DATA CENTER DEVELOPMENT

Comprehensive Mitigation Strategies for Community Concerns

Technologies, Practices, and Verified Examples from Industry, Municipal, and Utility Sources

January 2026

Phi Strategies

DOCUMENT OVERVIEW, INTENDED USE & DISCLAIMERS

Purpose and Intended Use

This document provides a policy options framework for regulating data center development in San Marcos and Hays County, Texas. It is intended to serve as:

1. An informational resource for elected officials, appointed commissioners, and municipal/county staff considering data center land use policies
2. A compilation of best practices from other jurisdictions that have addressed similar development pressures
3. A starting point for public discussion regarding appropriate standards for large-scale industrial development in sensitive environmental areas
4. A framework for integrating conservation objectives with responsible economic development

This document is NOT a legal opinion, engineering study, environmental assessment, or official recommendation from any governmental body. It does not represent the official position of the City of San Marcos, Hays County, or any other public or private entity.

Disclaimers and Limitations

DATA ACCURACY AND CURRENCY

Information contained herein was compiled from publicly available sources believed to be reliable as of January 2026. Regulatory frameworks, tax rates, organizational contacts, and market conditions change frequently. Users should independently verify all information before relying upon it for any purpose. No representation is made regarding the completeness, accuracy, or current validity of any data, statistics, or regulatory citations.

Regulatory Information: References to ordinances, statutes, and regulations from Virginia, Texas, and other jurisdictions are summarized for illustrative purposes. Actual regulatory requirements may differ from descriptions provided. Users should consult original source documents and qualified legal counsel before taking any action based on regulatory information presented.

Financial and Tax Information: Tax revenue estimates, property valuations, and fiscal projections are illustrative only and based on generalized industry data. Actual tax implications depend on specific property characteristics, applicable exemptions, negotiated agreements, and appraisal district determinations. Users should consult qualified tax and financial professionals for site-specific analysis.

Environmental Information: References to Edwards Aquifer zones, recharge characteristics, and environmental conditions are general in nature. Site-specific determinations require qualified professional assessment, including geologic surveys, hydrologic studies, and review by the Texas Commission on Environmental Quality (TCEQ) and other regulatory authorities.

Contact Information: Organizational contacts and personnel identified were current as of the document date based on publicly available information. Personnel assignments change; users should verify current contacts before initiating outreach.

Release from Liability

THIS DOCUMENT IS PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED. THE AUTHOR DISCLAIMS ALL LIABILITY FOR ANY ERRORS, OMISSIONS, OR INACCURACIES IN THE INFORMATION PROVIDED, AND FOR ANY ACTIONS TAKEN OR NOT TAKEN BASED ON THIS DOCUMENT. By using this document, the reader acknowledges and agrees that: (1) the document is for informational and discussion purposes only; (2) no professional-client relationship is created; (3) the author assumes no responsibility for decisions made based on this information; and (4) the reader will seek independent professional advice appropriate to their specific circumstances before taking any action.

Author's Role and Professional Capacity

This document was prepared by Lauren Romero in her capacity as an independent strategic consultant. Ms. Romero is:

- Principal, Phi Growth Strategies — a consulting practice focused on conservation-commerce integration and regional economic development strategy
- Licensed Texas Real Estate Sales Agent (TREC #843653) affiliated with Keller Williams, specializing in Hill Country land, luxury, and commercial properties
- MBA graduate of the McCombs School of Business, University of Texas at Austin, with 30 years of experience advising Fortune 500 companies on marketing research, consumer behavior, and strategic planning

This document was prepared as a public interest contribution to inform community discussion regarding data center development policy. It was not prepared at the direction of, or under contract with, any governmental body, developer, property owner, or advocacy organization. The author has no financial interest in any property referenced herein, nor any pending development application anywhere.

The author's real estate license requires disclosure that information regarding real property should not be relied upon without independent verification. Nothing in this document constitutes real estate advice, and readers considering real property transactions should engage their own licensed professionals.

Document Version and Distribution

Version: 1.0

Date: January 26, 2026

Distribution: This document may be freely distributed for non-commercial educational and public policy discussion purposes with appropriate attribution.

Commercial use requires written permission from the author.

Contents

Executive Summary

Community opposition to data center development consistently centers on four primary concerns: water consumption, power demand and grid strain, noise pollution, and air quality/emissions.

This document presents a comprehensive inventory of mitigation strategies, technologies, and verified examples demonstrating how these concerns can be addressed.

Sources include U.S. Department of Energy, International Energy Agency (IEA), Environmental and Energy Study Institute (EESI), Ceres, S&P Global, industry leaders (Google, Microsoft, Meta, AWS), municipal governments, utility companies, and engineering consultancies.

Window of Opportunity

The current moment – with newly appointed leadership in Economic Development (Helen Ramirez) and Planning (Terry Floyd), plus ongoing Land Development Code updates through October 2025 – represents an optimal window for establishing clear data center standards before additional projects advance.

1. Water Consumption Mitigation

Data centers can consume 1.8 million to 5 million gallons of water daily for cooling. According to EESI, this equals the water use of a town of 10,000-50,000 people. However, multiple proven technologies and strategies can reduce or eliminate water consumption entirely.

