 3rd, 2025. https://apps.dtic.mil/sti/tr/pdf/ADA175875.pdf.

Environmental Protection Agency (U.S.). 1980. "Hazardous Waste Management System Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities." *Federal Register* 45, no. 98 (May 19): 33217.

Environmental Protection Agency (U.S.). 1987. "Toxic Chemical Release Reporting: Community Right-to-Know." *Federal Register* 52, no. 107 (June 4): 21152.

Environmental Protection Agency (U.S.). 2022. "Revisions to Standards for the Open Burning/Open Detonation of Explosive Wastes." Webinar, December 2, 2022. Accessed on October 3rd, 2025. https://www.epa.gov/system/files/documents/2022-12/Public%20Webinar%20for%20OB_OD%20Proposed%20Rule_508.pdf.

Environmental Protection Agency (U.S.). 2024. "Revisions to Standards for the Open Burning/Open Detonation of Waste Explosives." *Federal Register* 89, no. 55 (March 20): 19952.

Environmental Protection Agency (U.S.). 2025. "Current Open Burning / Open Detonation Facilities." Last updated March 12, 2025. Accessed on October 3rd, 2025. https://www.epa.gov/hwpermitting/current-open-burning-open-detonation-facilities.

Feng, Zhaohui, Wenwei Hu, William N. Rom, Frederick A. Beland, and Moon-shong Tang. 2002. "4-Aminobiphenyl is a Major Etiological Agent of Human Bladder Cancer: Evidence from Its DNA Binding Spectrum in Human p53 Gene." *Carcinogenesis* 23, no. 10: 1721–27. https://doi.org/10.1093/carcin/23.10.1721

Fuhrmann, Lisa, and Darya Minovi. 2022. *An Explosive Problem: The Radford Arsenal's Toxic Operations*. Earthjustice. Accessed on October 3rd, 2025. https://earthjustice.org/wp-content/uploads/open_burn_9-19-22.pdf.

Hankey, Betty F., Lynn A. Ries, and Brenda K. Edwards. 1999. "The Surveillance, Epidemiology, and End Results Program: A National Resource." *Cancer Epidemiology, Biomarkers & Prevention* 8, no. 12: 1117–21. Accessed on October 3rd, 2025. https://pubmed.ncbi.nlm.nih.gov/10613347/.

Haraburda, Scott S. 2017. *Conventional Munitions Industrial Base*. The Land Warfare Papers, no. 113. Arlington, VA: Institute of Land Warfare, Association of the United States Army. Accessed on October 3rd, 2025. https://www.ausa.org/sites/default/files/publications/LWP-113-Conventional-Munitions-Industrial-Base.pdf.

Helsinki Commission (HELCOM). *Sources and Pathways of Nutrients to the Baltic Sea*. Baltic Sea Environment Proceedings No. 153. Helsinki: HELCOM, 2018. Accessed October 3rd, 2025. https://helcom.fi/wp-content/uploads/2019/08/BSEP153.pdf.

Iglesias, Maria Laura, Angelica Schmidt, Abir Al Ghuzlan, Ludovic Lacroix, Florent de Vathaire, Sylvie Chevillard, and Martin Schlumberger. 2017. "Radiation Exposure and Thyroid Cancer: A Review." *Archives of Endocrinology and Metabolism* 61, no. 2: 180–87. https://doi.org/10.1590/2359-3997000000257.

International Agency for Research on Cancer (IARC) Working Group on the Evaluation of Carcinogenic Risks to Humans. 2012. "4-Aminobiphenyl." In *Chemical Agents and Related Occupations*. Vol. 100F of *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, 41–50. Lyon, France: International Agency for Research on Cancer. Accessed October 3rd, 2025. https://publications.iarc.who.int/_publications/media/download/3076/73443059d4ec0adde733204bab30939c7470dd2b.pdf.

Knobelman, Jorel. "Removal of Nitrates from Wastewater at Radford Army Ammunition Plant Using Counter-Current Ion Exchange Technology." U.S. Army Armament Research, Development and Engineering Center (ARDEC), 2017. Accessed August 24, 2025. https://www.denix.osd.mil/ndcee/denix-files/sites/44/2017/02/N_0829.pdf.

Lein, Pamela J. 2023. "Military Burn Pits: A Toxic Legacy of War." *Open Access Government*, Accessed February 1st, 2025. https://www.openaccessgovernment.org/military-burn-pits-a-toxic-legacy-of-war-verteran-health-conflict/149605/.

Mirecki, June Elizabeth, Beth Porter, and Charles A. Weiss. 2006. *Environmental Transport and Fate Process Descriptors for Propellant Compounds*. Vicksburg, MS: US Army Corps of Engineers, Engineer Research and Development Center. Accessed on October 3rd, 2025. https://apps.dtic.mil/sti/tr/pdf/ADA450743.pdf.

