Review of the Scientific Literature:

Environmental and Health Area of Effect (AoE) Analysis for the Proposed Trident Data Center

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Executive Summary

This report provides an abbreviated academic summary of the anticipated Area of Effect (AoE) associated with the proposed Trident Data Center at Windler, Aurora, Colorado. To provide spatial perspective, the physical building footprint and mechanical utility envelope is approximately the size of a hyperscale e-commerce distribution center

Based on the limited quantitative information available in the Trident Data Center Site Plan submitted to the City of Aurora on August 25, 2025, good faith estimates, and synthesizing publicly available peer-reviewed scientific literature, government regulatory frameworks, and established atmospheric and acoustic physical principles, this review examines four primary vectors of potential environmental and community stress:

- **Diesel Particulate Matter (**$PM_{2.5}$ **/ DPM):** Primary combustion aerosols generated during generator readiness testing, scheduled maintenance, and emergency standby operation.
- **Photochemical Ozone Precursors (**NO_x**):** Nitrogen oxide emissions that contribute to regional surface-level ozone formation (smog) across the Denver-Aurora nonattainment basin.
- **Low-Frequency Noise (LFN):** Long-wavelength mechanical acoustic emissions (20–200 Hz) originating from continuous exterior cooling chiller arrays, compressor banks, and mechanical plant operations.
- **Micro-Urban Anthropogenic Heat Flux:** Localized thermal plume formation resulting from large-scale sensible heat rejection by cooling infrastructure.

These environmental vectors are evaluated across three screening-level geographic tiers centered on the proposed Trident site:

- **The 1-Mile Immediate Impact Zone:** Evaluates near-field acoustic immersion, aerodynamic building wake downwash, and direct sensible thermal plume interactions (see Section 2.0).

- **The 2-Mile Secondary Impact Zone:** Evaluates mid-field acoustic propagation through structural barriers and cumulative exposure for sensitive residential and educational receptors (see Section 3.0).
- **The 3-Mile Extended Environmental Effect Area:** Establishes the regional outer screening boundary for far-field atmospheric dispersion modeling under stable atmospheric inversion regimes (see Section 4.0).

Summary of Health Consequences Across Demographic Groups

Synthesizing the clinical and epidemiological literature detailed in Section 5.0, the potential adverse health consequences associated with these four identified hazards are mapped across four key demographic groups:

Demographic Group	Air Quality ($PM_{2.5}$) Diesel Exhaust	Regional Ozone (Smog)	Low-Frequency Noise
1. General Population	Systemic vascular inflammation, pulmonary oxidative stress, cardiovascular disease (CVD)	Airway hyper-reactivity, reduced vital lung capacity, chronic respiratory irritation	Sleep fragmentation, elevated nocturnal cortisol, autonomic cardiovascular strain
2. Children & Students	Impaired pulmonary alveolar development, disproportionate mass-dose air intake	Accelerated pediatric asthma exacerbations, respiratory distress, school absenteeism	Nocturnal cortisol elevation, cognitive disruption, sustained attention and reading deficits
3. Older Adults (55+ Communities)	Ischemic stroke, cardiac arrhythmia, acute cardiopulmonary mortality	Cardiopulmonary hospitalization spikes during summer heat waves	Unmasked low-frequency hum, sleep fragmentation, neurocognitive fatigue, cardiovascular and cognitive vulnerability
4. Disabled Veterans (PTSD / TBI)	Aggravation of pre-existing chronic pulmonary and respiratory comorbidities	Acute pulmonary distress and heightened systemic physiological stress	Mechanistic vulnerability to sensory gating deficits, central hyperacusis, autonomic hyperarousal, and trauma triggers

1.0 Trident Baseline Emissions Profile (Anticipated Facility Operations)

Hyperscale data centers deploy banks of stationary industrial diesel backup generators to ensure uninterrupted facility uptime during utility power curtailments, heat waves, and grid disturbances. Standard configurations for hyperscale campuses utilize units averaging approximately 3.0 MW electrical capacity. Each generator, housed within a weather-protective sound-attenuated enclosure, typically measures 30 to 40 feet in length, 10 feet in width, and 12 feet in height, comparable in physical scale to a diesel locomotive engine.