1.1 Zero-Water and Closed-Loop Cooling Technologies

- **Closed-Loop Liquid Cooling:** Coolant circulates in a sealed system between servers and chillers with no evaporation. Microsoft reports reducing Water Usage Effectiveness (WUE) from 0.49 L/kWh to 0.30 L/kWh using this approach, with zero additional water input after initial fill. Pilot deployments are operational in Phoenix, AZ and Mt. Pleasant, WI.
- **Immersion Cooling:** Servers are submerged in non-conductive dielectric fluid, eliminating fans and water-based cooling entirely. Microsoft has deployed two-phase immersion cooling that achieves near-zero water consumption while enabling higher computational density. Key vendors include LiquidStack, Iceotope, and GRC.
- **Direct-to-Chip Liquid Cooling:** Cold plates attached directly to processors capture 70-75% of heat in liquid, dramatically reducing water needs versus evaporative systems. Lawrence Berkeley National Laboratory has validated this technology through extensive testing.
- **Air-Cooled Systems:** In suitable climates, adiabatic cooling using outside air achieves zero water consumption. Microsoft's Arizona datacenter region operates for more than six months annually without water cooling. Evolution Data Centres in Singapore has deployed fully air-cooled, closed-loop systems operating in hot, humid climates.
- **X-Cooling Waterless System:** Developed by Vertiv with Bridge Data Centres and Chindata Group, this system uses advanced thermal controls and ambient air to achieve zero WUE and PUE under 1.1. In Hebei Province, China, implementation is projected to save 1.2 million tons of water per 100 MW annually.

1.2 Alternative Water Sources

- **Recycled/Reclaimed Wastewater:** Google reports that reclaimed water made up 22% of data center cooling volume in 2023, including facilities in Singapore and Douglas County, Georgia. This diverts water from discharge while preserving potable supplies.
- **Industrial Water Reuse:** Microsoft collaborated with the City of Quincy, Washington to build the Quincy Water Reuse Utility, which recycles and recirculates process water for cooling, using only non-potable sources.
- **On-Site Treatment:** Filtration and purification systems enable cooling water reuse multiple times, reducing total consumption by up to 70%.

1.3 Water-Positive Commitments and Watershed Restoration

Major hyperscalers have committed to replenish more water than they consume by 2030:

- **Google:** Committed to replenishing 120% of freshwater consumed across offices and data centers by 2030. In 2023, replenishment projects restored approximately 1 billion gallons. Projects include wetland restoration in Tennessee's Cumberland River watershed, aquifer storage expansion in the Netherlands, and groundwater recharge in Chile's Maipo Basin.
- **Microsoft:** Committed to water-positive operations by 2030. As of July 2024, invested over $34 million in 76 replenishment projects worldwide, with estimated volumetric benefit exceeding 100 million cubic meters. Projects include oxbow wetland restoration across the Midwest and leak detection partnerships in Phoenix-area utilities.
- **Meta:** Committed to water-positive by 2030, restoring 200% of water consumed in high-stress areas and 100% in medium-stress areas. Projects in California, New Mexico, Oregon, and Utah have restored floodplains, riparian areas, and wetlands.
- **AWS:** Achieved global WUE of 0.19 L/kWh (24% improvement year-over-year), targeting water-positive operations with replenishment projects globally, including 3.9 billion liters annually.

1.4 Verified Examples

Location	Company	Mitigation Strategy
Phoenix, AZ	Microsoft	Zero-water cooling pilot; leak detection partnerships with local utilities
Quincy, WA	Microsoft	Advanced wastewater treatment system for cooling water reuse
Prineville, OR	Apple & Meta	Innovative groundwater storage project expanding city potable water supplies
Douglas County, GA	Google	Reclaimed wastewater for cooling, protecting Chattahoochee River

2. Power and Grid Impact Mitigation

Data centers may consume 9% of U.S. electricity by 2030 (Electric Power Research Institute). The IEA reports that data centers account for 1-1.5% of global electricity use. Mitigation focuses on clean energy procurement, grid investment, and demand flexibility.

2.1 Renewable Energy Procurement

- **Power Purchase Agreements (PPAs):** Long-term contracts directly fund new renewable energy projects. Amazon, Microsoft, Meta, and Google have contracted nearly 50 GW of renewable energy through PPAs, equal to Sweden's entire generation capacity.
- **24/7 Carbon-Free Energy (CFE):** Google and Microsoft target 100% CFE matching on an hourly basis by 2030. Google's Finland data center achieved 97% CFE. This means actual renewable consumption every hour, not just annual certificate matching.
- **On-Site Generation:** Solar installations, geothermal projects (Meta partnered with Sage Geosystems for 150 MW in Texas; Google with Fervo Energy in Nevada/Utah), and advanced nuclear (Amazon, Google, Microsoft exploring small modular reactors).
- **Additionality:** Microsoft has signed PPAs bringing over 10 GW of new renewable energy capacity online globally. These contracts provide guaranteed income enabling financing for new solar/wind projects that would not otherwise be built.

2.2 Grid Investment and Infrastructure

- **Direct Grid Investment:** Data center operators fund transmission and distribution upgrades. PG&E has mapped 10 GW of new data center load over the next decade and is pursuing multibillion-dollar transmission upgrades, with costs shared by operators.
- **Battery Energy Storage Systems (BESS):** Aligned Data Centers announced a 31 MW/62 MWh battery alongside a Pacific Northwest facility, enabling interconnection years earlier than traditional upgrades. BESS provides peak shaving, grid stabilization, and reduces strain on utilities during high-demand periods.
- **Demand Response Programs:** Data centers can reduce grid load during peak periods. Behind-the-meter generation and storage can be programmed to contribute back to the grid during system emergencies.
- **Clean Transition Tariffs:** Collaborative agreements between utilities and data centers that share infrastructure costs, create predictable cost structures, and expedite clean energy development.