National Academies of Sciences, Engineering, and Medicine. 2018. "Most Alternative Technologies to Open Burning and Open Detonation of Conventional Waste Munitions Are Mature, Says New Report." News release, December 6, 2018. Accessed October 3rd, 2025. https://www.nationalacademies.org/news/2018/12/most-alternative-technologies-to-open-burning-and-open-detonation-of-conventional-waste-munitions-are-mature-says-new-report.

National Academies of Sciences, Engineering, and Medicine. 2019. *Alternatives for the Demilitarization of Conventional Munitions*. A Consensus Study Report of the National Academies of Sciences, Engineering, Medicine. Washington, DC: National Academies Press. DOI: 10.17226/25140.

National Cancer Institute and the Centers for Disease Control and Prevention (U.S.). 2025. *State Cancer Profiles*. Accessed August 24, 2025. https://statecancerprofiles.cancer.gov/index.html.

Oliveira, Karen Jesus, Maria Isabel Chiamolera, Gisele Giannocco, Carmen Cabanelas Pazos-Moura, and Tania Maria Ortiga-Carvalho. 2019. "Thyroid Function Disruptors: From Nature to Chemicals." *Journal of Molecular Endocrinology* 62, no. 1: R1–R19. .https://doi.org/10.1530/JME-18-0081.

Organisation for Economic Co-operation and Development. 2008. *The Polluter Pays Principle: Definition, Analysis, Implementation*, OECD Publishing, Paris. https://doi.org/10.1787/9789264044845-en.

R Core Team. 2025. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. Accessed on October 3rd, 2025. https://www.R-project.org/.

de Sadeleer, Nicolas Michel. 2012. "The polluter-pays principle in EU law-bold case law and poor harmonisation." Pro Natura: Festskrift Til HC Bugge, Oslo, Universitetsforlaget : 405-419. Accessed on October 3rd, 2025. https://tradevenvironment.eu/wp-content/uploads/2024/03/de-Sadeleer.pdf.

Sheffield, Steven R. 1997. *Owls as biomonitors of environmental contamination.* In: Duncan, James R.; Johnson, David H.; Nicholls, Thomas H., eds. B*iology and conservation of owls of the Northern Hemisphere: 2nd International symposium.* General Technical Report NC-190. St. Paul, MN: U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station. 383-398. Accessed on October 3rd, 2025. https://www.nrs.fs.usda.gov/pubs/gtr/gtr_nc190/gtr_nc190_383.pdf.

Soskolne, Colin L., Gian S. Jhangri, Jack Siemiatycki, Ramzan Lakhani, Ron Dewar, J. David Burch, Geoffrey R. Howe, and Anthony B. Miller. 1992. "Occupational Exposure to Sulfuric Acid in Southern Ontario, Canada, in Association with Laryngeal Cancer." *Scandinavian Journal of Work, Environment & Health* 18, no. 4: 225–32. DOI: 10.5271/sjweh.1585 https://www.jstor.org/stable/40965998

Tenailleau, Quentin, Caroline Lanier, Julie Prud'homme, Damien Cuny, Annabelle Deram, and Florent Occelli. "Distance-Based Indicators for Evaluating Environmental Multi-Contamination and Related Exposure: How Far Should We Go?" *Environmental Science and Pollution Research*_31, no. 38 (August 2024): 50642–50653. https://doi.org/10.1007/s11356-024-34519-9.

Turyk, Mary E., Craig Lehmler, Linda D. Scherer, Rebecca Li, Susan C. Bailey, and Henry A. Anderson. 2012. "Risks and Benefits of Consumption of Great Lakes Fish." *Environmental Health Perspectives* 120, no. 1: 11–18. DOI: 10.1289/ehp.1003396.

U.S. Army Medical Bioengineering Research and Development Laboratory. 1978. *Preliminary Problem Definition Study of 48 Munitions-Related Chemicals*. Technical Report ADA066308. Fort Detrick, MD. Accessed on October 3rd, 2025. https://apps.dtic.mil/sti/tr/pdf/ADA066308.pdf.

U.S. Congress. House. 1976. *Resource Conservation and Recovery Act*. Pub. L. 94-580. 94th Cong., 2nd sess.

U.S. Congress. House. 2022. *The Sergeant First Class Heath Robinson Honoring Our Promise to Address Comprehensive Toxics Act*. Pub. L. 117-168. 117th Cong., 2nd sess.

Virginia Administrative Code. 2024. "Variances." 12 Va. Admin. Code § 5-630-170. (*Virginia Register* Volume 41, Issue 4, effective November 6, 2024).

Virginia Department of Environmental Quality. 2024. "Unauthorized Discharge of Pollutant(s) (UDP) 315991- Dibutyl Phthalate Release, BAE Systems Inc. OSI, RAAP, Montgomery Co." Accessed April 15, 2025. https://portal.deq.virginia.gov/prep/prepReport/315991.