Anticipated Operational Profile & Advanced Emissions Controls

This analysis specifically evaluates the realistic anticipated operational profile for the proposed Trident facility:

- **Operating Schedule:** Routine readiness testing, load banking, and preventative maintenance are evaluated at an industry-typical schedule of **40 operational hours per engine per year**.
- **Fleet Sizing Phase One (CO21):** A total planned fleet of **28 industrial diesel generators** of 3.0 MW each, representing an aggregate backup capacity of 84.0 MW electrical (≈123,200 bhp mechanical prime-mover capacity; 112,600 hp electrical equivalent)[1].
- **Advanced Emissions Controls:** The analysis assumes that **Trident will deploy Tier 4-compliant Selective Catalytic Reduction (SCR) and active Diesel Particulate Filters (DPF)** to control exhaust emissions[2].

[1] The 2025 Trident Site Plan Fleet seems to consider only Phase One (CO21); it does not seem to consider Phase Two (CO22), which is expected to add an additional 28 industrial diesel generators, for a total of 56 generators. This good faith estimate does not include additional generator capacity required by the Trident chiller arrays. The *Review of the Scientific Literature* only considers Phase One (CO21).

[2] These details were not discovered in the August 2025 Site Plan submitted by Vantage Data Centers to the City of Aurora. The *Review of the Scientific Literature* assumes a best-case scenario.

Operational & Engineering Metric	Baseline Design Specification	Analytical Notes & Regulatory Framework
Fleet Sizing Phase One (CO21)	28 Industrial Diesel Generators	Units rated at 3.0 MW electrical capacity (≈4,400 bhp mechanical prime-mover rating; 4,023 hp electrical equivalent)
Aggregate Fleet Backup Capacity	84.0 MW Electrical (≈123,200 bhp mechanical)	Dedicated stationary standby power generation envelope
Anticipated Operational Schedule	40 hours/engine/year	Routine testing, readiness runs, and preventative load banking
Cumulative Fleet Operational Runtime	1,120 engine-hours/year	Aggregate annual diesel operating duration (28 engines×40 hours)
Full-Load Fuel Consumption Rate	≈203.0 gal/hours/generator	Engineering benchmark for large stationary industrial engines at 100% load
Annual Testing Diesel Fuel Burn	227,360 gallons/year	Total fuel consumed during routine annual testing schedule

2.0 Immediate Impact Zone (0 to 1-Mile Radius AoE)

The 1-mile radius AoE encompasses residential neighborhoods, three K-12 educational campuses, and an age-restricted (55+) community. Populations within the AoE are expected to be affected by acute mechanical and atmospheric stressors, necessitating rigorous modeling to quantify their effects on human health for both acoustic energy and pollutant downwash.

2.1 Acoustic Hazards and Low-Frequency Noise (LFN) Propagation

Hyperscale data centers generate powerful mechanical noise primarily through large HVAC installations and exterior chiller arrays. These exterior chiller arrays and mechanical plant infrastructure operate continuously 24 hours per day, 365 days per year, maintaining

critical server inlet temperatures regardless of season, with acoustic emissions intensifying under maximum heat rejection loads during peak summer periods.

- **Spectral Characteristics and Regulatory Metric Limitations**: While regulatory frameworks, including the City of Aurora Unified Development Ordinance (UDO), typically utilize the A-weighted scale (dBA) to mimic human hearing sensitivity, the A-weighting scale substantially de-emphasizes and attenuates low-frequency sound energy (20–200 Hz), thereby masking intrusive tonal hums that C-weighting (dBC) or unweighted octave bands reveal (*Berglund et al., 1996*). For example, A-weighting suppresses sound pressure levels by -26.2 dB at 63 Hz and by -39.4 dB at 31.5 Hz.

