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Clackamas County

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October 21, 2026 BCC Agenda Date/Item: _____

Board of County Commissioners
Clackamas County

First Public Hearing and Consideration of a Resolution Adopting a Moratorium on Data Centers

Previous Board Action/Review: Policy Session July 7, 2026; Issues August 4, 2026; Issues August 11, 2026; Issues September 15, 2026
Performance Clackamas: Safe, Secure and Livable Communities; Vibrant Economy; Public Trust in Good Government
Counsel Review: Yes **Procurement Review:** N/A
Contact Person: Caleb Huegel **Contact Phone:** 503-655-8364

EXECUTIVE SUMMARY: ORS 197.520 allows local governments to adopt moratoria on certain land uses. The statute requires a public hearing on the proposed moratorium, notice to the Department of Land Conservation and Development (DLCD) 45 days before the public hearing, and findings justifying the moratorium. Those findings must include, among other things, a demonstration of "compelling need" due to "irrevocable public harm" that would occur without the moratorium, and a determination that resources are available to develop a permanent solution during the moratorium period. Moratoria adopted by local governments may be appealed to the Land Use Board of Appeals (LUBA). The initial moratorium period may not exceed 120 days. However, after holding another public hearing, the local government may extend the moratorium by up to six months if the problem continues to exist and the local government is making reasonable progress towards alleviating it.

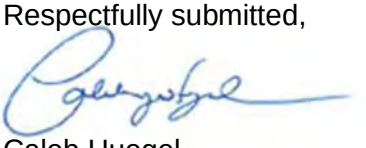
A resolution adopting a moratorium and supportive findings are attached. The moratorium would prohibit the County from accepting, processing, or approving any new application for the development of a new or the expansion of an existing data center as a primary use on land in unincorporated areas for 120 days. Notice was provided to DLCD on August 13, 2026.

The purpose of the moratorium is to temporarily pause data center development to give the County time to develop and adopt amendments to the ZDO to more appropriately regulate data centers. The purpose of this public hearing is to give the public an opportunity to comment on whether the County should adopt the moratorium. In providing those comments, the public may also discuss the concerns that they have about data centers in general. However, the purpose of this public hearing is not for staff to discuss proposed amendments to the ZDO. If the County adopts a moratorium, staff will present proposed amendments at a future policy session for the Board's consideration.

For Filing Use Only

RECOMMENDATION: Staff recommends that the Board conduct this public hearing. The adoption of a moratorium is a discretionary policy matter on which the Office of County Counsel takes no position.

Respectfully submitted,



Caleb Huegel
Assistant County Counsel

ATTACHMENTS:
Resolution with Findings
Sources Referenced in Findings

BEFORE THE BOARD OF COUNTY COMMISSIONERS

OF CLACKAMAS COUNTY, STATE OF OREGON

In the Matter of Adopting a Moratorium on Data Centers	}	Resolution No. *Page 1 of 2*

Whereas, members of the public in Clackamas County and across the State of Oregon have raised concerns relating to the noise, heat, and air impacts; the water and electricity demands; and the employment density of data centers; and

Whereas, the County desires to ensure that its Zoning and Development Ordinance (ZDO) adequately accounts for and addresses these issues; and

Whereas, it will take time for the County to thoroughly review and analyze these issues and develop and adopt amendments to the ZDO; and

Whereas, it is necessary to temporarily pause data center development in order to avoid public harm from additional developments occurring before the County completes that review and analysis and develops and adopts those amendments; and

Whereas, ORS 197.520 allows local governments to adopt moratoria on certain land uses, provided they hold a public hearing on the proposed moratorium, provide notice to the Department of Land Conservation and Development (DLCD) 45 days before the public hearing, and adopt findings justifying the moratorium; and

Whereas, the County provided notice to DLCD on August 13, 2026, and held public hearings before the Board on October 21 and 22, 2026;

NOW, THEREFORE, the Clackamas County Board of Commissioners does hereby resolve as follows:

Section 1. As used in this resolution:

A. "Data center" means a facility for the storage, management, processing, and/or transmission of digital data, which houses computer and/or network equipment, systems, servers, appliances, and other associated components related to digital data operations. "Data center" includes, but is not limited to, facilities used for colocation services, cloud computing services, artificial intelligence training or inference services, or digital asset mining services, whether such services are internal or external services, *i.e.*, provided to third parties or operated for the owner's own commercial operations. "Data center" does not include a telecommunications switching, routing, or network transmission center whose primary design and function is the carriage of voice, video, or broadband communications rather than the storage, processing, or hosting of data for end users.

BEFORE THE BOARD OF COUNTY COMMISSIONERS

OF CLACKAMAS COUNTY, STATE OF OREGON

In the Matter of Adopting a Moratorium on Data Centers	}	Resolution No. *Page 2 of 2*

B. "Primary use" means the principal activity or combination of activities of chief importance on a site, and which is one of the main purposes for which the land or structures are intended, designed, or ordinarily used. A site may have more than one primary use.

C. "Site" means a lot, parcel, other unit of land, or combination of lots, parcels, or other units of land in common ownership.

Section 2. The County shall not accept, process, or approve any new application for the development of a new or the expansion of an existing data center as a primary use on land in unincorporated areas.

Section 3. The Board adopts the findings shown in Exhibit A, attached hereto and by this reference incorporated herein.

Section 4. This resolution shall take effect immediately upon adoption and shall be effective for a period of 120 days, unless earlier extended or repealed.

DATED this 22nd day of October 2026

BOARD OF COUNTY COMMISSIONERS

_____
Chair

_____
Recording Secretary

Exhibit A
Resolution Adopting a Moratorium on Data Centers
Findings of Consistency with ORS 197.520

OVERVIEW

ORS 197.520 allows local governments to adopt moratoria on certain land uses. The statute requires a public hearing on the proposed moratorium, notice to the Department of Land Conservation and Development (DLCD) 45 days before the public hearing, and findings justifying the moratorium. Moratoria adopted by local governments may be appealed to the Land Use Board of Appeals (LUBA). The initial moratorium period may not exceed 120 days. However, after holding another public hearing, the local government may extend the moratorium by up to six months if the problem continues to exist and the local government is making reasonable progress towards alleviating it. The resolution to which these findings are attached adopts a moratorium which prohibits the County from accepting, processing, or approving any new application for the development of a new or the expansion of an existing data center as a primary use on land in unincorporated areas for 120 days.

NOTICE, HEARINGS, AND COMMENT

As stated above, ORS 197.520 requires a public hearing on the proposed moratorium and notice to DLCD 45 days before the public hearing. Notice was provided to DLCD on August 13, 2026. Two public hearings were held before the Board of County Commissioners (Board): one on October 21, 2026, and another on October 22, 2026. Notice of the public hearings was published in a press release, on the County's website, and on various social media platforms. As of October 11, 2026, the County had received comments from nine individuals. Four expressed support for the proposed moratorium. Two proposed amendments to the ZDO to more appropriately regulate data centers. Three expressed opposition to data center development in general. Many cited the public harms discussed below. None opposed the proposed moratorium.

FINDINGS

As stated above, ORS 197.520 requires findings justifying the moratorium. Compliance with the relevant portions of the statute is discussed below.

ORS 197.520(3)

> *A moratorium not based on a shortage of public facilities under subsection (2) of this section may be justified only by a demonstration of compelling need. Such a demonstration shall be based upon reasonably available information and shall include, but need not be limited to, findings:*

The moratorium is based on compelling need under ORS 197.520(3), not a shortage of public facilities under ORS 197.520(2).

These criteria are applicable.

ORS 197.520(3)(a)

For urban or urbanizable land:

The moratorium applies to both urban and urbanizable land.

These criteria are applicable.

ORS 197.520(3)(a)(A)

That application of existing development ordinances or regulations and other applicable law is inadequate to prevent irrevocable public harm from development in affected geographical areas;

Under the current ZDO, data centers are allowed in the County's urban industrial zones as "Information Services" uses under ZDO table 602-1. However, data centers generally have greater noise, heat, and air impacts than other Information Services uses, such as publishing industries, recording studios, and financial transaction processing. *See* Va. Joint Legis. Audit & Rev. Comm'n, Report No. 598, *Data Centers in Virginia* (2024); Miguel Yañez-Barnuevo, *Communities Are Raising Noise Pollution Concerns About Data Centers*, Env't & Energy Study Inst. (Mar. 23, 2026), https://www.eesi.org/articles/view/communities-are-raising-noise-pollution-concernsabout-data-centers; Andrea Marinoni et al., *The Data Heat Island Effect: Quantifying the Impact of AI Data Centers in a Warming World* (Apr. 21, 2026) (unpublished manuscript); David J. Sailor, Soroush Samareh Abolhassani & Eli P. Martin, *Data Center Waste Heat as an Emerging Urban Thermal Hazard: First Field Measurements of Neighborhood-Scale Air Temperature Impacts*, 7 J. Eng'g for Sustainable Bldgs. & Cities, May 2026, at 1; *Data Centers, Urban Heat, and AI Growth*, Yale Sch. of the Env't, https://environment.yale.edu/news/article/data-centers-urban-heat-and-ai-growth (last visited Sept. 23, 2026); April Ehrlich, *Why Data Centers Pose an Outsized Threat to Eastern Oregon's Air Quality*, OPB (July 22, 2026), https://www.opb.org/article/2026/07/22/data-center-eastern-oregon-air-quality-umatilla-basin/. The impacts of data centers are even greater when they cluster together, and they vary significantly across counties. *See* Damian Pitt, Ivan Suen & Ellie Plisko, *Localized Air Pollution Impacts from Data Centers in Northern Virginia* (Inst. for Sustainable Energy & Env't, Va. Commonwealth Univ. 2026); Yuelin Han et al., *Health-Informed Computing: Estimating and Addressing the Public Health Impact of Data Centers* (June 8, 2026) (unpublished manuscript). Some of the County's industrial zones, such as those in the Jennings Lodge and Clackamas areas, are adjacent to residential zones, which are relatively sensitive to such impacts.

Data centers also generally have greater demands for water and electricity than other Information Services uses. *See* Josh Mahan, *How Much Power Does a Hyperscale Data Center Use? In-Depth Analysis*, C & C Tech. Grp. (Dec. 15, 2025), https://cc-techgroup.com/blog/how-much-power-does-a-hyperscale-data-center-use/; Melissa Farney, *The Data Center Power Squeeze: Mapping the Real Limits of AI-Scale Growth*, Data Ctr. Frontier (Dec. 1, 2025), https://www.datacenterfrontier.com/energy/article/55333263/the-data-center-power-squeeze-mapping-the-real-limits-of-ai-scale-growth. However, the current ZDO does not regulate development based on electricity consumption or availability, nor does it regulate development based on water consumption or availability outside public or community water system service areas and groundwater limited areas.

In addition, data centers generally have a low employment density relative to other industrial uses, requiring large amounts of land and, when fully operational, employing relatively few people. *See* E.D. Hovee & Co., *Hillsboro Economic Opportunities Analysis* (2021); Christopher Tozzi, *How Many Jobs Do Data Centers Create? It Depends*, Data Ctr. Knowledge (Aug. 28, 2025), https://www.datacenterknowledge.com/operations-and-management/how-many-jobs-do-data-centers-create-it-depends. According to the County's 2025 Employment Site Readiness Study, there is only one industrially zoned parcel in the unincorporated areas of Clackamas County with at least five acres of contiguous vacant land. It may be desirable to ensure that that land remains available for industrial uses with higher employment densities.

Existing law is inadequate to prevent these public harms because, under the current ZDO, nothing would prevent a low-employment-density data center from developing on the County's limited industrial land adjacent to or near a sensitive residential zone, nor would anything prevent data centers from clustering together, regardless of how much electricity and, outside public and community water system service areas, how much water they will consume relative to how much is available. These public harms are irrevocable because, once a data center or cluster is lawfully established, it becomes a protected "nonconforming use," which may continue indefinitely under ORS 215.130.

This criterion is met.

ORS 197.520(3)(a)(B)

> *That the moratorium is sufficiently limited to ensure that a needed supply of affected housing types and the supply of commercial and industrial facilities within or in proximity to the city, county or special district are not unreasonably restricted by the adoption of the moratorium;*

The moratorium is limited to data centers. It does not restrict the supply of housing or of commercial or other industrial facilities. For that reason, it is not unreasonable.

This criterion is met.

ORS 197.520(3)(a)(C)

> *Stating the reasons alternative methods of achieving the objectives of the moratorium are unsatisfactory;*

The purpose of the moratorium is to temporarily pause data center development in order to avoid public harm from additional developments occurring before the County adopts amendments to the ZDO to more appropriately regulate data centers. The only alternative is to develop and adopt those amendments without first adopting a moratorium. However, the development and adoption of those amendments will take time. If additional developments occur before the County adopts those amendments, it will substantially undermine the purpose of the moratorium.

This criterion is met.

ORS 197.520(3)(a)(D)

That the city, county or special district has determined that the public harm which would be caused by failure to impose a moratorium outweighs the adverse effects on other affected local governments, including shifts in demand for housing or economic development, public facilities and services and buildable lands, and the overall impact of the moratorium on population distribution; and

The only effect that the moratorium will have on other local governments is the potential for data centers that would have located in Clackamas County to locate elsewhere. However, the moratorium period is relatively short compared to the period that companies spend planning the siting and construction of new data centers. In addition, a map of probable data center locations in the Metro region prepared by DLCD in April 2026 shows that no data centers are likely to locate in Clackamas County to begin with. For these reasons, the moratorium is unlikely to result in a surge of data center development in other jurisdictions. The effect that the moratorium will have on other local governments is likely to be minimal, and it is outweighed by the public harms discussed above.

This criterion is met.

ORS 197.520(3)(a)(E)

That the city, county or special district proposing the moratorium has determined that sufficient resources are available to complete the development of needed interim or permanent changes in plans, regulations or procedures within the period of effectiveness of the moratorium.

The moratorium is effective for a period of 120 days. Under the current ZDO and state law, and with practical constraints, amending the ZDO takes approximately 114 days. The County will endeavor to amend its 2025-27 Long-Range Planning Work Program to accommodate the development and adoption of amendments to the ZDO to more appropriately regulate data centers during the moratorium period.

This criterion is met.

ORS 197.520(3)(b)

For rural land:

In addition to urban and urbanizable land, the moratorium applies to rural land.

These criteria are applicable.

ORS 197.520(3)(b)(A)

That application of existing development ordinances or regulations and other applicable law is inadequate to prevent irrevocable public harm from development in affected geographical areas;

Under the current ZDO, data centers are not expressly allowed in the County's Rural Industrial (RI) zone. However, data centers could potentially be allowed in RI-zoned areas as a "similar use" under ZDO section 106. Some of the County's RI zoned-areas, such as those in the Boring and Damascus areas, are adjacent to residential zones, which are relatively sensitive to the impacts of data centers discussed above. In addition, as discussed above, data centers generally have a low employment density relative to other industrial uses, and it may be desirable to ensure that RI-zoned land remains available for industrial uses with higher employment densities. Existing law is inadequate to prevent these public harms because, under the current ZDO, it is possible for a low-employment-density data center to develop in an RI-zoned area adjacent to or near a sensitive residential zone, and it is possible for them to cluster together. These public harms are irrevocable with respect to rural land for the same reason they are irrevocable with respect to urban and urbanizable land.

This criterion is met.

ORS 197.520(3)(b)(B)

Stating the reasons alternative methods of achieving the objectives of the moratorium are unsatisfactory;

The alternative of developing and adopting amendments to the ZDO without first adopting a moratorium is unsatisfactory with respect to rural land for the same reason it is unsatisfactory with respect to urban and urbanizable land. If additional developments occur before the County adopts those amendments, it will substantially undermine the purpose of the moratorium.

This criterion is met.

ORS 197.520(3)(b)(C)

That the moratorium is sufficiently limited to ensure that lots or parcels outside the affected geographical areas are not unreasonably restricted by the adoption of the moratorium; and

The moratorium temporarily pauses data center development in unincorporated areas. It does nothing to restrict lots or parcels outside those geographical areas.

This criterion is met.

ORS 197.520(3)(b)(D)

That the city, county or special district proposing the moratorium has developed a work plan and time schedule for achieving the objectives of the moratorium.

The County will endeavor to amend its 2025-27 Long-Range Planning Work Program to accommodate the development and adoption of amendments to the ZDO to more appropriately regulate data centers during the moratorium period. The County will endeavor to provide notice of those amendments on December 7, 2026, hold a public hearing before the Planning Commission by January 11, 2027, hold a public hearing before the Board by February 2, 2027, and enable the Board to adopt the amendments by February 18, 2027.

This criterion is met.

Commonwealth of Virginia
December 9, 2024

Report to the Governor and the General Assembly of Virginia

Data Centers in Virginia

2024



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AND REVIEW COMMISSION

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Summary: Data Centers in Virginia

WHAT WE FOUND

Data centers provide positive economic benefits to Virginia's economy, mostly during their initial construction

Data centers provide positive benefits to Virginia's economy mostly because of the industry's substantial capital investment. The primary benefit comes from the initial construction of data centers. Most construction spending likely remains in the state economy because much of it goes to Virginia-based businesses providing construction materials and services.

Data centers employ fewer employees than some other industries, but data center jobs tend to be high paying. Several data center representatives indicated that a typical 250,000-square-foot data center may have approximately 50 full-time workers, about half of which are contract workers. Data center construction supports a substantially larger number of workers. Construction of an individual data center building usually takes about 12 to 18 months, and data center representatives indicated that, at the height of construction, approximately 1,500 workers are on site from various construction-related industries.

Overall, the data center industry is estimated to contribute 74,000 jobs, $5.5 billion in labor income, and $9.1 billion in GDP to Virginia's economy annually. Most of these economic benefits derive from the construction phase rather than data centers' ongoing operations. The economic benefits from the industry are concentrated in Northern Virginia, where most data centers are located, but other regions of the state also benefit because data centers are also located there, or they are home to businesses that provide materials for data center construction.

WHY WE DID THIS STUDY

In 2023, the Joint Legislative Audit and Review Commission directed staff to review the impacts of the data center industry in Virginia.

ABOUT DATA CENTERS

Data centers are specialized facilities that manage, process, and share large amounts of data. They enable the digital services that people rely on daily, including websites, electronic applications, and cloud-based platforms, such as email and media streaming. Northern Virginia is the largest data center market in the world, constituting 13 percent of all reported data center operational capacity globally and 25 percent of capacity in the Americas. Multiple factors have contributed to Northern Virginia's market prominence, including a strong fiber network, supply of reliable cheap energy, available land, proximity to major national customers, and the creation of a state data center tax incentive. The data center industry is growing rapidly in Virginia, both in established markets and newer ones. Significant new market growth is expected in counties outside of Northern Virginia and along the I-95 corridor to Central Virginia.