2.3 Ratepayer Protection

Microsoft's Community-First AI Infrastructure initiative commits: "We'll pay our way to ensure our datacenters don't increase your electricity prices." This includes direct infrastructure investment, shared financing mechanisms, and transparency on consumption data published by region.

2.4 Verified Examples

Location	Company	Renewable Energy Strategy
Sweden Region	Microsoft	First region achieving 100% CFE for each hour of consumption; lower-carbon backup fuel
Fredericia, Denmark	Google	Rødby Fjord solar project adds CFE directly to local grid
Abilene, TX	Crusoe/Stargate	1.2 GW capacity with regional wind integration and grid-scale BESS
Pacific Northwest	Aligned	31 MW BESS enabling accelerated grid interconnection (operational 2026)

3. Noise Pollution Mitigation

Data centers generate noise from cooling systems (HVAC, cooling towers), backup generators, and server fans. Noise levels can reach 96 dBA inside facilities. Community regulations typically set limits of 50-60 dBA, with special concern for low-frequency hum that travels long distances.

3.1 Acoustic Engineering Solutions

- **Sound Barrier Walls:** Modular steel panels with sound-absorptive materials (16-gauge solid outer skin, 22-gauge perforated inner skin with acoustical fill) reduce noise from cooling towers and generators by 10-14 dBA. Sound Fighter Systems has 50 years of deployment experience.
- **Equipment Enclosures:** Sound-insulated housings for particularly loud equipment. Generator enclosures (Level 3 per Albemarle County, VA ordinance) contain noise at source. Verified reduction: 48.5 dBA to 36.5 dBA at complainant locations (Industrial Noise & Vibration Centre case study).
- **Air Handling Unit Modifications:** Changing AHU geometry and introducing internal modifications can cut broadband noise by >10 dBA with no effect on fan efficiency.
- **Hybrid/Immersion Cooling:** These systems operate more quietly than air cooling, eliminating multiple fans. Immersion cooling removes the need for fans within server racks entirely.
- **Natural Barriers:** Trees, berms, and landscaping complement artificial barriers. Dense plantings can minimize low-frequency noise while improving aesthetics.

3.2 Site Design and Zoning

- **Setback Requirements:** Fairfax County, VA requires data centers to be at least 200 feet from residential districts. Albemarle County, VA requires 200-foot setbacks from all lot lines and 500 feet from Rural Areas zoning.
- **Equipment Placement:** Generators and cooling equipment positioned away from residential areas, ideally in rear yards with maximum distance from sensitive receptors.
- **Noise Limits:** Albemarle County, VA: 60 dBA daytime, 55 dBA nighttime at property line. DeKalb County, GA requires pre- and post-construction sound studies and ongoing compliance monitoring.
- **Generator Testing Schedules:** Chandler, AZ and Albemarle County, VA restrict routine generator testing to weekdays 10 AM-4 PM, minimizing community disruption.

3.3 Monitoring and Community Engagement

- **Continuous Noise Monitoring:** Real-time systems with preset threshold alerts enable proactive response. Larson Davis and other providers offer outdoor monitoring systems specifically designed for data center applications.
- **Pre/Post-Construction Studies:** Fairfax County, VA requires noise studies before and after construction. Multiple jurisdictions require licensed acoustic engineers to model predicted levels and verify compliance.
- **Community Feedback Platforms:** AI-powered monitoring systems can identify noise fluctuations and enable residents to voice complaints immediately. Machine learning predicts peak periods for proactive mitigation.

4. Air Quality and Emissions Mitigation

Backup diesel generators emit NOx, PM2.5, and other pollutants linked to respiratory disease and cancer. EPA limits emergency generators to 100 hours annually for non-emergencies. Mitigation focuses on cleaner technologies and operational controls.

4.1 Cleaner Backup Power Technologies

- **Battery Storage Replacing Diesel:** BESS provides backup power without emissions, noise, or fuel storage. Aligned Data Centers is deploying utility-scale batteries as backup, reducing reliance on diesel generators.
- **Natural Gas Generators:** Cleaner-burning than diesel with lower NOx and particulate emissions. Combined Heat and Power (CHP) microgrids achieve efficiency rates up to 80% versus 40% for traditional grid power.
- **Hydrogen Fuel Cells:** Microsoft tested hydrogen fuel cells for backup power at datacenters, producing zero direct emissions. Bloom Energy solid-oxide fuel cells use gas without combustion, achieving 60% electrical efficiency.
- **Hydrotreated Vegetable Oil (HVO):** A drop-in diesel substitute reducing carbon emissions by up to 90%. Microsoft plans to phase out petroleum-based diesel by 2030, partly by adopting HVO and renewable diesel variations.
- **Tier 4 Generators with SCR:** Selective Catalytic Reduction systems reduce NOx emissions by 90% or more. Tier 4 generators meet stricter hourly emission standards and can operate longer without violating air quality limits.

4.2 Operational Controls

- **Runtime Limitations:** EPA limits non-emergency generator use to 100 hours annually. Facilities can request fuel usage limitations instead of runtime hours to maximize flexibility while staying compliant.
- **Stack Design:** Vertical, uncapped exhaust stacks improve emissions dispersion versus horizontal or short stacks. Site layout optimizing generator placement relative to sensitive receptors reduces ground-level concentrations.
- **Minor Source Status:** Keeping emissions below 100 tons/year for criteria pollutants avoids Title V Major Source classification and associated regulatory burden. Design choices including emission controls and operational restrictions help maintain minor source status.