  A data center may therefore achieve formal compliance under a municipal dBA standard while still propagating high-energy low-frequency acoustic waves into neighboring residential zones. At the facility source, exterior cooling arrays, transformers, and mechanical yards radiate continuous low-frequency acoustic power concentrated in the 31.5 to 125 Hz octave bands ($L_W \approx$ 130 to 138 dBZ, or 10 to 63 W of radiated acoustic power), generating a persistent tonal hum and indoor standing-wave pressure maxima inside neighboring residences.
- **Architectural Penetration and Structural Resonance:** The physical wavelengths of low-frequency sound are exceptionally long (≈5.7 to 57 feet), allowing them to penetrate standard residential architectural assemblies and exterior sound barriers with minimal energy attenuation. Indoor standing waves can further create acoustic room resonances that amplify perceived vibration and humming inside homes (*Leventhall, 2004*).
- **Remediation Realities:** Acoustic literature indicates that structural retrofits for low-frequency attenuation require substantial capital outlays due to the mass and decoupling required to impede long-wavelength acoustic energy. Standard noise fences and residential window upgrades provide negligible attenuation against low-frequency mechanical resonance.

2.2 Diesel Particulate Matter (DPM) and Building Downwash Mechanics

During backup generation cycles, diesel engines emit fine particulate matter ($PM_{2.5}$ / DPM) and nitrogen oxides (NO_x, comprising NO and NO_2).

- **Aerodynamic Wake Turbulence:** Within the immediate 1-mile radius AoE, atmospheric dispersion is heavily influenced by aerodynamic turbulence created by the proposed Trident facility's architectural structure. When exhaust stacks are not sufficiently tall relative to the building's geometry (as evaluated under the EPA's Building Profile Input Program [BPIP-PRIME]), plumes become trapped within the recirculating wake cavity downwind.
- **Physical & Photochemical Separation:** Building downwash traps primary diesel particulate matter (DPM) and nitrogen oxides (NO_x/NO_2), while NO_x serves as a

regional precursor to secondary surface-level ozone downwind across the Denver-Aurora nonattainment basin.

In the immediate near-field wake, freshly emitted nitric oxide (NO) actively consumes ambient ozone via the titration reaction ($NO + O_3 \rightarrow NO_2 + O_2$), temporarily suppressing localized ozone at the fence-line while sharply increasing primary NO_2 and particulate ground-level concentrations (GLCs). Subsequently, as the NO_x plume disperses miles downwind in the presence of solar radiation and volatile organic compounds (VOCs), it photochemically generates secondary surface-level ozone across the regional air basin.

2.3 Micro-Urban Heat Island (UHI) Effect

Hyperscale data centers operate as significant sources of anthropogenic heat, converting gigawatts per year of electrical energy into thermal exhaust (*Sailor, 2011*). Air-cooled chiller arrays typically discharge air that is 14°F to 25°F warmer than ambient temperatures, generating concentrated thermal plumes (*Yuan et al., 2017*). Downwind transport of these plumes can elevate localized neighborhood temperatures by as much as 2°F to 4°F under stagnant conditions (*Yuan et al., 2017*).

This addition of substantial heat flux over the proposed impervious data center campus surfaces threatens to exacerbate the existing urban heat island effect. During summer heat waves, localized thermal elevations increase residential cooling loads and energy costs precisely when data center chiller arrays and mechanical systems are operating under maximum load (*Sailor, 2011; Yuan et al., 2017*).

2.4 Affected Infrastructure

Specific community and educational infrastructure within the 1-mile AoE includes:

- **Pitt Waller K-8 School:** Located approximately 0.7 miles from the proposed Trident site.
- **Aurora Highlands P-8:** Located approximately 0.9 miles from the proposed Trident site.
- **The Reserve, a 55+ age-restricted residential development:** Located adjacent to the proposed Trident site.
- **King Soopers Marketplace (Planned 2027):** Located approximately 0.5 miles from the proposed Trident site.

3.0 Secondary Impact Zone (1 to 2-Mile Radius AoE)

The 2-mile radius AoE encompasses broader residential neighborhoods and three additional K-12 educational campuses:

- **Green Valley Elementary School:** Located approximately 1.6 miles from the proposed Trident site.

- **Sandra Todd-Williams Academy:** Located approximately 1.7 miles from the proposed Trident site.
- **Omar D. Blair Charter School:** Located approximately 1.7 miles from the proposed Trident site.

Within this zone, sensitive populations face potential cumulative exposure to persistent low-frequency noise propagation through architectural barriers, broader atmospheric dispersion of fine particulate matter, and regional photochemical ozone precursors. The presence of multiple educational campuses within this radius indicates a high concentration of sensitive demographics subject to potential environmental burdens.