Data centers can generate substantial local tax revenues for localities that have them

Localities with data centers can collect substantial tax revenues from the industry, primarily from business personal property and real property (real estate) taxes. The amount of local data center revenue depends on several factors, such as the size of a locality's data center market and local tax rates. Some localities have greatly reduced their business personal property tax rates for computer equipment to try to attract data centers, but this also reduces the revenue they can collect from the industry. For the

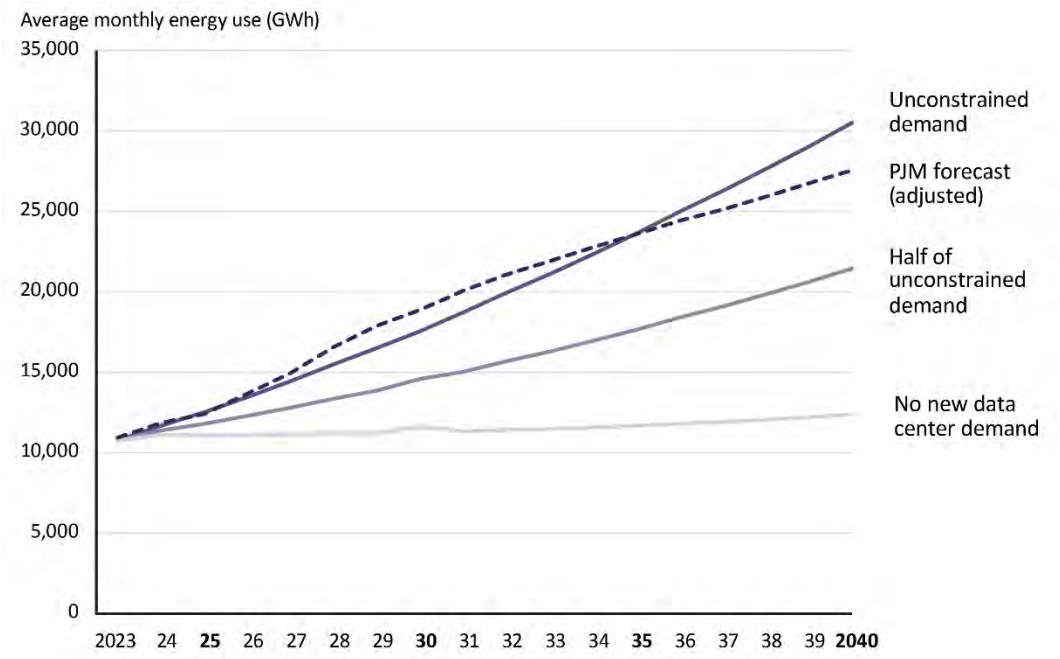
five localities with relatively mature data center markets, data center revenue ranged from less than 1 percent to 31 percent of total local revenue.

Localities in economically distressed areas of the state could benefit from data centers through increased local tax revenue, but these localities could have difficulty attracting the industry. Access to power and large, flat areas of land are key requirements for data centers, but are not available in some distressed areas, particularly in Southwest Virginia. Many distressed localities are also in rural areas that are away from data center customers and population centers, which makes it harder for them to attract the industry. However, these localities may be able to compete for data centers running certain artificial intelligence (AI) workloads, such as training. These localities could potentially become more attractive to the industry if they are able to proactively develop industrial sites suitable to data centers.

Data center industry is forecast to drive immense increase in energy demand

Modern data centers consume substantially more energy than other types of commercial or industrial operations. Consequently, the data center industry boom in Virginia has substantially driven up energy demand in the state, and demand is forecast to continue growing for the foreseeable future. The state's energy demand was essentially flat from 2006 to 2020 because, even though population increased, it was offset by energy efficiency improvements. However, an independent forecast commissioned by JLARC shows that unconstrained demand for power in Virginia would double within the next 10 years, with the data center industry being the main driver. JLARC's independent forecast largely matches the most recent forecast by PJM, which is the regional organization that coordinates generation and transmission operations for Virginia and several other eastern and midwestern states.

Data center demand would drive immense increase in energy needs in Virginia, based on JLARC's independent forecast and other forecasts

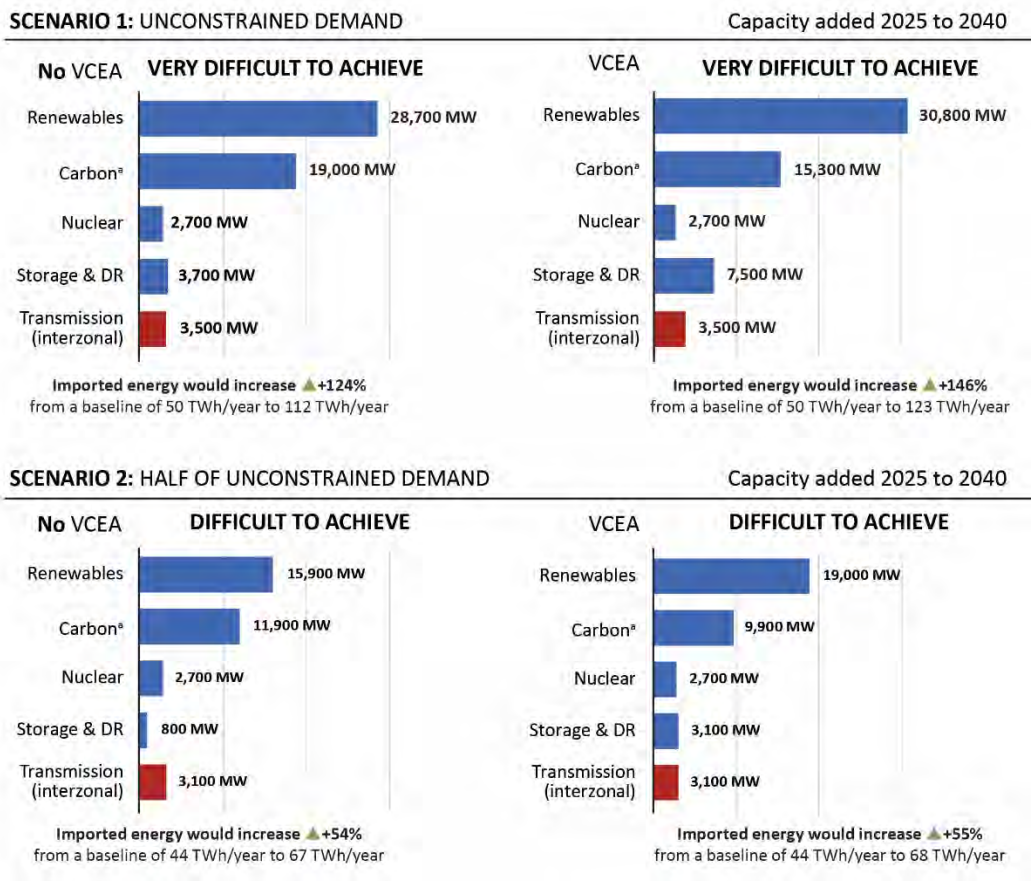


SOURCE: JLARC staff consultant analysis.
NOTE: A detailed note is provided for this figure in Chapter 3.

Building enough infrastructure for unconstrained data center demand will be very difficult and meeting half that demand is still difficult

An independent model of the energy grid commissioned by JLARC staff found that a substantial amount of new power generation and transmission infrastructure will be needed in Virginia to meet unconstrained energy demand or even half of unconstrained demand. Building enough infrastructure to meet unconstrained energy demand will be very difficult to achieve, with or without meeting the Virginia Clean Economy Act (VCEA) requirements (Scenario 1, figure). New solar facilities, wind generation, natural gas plants, and increased transmission capacity would all be required to meet unconstrained demand, and the number of projects needed would be very difficult to achieve. For example, new solar facilities would have to be added at twice the annual rate they were added in 2024, and the amount of new wind generation needed would exceed the potential capabilities of all offshore wind sites that have so far been secured for future development. Large natural gas plants would also need to be added at an equal or faster rate than the busiest build period for these facilities (2012 to 2018), depending on VCEA compliance.

Estimated generation mix needed to meet demand scenarios, with and without meeting VCEA requirements



SOURCE: E3 grid modeling analysis.
NOTE: A detailed note is provided for this figure in Chapter 3.
[a] Carbon includes natural gas, coal, and oil. Biomass facilities are counted as renewable resources, per the VCEA. However, starting in 2045, E3's grid model assumes natural gas plants would be converted to hydrogen fuel in each scenario when VCEA requirements are met.

Building enough infrastructure to meet half of unconstrained energy demand would also be difficult (Scenario 2 above). If VCEA requirements were not considered, the biggest challenge would be building new natural gas plants. New gas would need to be added at the rate of about one large 1,500 MW plant every two years for 15 consecutive years, equal to the busiest period of the last decade (2012 to 2018). If it is assumed that VCEA requirements would be met, the biggest challenges would be building enough wind, battery storage, and natural gas peaker plants. Wind generation needs would be the same as the unconstrained demand scenario. The amount of new battery storage would be several times the small amount currently in place in Virginia and a significant number of new natural gas peaker plants would have to be constructed. Both Scenarios 1 and 2 would rely on energy from as yet unproven nuclear technologies.

The state could encourage or require data centers to take actions to help address their energy impacts by promoting development of renewable energy generation, participating in demand response programs, and managing energy efficiency. However, these actions would have only a marginal impact on decreasing data center energy demand.

Existing electric utility requirements and processes help limit risks associated with system capacity and reliability

Data centers' projected energy demand increases have raised concerns about whether enough infrastructure can be built to keep pace. Currently, PJM attempts to protect regional grid reliability by requiring utilities to secure sufficient generation capacity plus a reserve margin, and the state requires utilities to develop plans that describe how generation capacity needs will be met. However, individual electric utility planning does not guarantee that the generation resources needed for the whole PJM region will be built because regional generation is not centrally planned. This is less of a concern with transmission because PJM and utility transmission owners centrally identify the impact large loads are expected to have, and how those loads can be brought on safely without causing transmission reliability problems.

If utilities are unable to build enough new infrastructure to keep pace with demand, one of the main ways they can protect grid reliability is by delaying the addition of new large load customers until there is adequate generation and transmission capacity. Utilities appear to be able to delay large load additions for transmission-related concerns, but it is less clear if they are allowed to delay adding new load because of generation concerns.

Data centers are currently paying their full cost of service, but growing energy demand is likely to increase other customers' costs

JLARC staff commissioned an independent study of electric utility cost recoveries under current rate structures to see if the data center industry is paying its share of current costs. The study found that current rates appropriately allocate costs to the customers responsible for incurring them, including data center customers.

However, data centers' increased energy demand will likely increase system costs for all customers, including non-data center customers, for several reasons. A large amount of new generation and transmission will need to be built that would not otherwise be built, creating fixed costs that utilities will need to recover. It will be difficult to supply enough energy to keep pace with growing data center demand, so energy prices are likely to increase for all customers. Finally, if utilities are more reliant on importing power, they may not always be able to secure lower-cost power and will be more susceptible to spikes in energy market prices. A typical residential customer of Dominion Energy could experience generation- and transmission-related costs increasing by an estimated $14 to $37 monthly in constant (or real) dollars by 2040 (independent of inflation). Establishing a separate data center customer class, changing cost allocations,

and adjusting utility rates more frequently could help insulate non-data center customers from statewide cost increases.

Data centers create additional financial risks to electric utilities and their customers

The data center industry presents additional financial risks to electric utilities and their customers because of the sheer size of the industry's energy demand. One risk is that utilities will build more generation and transmission infrastructure than is needed if forecast demand does not materialize, or several large data centers close. This could strand utilities with infrastructure costs that would have to be recouped from their existing customer base. Another risk is particular to electric co-ops, which are not-for-profit companies that are owned by their member customers. If a data center customer delayed, disputed, or failed to pay an energy generation bill and the co-op was unable to recoup these costs from the customer, they would ultimately have to be paid by all other co-op members. A large enough bill could potentially result in a co-op defaulting and going bankrupt.

Another risk relates to data center participation in the state's retail choice program, which allows data centers and other large load customers to purchase generation through third parties rather than through their incumbent electric utility. This also has the potential to shift generation costs to other customers if enough data centers "leave" their incumbent utility for retail choice.

Data center backup generators emit pollutants, but their use is minimal, and existing regulations largely curb adverse impacts

To ensure constant operations in the event of a power outage, nearly all data centers maintain diesel generators on-site for backup power. Diesel generators emit several harmful air pollutants, such as nitrogen oxides, carbon monoxide, and particulate matter. To limit potential emissions from backup generators, the Virginia Department of Environmental Quality (DEQ) permits limit when they can be run, how long they can be run, and the maximum annual emissions each permitted site is allowed. Nearly all current data centers use "Tier 2" diesel generators, which DEQ allows to run only in emergencies or as part of routine maintenance testing.

Data center generators are run mostly only for maintenance, and most data center operators interviewed by JLARC staff reported experiencing zero to two minor outages per site in the last two years, with nearly all outages lasting only a few hours. Consequently, data centers' diesel generators are a relatively small contributor to regional air pollution—in Northern Virginia, they make up less than 4 percent of regional emissions of nitrogen oxides and 0.1 percent or less of carbon monoxide and particulate matter emissions. While they make up only a small part of regional emissions, DEQ is conducting further study to ensure no harmful impacts occur locally. If the study detects any local air quality impacts, DEQ has the authority to increase protections as needed.

Data center water use is currently sustainable, but use is growing and could be better managed

Data centers require industrial-scale cooling, which is sometimes dependent on water, to manage the heat generated by their computing equipment. Most data centers use about the same amount of water or less as an average large office building, although a few require substantially more, and some require less than a typical household. The amount of water a data center uses depends on its size, computing density, and type of cooling system.

Most data centers receive their water from local water utilities, which make withdrawals from Virginia's water sources (rivers, groundwater). DEQ regulates water withdrawals, including requiring permits for large-scale withdrawals, to protect future water availability and environmental sustainability. However, while DEQ is responsible for ensuring water sustainability, there is less oversight over how available water should be shared across various uses in a locality. Virginia as a whole is relatively water rich, but water is more limited for some localities that do not have access to large amounts of surface water and are in groundwater management areas.

Localities have allowed data centers to be built near neighborhoods, but some localities are taking steps to minimize residential impacts

The industrial scale of data centers makes them largely incompatible with residential uses. One-third of data centers are currently located near residential areas, and industry trends make future residential impacts more likely.

Inadequate local planning and zoning have allowed some data centers to be located near residential areas, which sometimes causes impacts on those residents. In some cases, this occurred because local zoning ordinances did not consider data centers to be an industrial use. In addition, some localities have zoned industrial areas next to residential areas, even though land use principles state that industrial uses and residential uses should not be zoned next to each other. Local elected officials have also granted data centers exceptions that led to adverse residential impacts, such as approving rezonings that would allow data centers next to sensitive locations.

In response to increased residential opposition, some localities have taken steps to minimize the residential impacts of data centers. The three Virginia localities with the largest data center markets have taken or are considering changes to zoning ordinances to better manage future data center development, and several localities considering their first data center projects are proactively implementing planning and zoning changes to promote appropriate industry development. The effectiveness of local efforts to minimize residential impacts ultimately depends on the decisions of local elected officials when considering more restrictive zoning ordinances or individual special permit or rezoning requests.

Data center noise near residential areas presents unique challenges, and some localities are unsure about their authority to address it

The constant nature of data center noise has sometimes been a problem when data centers are located near residential areas. Data centers emit low-frequency noise that is not loud enough to damage nearby residents' hearing and rarely loud enough to violate noise ordinances. However, some nearby residents report that the constant noise generated by some data centers affects their well-being. Although noise has been a problem for some data centers, a large majority of data centers do not generate noise complaints because of their location or design.

Localities traditionally use noise ordinances to address noise concerns, but those typically target excessively loud noise from short-term sources, such as parties and barking dogs, and carry a low maximum civil penalty of $500. Noise restrictions for data centers could be more effective if included in zoning ordinances instead, but some localities were uncertain whether they have the authority to establish these restrictions in such ordinances. Zoning ordinances that establish maximum allowable sound levels for both new and existing data centers would allow localities to better account for the low-frequency noise data centers emit, prescribe a better process for measuring potential noise violations, and impose more effective penalties for addressing any violations.

Some data center companies are conducting sound modeling studies *before* building data centers, but not all Virginia localities currently require this, and some were unsure whether they had the authority to do so.

Changes to the state's data center sales tax exemption could address some policy concerns related to the industry

Since 2010, Virginia has offered an exemption to the state's retail sales and use tax to attract large-scale data centers. The exemption allows data centers and their tenants to purchase computers and other equipment, such as servers, network infrastructure, cooling equipment, and generators, without paying sales tax. Because data centers are capital intensive, the exemption is valuable to the industry (providing $928 million in tax savings in FY23), and about 90 percent of the industry uses the exemption. Data center companies report the exemption is an important factor when deciding where to locate and expand, and most of the other states that Virginia competes with for new data center developments have similar exemptions.

Because the data center exemption is a valuable incentive and used by most of the industry, it could be used to incentivize data centers to take actions to address many of the issues discussed throughout this report. There are a range of changes that could be made to the exemption, depending on the General Assembly's policy objectives.

Extend the exemption to maintain industry growth — If the General Assembly wishes to maintain data center industry growth in Virginia and the associated economic and local tax revenue benefits, it could extend the exemption. The exemption is scheduled to expire in 2035, and data center representatives unanimously reported

that expiration of the exemption would negatively affect the state's ability to attract new data centers and keep existing ones. Data center companies typically consider the cost of ownership over a 15- to 20-year period when making location decisions, so to influence future site selection decisions, an extension would need to be in place well before 2035.

Allow the exemption to expire to reduce industry growth and associated energy impacts — If the General Assembly wishes to slow the data center industry's growth in Virginia because it determines that energy impacts, including increasing costs to residential and other customers, outweigh the industry's economic benefits, it could allow the exemption to expire in 2035. While the General Assembly could allow the exemption to expire only in certain regions, like Northern Virginia, that approach would be less effective in reducing overall growth in energy demand because significant growth is occurring in several counties outside of Northern Virginia and is expected to continue.

Change the exemption to balance industry growth and energy impacts — Rather than choosing between economic benefits or reduced energy impacts, the exemption could be changed to try to balance these competing impacts. The General Assembly could allow the full exemption to expire in 2035 (or end it before then) and apply a partial sales tax exemption until 2050. A partial exemption would also better align the economic benefits the state receives with the value of the exemption. Most economic benefits occur during construction, and switching to a partial exemption in 2035 would reduce the value of the exemption in later years when the economic impacts of current and planned data centers could be expected to slow. A partial exemption could also generate more tax revenue for the state.

Use the exemption to address other policy concerns related to the data center industry — If the General Assembly extends the exemption, even as a partial exemption, there are several additional options the General Assembly could implement to address concerns in specific policy areas. The exemption could be modified to address energy, natural resource, historic resource, and residential impacts.

WHAT WE RECOMMEND

This report includes multiple policy options for the General Assembly to consider depending on its policy goals for the data center industry in Virginia. The report also includes several recommendations. The following recommendations include only those highlighted in the report summary. The complete list of recommendations and options is available on page xi.