Virginia Department of Health. n.d. "Fish Consumption Advisory." Accessed June 6, 2025. https://www.vdh.virginia.gov/environmental-health/public-health-toxicology/fish-consumption-advisory/.

Virginia Waste Management Board (VWMB). 2024. "Public Hearing – Radford Army Ammunition Plant Hazardous Secondary Materials Variance Request." Virginia Department of Environmental Quality. Accessed on October 3rd, 2025. https://townhall.virginia.gov/L/ViewMeeting.cfm?MeetingID=40585.

Vinti, Giovanni, Valerie Bauza, Thomas Clasen, Kate Medlicott, Terry Tudor, Christian Zurbrügg, and Mentore Vaccari. 2021. "Municipal Solid Waste Management and Adverse Health Outcomes: A Systematic Review." *International Journal of Environmental Research and Public Health* 18, no. 8: 4331. https://doi.org/10.3390/ijerph18084331.

Wilson, Reda J., A. Blythe Ryerson, Shamly D. Singh, and Julie B. King. "Cancer Incidence in Appalachia, 2004-2011." *Cancer Epidemiology, Biomarkers & Prevention* 25, no. 2 (February 2016): 250-258. https://doi.org/10.1158/1055-9965.EPI-15-0946.

Yang, Xiao-e, Xiang Wu, Hu-lin Hao, and Zhen-li He. 2008. "Mechanisms and Assessment of Water Eutrophication." *Journal of Zhejiang University SCIENCE B* 9, no. 3: 197–209. https://doi.org/10.1631/jzus.B0710626.

Michael Lemke is a 5th-year Pharmacology student at the University of Virginia Biomedical Sciences Graduate Program. He studies under-investigated proteins associated with metabolic disease and cancer. After earning his PhD, Mike plans to pursue a career in science policy and community outreach.

Alissa Ganser completed her Ph.D. in the Department of Fish and Wildlife Conservation at Virginia Tech. She primarily works with freshwater mussels, a diverse and highly imperiled fauna. Her research includes mussel thermal tolerances, physiological responses to stress, life history, and population dynamics. Alissa hopes to continue championing vulnerable aquatic species and help bridge the gap between science and policy in aquatic systems.

Jane Remfert is a Ph.D. candidate in the Integrative Life Sciences Ph.D. program at Virginia Commonwealth University. Her research focuses on the conservation of biodiversity in human-managed landscapes, situated at the intersection of population genetics and ecology. After graduation, she hopes to enter the science policy and advocacy spaces to promote evidence-based policies that balance human and natural systems.

Julia Davis is a Ph.D. candidate in the Department of Civil and Environmental Engineering at the University of Virginia. Her research explores the impacts of climate-related events and infrastructure on human populations. She has previously earned her master's degree in public policy at the University of Virginia, allowing her to bring an interdisciplinary approach to studying human-environmental systems. After graduation, Julia hopes to continue her systems-based research approach to inform sustainable policies that address the complex challenges of climate change.

Trisha Vaidyanathan is the Senior director of Research at Defend Our Health where she helps translate science into policy to advocate for environmental justice. Previously, Trisha received her Ph.D. in Neuroscience at UCSF and completed her postdoctoral research at Duke University.

Katherine Canada is a third-year Ph.D. student in the University of Virginia Biomedical Sciences Graduate Program, studying endogenous protein pathways downstream of autism spectrum disorder-associated genes and how genetic variation and environmental factors disrupt cellular function. She plans to continue research and advocacy on gene-environment interactions in autism after completing her doctorate.

Peter Forstner is a 2nd year Ph.D. student at Virginia Tech in the School of Plant and Environmental Science. He studies interactions between the plant metabolome and plant stress factors. After completing his Ph.D., Peter hopes to investigate ways to modify plant metabolic pathways to aid in the breakdown of industrial pollutants.

Jordan Thompson is a master's student in Entomology at Virginia Tech, where she studies the ecological impact of invasive Asian jumping worms on soil health, turfgrass systems, and arthropod communities. She is also the co-owner of two plant healthcare businesses and plans to continue bridging the gap between science, business, and public education in invasive species management.

J. Maxwell Ebert has over a decade of experience working in public health and healthcare and received his MPH from George Washington University. He is passionate about tech and healthcare to reduce friction in achieving improved health outcomes through the lens of data science.

Acknowledgements
We gratefully acknowledge the significant advocacy efforts of Alyssa Carpenter and the CAA concerning RAAP, which have been instrumental to this work. Additionally, we express our deep appreciation to Preston Thompson for their generous support and contributions to the manuscript. We also thank the reviewers who provided feedback that greatly contributed to the final version of this manuscript.