4.0 Extended Environmental Effect Area (2 to 3-Mile Radius AoE)

The 3-mile radius establishes the outer boundary for far-field atmospheric dispersion screening, dependent heavily upon localized meteorology and thermodynamic boundary layer stability.

- **Atmospheric Inversion Dynamics:** Along the Colorado Front Range, nocturnal surface cooling and local topographical drainage frequently establish strong temperature inversions that suppress vertical mixing. Under these meteorological conditions, particulate plumes can advent horizontally for 1 to 3 miles with minimal vertical dilution, maintaining elevated ground-level concentrations (*EPA Guideline on Air Quality Models, 40 CFR Part 51, Appendix W*).
- **Regulatory Consistency:** In accordance with the EPA Guideline on Air Quality Models (40 CFR Part 51, Appendix W) and Colorado CDPHE-APCD modeling guidelines, establishing an air dispersion modeling domain extending 2 to 3 miles from major combustion and industrial emission point sources represents standard regulatory practice to fully capture Significant Impact Levels (SILs) and the geographic point of maximum ground-level concentration (GLC_{max}).

5.0 Health Consequences of Identified Hazards (Literature Synthesis)

Hazard Vector	Target Demographic Group	Clinical & Epidemiological Correlates
Low-Frequency Noise (LFN: 20–200 Hz)	**General Population**	Chronic sleep fragmentation, nocturnal cortisol elevations, autonomic cardiovascular strain (*Berglund et al., 1996; Leventhall, 2004*)
	Children & Students	Nocturnal cortisol elevations, cognitive disruption, sustained attention and reading comprehension deficits (*Ising & Ising, 2002; Persson Waye et al., 2003; Stansfeld et al., 2005*)
	Older Adults	Sleep fragmentation, neurocognitive fatigue, exacerbated anxiety, physiological vulnerability to cognitive decline (*Berglund et al., 1996; Cantuaria et al., 2021*)
	Veterans (PTSD / TBI)	Mechanistic vulnerability via compromised P50 sensory gating, clinical hyperacusis, and autonomic hyperarousal (*Fagelson, 2007; Holstein et al., 2010; Theodoroff et al., 2019*)
Particulate Matter($PM_{2.5}$ / DPM) & **Ozone**	**General Population**	Systemic vascular inflammation, pulmonary oxidative stress, endothelial dysfunction, cardiovascular morbidity (*Brook et al., 2010*)
	Children	Stunted pulmonary alveolar development, pediatric asthma exacerbations, acute respiratory distress (*CDC & EPA, 2021*)
	Older Adults	Cardiac arrhythmia, ischemic stroke, acute cardiopulmonary hospital admissions and mortality (*CDC & EPA, 2021*)

5.1 Acoustic Hazards and Low-Frequency Noise (LFN)

- **General Population:** Chronic exposure to indoor low-frequency noise in residential settings has been strongly associated with sleep disruption, elevated nocturnal cortisol levels, increased cardiovascular strain, and cognitive fatigue (*Berglund et al., 1996; Leventhall, 2004*)[3].
- **Pediatric Populations:** Controlled low-frequency noise and heavy-traffic exposure studies (*Ising & Ising, 2002; Persson Waye et al., 2003*), reinforced by the large-scale transportation noise cohort findings of Stansfeld et al. (2005), indicate that children exposed to persistent low-frequency and environmental noise experience nocturnal cortisol elevations, cognitive disruption, sustained attention deficits, and upward cochlear masking that degrade the learning environment.
- **Older Adults:** Age-related high-frequency hearing loss (presbycusis) reduces ambient masking while leaving apical cochlear sensitivity to low-frequency hums relatively intact (*Berglund et al., 1996*). Furthermore, the large-scale transportation noise cohort research of Cantuaria et al. (2021) linking chronic residential noise exposure and sleep disruption to elevated incidence of dementia illustrates the physiological vulnerability of older adults subjected to pervasive nocturnal acoustic energy.
- **Veterans and Individuals with PTSD/TBI:** As a mechanistically grounded clinical vulnerability hypothesis, individuals suffering from Traumatic Brain Injury (TBI) and Post-Traumatic Stress Disorder (PTSD) frequently exhibit impaired thalamocortical P50 sensory gating (*Holstein et al., 2010*) and high rates of blast-related clinical hyperacusis and decreased sound tolerance (*Fagelson, 2007; Theodoroff et al., 2019*), which can cause continuous indoor low-frequency humming and structural vibration to trigger autonomic hyperarousal and sleep disruption.