Legislative action

- Clarify that electric utilities have the authority to delay, but not deny, service to customers when the addition of customer load cannot be supported;

- Direct Dominion Energy to develop a plan for addressing the risk of infrastructure costs being stranded with existing customers, and file that plan with the State Corporation Commission;
- Expressly authorize local governments to require and consider water use estimates for proposed data center developments;
- Expressly authorize local governments to require sound modeling studies for proposed data center developments; and
- Expressly authorize local governments to establish and enforce maximum allowable sound levels for operational data center facilities using alternative low frequency metrics and zoning ordinances.

Executive action

- The Virginia Economic Development Partnership should clarify that grants under the Virginia Business Ready Sites Program can be used for potential data center sites.

Recommendations and Policy Options: Data Centers in Virginia

JLARC staff typically make recommendations to address findings during reviews. Staff also sometimes propose policy options rather than recommendations. The three most common reasons staff propose policy options rather than recommendations are: (1) the action proposed is a policy judgment best made by the General Assembly or other elected officials, (2) the evidence indicates that addressing a report finding is not necessarily required, but doing so could be beneficial, or (3) there are multiple ways in which a report finding could be addressed and there is insufficient evidence of a single best way to address the finding.

Recommendations

RECOMMENDATION 1

The Virginia Economic Development Partnership should clarify in site characterization and development guidelines that potential data center sites are eligible for grants under the Virginia Business Ready Sites Program. (Chapter 2)

RECOMMENDATION 2

The General Assembly may wish to consider amending the Code of Virginia to clarify that electric utilities have the authority to delay, but not deny, service to customers when the addition of customer load cannot be supported by the transmission system or available generation capacity. (Chapter 3)

RECOMMENDATION 3

The General Assembly may wish to consider amending the Code of Virginia to expand the Accelerated Renewable Buyers program, which allows large customers of energy utilities to claim credit for purchases of solar and wind *energy* to offset certain utility charges, to also allow customers to claim partial credit for purchases of *capacity* from battery energy storage systems based on the current PJM electric load carrying capacity rating. (Chapter 3)

RECOMMENDATION 4

The General Assembly may wish to consider amending the Code of Virginia to require that utilities establish a demand response program for large data center customers and to require that these customers participate in the program. (Chapter 3)

RECOMMENDATION 5

The General Assembly may wish to consider amending the Code of Virginia to direct Dominion Energy to develop a plan for addressing the risk of generation and transmission infrastructure costs being stranded with existing customers and file that plan with the State Corporation Commission as part of its biennial rate review filing or as a separate filing. (Chapter 4)

RECOMMENDATION 6

The General Assembly may wish to consider amending the Code of Virginia to expressly authorize local governments to (i) require proposed data center developments to submit water use estimates and (ii) consider water use when making rezoning and special use permit decisions related to data center development. (Chapter 5)

RECOMMENDATION 7

The General Assembly may wish to consider amending the Code of Virginia to expressly authorize local governments to require sound modeling studies for data center development projects prior to project approval. (Chapter 6)

RECOMMENDATION 8

The General Assembly may wish to consider amending the Code of Virginia to expressly authorize local governments to establish and enforce maximum allowable sound levels for data center facilities, including (i) using alternative low frequency noise metrics and (ii) setting noise rules and enforcement mechanisms in their zoning ordinances, separate from existing noise ordinances. (Chapter 6)

Policy Options to Consider

POLICY OPTION 1

The General Assembly could consider amending the Code of Virginia to require that, as a condition of receiving the sales tax exemption, data center companies meet and certify to an energy management standard, such as the International Organization for Standardization's 50001 standard for energy management. (Chapter 3)

POLICY OPTION 2

The General Assembly could consider amending the Code of Virginia to allow electric cooperatives to create for-profit subsidiary companies that could fulfill their legal obligation to provide energy services (retail sales) to customers with load capacity of over 90 MW. (Chapter 4)

POLICY OPTION 3

The General Assembly could consider amending the Code of Virginia to require that electric utilities establish caps on participation in retail choice that protect ratepayers from undue costs, and that such caps be approved by the State Corporation Commission through a formal case process. (Chapter 4)

POLICY OPTION 4

The General Assembly could amend the Code of Virginia to require that, as a condition of receiving the data center sales and use tax exemption, all new data center developments in the Northern Virginia Ozone Nonattainment Area use only Tier 4 generators, Tier 2 generators with selective catalytic reduction systems, or generators with equivalent or lower emission rates. (Chapter 5)

POLICY OPTION 5

The General Assembly could amend the Code of Virginia to require that, as a condition of receiving the sales and use tax exemption, data center companies meet and certify to an environmental management standard, such as the International Organization for Standardization's 14001 standard for Environmental Management Systems. (Chapter 5)

POLICY OPTION 6

The General Assembly could amend the Code of Virginia to require that, as a condition for receiving the sales and use tax exemption, data center companies conduct a Phase I historic resource study of a proposed development site, as well as a viewshed analysis when a proposed site is located within a certain distance of a registered historic site, and report the study findings to the appropriate locality prior to development. (Chapter 5)

POLICY OPTION 7

The General Assembly could amend the Code of Virginia to require that, as a condition for receiving the sales and use tax exemption, data center companies conduct a sound modeling study prior to the development of a proposed data center that is to be located within a certain distance of a residential development or area zoned for residential development and provide the study findings to the appropriate locality. (Chapter 6)

POLICY OPTION 8

The General Assembly could amend the Code of Virginia to extend the expiration date for the state's sales and use tax exemption for data centers from 2035 to 2050. (Chapter 7)

POLICY OPTION 9

The General Assembly could allow the sales and use tax exemption for data centers to expire in 2035. (Chapter 7)

POLICY OPTION 10

The General Assembly could amend the Code of Virginia to extend a partial sales and use tax exemption for data centers from 2035 to 2050. (Chapter 7)

1 Overview of the Data Center Industry

In 2023, the Joint Legislative Audit and Review Commission (JLARC) directed its staff to review the impacts of the data center industry in Virginia. Specifically, staff were directed to assess the impact of the industry on state and local revenue; Virginia's energy demand and supply; natural, historic, and cultural resources; and local residents. Staff were also directed to forecast future growth of the industry in Virginia and determine (i) how any economic benefits could be more widely distributed and (ii) if Virginia's data center tax exemption could be improved. (See Appendix A for the study resolution.)

To complete this study, JLARC staff conducted over 250 interviews with more than 150 different stakeholders, including local residents and stakeholder groups; data center companies and developers; state and local officials; electric and water utility companies; and subject-matter experts. Staff analyzed water usage and air quality and emissions data, as well as capital expenditure, employment, and tax benefit data from users of the data center tax exemption. Staff also reviewed state and local land use regulations and conducted case reviews of local data center-related zoning and permitting requests. (See Appendix B for more information on methods used for this study.)

JLARC staff contracted with two consultants as part of this study. Faculty from the Weldon Cooper Center for Public Service at the University of Virginia (Weldon Cooper Center) developed an economic impact analysis of Virginia's data center industry and an independent energy demand forecast for Virginia and its utilities. Consulting firm Energy + Environmental Economics (E3) modeled how data center growth was likely to affect future generation and transmission needs, carbon emissions, and utility costs, including how costs could be passed on to ratepayers. E3 also made additional refinements to the Weldon Cooper Center energy demand forecast.

Data centers are key hubs of the world's digital infrastructure

Data centers are specialized facilities that manage, process, and share large amounts of data. They enable the digital services that people rely on daily, including websites, electronic applications, and cloud-based platforms such as email and media streaming. These services are also critical to businesses and organizations, for example, allowing businesses to make secure transactions electronically or conduct complex computing tasks using artificial intelligence (AI). Given their essential role in daily life, business, and the economy, data centers have become a critical part of the world's digital infrastructure (sidebar).

Digital infrastructure encompasses the systems and technologies needed for the internet, online services, and other digital activities to function. This includes networks (e.g., fiber, switches), hardware (e.g., computers, servers), software (e.g., operating systems, applications), data centers, and the personnel who manage and maintain these components.

A typical, modern data center is a large industrial building filled with computing equipment, including servers, storage drives, and network hardware. Externally, these buildings often resemble warehouses or distribution centers. Data centers can vary greatly in size, ranging from smaller facilities with a few thousand square feet to large, multi-story buildings exceeding one million square feet. Data centers are often located on campuses alongside other facilities or other data centers operated by the same company. In addition, many data centers have physical security measures, such as floodlights, fencing, and access controls, to protect the facility and its data.

Megawatts are units used to measure power, equivalent to one million watts. Megawatts measure the amount of energy produced or consumed at any instant, rather than total over time. A different unit of measure is used to measure the amount of energy produced or consumed over a given time period. For example, megawatt-hours describe the number of megawatts produced or consumed during an hour.

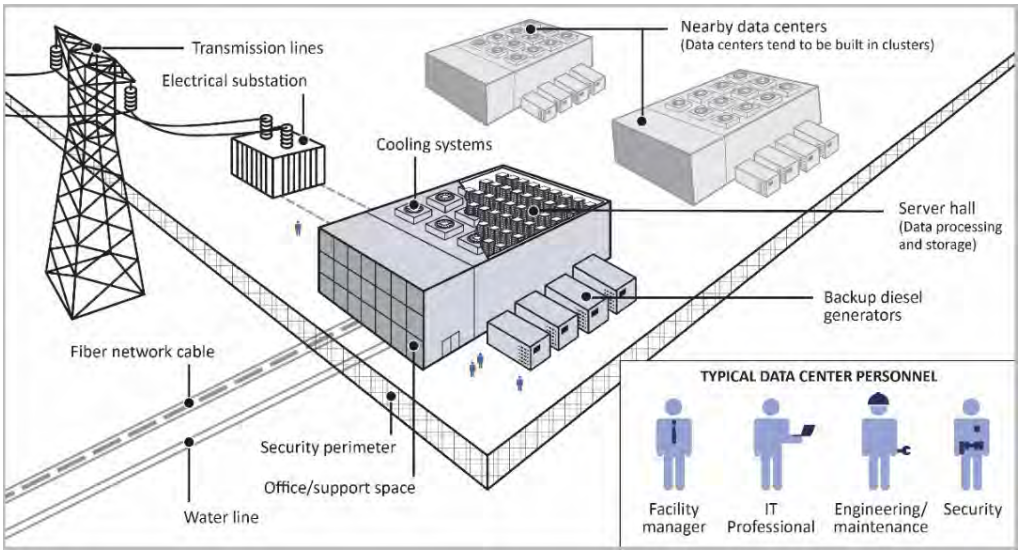
Data centers require large amounts of electricity to operate. This energy powers the computing equipment inside, as well as cooling equipment that prevents the computing equipment and building from overheating. The amount of electricity needed for a data center varies based on its size, the density and type of computing equipment, and the cooling system used. A small data center can require five to 20 megawatts of power, while a larger data center can require 100 or more megawatts (sidebar). Given the amount of electricity needed for operations, data centers often have power lines and substations connecting them directly to nearby high-voltage transmission lines. All data centers also have backup generators on-site to ensure continuity of operations if their primary power supply fails.

For context, **a Virginia town of 10,000 people uses approximately 10 megawatts**.

Data centers are operated and maintained by a skilled workforce, including technicians, electricians, and network engineers. Data centers also generally have security personnel.

Figure 1-1 illustrates the infrastructure, equipment, and personnel found in and around a typical, modern data center.

FIGURE 1-1
Common infrastructure, equipment, and personnel at a typical data center



SOURCE: JLARC staff.
NOTE: Illustrative example. Data centers may have different equipment, e.g., based on their cooling system.

There are various types of data centers, ranging from traditional enterprise and colocation facilities to newer hyperscale operations.

- Enterprise data centers are private facilities owned and operated by a single company, designed specifically to meet that company's IT and data storage needs. These are generally non-technology companies, such as banks, insurance firms, and credit card companies, that rely heavily on secure, in-house data processing and storage. Enterprise data centers are generally located on-site, such as within a corporate campus or integrated into a larger office building. Enterprise data centers are a shrinking segment of the data center market as companies increasingly rely on the cloud for their computing needs.
- Colocation data centers are facilities owned and operated by a company that leases physical space within their data center to other companies and organizations. These tenants, which include smaller technology companies, online retailers, and government agencies, house their computer equipment within their leased space and have their own staff who maintain and upgrade this equipment. Tenants rely on the data center owner to provide all other services such as power, cooling, and physical security. Colocation data centers generally serve multiple tenants—often upwards of 20 or more—which allows these companies to benefit from economies of scale.
- Hyperscale data centers are purpose-built facilities designed to serve the world's major technology companies (e.g., Amazon Web Services [AWS], Google, Meta, Microsoft), often known as "hyperscalers." These are the largest data centers with the largest operational capacity and power requirements (sidebar). Hyperscale data centers can either be owned and operated by the hyperscaler company or by a third-party that leases the facility to the hyperscaler. In some cases, the third party that owns the data center also provides services such as power, cooling, and security, while in others the hyperscaler manages all building operations. Hyperscale data centers are a growing segment of the data center market.

Operational capacity—also called "capacity"—refers to the amount of power a data center needs to operate. This includes all the power needed to run the computing equipment, cooling systems, and other building operations. Capacity is often used to describe the size of a data center. For the purposes of this chapter, capacity is measured in megawatts.

Data center industry is growing rapidly, driven by a combination of established and emerging trends

The data center industry spans markets around the world, clustering in locations that provide access to land, energy, and fiber, and are business friendly, politically stable, and at low risk from natural disasters. Many data center markets are located near key population, business, and government centers because they are close to their customers and end users. Being in proximity to customers reduces the time it takes for data to travel between the data center and the customer, ensuring fast processing, which can be critical for certain business operations, such as financial transactions (sidebar).

The time it takes for data to travel from one point to another, such as from a data center to the end user, is called "**latency**." Low latency indicates data is traveling more quickly; high latency indicates there is a longer delay. Many factors affect latency, most notably the geographic distance between the data center and user. Some tasks—such as financial transactions—are more "latency sensitive" than others, meaning they require as low latency as possible.

It also reduces time for end users to access data, which, for example, reduces buffering times and increases picture quality when streaming media.

The data center industry is dominated by a few large participants. In the U.S., four hyperscaler companies—AWS, Google, Meta, and Microsoft—are responsible for much of the data center industry. These companies operate their own hyperscale data centers, lease other hyperscale data centers, and can also be customers within traditional colocation data centers.

Data center industry is growing rapidly worldwide

The data center industry is growing worldwide, with many data centers under construction or in development. Market reports and trade literature indicate the industry has grown significantly over the past decade, with an especially rapid growth rate in recent years, particularly in the Americas. For example, a 2024 report from the real estate firm Cushman & Wakefield estimates 44,600 megawatts of data center capacity is in development worldwide. More than half (55 percent) of this capacity is in the Americas region, 30 percent is in the Asia–Pacific region, and the remaining 15 percent is in the Europe, Middle East, and Africa (EMEA) region. When completed, this growth would double existing capacity across the EMEA markets and more than double existing capacity in the Americas and Asia–Pacific markets.

The industry is growing both in terms of the number of data centers under construction as well as the size and scale of those data centers. More data centers are being built, and many of the new data centers under construction are larger and have more operational capacity. For example, the capacity of a typical data center has increased from requiring only a few megawatts of power to more than 100 megawatts.

There has also been a recent shift toward companies building data center *campuses,* rather than individual data centers, to serve the needs of hyperscalers. Such campuses can be made up of multiple parcels of land and house several data centers owned by the same entity. Collectively, the operational capacity of these campuses can reach hundreds of megawatts, and in some cases, exceed one gigawatt (i.e., 1,000 megawatts). Companies are increasingly developing data center campuses, rather than individual facilities, to consolidate operations, improve efficiency, and more easily expand capacity in response to growing demand.

Industry expected to grow for foreseeable future, though factors could shift where growth occurs

The data center industry is expected to keep growing, driven by demand for digital services, such as e-commerce, media streaming, and cloud-based applications. This trend accelerated during the COVID-19 pandemic as more people and businesses relied on these services and is expected to continue. As the economy becomes increasingly digitized, more consumers use digital services, and the number of internet-

connected devices rises, the need for data storage, processing, and network capacity will continue to grow.

The recent emergence of AI is another significant driver of data center growth. AI applications, such as machine learning and data analytics, require immense computing power and storage to process large amounts of data. As businesses increasingly adopt AI tools, and AI is integrated into commercial applications, the demand for data centers to support these technologies has surged and is expected to continue to grow.

AI also has the potential to reshape how and where the data center industry grows. For example, some AI workloads, such as large language model training, are not latency sensitive, allowing data centers housing these tasks to be located farther from established data center markets. Additionally, AI workloads are often much larger than typical data center demands, requiring larger facilities with more computing capacity and more power needs (sidebar).

Market constraints could also shift where the industry grows. Key factors, such as power availability, land price and availability, local opposition, and regulatory environments, are constraining the industry, especially in established markets. As these constraints grow, some markets may become less attractive for development, driving data center growth toward other locations.

AI workloads typically require more power than traditional data center tasks because they use more energy-intensive hardware. The servers conducting AI tasks often include graphics processing units (GPUs) alongside central processing units (CPUs), because GPUs are better suited to running large, simultaneous data processes required for AI applications. Since GPUs consume more power than CPUs, AI tasks are generally more energy demanding.

Northern Virginia has the largest data center market in the world, and the state's industry is growing

There are approximately 150 data center sites in Virginia, which collectively house around 340 data center buildings. These sites vary in size, ranging from a single 2,400-square-foot data center building to a campus of seven buildings that total more than 3 million square feet. In total, Virginia has over 63 million square feet of data center space on 7,200 acres of land (sidebar).

Virginia data center sites also vary in size in terms of operational capacity. The smallest sites require only about one megawatt of power, while some larger campuses are estimated to need 200 or more megawatts and are still growing. In total, Virginia data center sites use approximately 5,050 megawatts of power (sidebar). (This is based on the 2024 peak load forecast by Dominion Energy and Mecklenburg, Northern Virginia, and Rappahannock electric cooperatives in August 2023.)

For context, **Pocahontas State Park—the largest in Virginia—covers 7,600 acres.** The entire state park system spans a total of 75,900 acres.