5. Waste Heat Reuse

Data centers produce significant waste heat that can be captured and repurposed for district heating, industrial processes, or agriculture. The EU's revised Energy Efficiency Directive mandates waste heat action plans by 2030.

5.1 District Heating Integration

- **Microsoft-Fortum Partnership (Finland):** Will supply approximately 40% of district heating demand for Espoo, Kauniainen, and Kirkkonummi, serving 250,000 people. Called the world's largest data center heat recovery project, scheduled to go live by 2026.
- **Meta Odense Campus (Denmark):** Provides up to 165,000 MWh of heat annually to 11,000 homes through Munters Oasis indirect evaporative cooling with heat recovery. Heat is provided free of charge to the community.
- **Stockholm Data Parks (Sweden):** Integrated over 20 data centers into the municipal network, warming approximately 30,000 apartments with emissions reductions of about 50 gCO_2/kWh.
- **Mäntsälä, Finland:** Nebius data center recovers approximately 20 MWh of waste heat, providing two-thirds of the town's heating needs (equivalent to 2,500 homes) for a decade.
- **Tallaght, Ireland:** Amazon data center waste heat saved 1,100 tonnes of CO_2 in first year of district heating scheme operation.
- **atNorth DEN01 (Denmark):** Partnership with Vestforbrænding will heat 8,000+ homes from 2028 onwards using direct liquid cooling waste heat.

5.2 Other Heat Applications

- **Greenhouse Agriculture:** atNorth partnered with Wa3rm for circular agriculture initiatives including vegetable cultivation near data centers. In Finland, atNorth channels heat from FIN02 to an adjacent Kesko retail outlet.
- **Swimming Pool Heating:** IBM Switzerland heats a nearby swimming pool with recovered waste heat. At the 2024 Paris Olympics, Equinix data center surplus heat maintained pool temperatures at 27-28°C.
- **Industrial Processes:** Heat pumps can elevate data center waste heat (35-50°C) to 80-85°C for industrial applications. Economic payback periods under two years have been demonstrated.

6. Community Benefits and Visual Mitigation

6.1 Community Benefits Agreements

- **Lancaster, PA:** CBA for multiple data center campuses included water-use caps, noise/air emissions controls, and $20 million in community contributions (half for economic development, half for sustainable development).
- **Local Hiring Requirements:** CBAs can require first-source hiring policies, apprenticeship programs, and partnerships with community colleges. Northern Virginia Community College's Data Center Operations program has graduated over 200 students with 70% job placement in the industry.
- **Infrastructure Investment:** Data centers fund utility upgrades, road improvements, and broadband expansion. Google and Microsoft invest in water conservation and infrastructure projects benefiting entire communities.
- **Tax Revenue:** Loudoun County, VA data centers contributed $875 million in 2024 (38% of county tax revenue) while occupying only 3% of land. This funds schools, public safety, and infrastructure countywide.

6.2 Visual Screening and Design

- **Landscaping Requirements:** DeKalb County, GA requires 20-foot landscaped buffers with 8-foot walls and canopy trees every 30 feet. Fairfax County, VA requires 35-foot transitional screening yards adjacent to single-family dwellings.
- **Façade Design:** Prince William County, VA requires visually interesting exterior designs for facilities visible from incompatible uses. DeKalb County requires 30% fenestration on front façades. Design elements every 150 horizontal feet prevent monotonous walls.
- **Equipment Screening:** Substations, mechanical yards, and exposed equipment required to be located in rear yards in least visible locations. Rooftop equipment must be screened from public view.
- **Height Restrictions:** Typical limits of 80-100 feet with additional setback requirements for taller structures. Some jurisdictions require roof-mounted equipment included in height calculations.

7. Greenspace, Landscaping, and Visual Integration

Strategic integration of vegetation into and around data center developments addresses multiple community concerns simultaneously: visual screening, thermal management, stormwater control, biodiversity support, and enhanced property values. This section documents proven approaches from industrial facilities worldwide.

7.1 Rooftop Green Systems

Green roofs on industrial facilities deliver quantifiable benefits in thermal performance, stormwater management, and equipment longevity. The technology has matured significantly with extensive documentation from large-scale implementations.

Measured Benefits (EPA/DOE Data)

- **Surface temperature reduction:** Green roof surfaces can be 56°F cooler than conventional roofs, reducing nearby air temperatures by up to 20°F (EPA Heat Islands Report, 2025)
- **Cooling load reduction:** Up to 70% reduction in cooling load; indoor temperatures lowered by up to 27°F compared to conventional roofs
- **Energy savings:** $0.15–$0.57/sq yd annually for cooling; $0.18/sq yd for heating (EPA)
- **Stormwater retention:** 60–100% runoff reduction; Penn State research shows 80% rainfall capture vs. 24% for conventional roofs
- **Roof lifespan extension:** 2–3x longer lifespan by protecting membrane from UV and thermal stress; German installations have exceeded 40 years
- **Air quality benefits:** Kansas City study (EPA 2018): 700,000 sq ft of green roofs avoided 384 lbs NOx, 734 lbs SO_2, 269 tons CO_2 annually; monetized health benefits $35,500–$80,500/year

Example of Major Industrial Implementation: Ford River Rouge Plant

The Ford Dearborn Truck Plant at the River Rouge Complex represents the gold standard for industrial green roof implementation, demonstrating two-decade performance data:

- **Scale:** 10.4 acres (454,000 sq ft) of sedum-covered roof—held Guinness World Record for largest living roof (2004)
- **Design:** XeroFlor vegetated mat system, ultra-thin profile (10 lbs/sq ft saturated), grown locally on Ford property to reduce shipping
- **Stormwater performance:** Retains one inch of rainfall; part of $18M stormwater system that saved Ford $50M vs. mechanical treatment alternative
- **Thermal performance:** 10°F warmer in winter, 10°F cooler in summer, significantly reducing HVAC costs for 1.1M sq ft assembly plant
- **Maintenance:** After initial 2003 establishment season, irrigation reduced to once monthly in extreme heat; no weeding; spring fertilizer application every 1–2 years
- **Longevity:** 2010 survey: 13 of original 15 species thriving with 93–98% coverage after 7 years; roof still performing well after 20+ years
- **Wildlife habitat:** Supports nesting songbirds, Canadian geese, mallard ducks, and killdeer—demonstrating biodiversity value

Data Center Green Roof Implementations

- **Equinix (Netherlands, Switzerland, France):** Sites AM3, ZH5, and PA6 feature rooftop vegetation that lowers cooling costs and reduces stormwater runoff; company targets LEED Silver or equivalent for all new builds
- **Citi German Data Center:** Green roofing system reduces heat absorption, lowers cooling needs, and contributes to urban biodiversity; cited as industry case study for sustainable practices
- **Victorian Desalination Project (Australia):** 26,000+ m² (280,000 sq ft) 'living tapestry' of 98,000 indigenous plants providing acoustic protection, thermal control, and visual integration with landscape

7.2 Vertical Gardens and Green Walls

Patrick Blanc: Pioneer of Modern Vertical Gardens

Patrick Blanc, French botanist at the National Centre for Scientific Research (CNRS), invented the modern hydroponic vertical garden system (Le Mur Végétal) that has enabled large-scale implementation worldwide. His system uses a metal frame supporting PVC and polyamide felt layers that mimic cliff-growing mosses, with nutrient solution delivered via capillary action—eliminating soil weight and allowing installation on virtually any surface.

Key Blanc Implementations:

- **Musée du Quai Branly, Paris (2006):** 800 m² (8,600 sq ft) vertical garden, 200m long x 12m high, featuring 15,000 plants of 150 species. Provides natural insulation, improves air quality by creating micro-climate, serves as biodiversity refuge for birds and insects. Has operated successfully for 19+ years with 2018 structural renovation.
- **One Central Park, Sydney (2013):** World's tallest vertical garden at 150 meters, with 1,200 m² of green walls across 23 panels plus 7 kilometers of cable trellising. Features 85,000 plants of 350 species (250 Australian native). Irrigated with recycled wastewater from on-site treatment. Won 2014 CTBUH Best Tall Building Worldwide, 2015 MIPIM Best Innovative Green Building. 5-star Green Star certified.
- **CaixaForum Madrid (2007):** 300+ vertical gardens completed globally over 30+ year career. Blanc's home installation has thrived for 25+ years, demonstrating long-term viability.
- **Cost benchmark:** Approximately $65/sq ft plus labor for Blanc-designed systems; more economical alternatives available from other providers.

Measured Vertical Garden Benefits

- **Thermal insulation:** Reduces heat transfer through building envelope; provides natural shield between occupants and exterior temperatures
- **Air purification:** Plants absorb air pollutants including particulates, trap CO_2, release oxygen; research documents noise reduction of 21–40%
- **Biodiversity:** Provides nesting sites and food sources for birds, beneficial insects, pollinators in urban settings—documented up to 19 stories high
- **Human wellbeing:** Biophilic design research shows reduced stress, lower blood pressure, improved cognitive function from exposure to vegetation

7.3 Perimeter Landscaping and Visual Buffers

Municipal zoning codes nationwide mandate landscaped buffers between industrial uses and incompatible adjacencies. These requirements serve multiple functions: visual screening, noise attenuation, dust/pollutant filtering, and property value protection for surrounding areas.

Typical Municipal Buffer Requirements

Buffer Type	Width	Specifications
Type A – Opaque	15–50 feet	100% sight-obscuring from ground to 6 ft minimum; trees to 20 ft mature height; wall/fence/berm with vegetation
Type B – Semi-Opaque	10–25 feet	Opaque 0–3 ft; intermittent visual obstruction to 16 ft minimum; canopy trees every 25–30 lineal feet
Industrial/Residential Interface	20–50 feet	80% opaque year-round; 6 ft fence + evergreen trees @ 10 ft centers + shrubs reaching 6 ft within 3 years
Natural/Planted Buffer	25–100 feet	Dense native woods and undergrowth; sufficient depth/density to interrupt light, sound, visibility

Planting Specifications

- **Street trees:** 2-inch caliper minimum, spaced 25–30 ft on center
- **Evergreen screening trees:** 6 ft minimum height at installation, 10–15 ft spacing
- **Large shrubs:** 18–24 inches at installation, 5 ft on center, >10 ft at maturity
- **Ground cover:** Full coverage required; native/drought-tolerant species preferred
- **Berms:** 3:1 or gentler slope; can substitute for additional buffer width; combined with fence/vegetation for maximum screening

7.4 Wildlife Corridors and Habitat Integration

Perimeter landscaping can serve dual purposes as wildlife corridors when designed with ecological connectivity in mind. Research demonstrates that connected habitat patches support 14% more species than isolated patches (Conservation Biology, 2019).