5.2 Diesel Particulate Matter (DPM) and Surface-Level Ozone

- **General Population:** Exposure to fine particulate matter ($PM_{2.5}$) and surface-level ozone generated from industrial combustion sources is clinically associated with systemic inflammation, chronic respiratory irritation, diminished lung function, and aggravated cardiovascular morbidity (*Brook et al., 2010*).
- **Children:** Children exhibit higher relative respiration rates per unit of body mass. Exposure to $PM_{2.5}$ and ozone during critical stages of lung development is clinically linked to stunted pulmonary growth, increased asthma prevalence, and acute respiratory distress (*CDC & EPA, 2021*).

[3] While epidemiological cohort studies on transportation noise (Stansfeld et al., 2005; Cantuaria et al., 2021) and clinical neurotrauma studies on sensory gating and hyperacusis (Fagelson, 2007; Holstein et al., 2010; Theodoroff et al., 2019) establish physiological and mechanistic vulnerability pathways, site-specific acoustic modeling of data center tonal LFN spectra is necessary to quantify equivalent resident exposure.

- **Older Adults:** Age-related physiological decline renders older adults highly vulnerable to particulate and ozone exposure, correlating with elevated hospital admissions for asthma exacerbation, cardiac arrhythmia, stroke, and premature cardiovascular mortality (*CDC & EPA, 2021*).

6.0 Cumulative Effects of Concurrent Regional Development

The potential environmental burdens outlined in this review must be evaluated within the broader industrial development landscape of the region. Multiple additional hyperscale data centers are currently proposed or planned along the immediate E-470 corridor.

The concurrent operation of multiple hyperscale campuses introduces compounding risks:

- **Additive Noise and Emissions:** Dozens of industrial diesel generators undergoing periodic testing and extensive HVAC chiller arrays operating concurrently will significantly elevate baseline ambient LFN levels, regional primary $PM_{2.5}$ and NO_x emissions.
- **Regional Nonattainment Status:** The Denver-Aurora metropolitan area is designated as a Severe Nonattainment Area under the federal 8-hour ground-level ozone National Ambient Air Quality Standards (NAAQS). Both Adams and Arapahoe Counties repeatedly receive failing grades for ozone pollution from public health organizations. Siting substantial new stationary sources of NO_x—a key ozone precursor—upwind of residential communities amplifies the regional public health burden, necessitating comprehensive regional modeling rather than isolated site analyses.

7.0 Conclusion & Recommendations

An objective scientific literature review indicates that establishing a 1-mile immediate and 2-mile secondary Area of Effect (AoE), coupled with an extended 3-mile atmospheric screening radius, constitutes a sound, evidence-based scope for evaluating public health and environmental risks associated with the proposed Trident Data Center.

To ensure comprehensive public protection and verify the effectiveness of proposed mitigations, reviewing authorities should require:

1. **Certified Site-Specific Atmospheric Dispersion Modeling:** Detailed AERMOD simulations incorporating BPIP-PRIME building downwash algorithms, localized multi-year meteorological datasets, and regional photochemical ozone considerations in accordance with the EPA Guideline on Air Quality Models (40 CFR Part 51, Appendix W) and CDPHE-APCD modeling guidelines.
2. **C-Weighted and 1/3-Octave Acoustic Modeling:** Full-spectrum acoustic modeling extending across the 10 to 200 Hz low-frequency range (dBC and unweighted dBZ

1/3-octave bands) to quantify indoor standing-wave penetration and verify compliance with objective health-based thresholds: (a) indoor nighttime $L_{pA,LF} \leq 20.0$ dB (10–160 Hz), (b) outdoor residential façade $L_{Ceq} \leq 55$ dBC nighttime / 60 dBC daytime with spectral imbalance $L_{Ceq} - L_{Aeq} \leq 15$ dB (ANSI/ASA S12.9 Part 4), and (c) school façade $L_{Ceq} \leq 50$ dBC (ANSI/ASA S12.60).