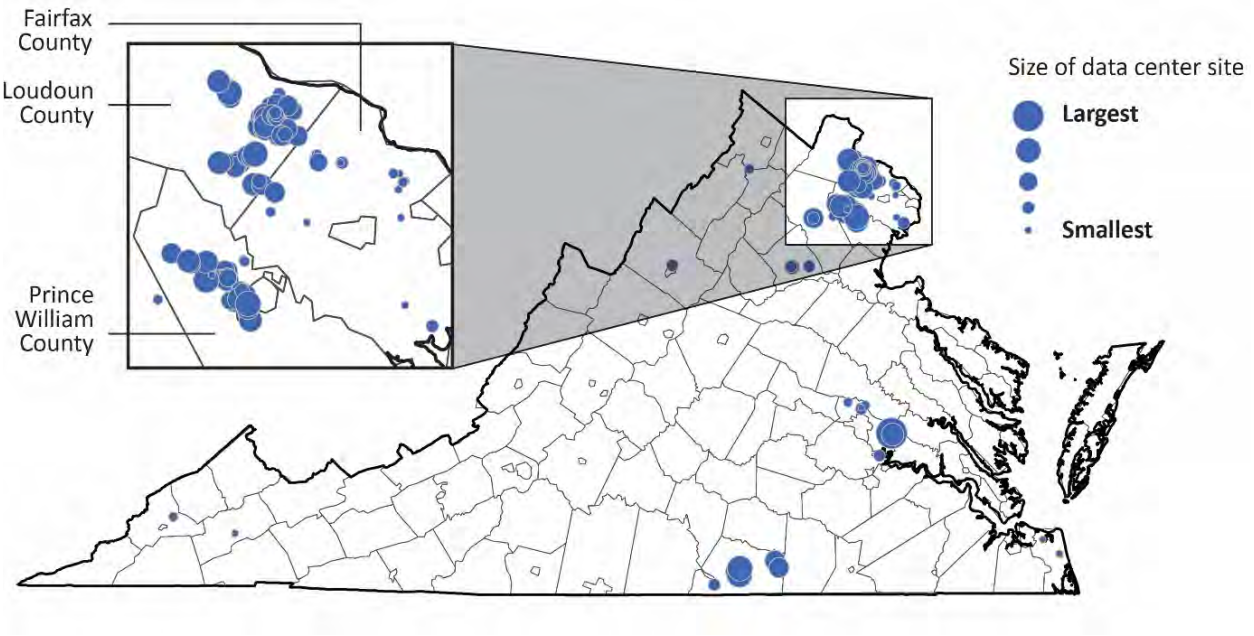
Data centers' power usage in Virginia—about 5,050 megawatts— is roughly **equivalent to the electricity needs of 2 million Virginia households** (about 60 percent of households in the state).

Virginia's data center industry is mostly concentrated in Northern Virginia, with other small clusters near Richmond and Mecklenburg

Data centers are located across the state, but 80 percent of Virginia's data center industry is concentrated in three Northern Virginia localities: Loudoun, Prince William, and Fairfax (Figure 1-2). Loudoun County alone accounts for approximately half of the state's data center industry in terms of number of sites, building square footage, and estimated energy usage. The eastern part of the county north of Dulles

International Airport has become known as "Data Center Alley" because of its high concentration of data centers. The remaining 20 percent of Virginia's data center sites are in 11 other localities, with the most notable clusters in the Richmond region and Mecklenburg County.

FIGURE 1-2
Most of Virginia's data center industry is concentrated in Northern Virginia

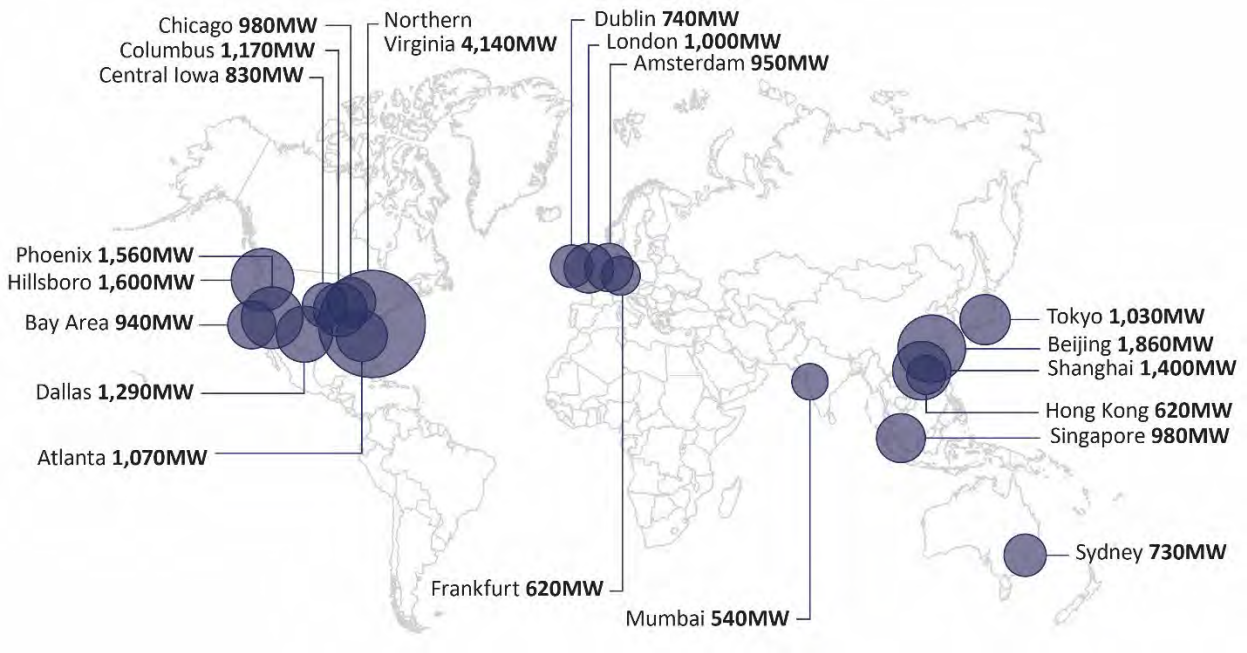


SOURCE: JLARC analysis of Virginia Department of Environmental Quality data and county property real estate records.
NOTE: Map shows one dot per data center site, which may include multiple data center buildings. Size of each site represented by size of dot, as measured by the maximum capacity (in terms of megawatts) the site is permitted to backup via diesel generators. This capacity is larger than the current operational capacity because it (i) accounts for the site's full build-out potential, which many sites have not yet reached, and (ii) includes allowances for redundancy. Data center operators report 0 to 25 percent of backup capacity is typically for redundancy.

Northern Virginia is the largest data center market in the world because of multiple factors

Northern Virginia has the highest concentration of data centers in the world and is recognized as the world's premier data center market. The exact size of the Northern Virginia data center market (in terms of the number of sites and energy demand) varies based on the sources used; however, every source indicates Northern Virginia is the global leader. According to data reported by Cushman & Wakefield, in terms of megawatts, the Northern Virginia market is more than twice the size of the next largest market in the world, Beijing, and nearly three times the size of the next largest market in the U.S., located in and around Hillsboro, Oregon (Figure 1-3). The Northern Virginia market constitutes 13 percent of all reported data center operational capacity globally and 25 percent of capacity in the Americas region.

FIGURE 1-3
Virginia has the most operational capacity of all global markets



SOURCE: JLARC analysis of Cushman & Wakefield 2024 Global Data Center Market Comparison.
NOTE: Reflects market size in terms of operational capacity as measured by megawatts. Shows 20 largest markets. "Northern Virginia" refers to an estimate of data center capacity in the traditional Northern Virginia market consisting of Fairfax, Loudoun, and Prince William counties and Manassas. The Cushman & Wakefield report also includes an estimated 560 megawatts of capacity in Culpeper and Fauquier counties and the Richmond metropolitan region.

Multiple factors have contributed to Northern Virginia's market prominence. The region's role in the early stages of the internet's development gave it a head start as a key data center hub. In the mid-20th century, early data processing companies contracting with government agencies and high-technology government labs were drawn to the region given its proximity to their federal government customers. The establishment of an internet exchange point in the 1990s further attracted major telecommunications and early internet companies to the region.

As the internet grew, a strong fiber network, supply of reliable cheap energy, and available land encouraged more data centers to locate in the region. Data centers were also drawn to the region given its proximity to major national customers, including most notably the federal government, government contractors, and technology firms that held an enormous amount of government and other data. With the rapid growth of the internet in the 2000s, it became advantageous for data centers to cluster near each other so they could share information more quickly. The high concentration of data centers also led to a burgeoning ecosystem of industry professionals, real estate developers, construction companies, and tradespeople with expertise in data centers, which continues to make the region attractive today.

The creation of a state data center tax incentive has also been a key factor in the industry's development in Northern Virginia, as well as the state more broadly. In 2010, Virginia adopted a sales and use tax exemption that exempted data centers from paying retail sales tax on computer and related equipment purchases, and the General Assembly has since expanded the exemption. (See Chapter 2 for more information about the sales and use tax exemption and its impact.)

Data center industry is growing rapidly in Virginia, both in established markets and newer ones

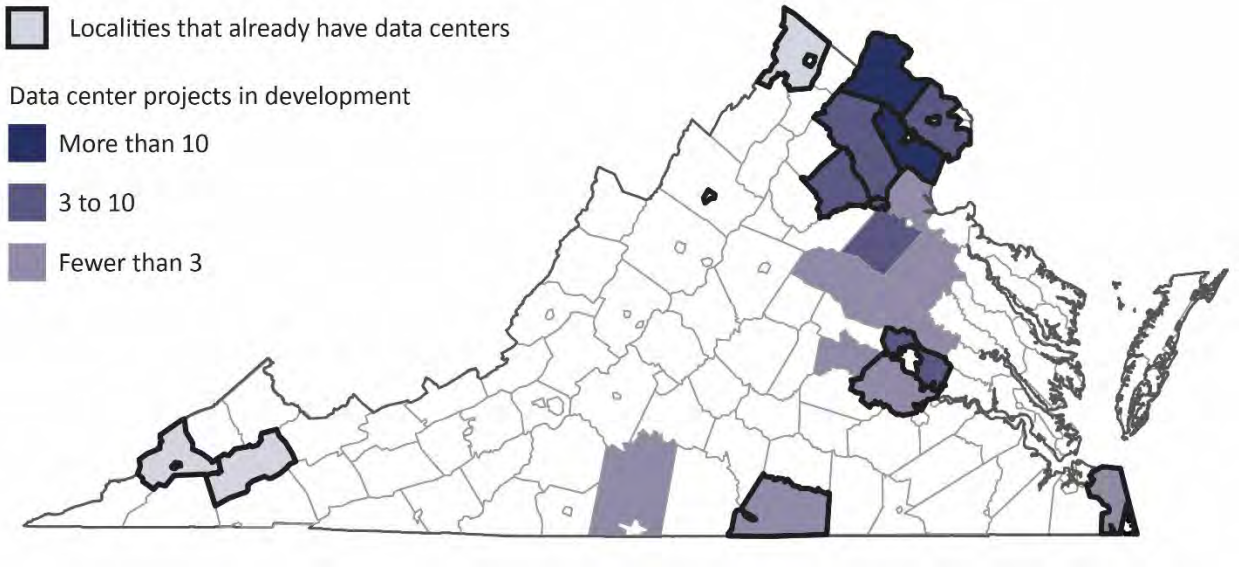
The data center industry is growing rapidly in Virginia. Since 2020, data center *space* in Virginia has more than doubled, with over a quarter of the state's existing data center square footage built in 2022 and 2023. Additional square footage has been built in 2024. A 2024 Cushman & Wakefield report underscores this trend, noting there is a record amount of data center *capacity* in development in the state. This includes 1,500 megawatts under construction and 2,900 megawatts in earlier stages of development. When this development is complete, it will nearly double the size of data center capacity in Virginia.

As of September 2024, there are at least 70 new known data center sites under active development across the state. These projects are at various stages of the development process, with more than half having received full local government approval and/or are under construction. The remaining projects are at earlier stages, such as awaiting local rezoning or approval.

Much of the data center development is occurring in the established markets of Northern Virginia, the Richmond region, and Mecklenburg County. Within these existing markets, the majority of growth continues to be in Loudoun and Prince William counties, with Prince William County being the fastest-growing locality (Figure 1-4). The growth in these markets is driven by data center developers and companies building at new sites as well as expanding existing campuses.

The data center industry is also growing in new Virginia markets, most notably in counties outside of the established Northern Virginia market and along the I-95 corridor (Figure 1-4). For example, seven localities without any data centers have recently approved new campuses or have applications pending. According to stakeholders, data center development is moving into these new markets as land availability and local regulatory environments become more challenging in Northern Virginia. Additionally, AWS is leading development into localities along I-95 as part of its agreement with the state to invest $35 billion in data centers in new Virginia locations by 2040.

FIGURE 1-4
Data center industry still growing in established markets, but development starting to spread into new areas, such as along I-95



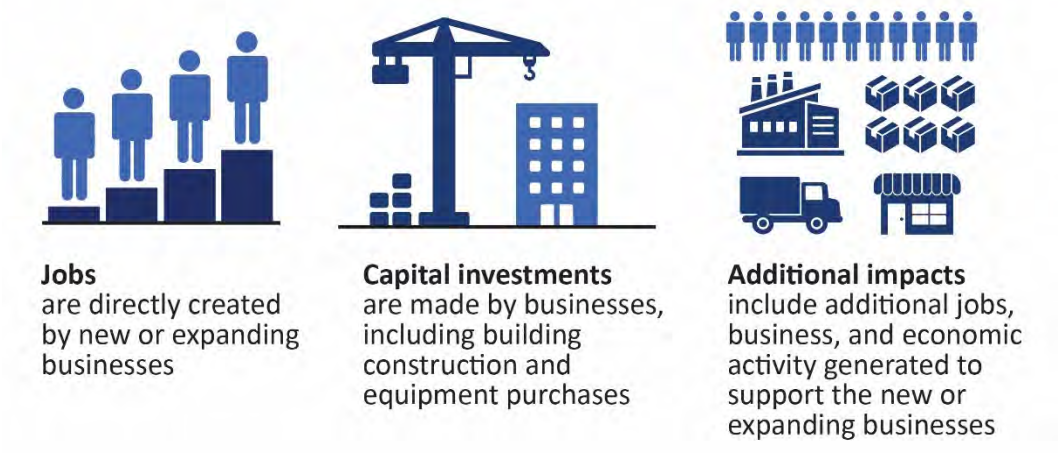
SOURCE: JLARC summary analysis as of September 2024.
NOTE: "In development" includes projects that are under construction, permitted, and/or have been approved through local rezoning or other approval processes (if applicable).

2 Economic and Fiscal Impacts

States strive to build and maintain a strong and diverse economy. A strong economy benefits the state by increasing the wealth of its citizens, helping its businesses succeed, and generating tax revenues to support state and local government operations. Tax revenues help pay for essential services like roads, schools, and public safety.

Virginia looks to improve its economy by attracting new businesses and having existing businesses expand their operations. Businesses benefit the economy directly by creating new jobs and making capital investments, such as constructing new buildings and purchasing vehicles and equipment. Business activities have many additional impacts that further economic growth, such as creating additional jobs at in-state suppliers and in the service industries that support the original business and its employees (Figure 2-1).

FIGURE 2-1
Businesses create jobs and capital investment and have additional impacts that benefit the state economy



SOURCE: JLARC staff analysis.

Data center industry provides positive economic benefits to state

State and local economic development agencies view data centers as an attractive industry. Data center companies are some of the largest and most well-resourced technology companies in the world. Though data centers directly employ relatively fewer employees than some industries, data center jobs tend to be higher paying, so jobs

have a higher economic impact. Data centers also meet other characteristics of a high impact industry: they are in a tradable industry sector and have a high employment multiplier (sidebar). Data centers—like manufacturers, steel producers, and transportation industries—are also capital intensive. Their facilities are enormous and require multibillion-dollar outlays for construction and equipment, which can provide substantial tax revenue for local governments and a comparatively smaller amount of tax revenue for the state (for the portion that is not tax-exempt).

Tradeable sector includes businesses that compete or export goods and services outside of where they are located. They have larger economic impacts because they bring in new revenue from outside the state instead of simply reallocating existing economic activity.

An **employment multiplier** is an estimate of the number of additional jobs created in the economy to support each job created directly by an industry.

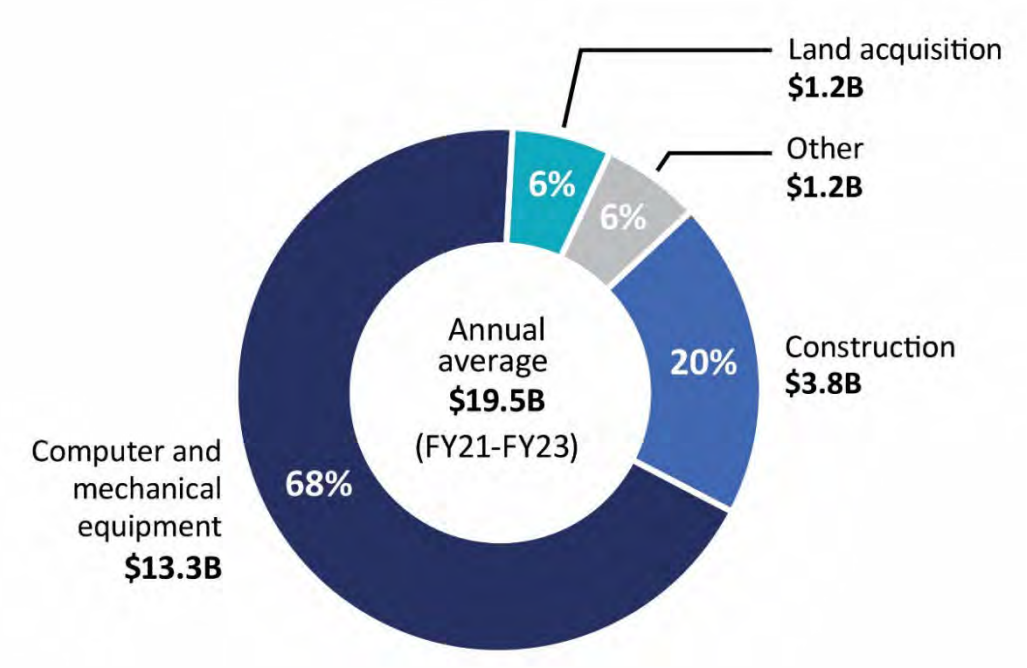
The data center industry provides secondary economic benefits to the state as well. The clustering of data centers in a region, like Northern Virginia, can have "knock on" economic effects by indirectly attracting other related technology businesses, which help create a well-trained, regional IT workforce. This clustering of data centers, related businesses, and skilled workers can further improve the region's attractiveness to additional businesses in the technology sector and other sectors.

Data center capital investment is substantial, although only a portion of it benefits Virginia's economy

Capital investment in Virginia data centers is substantial, exceeding $24 billion in FY23, and primarily consists of equipment purchases from Virginia-based and out-of-state companies. Data center investment represented 84 percent of the total capital investment across all economic development projects announced by the Virginia Economic Development Partnership (VEDP) between FY22 and FY24. However, like capital investments made by other industries, only a portion of data center capital investment benefits the Virginia economy. The primary benefit to Virginia's economy is related to data center construction, which comprises about 20 percent of total data center capital investment (Figure 2-2). Most construction spending likely remains in the state economy because much of it goes to Virginia-based businesses performing key construction services such as clearing and grading sites, erecting steel frames, installing high-voltage electrical equipment, installing industrial-scale cooling systems, and running miles of cable, conduit, and piping. Materials used in data center construction are often also sourced from Virginia businesses throughout the state.