Corridor Design Principles

- **Width:** Minimum 30 meters (100 ft) recommended for meaningful ecological function; wider for larger wildlife
- **Connectivity:** Link to existing riparian corridors, forest patches, parks; continuous preferred over fragmented
- **Native species:** Local ecotype plants support local food webs; provide seasonal food sources (berries, seeds, nectar)
- **Structural diversity:** Multiple vegetation layers (canopy, understory, shrub, ground) support diverse species; include dead wood/brush piles
- **Water features:** Bioswales, rain gardens, detention basins with naturalized edges increase habitat value

Central Texas Native Species for Buffers

Texas A&M research and Lady Bird Johnson Wildflower Center have documented species performing well in Central Texas conditions, including on green roofs without irrigation once established:

- **Canopy/Shade Trees:** Live Oak (Quercus virginiana), Texas Red Oak (Q. buckleyi), Cedar Elm (Ulmus crassifolia), Pecan (Carya illinoinensis)
- **Understory/Screening:** Texas Mountain Laurel (Sophora secundiflora), Yaupon Holly (Ilex vomitoria), Desert Willow (Chilopsis linearis), Elbow Bush (Forestiera pubescens)
- **Drought-Tolerant Shrubs:** Cenizo (Leucophyllum frutescens), Agarito (Mahonia trifoliata), Flame Acanthus (Anisacanthus quadrifidus var. wrightii)
- **Green Roof/Hot Climate Succulents:** Hesperaloe parviflora (Red Yucca), Agave parryi, Opuntia ellisiana (Spineless Prickly Pear), Manfreda maculosa

Native Grasses: Bouteloua curtipendula (Sideoats Grama), Muhlenbergia lindheimeri (Lindheimer Muhly), Nassella tenuissima (Mexican Feathergrass)

8. Environmental Recharge: Long-term Benefits

For properties within the Edwards Aquifer Contributing Zone, a third land use option merits serious consideration: environmental recharge and habitat restoration. While this option generates minimal direct tax revenue, it provides ecosystem services of substantial regional value.

8.1 The Case for Environmental Restoration

Central Texas landscapes have been significantly depleted through decades of overgrazing, cedar encroachment, and development that increased impervious cover. The resulting hydrological impacts include reduced groundwater recharge, degraded water quality, increased flood intensity, and diminished baseflow to springs and streams. The Edwards Aquifer—the primary drinking water source for over two million Central Texans—depends on healthy recharge zones for both quantity and quality.

Beaver Reintroduction as Restoration Tool: Emerging research from Stanford University, the Beaver Institute, and multiple Western state agencies demonstrates that beaver reintroduction and beaver dam analog (BDA) construction can dramatically accelerate watershed restoration. Beaver wetland complexes provide:

- Groundwater recharge: Beaver ponds slow water flow and increase infiltration, raising local water tables and recharging underlying aquifers
- Water quality improvement: Dams trap sediment and pollutants, acting as natural biofilters; nitrogen and heavy metal retention has been documented
- Biodiversity enhancement: Studies show 75% increase in bird diversity and 80% increase in trout populations following beaver restoration
- Drought and flood resilience: Beaver wetlands store water during wet periods and release it slowly during dry periods, moderating both extremes
- Carbon sequestration: Wetlands created by beavers store significant amounts of carbon in vegetation and soils
- Cost-effectiveness: Beaver-related restoration costs approximately one-tenth of traditional engineered stream restoration per mile

8.2 Funding Mechanisms for Conservation

Environmental recharge land uses need not be fiscally burdensome. Several mechanisms can offset the foregone tax revenue from development:

- Conservation Easements: San Antonio's Edwards Aquifer Protection Program has invested nearly $1 billion protecting over 240,000 acres in the recharge and contributing zones; similar programs could extend to Hays County properties
- Corporate Offsets: Microsoft recently contributed $850,000 toward a Comal County conservation easement as partial offset for its water-intensive data center operations; similar contributions could be negotiated as conditions of data center approval elsewhere
- Tax Benefits to Landowners: Conservation easements provide federal income tax deductions and can reduce property tax assessments by 50% or more while allowing continued agricultural use
- Water Utility Partnerships: San Antonio Water System and Austin Water Utilities have both invested in land acquisition and easements to protect water quality; such partnerships could extend into the San Marcos area
- Foundation and Grant Funding: The Walton Family Foundation, The Nature Conservancy, and other organizations actively fund beaver-related restoration and watershed protection projects

9. TAX REVENUE AND LAND USE COMPARISON

A central question for local decision-makers is whether data center development represents the highest and best use of land from a fiscal and community benefit perspective. This section examines the comparative tax contributions of data centers versus alternative industrial land uses, and introduces environmental recharge as a land use option with distinct long-term value.

9.1 Texas Tax Structure for Commercial/Industrial Development

Texas imposes no state income tax, making property taxes the primary mechanism for local government revenue from commercial and industrial development. The relevant tax categories include:

- **Ad Valorem Property Tax:** Assessed on real property (land and improvements) based on market value, with rates set by overlapping taxing jurisdictions (county, city, school district, special districts)
- **Business Personal Property Tax:** Unlike many states, Texas does not tax inventory but does tax business equipment and fixtures—a significant factor for data centers with high-value server and cooling equipment
- **Sales Tax:** Applies to equipment purchases; Texas offers sales tax exemptions for qualifying data centers under the Comptroller's Data Center Certification program, reducing revenue compared to non-exempt industrial uses

Critical Texas Distinction: Unlike Virginia (where Loudoun County receives nearly half of all property tax revenue from data centers, and Prince William County reported $166.4 million in data center tax revenue in 2023), Texas's data center tax exemption programs significantly reduce the fiscal benefit to local jurisdictions. Texas allows up to $125,000 in state sales tax exemptions per qualifying facility, and counties may negotiate local abatements. As a result, data center tax revenue in Texas typically derives primarily from real property taxes alone, potentially yielding only several hundred thousand to a few million dollars annually per facility—far less than comparable Virginia operations.