3. **Binding Permit Commitments to Advanced Aftertreatment:** Formal permit codification ensuring that all installed backup engines deploy Tier 4-compliant Selective Catalytic Reduction (SCR) and active Diesel Particulate Filters (DPF), alongside enforceable annual testing hour restrictions.

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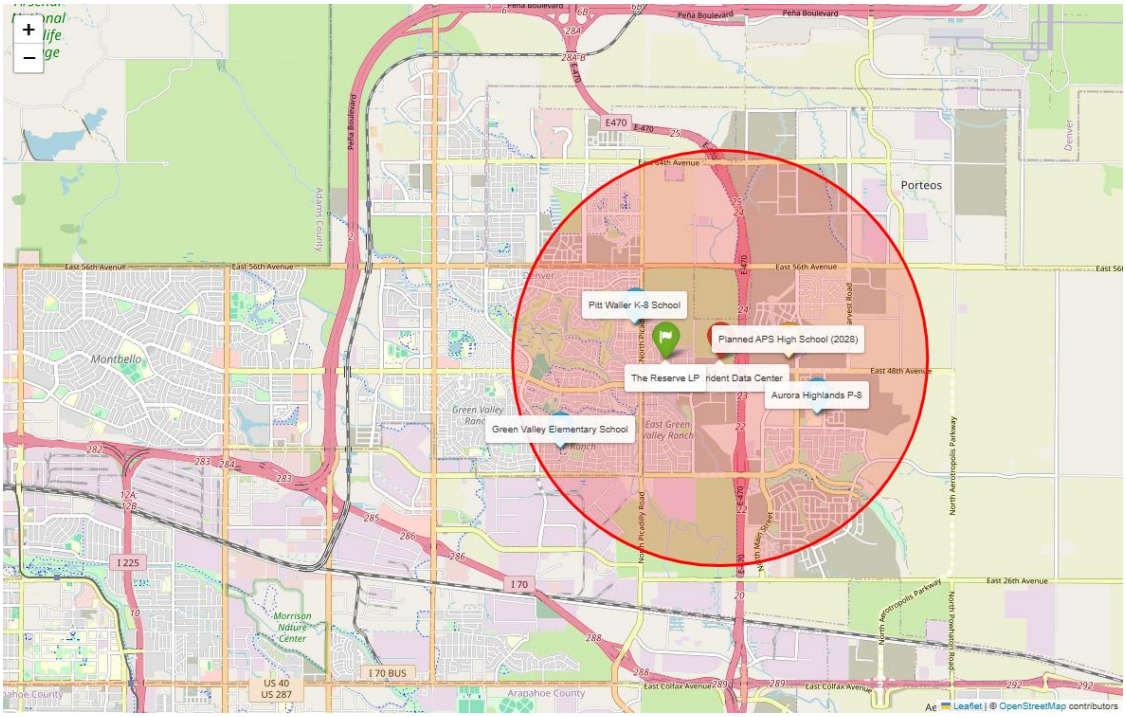
9.0 Map of Impact Zones

The cartographic analysis below delineates the **2-mile** impact zone centered on the proposed Trident Data Center site, identifying educational institutions, established residential neighborhoods, and planned commercial developments.



Trident Data Center Area of Effect Map[4]

Clarification of Document Precedence

This revised technical report supersedes and replaces the preliminary reports dated October 3, 2026 and October 16, 2026, in their entirety.

Note: The formal Legal, Regulatory, and Academic Disclaimer governing this report has been issued as a standalone companion instrument: Legal_Regulatory_and_Academic_Disclaimer.pdf.

[4] Cartographic Note: The map above focuses specifically on the 1-mile and 2-mile geographic impact zones, which encompass the primary areas of potential acoustic immersion, aerodynamic building downwash, and direct micro-urban heat flux. The 3-mile extended Area of Effect (discussed in Section 4.0) defines the wider regional screening boundary recommended for comprehensive AERMOD atmospheric dispersion modeling under stable atmospheric inversion regimes.