The largest portion of data center capital investment is for IT and mechanical equipment (68 percent), and most of this spending occurs with out-of-state companies. Computer servers are the biggest equipment expense and, because there are no major computer server manufacturers in Virginia, are sourced from outside the state or the country. Some other equipment used in data centers is sourced in Virginia. For example, Virginia has suppliers of electrical and cooling equipment, raised-access floors and hot/cold aisle containment systems, and fiber infrastructure. These suppliers have recently located or expanded operations in Virginia because of the state's large data center market. Even so, a substantial amount of non-computer equipment still likely comes from out-of-state, such as the diesel generators data centers use for backup power.

FIGURE 2-2
Primary benefit of data center capital investment to Virginia's economy is from construction, which comprises 20 percent of data centers' capital investment



SOURCE: JLARC staff and Weldon Cooper Center analysis of data center capital investment between FY21 and FY23 reported to VEDP.

Data center industry supports relatively small operations workforce and sizable construction workforce, both with average or above average wages

Data centers typically employ a small number of workers for data center operations, relative to their facility size. For example, several data center representatives indicated that a typical 250,000-square-foot data center may have approximately 50 full-time workers (one employee per 5,000 square feet versus one employee per 650 square feet for some distribution centers). About half of these workers are likely direct employees of the data center company (or for colocation data centers, direct employees of the tenant). These workers include facility managers, engineers, data technicians, and facility maintenance staff. The other half are contract workers, including electricians, pipefitters, and security personnel who work full-time at the facility (sidebar).

Data center direct employees and contract workers accounted for, by JLARC staff estimates, over 8,000 full-time jobs in FY23. A data center may add new jobs each year as new facilities begin and expand operations. In FY23, data centers added more than 800 new full-time jobs.

Data center construction, however, supports a substantially larger number of workers than data center operations. Construction of an individual data center building usually

Data centers require constant ongoing maintenance of electrical and cooling systems. Data centers have hundreds of electrical and mechanical components that must be replaced as they break down over time. Additionally, these systems can also be upgraded or configurations changed as computer equipment is upgraded and replaced.

takes about 12 to 18 months, and it can take five or more years to fully build out a campus. Data center representatives indicated that, at the height of construction, approximately 1,500 workers are on site building a facility and installing electrical and cooling systems and include occupations such as

- site developers and surveyors,
- equipment operators for land clearing and leveling,
- workers to erect steel building frames and concrete walls,
- electricians installing cabling, equipment, and generators, and
- pipefitters and HVAC technicians installing piping and cooling equipment.

Both data center operations and construction workers earn average or above average wages, contributing to the economic benefit of the industry. On average, data center employees and contractors earn about $100,000 per year, varying based on job role and area of the state. Many construction-related jobs do not require a college degree but are also relatively high-paying. For example, the starting salary for electricians is approximately $24 per hour, and a "journeyman" (fully trained) electrician can make approximately $56 per hour. These wages translate to $50,000 and $116,000 in annual wages, respectively, but the actual annual wages are likely higher because these workers often work over 40 hours per week and can earn overtime pay.

The growth of Virginia's data center industry has contributed to the expansion of the state's trades and construction industry. A representative from a construction supplier and contractor indicated that the data center industry is the largest construction sector right now, and data center projects are about one-third to one-half of their current projects and nearly two-thirds of their backlog. A representative of an electrical workers union in Northern Virginia indicated that, because of demand from the growing data center industry, their apprenticeship program has grown from 300 apprentices per training course to 500 in the last several years and could grow larger. A benefit of this growth is that many workers are able to stay in-state and move to another data center construction job after a project is complete, rather than moving to another state to find work.

Data center industry has added thousands of jobs and several billion dollars to state's economy, mostly from construction

The data center industry benefits the Virginia economy because of the additional jobs and personal income created and the value it adds to the Virginia economy (i.e., Virginia gross domestic product or GDP). JLARC staff commissioned an independent economic impact analysis of the data center industry in Virginia (sidebar). The analysis estimated that the data center industry provides approximately 74,000 jobs, $5.5 billion in labor income, and $9.1 billion in Virginia GDP overall to the state economy annually, based on average spending by the industry between FY21 and FY23 (Table 2-1). These estimates are just over 1 percent of total statewide employment, income, and Virginia GDP during the last three years. Most of the economic benefits have been in

JLARC's independent economic impact analysis was performed by staff from the Weldon Cooper Center. The analysis was conducted using economic modeling software developed by IMPLAN. The model uses an industry standard methodology but does not account for the cost of some potential externalities, such as health and environmental costs associated with increased carbon emissions, that may be associated with the industry's large energy demands. See Appendix D for additional details.

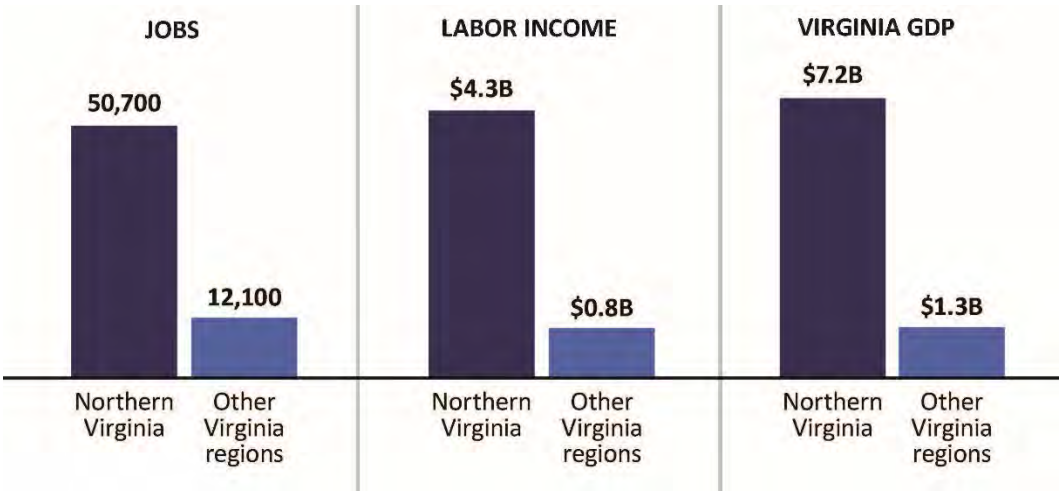
the Northern Virginia region, but other regions where data centers are located or under construction, or that have businesses that otherwise support the industry, also benefited (Figure 2-3).

TABLE 2-1
Data center industry has positive economic benefits on Virginia

	Annual average based on data center capital investment and related operation spending		
Economic impact	**Construction phase**	**Operations phase**	**Total impact**
Jobs	59,000 jobs *(35,000 direct)*	15,000 jobs *(4,400 direct)*	74,000 jobs *(39,400 direct)*
Labor income	$4.3 B *($2.6 B direct)*	$1.2 B *($0.4 B direct)*	$5.5 B *($3.1 B direct)*
Virginia GDP	$6.4 B *($3.3 B direct)*	$2.7 B *($1.1 B direct)*	$9.1 B *($4.4 B direct)*

SOURCE: Weldon Cooper Center economic impact analysis of the data center industry impacts, based on data center spending between FY21 and FY23 reported to VEDP, adjusted to account for non-exempt data centers. Numbers may not sum because of rounding.
NOTE: Direct operations jobs include only data center employees and exclude contractors that work full time at data centers. Total impact includes direct impacts plus indirect and induced impacts. Average data center economic impacts presented here likely underestimate the impacts in more recent years given the growth of the industry.

FIGURE 2-3
Economic impact from data centers is concentrated in Northern Virginia



SOURCE: Weldon Cooper Center economic analysis of the annual data center industry impacts, based on data center spending between FY21 and FY23 reported to VEDP, adjusted to account for non-exempt data centers.
NOTE: Totals for Northern Virginia and other Virginia regions do not sum to statewide totals shown in Table 2-1 because the analysis does not account for impacts from activity in Northern Virginia occurring in other Virginia regions and vice versa.

Much of the data center industry's economic benefits in Virginia derive from capital spending during the construction phase rather than spending during ongoing operations (Table 2-1). Annual average spending during the construction phase is estimated

to be more than three times annual operation spending, according to prior research. Data centers were estimated to contribute 59,000 jobs annually during the construction phase, accounting for 80 percent of total annual jobs resulting from data centers. This estimate includes 35,000 direct jobs, most of which were construction workers (28,000), although some were IT-related workers manufacturing and installing equipment (7,000). Another 24,000 jobs were estimated to be in supporting sectors, such as materials suppliers, and "induced jobs" in businesses that benefit from worker spending, such as restaurants and retail. The data center construction phase also accounted for most of the annual increase in total labor income (80 percent) and total Virginia GDP (70 percent) from data centers. Appendix D provides additional technical details on these and other analysis outcomes.

Because most of data centers' economic benefits are from construction, continued growth of the data center industry would be needed in Virginia to maintain the same level of economic impact. Current trends suggest continued growth is likely to happen, at least for the near future. Virginia's data center market is expected to double in the next few years based on the data center capacity currently under construction and in the early development stages.

Data centers generate substantial local tax revenues for localities that have them

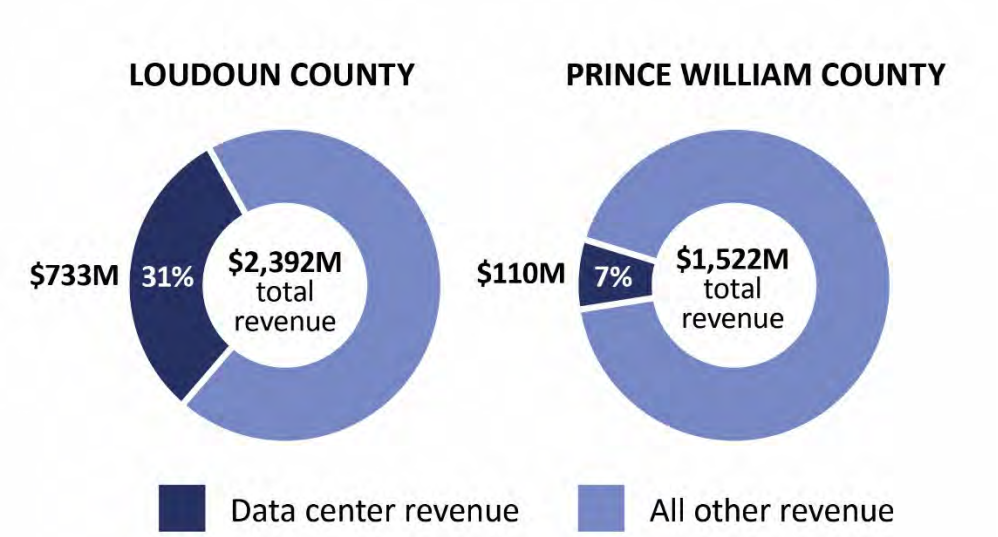
Business personal property taxes are levied by local governments on the value of property, such as furniture, fixtures, computer equipment, machinery, tools, and heavy equipment within their locality. State law allows a locality to tax certain classes of personal property at lower rates, including computer equipment for data processing.

Real property (or real estate) taxes are levied by a local government on land and improvements in their locality.

Local governments with data centers in their jurisdictions can collect substantial tax revenues from the industry. Data centers pay different types of local taxes, but the primary ones are business personal property and real property (real estate) taxes (sidebar). The business property tax, in particular, can generate substantial revenue. A single data center typically has business personal property valued in the millions, a large portion of which is computer equipment that is typically replaced every five years.

Although data center tax revenues can be substantial, the industry's share of local revenue varies. For the five localities with relatively mature data center markets (Loudoun, Prince William, Mecklenburg, Henrico, and Fairfax), data center revenue ranged from less than 1 percent to 31 percent of total local revenue. The amounts collected and percentage of local revenues vary substantially because of differences in the size and maturity of the data center markets, locality sizes and tax bases, and local tax rates and depreciation schedules. Loudoun and Prince William have the largest and most mature markets, and data center revenue accounted for 31 percent and 7 percent, respectively, of total local tax revenue (Figure 2-4). Loudoun collects substantially more revenue from data centers primarily because its data center market size is three times larger than Prince William's. Revenue estimates are not provided for all of these localities to protect taxpayer confidentiality.

FIGURE 2-4
Data center tax revenue can be substantial for local governments (FY23)



SOURCE: JLARC staff analysis of revenue collections from localities and the APA Local Government Comparative Report, FY23.

Tax rates also significantly affect the amount of revenue a locality can generate from data center developments. Some localities have greatly reduced their business personal property tax rates for computer equipment to try to attract the industry and, therefore, collect far less revenue than other localities with a higher tax rate would collect for a comparable project. For example, assuming a data center with $150 million in taxable computer equipment, counties could collect from $10.8 million to $0.4 million over a five-year period (after accounting for different tax rates and depreciation schedules) (Figure 2-5).

Even with the variation in tax revenue collections, local government staff from the five counties with the greatest data center presence indicated that data center revenue has benefited their locality. Local government staff indicated data center revenue has allowed their locality to

- lower real estate tax rates (Loudoun and Prince William),
- develop an affordable housing trust fund (Henrico County),
- establish revenue stabilization or reserve funds (Loudoun and Prince William), and
- construct new schools (Mecklenburg).

FIGURE 2-5
Some localities would collect far less revenue over a five-year period than others for the same data center development



SOURCE: JLARC staff analysis of locality property tax rates and depreciation schedules for computer equipment.
NOTE: Tax rate is the business personal property tax rate in 2024 for computer equipment. Amounts exclude real property taxes. Amounts are based on a data center with $150 million in equipment. Data center equipment is typically replaced every five years, which resets the depreciation schedule used to calculate the decline in value of equipment each year after its purchase.
[a] Culpeper provides a local tax rebate for data centers that invest at least $10 million and hire at least 10 new employees in the Culpeper Technology Zone, and therefore may reduce this amount for qualifying data centers. [b] Fredericksburg Region includes the City of Fredericksburg, Caroline County, King George County, Spotsylvania County, and Stafford County.

In addition to the revenue the industry generates, local government staff reported that data centers are an attractive industry because they impose minimal direct costs on the provision of government services compared with other industries. Data centers employ relatively few employees in comparison with other industries like manufacturing and logistics. Industries with more employees place greater demand on local roads, school systems, and other services.

Localities in distressed areas have difficulty attracting data centers

Data center developments could benefit localities in economically distressed areas of the state through increased local revenue. However, localities in these areas face several challenges in attracting data centers. To be considered, a locality likely needs to have 230kV transmission lines (the preferred voltage for modern data center campuses) and large and flat properties close to those transmission lines. These requirements could prevent many counties in distressed areas, particularly in Southwest Virginia, from being considered.

Localities in economically distressed areas that are away from population centers can also only compete for certain types of data centers. They cannot compete for data centers that need to be close to customers or require low latency, such as cloud computing and colocation facilities. However, they may be able to compete for data centers

running artificial intelligence (AI) workloads, such as training models, which do not need to be near populated areas and may not require low latency. AI is expected to drive a lot of future industry growth and presents an opportunity for more remote localities.

The state could improve the competitiveness of localities in distressed areas by helping them identify, prepare, and market industrial sites that are attractive to the data center industry. Data center companies prefer to move fast once a site has been identified, so available land should have access to roads and other utilities (water, sewer) that allow construction to begin soon after selection. Company representatives said industrial sites that are shovel-ready could be particularly attractive. The primary reason Mecklenburg was successful in attracting Microsoft was because the county had already identified a site suitable for data center development when Microsoft was looking for potential Virginia locations.

The Virginia Business Ready Sites Program, which is administered by VEDP, can be used for this purpose. The program identifies and assesses the readiness of potential industrial sites and provides site characterization and development grants to local governments and regional authorities. The program is intended to develop sites to attract large employers, such as manufacturers, but it can be used to identify and develop sites for which data centers would be a "best use" and would generate a positive return on investment for the state. For example, a 150-acre site that has limited road and rail infrastructure but is located close to 230kV transmission lines might be best used as a data center instead of a manufacturing plant. To help localities in distressed areas compete for data centers, VEDP should clarify that potential data center sites can be included in VEDP's site listings and are eligible for Virginia Business Ready Sites Program grants.

RECOMMENDATION 1

The Virginia Economic Development Partnership should clarify in site characterization and development guidelines that potential data center sites are eligible for grants under the Virginia Business Ready Sites Program.

The state made changes to its data center sales tax exemption, discussed in the next section, several years ago to try to attract data centers to distressed areas of the state (sidebar). However, very few data centers have qualified for the exemption under the changes, so the changes alone may not be sufficient to overcome other challenges to attract data centers to these areas.

The 2020 General Assembly **lowered the eligibility requirements** for the data center exemption in distressed areas of the state to 10 jobs and capital investment of $75 million to encourage growth in these areas.

State's data center exemption encourages industry growth and has moderate economic benefits

Virginia, like other states, uses incentives and other strategies to try to attract specific industries that can create new economic activity. The goal of targeting specific industries is to establish industry clusters or ecosystems.

Since 2010, Virginia has offered a retail sales and use tax exemption to attract large-scale data centers. The exemption allows qualifying data centers and their tenants to purchase computers and other equipment without paying the state sales tax on the following items, namely

- computer equipment such as servers, mainframes, network infrastructure, and data storage hardware; and
- other equipment such as cabling, switches, cooling equipment, generators, monitoring systems, and similar items used to operate exempt equipment.

This report includes higher **estimates of the tax revenue impact of the data center exemption** than was reported in prior years. Data centers using the exemption are now required to report to the Virginia Economic Development Partnership their annual eligible exemption expenditures and tax benefits.

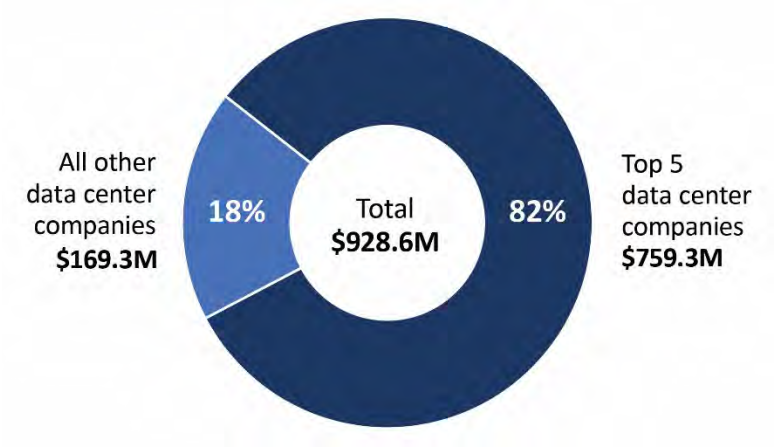
The statewide retail sales and use tax includes a 4.3 percent state share, a 1 percent local option share, and additional 0.7 percent to 1.7 percent regional share, depending on the region. In addition to collecting revenue from the local option, localities tax data center property in other ways, as described in this chapter.