9.2 Comparative Tax Revenue by Land Use Type

The following table presents estimated annual property tax revenue per acre for different industrial land uses in Central Texas, based on industry research and Texas Comptroller data. These are illustrative estimates; actual values depend on specific appraised values and local tax rates.

Land Use Type	Typical Assessed Value/Acre	Est. Annual Tax/Acre*	Jobs per Acre
Data Center (with abatements)	$2M–$5M	$15,000–$50,000	0.5–2
Data Center (full taxation)	$5M–$15M	$75,000–$225,000	0.5–2
Logistics/Fulfillment Center	$500K–$1.5M	$7,500–$22,500	15–50
Warehouse/Storage	$300K–$800K	$4,500–$12,000	3–10
Light Manufacturing	$400K–$1.2M	$6,000–$18,000	10–30
Conservation/Ag Exemption	$200–$1,500	$3–$25	<1

**Based on combined Hays County/San Marcos tax rate of approximately 1.5%. Actual rates vary by taxing jurisdiction.*

Key Observation: While data centers can generate higher per-acre property tax revenue than logistics or warehouse uses, their employment density is dramatically lower. A 250,000 SF data center typically employs approximately 50 full-time workers (half of whom may be contractors), while a comparable fulfillment center might employ 500–1,500 workers. For communities prioritizing job creation alongside tax revenue, logistics and light manufacturing may deliver superior combined benefits.

10. Summary of Best Practices

Concern	Key Mitigation Strategies
Water	Closed-loop/immersion cooling (zero water); recycled wastewater; water-positive commitments with local watershed restoration; air cooling in suitable climates; WUE targets ≤1.4 L/kWh within 3 years, ≤1.2 L/kWh within 5 years
Power/Grid	24/7 CFE through PPAs; BESS for peak shaving and grid stability; direct infrastructure investment; ratepayer protection commitments; demand response participation; PUE targets ≤1.4 within 3 years, ≤1.3 within 5 years; utility capacity verification required before permit
Noise	Sound barrier walls; full equipment enclosures (8 ft solid walls); setbacks (200+ feet from residential); restricted generator testing hours (weekdays 9 AM–5 PM only); continuous monitoring; pre/post-construction noise studies; 55 dBA daytime/50 dBA nighttime limits at residential property lines
Air Quality	Battery backup replacing diesel; Tier 4 generators with SCR; HVO/renewable diesel; hydrogen fuel cells; minor source design; optimized stack placement
Waste Heat	District heating integration; agricultural applications; industrial process heat; heat pump elevation for higher-temperature uses; feasibility study required for facilities >30 MW
Green Building	Green roof or cool roof on minimum 30% of roof area; façade articulation every 100 ft; architectural design standards preventing blank walls; dark sky compliant lighting (full cutoff, ≤3000K); building-integrated renewable energy where feasible
Conservation & Wildlife	100 ft vegetated buffer yards with multi-layer native plantings; 50 ft wildlife corridors along drainage features (unfenced); minimum 30% conservation set-aside on Edwards Contributing Zone sites; native seed mixes for all revegetation; invasive species management plan
Aquifer Recharge	Maximum 40% impervious cover (30% in Recharge Zone); 150 ft setback from karst features; beaver dam analogs in drainage corridors; enhanced bioretention with native plants; 100% 2-year storm retention on-site; secondary containment for all chemicals; 2:1 offsite mitigation for impacted recharge area
Stormwater	Bioswales with native vegetation; pervious pavement in parking areas; rainwater harvesting for landscape irrigation and cooling makeup; constructed wetlands for polishing; pre-treatment BMPs; spill response plan on file with Fire Marshal
Community	Community benefits agreements; 30% local hiring for construction; first-source hiring for operations; workforce development partnerships; \$500K–\$2M impact fees; annual community payments (40% education, 25% first responders, 20% infrastructure, 15% community programs); community oversight committee; annual public reporting; clawback provisions for missed benchmarks

Conclusion:

San Marcos and Hays County are at an inflection point.

The decisions made now about data center development standards will shape the region's fiscal health, environmental quality, and community character for decades to come.

By learning from the experiences of other jurisdictions, establishing clear and protective standards, and maintaining focus on the community's long-term interests, local leaders can welcome responsible investment while preserving the qualities that make the Texas Hill Country an exceptional place to live, work, and raise families.

As a resident of Hays County, Texas, I submit this analysis as a public service to my neighbors and fellow Texans.

It is a privilege to live in the beautiful Texas Hill Country, and I share your commitment to the best interests of this community.

Cordially,

Lauren Romero, MBA, REALTOR®
Principal Consultant | Phi Growth Strategies

Required disclosure: Keller Williams Realty – broker of record | TREC #843653

Reminder: This white paper is for informational purposes only, intended to assist stakeholders tasked with making the consequential decisions associated with these topics. All views and information expressed in this document are my own and do not represent those of any other person, entity, organization, or government. No one else has suggested, advised, encouraged, coerced or in any way participated in the conception of this document nor its contents.