Exemption provides qualifying data center companies with substantial tax reductions

Data center owners and their tenants, which can include a wide range of businesses in sectors like technology, health care, financial institutions, and retail, can claim the data center sales and use tax exemption if they meet eligibility requirements. To qualify, data centers must create a minimum of 50 jobs paying at least 150 percent of the prevailing annual average wage in the locality where the data center is located and make a $150 million capital investment. As noted above, the minimum thresholds are lower for distressed areas. Data centers and tenants reported saving $928.6 million in sales taxes in FY23 because of the exemption, including state, local, and regional portions of the tax (sidebar). The state portion of the exempted amount was an estimated $683 million, making it by far the state's largest economic development incentive, with the next closest incentive valued at $74 million.

Although approximately 30 data center companies (and their tenants, for colocation data centers) claim the exemption, most of the tax savings accrue to a small number of companies (Figure 2-6). Even so, the median savings for a data center company using the exemption was $5.4 million in FY23, and all but six companies saved $1 million or more.

FIGURE 2-6
Most of the tax savings from data center exemption go to only a few data center companies (FY23)



SOURCE: JLARC staff analysis of data center exemption information reported to VEDP.
NOTE: For colocation data centers, the tax savings is attributed to the data center owner rather than the individual tenant, because the data center owner is the "holder" of the MOU and the reporting entity.

Exemption likely affects data center location and expansion decisions

Data center companies consider several factors when determining where to locate, and state sales tax exemptions are regularly ranked among their top factors. The other top site selection factors are access to power, available land, workforce quality, customer needs, business-friendly regulatory climate, and utility and other costs. While it is impossible to precisely determine the exemption's importance in data centers' location decisions, representatives from data center companies indicated the exemption was a key consideration because it greatly reduces their costs.

Data center companies view the exemption as important because their industry is capital intensive, and the exemption provides substantial savings on those investments. If a typical modern 250,000-square-foot data center costs $250 million to $325 million to build and equip, the exemption would provide an initial benefit of about $9 million to $15.5 million in savings (depending on the locality). Companies also save on subsequent equipment purchases, usually made every five years when data centers replace and upgrade their computer equipment. For colocation data centers, the exemption is also important for meeting customer needs, because it provides savings to tenants who purchase their own equipment.

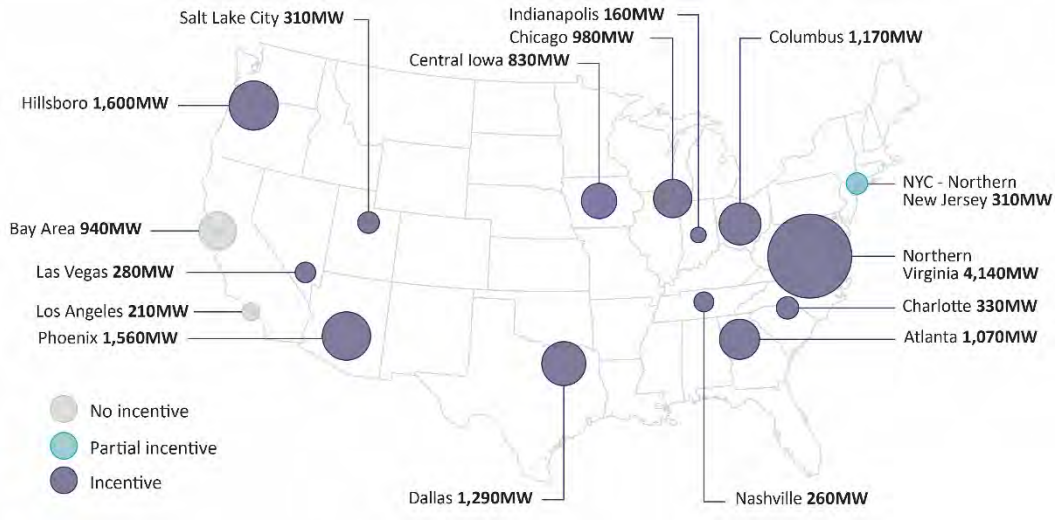
Virginia is competing for data centers with other states that have similar exemptions

Since the late 2000s, states have increased their efforts to attract data centers, primarily by adopting sales tax exemptions. In 2008, Virginia became the seventh state to adopt a sales tax exemption. (The initial exemption applied to very few localities and is no longer in effect, but a statewide exemption was adopted in 2010.) Today, the majority

of states either have a sales tax exemption for data centers (34) or do not have a sales tax (4). All states bordering Virginia provide a sales tax exemption to data centers. (See Appendix E for a map of states with a data center sales tax exemption.)

Virginia competes with other states for new data center developments, especially states that also have primary markets. Most other primary markets are located in states with exemptions, with the exceptions being markets in California and the New Jersey portion of the New York-northern New Jersey market (Figure 2-7). These two markets have a relatively small data center presence considering their proximity to major population centers, the California market's proximity to high tech firms in Silicon Valley, and the New Jersey market's proximity to the U.S. financial center in New York City.

FIGURE 2-7
All primary data center markets in the U.S. have exemptions, except for California and northern New Jersey markets, which are relatively small



SOURCE: JLARC staff analysis of Cushman & Wakefield 2024 Global Data Center Market Comparison.
NOTE: Oregon (Hillsboro market) does not have a sales tax (which has similar effect of the exemption). "Northern Virginia" refers to an estimate of data center capacity in the traditional Northern Virginia market consisting of Fairfax, Loudoun, and Prince William counties and Manassas. The Cushman & Wakefield report also includes an estimated 560 megawatts of capacity in Culpeper and Fauquier counties and the Richmond metropolitan region.

Data center exemption has moderate economic benefits and return in revenue to the state compared with other incentives

The data center exemption has moderate economic benefits and moderate return in revenue to the state compared with Virginia's other economic development incentives. (See *Data Center and Manufacturing Incentives,* JLARC, 2019.) It is rated as moderate because it is similar to the economic benefits and return in revenue for the average incentive (Table 2-2). Like most economic development incentives, the data center exemption does not pay for itself when considering just the state portion of the exemption cost and the state return in revenue.

TABLE 2-2
Data center exemption has moderate benefits compared with other incentives

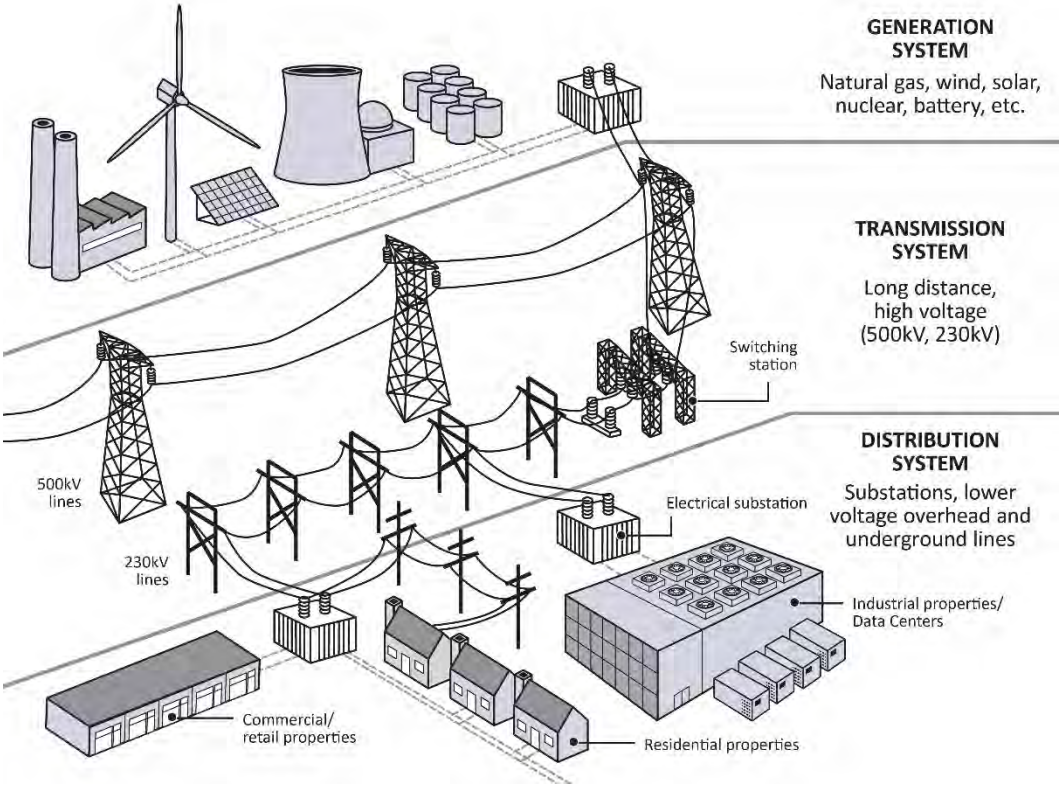
	Annual average	
	Data center exemption	**Average Virginia incentive**
Economic impact per $1 million spent on the exemption		
Jobs added	84 jobs	58 jobs
Income added	$6 M	$5 M
Virginia GDP increase	$10 M	$9 M
Impact on state revenue per $1 spent on the exemption		
Return in revenue per $1 spent	48¢	41¢

SOURCE: *Economic Development Incentives 2024*, JLARC 2024.

3 Energy Impacts

Virginia's power grid is part of the North American Eastern Interconnection, a massive energy infrastructure network that provides electricity to most states and several Canadian provinces east of the Rocky Mountains. The grid comprises three key interconnected systems: generation, transmission, and distribution (Figure 3-1). Power generation in Virginia has historically come from a few large carbon fuel and nuclear plants, but is increasingly coming from renewable sources like solar and wind. The transmission system moves power in bulk over long distances from where it is generated to the area where it is consumed. Power is then reduced to lower voltages and provided to homes, businesses, and other consumers through the distribution system.

FIGURE 3-1
Power grid is a complex network of generation, transmission, and distribution systems

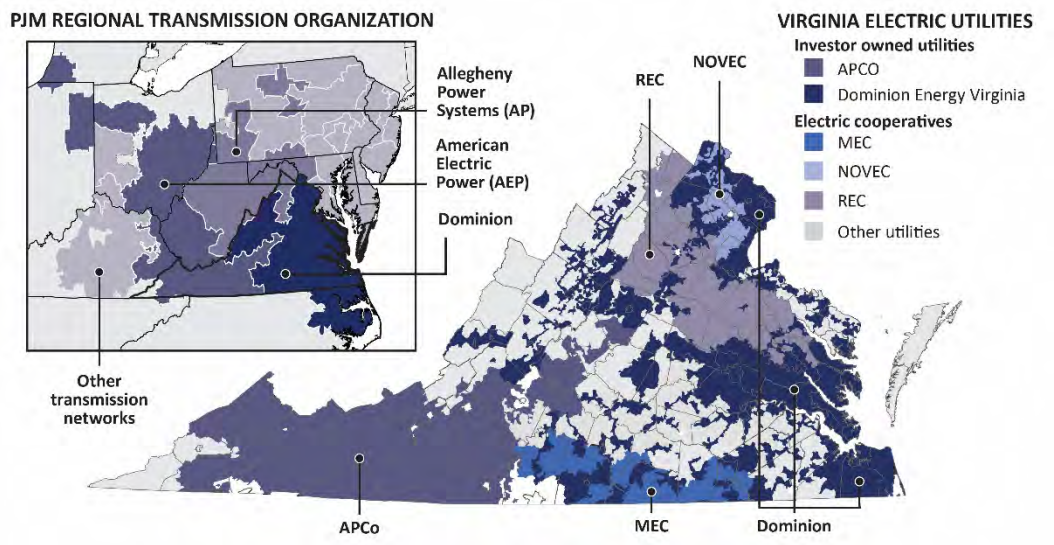


SOURCE: JLARC staff.

Within the eastern power grid, Virginia is part of the PJM regional transmission organization (Figure 3-2). PJM is a not-for-profit organization that coordinates generation and transmission operations and operates as a wholesale power market for its members, including utilities, independent power generators, and other energy companies. Within Virginia's section of PJM, the two main power utilities are Dominion and American Electric Power (AEP), which operate much of the generation and most of the transmission that serve the state. Dominion and AEP (under its subsidiary Appalachian Power Company, or APCO) are also the distribution utilities for much of the state. However, a significant portion of the state is served by 13 distribution cooperatives (the "co-ops"). Most co-ops purchase their power through another generation and transmission utility, the Old Dominion Electric Cooperative (ODEC), which operates or partially owns a few power plants, and contracts for additional power, in and outside of Virginia. The largest distribution co-op, the Northern Virginia Electric Cooperative (NOVEC), purchases its own generation and operates one power plant.

Virginia's power utilities are subject to state and federal laws and are regulated by the State Corporation Commission (SCC) and the Federal Energy Regulatory Commission (FERC). One of SCC's key functions is to approve new generation and transmission projects. See Appendix F for more discussion of generation and transmission projects' potential impacts and how regulators and utilities try to minimize those impacts.

FIGURE 3-2
Virginia is part of PJM and relies on transmission and distribution utilities



SOURCE: PJM and SCC maps.
NOTE: MEC = Mecklenburg Electric Cooperative. REC = Rappahannock Electric Cooperative. Additional cooperatives that are not named above include A&N, BARC, Craig-Botetourt, Community, Central Virginia, Northern Neck, Powell Valley, Prince George, Southside, and Shenandoah Valley. There are also several small municipal power utilities, and the investor-owned Eastern Kentucky Power Company serves a small portion of Southwest Virginia.

Data center industry is driving immense increase in energy demand and will require enormous new infrastructure investments

Modern data centers consume substantially more energy than other types of commercial or industrial operations. For example, one of the smaller data centers recently constructed in Virginia can draw up to 18 MW of power (sidebar). This is roughly equivalent to a mid-sized automobile assembly plant, 60 large commercial office buildings, or 4,500 homes. The largest new data centers can draw from 100 to over 200 MW each, which is more than most industrial consumers. Some planned data center campuses are expected to consume well over 1,000 MW, once fully built out, which is more than the 950 MW generation capacity of the state's largest nuclear reactor.

Data center power demand is typically measured in megawatts (MW). A watt measures the amount of energy produced or consumed at any instant, and a megawatt is equal to 1 million watts. For example, a 100 MW data center can consume up to 100 MW of energy at a given point in time. Energy consumption over time is typically measured in kilowatt-hours (KWh) or megawatt-hours (MWh).

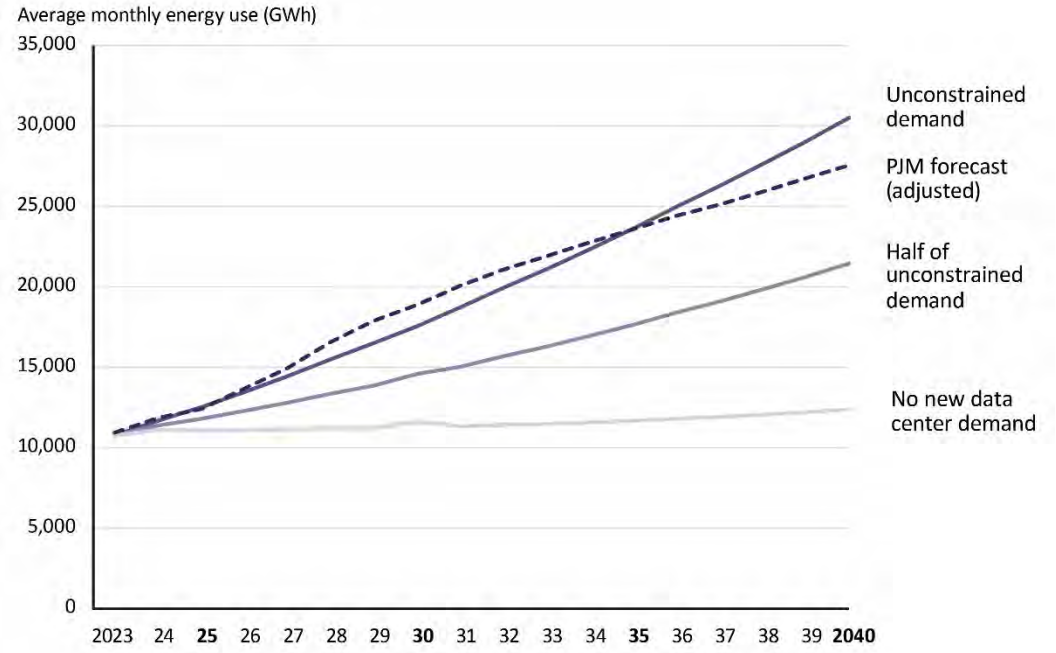
To evaluate the potential energy impacts of the data center industry, JLARC staff commissioned an independent forecast of *unconstrained* power demand growth in Virgina, based on historical data trends. The unconstrained forecast shows what demand would be before accounting for constraints like the ability to build enough energy infrastructure to meet demand. JLARC staff also commissioned an independent grid model to project what future generation and transmission infrastructure would be needed to meet (1) unconstrained demand and (2) half of unconstrained demand. The grid model also estimated infrastructure needs if there was no new data center demand, so that the effects of data center growth could be separated from other effects on the grid. The demand forecast was developed by staff from the Weldon Cooper Center for Public Service at the University of Virginia, and the grid model was developed by energy consultant Energy + Environmental Economics (E3). See Appendix B for additional details.

Data center industry is forecast to drive immense increase in energy demand

The data center industry boom in Virginia has substantially driven up energy demand, and demand is forecast to continue growing for the foreseeable future. The state's energy demand was essentially flat from 2006 to 2020 because, even though the population increased, improvements in energy efficiency offset that increase. However, by 2024, PJM forecast an unprecedented 5.5 percent year-over-year growth in the Dominion transmission zone, mainly because of increasing data center demand.

JLARC's independent forecast shows that unconstrained demand for power in Virginia is expected to double within the next 10 years, driven primarily by the data center industry's growth (Figure 3-3). Almost all of the demand growth is expected to occur in the Dominion transmission zone, which covers the Northern and Central Virginia regions, where most new data centers are being built. JLARC's forecast largely matched the most recent PJM forecast.

FIGURE 3-3
Data center demand would drive immense increase in energy demand in Virginia, based on JLARC's independent forecast and other forecasts



SOURCE: JLARC staff consultant analysis.
NOTE: Forecast is for Virginia. PJM forecast is the 2024 forecast for the Dominion transmission zone adjusted upward to account for APCO; this adjustment had no effect on the trendline shown and was done so that the forecasts could be more easily compared. JLARC's independent forecast was developed using actual, historical energy use and employed advanced statistical methods to project use going forward. While JLARC's forecast was checked against the data reported by utilities on future data center load requests, that data was not used to formulate the forecast.

The first five years of JLARC's unconstrained demand forecast are in line with the new data center load additions that are expected, based on existing utility service and data center construction agreements, data center projects that have been announced, and national energy research conducted by Lawrence Berkeley National Laboratory and the Electric Power Research Institute.

New generation and transmission infrastructure will need to be built to help address data center demand

JLARC's grid model found that a substantial amount of new generation and transmission infrastructure would need to be built in Virginia to meet unconstrained demand, or even half of unconstrained demand, and most of the new infrastructure needs would be attributable to the growing data center industry (Table 3-1). For each of the demand scenarios, the model considered the most feasible and economical approaches to meeting infrastructure needs with and without the requirements of the Virginia Clean Economy Act (VCEA). The modeling was done using industry standard approaches and tools for electric utility and state energy planning purposes. It is based

on current state and federal laws and regulations. Some costs, such as the social cost of carbon, were not explicitly included in the model.

VCEA was enacted in 2020 to drive investment in renewable resources and requires the phaseout of carbon-emitting generation in the state by 2050. (See Appendix G.) VCEA requires that an increasingly larger share of the energy sold by the investor-owned utilities, Dominion and APCO, to their retail customers come from renewable and in-state generation sources. While this results in slightly more generation being built in-state than would otherwise occur, it has little effect on new transmission infrastructure needs and could increase the amount of energy that is imported from out of state. VCEA's effects on renewable and in-state generation are not as pronounced as might be expected because the requirements for utilities to sell energy from these sources do not apply to the co-ops, and a majority of projected data center growth (~60 percent) is expected to occur in co-op service territories. See Appendix H for additional details on generation capacity and energy sources expected under each scenario.

TABLE 3-1
Addressing demand from data centers would require substantial investment in new in-state generation resources and transmission by 2040

			Change from 2025 to 2040			
			Scenario 1: Unconstrained demand		Scenario 2: Half unconstrained demand	
	Current system		No VCEA	VCEA	No VCEA	VCEA
Generation resources (in-state)	36,000 MW capacity	Net increase	+54,100 MW	+56,300 MW	+31,200 MW	+34,700 MW
		Data center share	*+35,600*	*+34,300*	*+12,800*	*+12,700*
Transmission (interzonal)	8,700 MW capacity	Net increase	+3,500 MW	+3,500 MW	+3,100 MW	+3,100 MW
		Data center share	*+3,500*	*+3,500*	*+3,100*	*+3,100*
Imported energy (net)	38 TWh annual energy [a]	Net increase	+62 TWh	+73 TWh	+24 TWh	+24 TWh
		Data center share	*+79*[b]	*+92*[b]	*+41*[b]	*+43*[b]

SOURCE: E3 grid modeling analysis. Current system capacity and energy are derived from Energy Exemplar PLEXOS database.
NOTE: Generation is in-state nameplate capacity that would need to be built, which can be significantly higher than the amount of energy produced by a resource over a year (e.g., Virginia solar facilities produce at around 25 percent of nameplate capacity). The model predicts new generation capacity would still be built even without data center growth, because the grid is expected to shift to cheaper renewable energy sources and construction of more in-state generation to reduce reliance on imports. Transmission shows only current and additional interzonal capacity needed for power exchange between the Dominion transmission zone and neighboring zones. It does not show transmission capacity or additions *within* the Dominion transmission zone.
[a] TWh=terawatt hours. TWh are used to measure large amounts of energy consumed over time. One TWh = 1,000,000 MWh.
[b] Data center share of imported energy is larger than the net increase because, without data center demand, imported energy would decline. For example, under Scenario 1 (no VCEA), energy imports would decrease −17 TWh from 2025 to 2040 without data center demand. +79 TWh data center share −17 TWh = net increase of +62 TWh.

Building enough infrastructure to meet growing data center demand will be difficult under both forecast scenarios

Historically, utilities and other PJM members have kept up with demand by building enough new generation resources and transmission to meet demand. Utilities have been able to do this because demand has increased slowly or been relatively flat over the past several decades, but the expected increase in demand from data centers will far outpace previous energy demand growth. If utilities are unable to build enough new generation and transmission to keep pace with forecast data center demand, there are two likely outcomes: (1) they will delay the retirement of older fossil fuel plants, and less economical plants, to the extent allowed by state and federal law, and (2) they will delay the addition of new large load customers, mainly data centers, until there is adequate transmission and generation capacity to serve them. On the demand side, data centers will seek out markets where demand can be met and pursue ways of contracting for and generating their own power. While it is possible that enough infrastructure could be built to meet growing data center demand in Virginia, it would be difficult to accomplish.

VCEA financially penalizes utilities that do not comply with renewables requirements by levying deficiency payments, but in practice, utilities may choose to pay those deficiency payments if it is more economical or feasible than securing new renewable generation. Statute directs any deficiency payments collected to be used in support of job training, energy efficiency, and renewable energy programs. The costs of deficiency payments are recovered from utility customers.

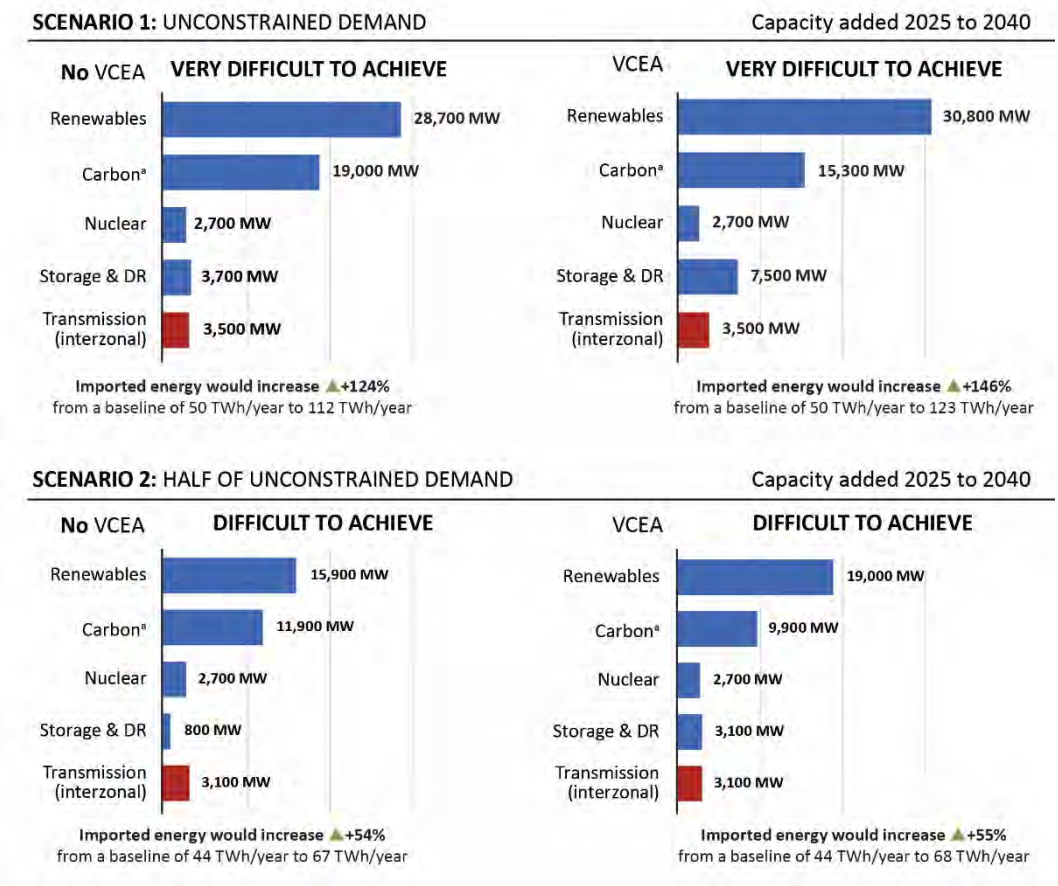
It could be especially challenging to meet demand while also fully meeting VCEA renewable requirements. Dominion's 2024 integrated resource plan indicates that it expects to meet VCEA renewable requirements for most, but not all, years between now and 2040 and expects to pay deficiency payments in some years (sidebar). In addition, in its previous 2023 plan, Dominion indicated it did not expect to meet VCEA requirements to retire carbon emitting assets that take effect in 2045. The previous plan stated: "Due to an increasing load forecast, and the need for dispatchable [i.e., easily scalable] generation, the [modeled planning scenarios] show additional natural gas-fired resources and preservation of existing carbon-emitting units beyond [the 2045] statutory retirement deadlines established in the VCEA." The revised 2024 plan does not comment on this and does not project out past 2040.

Building enough infrastructure to meet *unconstrained* energy demand will be very difficult, with or without meeting VCEA requirements (Scenario 1)

It will be very difficult to build new generation and transmission in Virginia fast enough to match unconstrained demand by 2040 (Scenario 1) and would require a massive and sustained build-out of new renewable, carbon, nuclear, and storage facilities (Figure 3-5). Build rates would have to greatly outpace what has been accomplished historically. Solar facilities would have to be added at about twice the annual rate they were added in 2024, and the amount of new wind generation needed (8,800 MW) would exceed the potential capabilities of all offshore wind sites that have so far been secured for future development (7,400 MW). New natural gas plants would have to be added at a rate of one large 1,500 MW plant almost every year (without meeting

VCEA requirements) or almost every 1.5 years (meeting VCEA requirements) for 15 consecutive years, which would be faster than the rate they were added during the busiest build period of the last decade in the state. Additional pipeline capacity may also need to be added to serve such a substantial increase in natural gas generation, which would create additional challenges. The unconstrained demand scenario would also require building more nuclear generation, presumably using new technologies.

FIGURE 3-4
Estimated generation mix needed to meet demand scenarios, with and without meeting VCEA requirements



SOURCE: E3 grid modeling analysis.
NOTE: The generation and transmission solutions generated by the model are tested to ensure they would produce a reliable system. Generation capacity is given in *nameplate* capacity, which can be significantly higher than the amount of power that can actually be expected after accounting for resource intermittency and downtime (firm capacity). The model predicts only interzonal transmission needed between PJM zones, but additional transmission would need to be built within the Dominion transmission zone. DR is demand response resources, which refer to customers who can reduce energy use during peak load events or add energy back on to the grid. The figure does not show what would need to be built if there were no new data center demand (Scenario 3). Under this scenario, the grid would be able to transition to a more renewable-based system with relatively less difficulty.
[a] Carbon includes natural gas, coal, and oil. Biomass facilities are counted as renewable resources, per the VCEA. However, starting in 2045, E3's grid model assumes natural gas plants would be converted to hydrogen fuel in each scenario when VCEA requirements are met.

To meet transmission needs, the state would have to increase interzonal capacity to the Dominion transmission zone by approximately 40 percent and construct additional transmission within the zone. Many of the new transmission lines would need to be built in densely populated regions of the state with limited options for siting new infrastructure. (Figure 3-4 shows only new interzonal transmission.)

In addition to building new in-state generation and transmission, the state would need to more than double the amount of energy imported from out of state. Consequently, Virginia would be reliant on additional generation being built at a rapid pace in other states in the PJM region and would need these other states to build sufficient generation capacity to serve Virginia's needs as well as their own.

Building enough infrastructure to meet only *half of unconstrained* energy demand will be difficult (Scenario 2)

It would likely still be difficult to build enough new generation and transmission to meet half of unconstrained demand by 2040 (Scenario 2). Meeting demand would also require a sustained build-out of new renewable, carbon, nuclear, and storage facilities. Solar facilities would have to be added at a rate of 650 to 700 MW per year, which is substantial but lower than the 1,000 MW expected to be added in 2024. New nuclear generation would also be needed.

If VCEA requirements are not considered, the biggest challenge would be building new natural gas plants. New gas would need to be added at the rate of about one large 1,500 MW plant every two years for 15 consecutive years, which would be about the same rate Dominion added these types of plants during its busiest period of the last decade (2012 to 2018).

If it is assumed VCEA requirements are met, the biggest challenges would be building enough wind, battery storage, and natural gas "peaker" plants (sidebar). Wind generation needs would exceed the potential capabilities of all secured offshore wind sites in Virginia. The amount of new battery storage needed would be several times the small amount of existing battery storage in Virginia but would be equivalent to what has already been installed in Texas and about half of California's installed capacity. A significant number of new natural gas "peaker" plants would also be needed to help balance intermittent generation from renewables.

Transmission needs would remain substantial under the half of unconstrained demand scenarios, especially in and around the Northern Virginia region, and building enough transmission capacity within a 15-year timeframe could be even more difficult than building enough generation. The amount of energy the state would need to import would increase by over 50 percent.

"Peaker" plants are 50 MW to 150 MW facilities used intermittently to supplement other types of generation when there is not sufficient energy to meet demand. Historically, they have mostly operated at times when cooling and heating needs are the highest among households. However, as more solar and wind generation is incorporated into the grid, they can be used to provide energy when these renewables are not producing (alongside battery storage).

New infrastructure projects face several challenges that make a rapid increase in construction difficult to achieve

Under the most favorable circumstances, it takes five or more years to develop and build new generation facilities, limiting how fast they can be added to the grid. New generation projects face several challenges that could keep them from being built, including community opposition (especially to solar and natural gas projects), long lead times to procure equipment, workforce constraints, and state and federal laws that limit what new carbon-emitting generation facilities can be built. PJM data shows that only a small percentage of projects that submit applications are ever actually built (sidebar).

PJM must study and approve the addition of most new utility-scale generation to the grid. PJM's approval process became overwhelmed by small-scale renewable projects in 2022, which led to a two-year pause in approvals while PJM reformed its process. This pause may have affected the number of projects that have been built in recent years, but project success rates were already low before the pause (29 percent in 2018).

A significant portion of new generation would need to come from solar projects, which could face challenges acquiring enough land. Generally, a solar facility in Virginia needs five to 10 acres to produce one MW of power. Assuming an average need of 7.5 acres per MW, and the scenarios modeled above, JLARC staff estimated that Virginia will have about 57,000 acres of land devoted to utility-scale solar by 2025, and new projects could require from 73,000 to 165,000 additional acres by 2040, depending on the demand scenario. Utilities and independent generators could face significant challenges in acquiring and gaining local approval for this much additional land, given the resistance solar projects have already encountered in some Virginia communities.

Small modular nuclear reactors have been identified as a potential future generation source. However, none have been successfully built in the United States, only a few exist worldwide, and this technology has not yet been proven to be a viable utility generation source. They also have high upfront costs that pose a barrier to their commercial viability, and some communities may oppose them being built nearby. Other promising, emerging technologies that have not yet proven to be commercially viable at a utility scale are hydrogen generation, long duration battery storage, and floating offshore wind.

Utilities also face challenges completing the many major transmission projects that will be needed to connect generation to data center markets, including the numerous new and dispersed renewable generation facilities that are expected to be built. For example, PJM's goal is to have $3.5 billion in Virginia transmission projects that were proposed in December 2023 for Virginia, mostly to serve data center demand, to be in service by June 2027. This 3.5-year timeline is possibly unrealistic considering that major new transmission projects often take five to seven years to complete.

Demand growth raises concerns about system capacity and reliability, but existing utility requirements and processes limit risks

Federal Energy Regulatory Commission (FERC) oversees the nation's electrical grid.

North American Electrical Reliability Corporation (NERC) sets reliability standards for the grid.

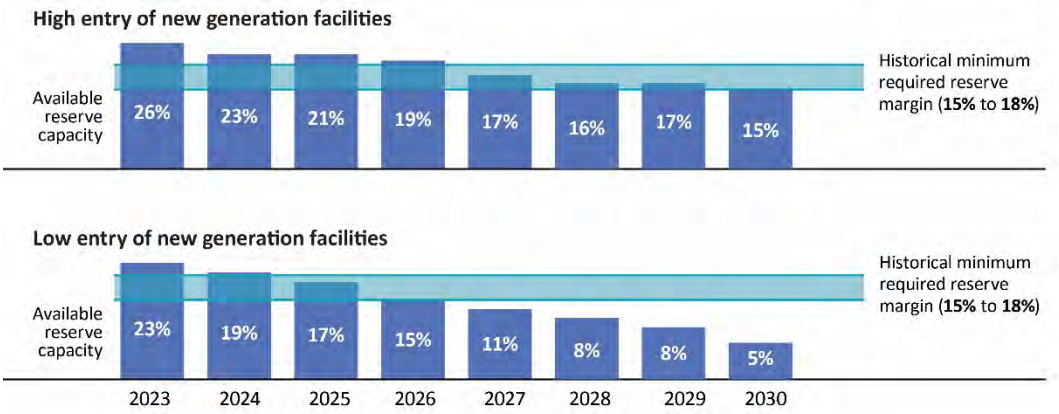
Electrical utilities in Virginia have an obligation to serve any customer within their service territory, but they are not required to provide service immediately upon request. Their foremost responsibility is to ensure the reliability of the power grid before adding any new, large customers like data centers. Federal and international bodies oversee transmission organizations and utilities and set reliability standards that PJM and Virginia utilities must follow (sidebar). The state also sets its own requirements for utilities, which SCC is responsible for enforcing. These requirements and processes are intended to identify future reliability problems and ensure they are resolved before the grid is affected.

Generation capacity concerns are partially addressed through PJM requirements and utility planning processes, but risks remain

PJM protects grid reliability by requiring utilities to secure enough generation capacity to meet the next three years of projected customer demand, plus a reserve margin to account for peak load (i.e., high energy use) events like hot summer days. The regional PJM grid appears to have sufficient generation capacity to meet current demand without causing any system reliability concerns. However, PJM estimates the grid could run out of needed reserve capacity by 2030, even under optimistic assumptions for adding new generation (Figure 3-5). If utilities are not able to secure enough capacity to meet projected demand, they would have to delay adding new load or shed existing load to meet capacity requirements and maintain system reliability.

Although PJM sets minimum capacity requirements for utilities, there is some uncertainty in whether regional generation will be sufficient because it is not centrally planned. PJM does not plan for and identify specific generation projects that are needed (like it does for transmission), cannot direct new generation to be built, does not own or operate any generation sources (like a utility), and cannot stop a utility or independent operator from retiring an existing generation facility (although it can offer "reliability must run" payments to keep a facility open in the short term). Virginia cannot address these structural issues because PJM is federally regulated, not state regulated. PJM is aware of generation capacity concerns and is working to try and address them.

FIGURE 3-5
PJM projects available generating capacity could decline below reserve levels within a few years



SOURCE: JLARC staff analysis of PJM data and reports.
NOTE: PJM's reserve capacity projections were prepared in February 2023, using its 2023 demand forecast. PJM has since revised its demand forecast upward and in August projected a potential 1,663 MW shortfall in total capacity by 2029/2030.

At the state level, utilities protect grid reliability by planning to meet their own generation needs and PJM capacity requirements. Dominion and APCO—Virginia's two investor-owned utilities—are required to develop integrated resource plans that describe how they will meet capacity needs and submit them to SCC as part of a litigated proceeding. SCC holds public hearings to review the plans and gain perspectives from the utility, SCC staff, and other stakeholders, such as environmental groups and business interests. Despite disagreements over utility plans (sidebar), this process ensures the state's largest utilities plan to meet future generation needs and that these plans are scrutinized by regulators and stakeholders. Virginia co-ops also plan for their future generation needs, although the process is not as formal or subject to the same scrutiny. Most co-ops plan to purchase energy for data center customers from the PJM market rather than building generation to serve data center energy needs.