I have no interest whatsoever, material or of any other kind, neither directly nor indirectly, in any real estate mentioned in this document in any location on the planet.

No information contained in this white paper should be considered professional advice in general nor specifically regarding the specific property mentioned herein. All suggestions made within this document should not be considered nor implemented without prior evaluation by qualified professionals, appropriately licensed.

CONSOLIDATED REFERENCES

Virginia Data Center Regulations

Fairfax County, VA. Zoning Ordinance Amendment, Data Center Standards. Adopted September 2024. Board of Supervisors.
Loudoun County, VA. Data Center Zoning Amendments. Removal of by-right data center development; board approval required.
York County, VA. Utility Capacity Verification Requirements for Data Centers. Energy usage 5-year review cycle.
King George County, VA. Data Center Development Standards and Setback Requirements.
Prince William County, VA. 2023 Data Center Industry Tax Revenue Report. Published October 2024. Office of the County Executive.
Joint Legislative Audit and Review Commission (JLARC). Data Centers in Virginia. Commonwealth of Virginia, 2024.

Texas Regulatory Framework

Texas Property Code, Chapters 201–202. Restrictive Covenants and Property Owners' Associations.
Texas Local Government Code, Chapter 211. Municipal Zoning Authority.
Texas Local Government Code, Chapter 232. County Subdivision Regulation.
Texas Comptroller of Public Accounts. Qualifying Data Centers Frequently Asked Questions. comptroller.texas.gov/taxes/data-centers/faq.php
Texas Commission on Environmental Quality (TCEQ). Edwards Aquifer Protection Program. 30 TAC Chapter 213.
City of San Marcos. Development Code (Land Development Code Updates 2025). sanmarcostx.gov
City of Irving, TX. Data Center Conditional Use Permit Requirements.
City of Glenn Heights, TX. Planned Development Standards for Data Centers.

Edwards Aquifer and Conservation

Edwards Aquifer Authority. Conservation Programs and Land Acquisition. edwardsaquifer.org
San Antonio Water System (SAWS). Land Acquisition Program. Sensitive Lands Protection. saws.org
City of San Antonio. Edwards Aquifer Protection Program (EAPP). Conservation easement acquisitions 2000–present.
The Nature Conservancy of Texas. Edwards Aquifer Protection. nature.org/texas
Texas Water Resources Institute (TWRI). "Protect Our Land, Protect Our Water." twri.tamu.edu, 2014.
Hill Country Alliance / Texas Hill Country Conservation Network. State of the Hill Country Report. 2022.
Dietz, Frank. "A Win for Edwards Aquifer Recharge Zone in Comal County." Herald-Zeitung, June 2024. (Microsoft conservation easement contribution.)

Beaver Restoration and Watershed Management

Stanford University / Woods Institute for the Environment. "How Reintroducing Beavers Can Build Watershed Resilience." August 2025.
Beaver Institute. "Restoring Western Headwater Streams with Low-Tech Process-Based Restoration (LTPBR)." White Paper, November 2022. beaverinstitute.org
Dittbrenner, B., et al. "Relocated Beaver Can Increase Water Storage and Decrease Stream Temperature in Headwater Streams." Ecosphere, July 2022.
National Association of Wetland Managers (NAWM). Beaver-Related Restoration Resources. nawm.org
Walton Family Foundation. "How Beavers Are Inspiring Efforts to Restore Degraded Rivers." April 2023.

Tax and Economic Analysis

Tax Foundation. "State Taxation of Data Centers." December 2025. taxfoundation.org
Tax Foundation. "Location Matters: Effective Tax Rates on Distribution Centers by State." December 2024.
Data Center Knowledge. "How Are Data Centers Taxed?" September 2025.
Data Center Knowledge. "U.S. Data Center Tax Incentives: A Special Report." September 2025.
PwC. "Data Centers: Key Tax Considerations." 2025. pwc.com
Olney Enterprise. "How Much Revenue Do Data Centers Generate for Local Governments?" November 2025.
Cardinal News. "Data Centers Can Bring High-Paying Jobs and Millions in Tax Revenue." April 2025.

Green Building and Environmental Standards

U.S. Environmental Protection Agency. "Using Green Roofs to Reduce Heat Islands." April 2025. epa.gov/heatislands
Massachusetts Department of Environmental Protection. "Green Roofs & Stormwater Management." mass.gov
NetZero Events. "Green Roof Technologies: Is It Beneficial for Data Center Design?" May 2024.

San Marcos and Hays County Official Sources

City of San Marcos. "City Names First Economic and Local Business Development Department Director" (Helen Ramirez). November 2025. sanmarcostx.gov
City of San Marcos. "City Selects New Planning and Development Services Director" (Terry Floyd). November 2025. sanmarcostx.gov
City of San Marcos. Land Development Code Updates. Draft Code October 2025. smtx.konveio.com
City of San Marcos. Planning & Zoning Commission. sanmarcostx.gov/585
City of San Marcos. Economic Development San Marcos Board. Ordinance and membership.
Hays County Commissioners Court. Court Members and Meeting Schedule. hayscountytx.gov
Hays Caldwell Economic Development Partnership (formerly Greater San Marcos Partnership). Rebranding announcement October 2024. Mike Kamerlander, President & CEO.

Note: *Website URLs and contact information were verified as of January 2026. Organizations frequently update their web presence; if a link does not resolve, search the organization name for current information.*

— End of Document —