Individual utility planning does not guarantee that the generation resources needed for the whole PJM region will be built, which contributes to uncertainty about the sufficiency of future capacity. Both investor-owned utilities and co-ops plan to fulfill some future share of their energy demand with energy imported from elsewhere in the PJM market and, as discussed above, there is some uncertainty in whether regional generation will be sufficient to meet that demand. Growing demand from the data center industry in other states, such as the growing Chicago and Ohio markets, could limit how much energy is available to be imported by Virginia utilities.

Stakeholders sometimes contest whether the integrated resource plans developed by utilities provide the best generation solutions for meeting future demand, or whether proposals conform to state law. For example, SCC staff recommended that Dominion's most recent 2023 plan be denied over VCEA compliance concerns, and the plan was not approved by the Commission.

Transmission reliability concerns appear to be effectively addressed through existing PJM and utility planning processes

PJM and utility transmission owners centrally identify the impacts large loads are expected to have, and how those loads can be brought on safely without causing transmission reliability problems. At the project level, transmission owners like Dominion are required to study how the addition of a proposed data center (or any other large load) would affect the transmission system. These interconnection studies determine if the existing transmission system is sufficient to handle the load or if upgrades are needed to avoid violations of national reliability standards, such as excessive voltage incidents or outages. At the system level, both PJM and transmission owners must review the expected cumulative impact of demand growth on the transmission system, from proposed data centers and all other sources, and identify needed improvements (sidebar). Utilities cannot add new large loads to the grid, including from data centers, until identified transmission improvements are made. For example, if a new transmission line is needed for proposed data centers in Northern Virginia, utilities cannot add new data center loads until that line is operational.

PJM evaluates the overall transmission system through its annual Regional Transmission Expansion Plan (RTEP). Under the RTEP process, both PJM and transmission owners assess the potential impacts of expected changes in demand and generation to see if and where standards violations or other reliability concerns could occur. They then solicit or propose system improvements, such as new transmission substations and lines, to address identified problems.

Transmission planning processes appear to be working properly to protect reliability. In 2022, Dominion paused adding new data center loads in Loudoun County for three months as it worked to resolve regional transmission constraints. Since then, Dominion has incrementally added new data center loads in Loudoun to ensure new additions do not compromise the reliability of the transmission system. The utility expects the constraints that limit new load additions will not be fully resolved until 2025. Similarly, in July 2024, Dominion sent a letter to customers informing them that future large load additions to any part of the Dominion transmission zone are expected to take 12 to 36 months longer than they have previously taken so that the utility can appropriately plan for and connect the "record pace" of new load requests to the transmission system.

State could clarify that utilities can delay the addition of new, large loads if necessary to protect grid reliability

If utilities are unable to build enough new infrastructure to keep pace with energy demand, one of the main ways they can protect grid reliability is by delaying the addition of new large load customers until there is adequate generation and transmission capacity. Utilities appear to have the authority to delay large load additions for transmission-related concerns because this has already been done without legal objections. It is less clear if utilities are allowed to delay adding new load because of generation concerns. For example, representatives from one co-op utility indicated they did not believe they had the authority to provide less load than requested or delay new load additions for capacity, costs, or other reasons. The state could explicitly give utilities the authority to delay additions of new large loads if it is necessary to maintain grid reliability and avoid exceeding available generation or transmission capacity constraints.

RECOMMENDATION 2
The General Assembly may wish to consider amending the Code of Virginia to clarify that electric utilities have the authority to delay, but not deny, service to customers when the addition of customer load cannot be supported by the transmission system or available generation capacity.

Some stakeholders have asserted that the state should have a process for determining *whether* demand from large load data center customers should be met, not just *how* it should be met. In theory, the state could require evaluation of large load requests and allow requests to be denied through the existing SCC case process. However, this would be a shift in the historical U.S. electric utility paradigm and could be subject to legal challenges.

State could encourage or require data centers to take actions to help address their energy impacts, but actions would have marginal impact on demand

Virginia's growing data center industry is projected to greatly increase energy demand and will require construction of new generation and transmission infrastructure beyond what would have otherwise been built. Although regulators and utilities have requirements and processes in place to manage risks to grid reliability, new infrastructure projects can put VCEA renewable energy goals at risk, affect local communities and natural and historic resources (Appendix F), and affect customers' utility rates (Chapter 4). Data center companies could help address their energy impacts by

- promoting development of renewable energy generation,
- participating in demand response programs, and
- managing energy efficiency.

Many data center companies are already taking some of these steps, and the state could encourage or require further action. Data center companies are also exploring options for generating their own power, but it is unclear if this would address their impacts on the main power grid (Appendix I).

While these actions could have a marginal effect on data centers' energy impacts, they will not substantially reduce their energy demand or the challenges posed by growing demand.

Data centers could adopt more effective strategies for promoting renewable energy, but these would not lower their energy demand

Data center companies—including the four hyperscaler companies that account for a vast majority of the industry in Virginia—have carbon neutral policy goals that encourage investment in new, renewable generation. Some companies also directly invest

in renewable energy projects in the PJM region and the development of new technologies, like small modular nuclear reactors. The scale of industry efforts is not easily quantifiable, so it is uncertain how much these efforts could help offset the industry's growing demand in Virginia.

Virginia's data center industry could be encouraged to further support investment in renewable energy and a reliable, decarbonized grid within the PJM region. The state already partially encourages this through VCEA's Accelerated Renewable Buyers program. Under the program, large customers with loads over 25 MW, which includes most data centers, can get credit for their purchases of renewable wind and solar energy made in the PJM region. Those credits go to offset what a utility charges customers for the utility's renewable generation projects, providing a financial incentive to participate. The program could be expanded to include utility-scale battery energy storage systems. Battery storage is needed because it can store and provide energy during periods when intermittent solar and wind generation is not producing power. Although battery storage systems do not count as net new generation, providing a financial incentive to invest in these resources is beneficial because of their importance in balancing loads from renewables. Any credit for using battery storage should be a partial credit per MW, based on capacity provided rather than energy consumed, and account for electric load carrying capacity (ELCC). ELCC is essentially a measure of the system energy contributions a given type of resource provides, and PJM assigns and regularly revises ELCC ratings. Currently four-hour battery storage has an ELCC rating of 59 percent for 2025/20026, meaning that a partial credit of 59 percent could be allowed for each MW of capacity purchased from battery storage resources.

RECOMMENDATION 3

The General Assembly may wish to consider amending the Code of Virginia to expand the Accelerated Renewable Buyers program, which allows large customers of energy utilities to claim credit for purchases of solar and wind *energy* to offset certain utility charges, to also allow customers to claim partial credit for purchases of *capacity* from battery energy storage systems based on the current PJM electric load carrying capacity rating.

The program could be further expanded in the future to include other renewable or non-carbon energy sources, such as hydrogen generation and small modular reactors. This could help bring more generation resources online to serve growing data center demand but would not reduce energy demand.

Demand response programs could have a more meaningful impact on energy consumption

Under demand response programs, utility customers agree to reduce their power use or send power back to the grid during peak load events. This reduces the need for

additional generation and transmission to meet peak loads, and customers benefit by not getting billed higher peak load energy prices. Demand response programs are an effective way to reduce the need for new generation and transmission. As data centers become an increasingly large share of Virginia's base energy load, their participation in demand response programs could reduce the need for new infrastructure.

Data center companies in Virginia do not currently participate in demand response programs. Company representatives indicated that they have little flexibility to decrease energy use during peak load events because energy use is driven by computing activity, and computing activity is driven by customer and end user demand. From a business perspective, data center companies have strong incentives to keep facilities fully operational to meet their customer and end-user computing needs, and these typically outweigh financial incentives offered by voluntary utility demand response programs.

Despite limitations, there appear to be several viable ways that data center companies could participate in demand response programs. These include options for reducing demand during peak load events and adding energy to the grid during such events to offset a portion of their demand. Companies could

- shift some computing activity to other facilities outside of the region during peak load events,
- make operational adjustments that temporarily reduce energy use within the facility, such as small temperature adjustments for short periods, or
- install more environmentally friendly backup generators that are permitted to operate in non-emergency situations (sidebar), which could range from all generators at a facility to a subset of the generators used, or
- host battery storage systems that could serve as both a general utility and a demand response resource.

JLARC's consultant modeled the energy impact if data centers participated in demand response programs by using battery storage or backup generators to reduce or offset the equivalent of 10 percent of their load in a peak load emergency. The model found data centers could provide 2,000 to 2,400 MW of capacity value to the grid, which would slightly reduce the need for new in-state generation and transmission. A key consideration is that these demand response capabilities would have to be in place before new generation is added to have maximum effect.

Without state direction, most data center companies appear unlikely to participate in demand response programs. The state should not require a specific demand response method because different approaches may be more or less feasible for different companies. Instead, the state could direct utilities to implement a demand response program for large data center customers, such as any customer over 25 MW, and require these customers to participate in the program. This requirement could be phased in

Most data centers backup generation' comes from Tier 2 diesel generators, which cannot and should not be used as a demand response resource because of their emissions (nitrogen oxides, carbon monoxide, and particulate matter). Natural gas and Tier 4 diesel generators have lower emissions and can be used for demand response under state and federal law. Backup generation is discussed more in Chapter 5.

gradually to give companies time to work with utilities on demand response solutions and participation levels (e.g., MW or percentage of load a customer will commit) that are feasible for all parties. The requirement could be initially limited to investor-owned utilities and later expanded to include co-ops.

RECOMMENDATION 4

The General Assembly may wish to consider amending the Code of Virginia to require that utilities establish a demand response program for large data center customers and to require that these customers participate in the program.

Improving data center efficiency makes better use of energy but is likely to have only a marginal impact on demand

Data centers can improve energy efficiency in two primary ways. First, they can use newer and more efficient computer chips; computing activity ultimately drives almost all energy use in a data center. Second, they can improve the efficiency of their building systems, especially the cooling systems that account for most of the remaining energy use.

To promote energy efficiency, the state could encourage data center companies to meet an energy management standard, such as the International Organization for Standardization's (ISO) 50001. ISO 50001 requires organizations to set improvement goals, continually measure and evaluate outcomes, and revise policies to better achieve energy goals. An energy management standard can be fairly applied to all companies regardless of their business model. It is also preferable to requiring green building standards, such as Leadership in Energy and Environmental Design (LEED) building standards. Building standards could be required for new construction but may be unreasonable to retroactively apply to existing facilities.

The state could encourage data centers to adopt an energy management standard by making the state's sales and use tax exemption contingent on adoption. Many data center companies already set energy efficiency goals and policies, and a well-designed state incentive would complement these efforts and encourage other companies to adopt similar goals and policies.

POLICY OPTION 1

The General Assembly could consider amending the Code of Virginia to require that, as a condition of receiving the sales tax exemption, data center companies meet and certify to an energy management standard, such as the International Organization for Standardization's 50001 standard for energy management.

Recent legislation proposed requiring data centers to meet a specific Power Usage Effectiveness (PUE) ratio. The efficiency of cooling and other building systems in data centers is commonly measured using a PUE ratio. However, PUE does not indicate a

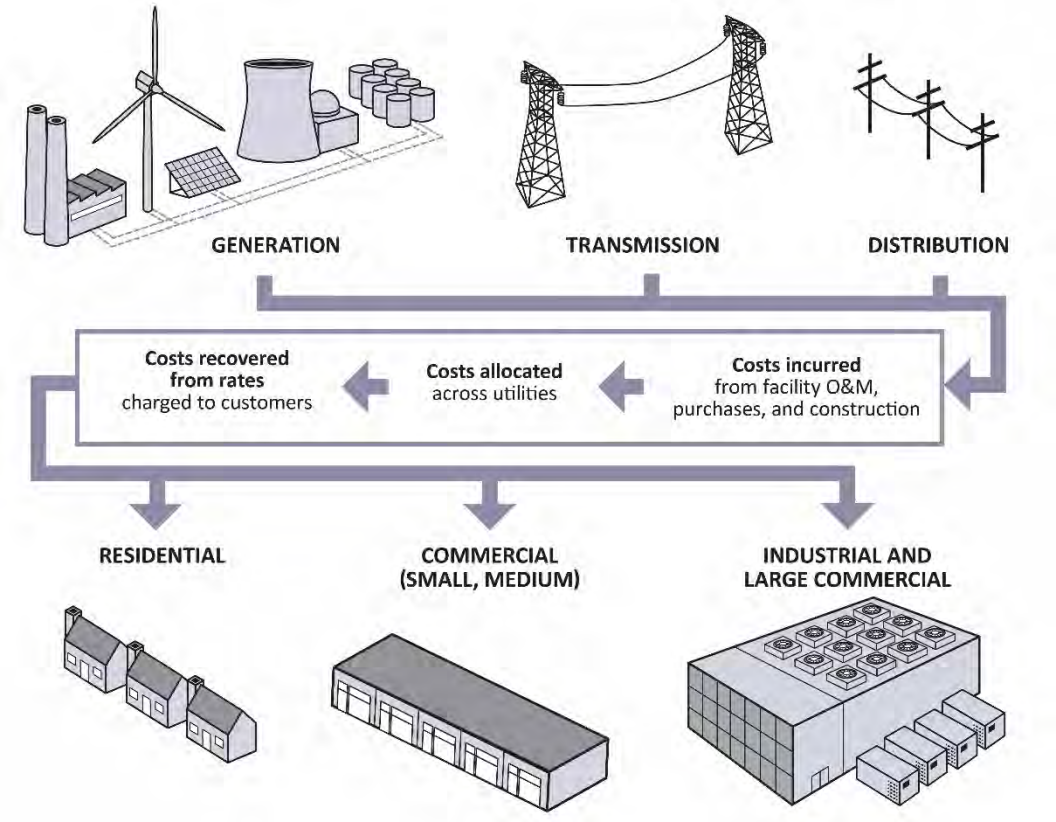
data center's overall energy efficiency; it measures only the efficiency of cooling and other building systems that support facility operations. The data center industry has a strong market incentive to be energy efficient because energy is one of their largest operating costs. Requiring a specific and narrow requirement, like meeting a specific PUE ratio, could have unintended consequences, and could not be as widely applied as the ISO 5001. (See Appendix J for additional information on PUE.)

Energy efficiency in general is an important goal for the data center industry, but efficiency improvements are unlikely to reduce the industry's overall energy demand. Currently, the data center industry is growing fast, demand for energy exceeds the available supply, and companies want to maximize the value of their multimillion-dollar assets. Consequently, any energy saved from efficiency gains is likely to be used to perform more computing activity. One company representative noted "at the end of the day, a 200 MW data center is going to be a 200 MW data center."

4 Energy Costs

Utilities incur costs to build, operate, and maintain the energy grid and provide power to customers. These costs are ultimately recouped through rates charged to customers (Figure 4-1). The main principle underlying utility rates is that the rates charged to different types of customers should recover costs that are approximately equal to the costs of serving those customers.

FIGURE 4-1
Utilities recover costs through rates charged to customers



SOURCE: JLARC staff analysis.

Utilities group their customers into classes of similar users, based on their cost of service. While the exact customer classes vary slightly among utilities, they generally fall into three groupings:

- residential customers,
- small to medium commercial customers, and

- industrial and other large commercial customers.

Within each customer class, customers are charged three categories of rates: generation, transmission, and distribution rates. Each rate is intended to recover costs related to that part of the system. For example, generation rates recover costs associated with operating power plants, constructing new plants, purchasing energy, and securing generation capacity from third parties. Transmission rates recover the cost of building and maintaining transmission lines. Distribution rates recover costs of building and maintaining substations, street-level powerlines, and other infrastructure needed to serve end-use customers. Utility rates sometimes include "riders" or "rate adjustment clauses" specifically intended to capture the cost of new infrastructure (e.g., a generation plant) or a specific initiative (e.g., grid modernization). Some costs can also be directly assigned to customers.

The State Corporation Commission (SCC) regularly reviews and approves utility rates to ensure they are reasonable. For example, SCC reviews Dominion's rates every one to two years, depending on the rate type. SCC reviews consider if a utility is over- or under-collecting costs by customer class and whether any changes are needed to address any allocation issues. In making its determinations, SCC examines cost of service studies and other information presented by the utility and sometimes performs its own independent analysis. SCC's responsibilities are established in state law.

Data centers are currently paying full cost of service

JLARC's cost recovery study was performed by energy consultant E3. See Appendix B for additional details.

JLARC staff commissioned an independent study of utility cost recoveries under current rate structures to see if the data center industry is paying for its current costs (sidebar). The study focused on rates charged by Dominion, the Northern Virginia Electric Cooperative, and the Mecklenburg Electric Cooperative (the co-ops) because most existing data centers are located in their service territories. The study found that current rates appropriately allocate costs to the classes and customers responsible for incurring them, including data center customers. For example, the consultant's independently derived cost allocations for Dominion closely match the ones that the utility uses to set its rates, with only a few small differences for residential and large customer rates (Table 4-1). This finding is corroborated by SCC reviews of utility cost recoveries, especially its biennial reviews of Dominion's rates.

Utilities try to ensure data center customers pay the costs they incur in several ways. Dominion groups data centers into the same class with similar industrial and large commercial customers, charges rates based on energy and system use, and ensures recovery of costs associated with any new distribution infrastructure for data centers through contractually required minimum payments. Co-ops essentially treat data centers as their own customer class, charge rates based on energy and system use, and directly assign distribution costs for data centers to each specific customer. Co-ops take additional steps to separate the energy sources they use for data centers from the sources they use to serve the rest of co-op customers.

TABLE 4-1
Consultant's independent cost allocations closely match allocations Dominion uses to set customer rates

	Generation-related costs		Transmission-related costs	
Customer class	Independent consultant allocation	Dominion allocation	Independent consultant allocation	Dominion allocation
Residential	40%	41%	53%	55%
GS-1 (small non-residential)	5%	5%	5%	5%
GS-2 (intermediate)	14%	14%	12%	12%
GS-3 (large, secondary voltage)	15%	15%	12%	11%
GS-4 (large, primary voltage, includes most data centers)	26%	26%	18%	16%
Total	100%	100%	100%	100%

SOURCE: E3 analysis and Dominion rate schedules. Numbers may not sum because of rounding.
NOTE: GS = General Service. Table does not show churches or outdoor lighting customer classes because <1%.

Growing energy demand from data centers is likely to increase other customers' costs

Utility rates recover the cost of operating and maintaining the current system and any new infrastructure that must be built. Even though current rate structures appropriately allocate costs across customers, data centers' increased demand will likely increase system costs for all customers, including non-data center customers. This is because current utility rate structures are not designed to account for sudden, large cost increases from the construction of new infrastructure to serve a relatively small number of very large customers.

JLARC's consultant modeled the potential cost impacts of data center demand resulting from increased infrastructure needs. The model estimated costs under the two demand growth scenarios from Chapter 3: (1) unconstrained demand and (2) half of unconstrained demand, both with and without VCEA compliance. For this exercise, the model focused on cost and rate impacts in the Dominion transmission zone where most data centers are expected to be located (sidebar).

Dominion transmission zone includes the Northern, Central, and Tidewater regions of Virginia. These regions include Dominion's *distribution* service territory and the *distribution* territories of most of the state's electric cooperatives. See Chapter 3 for a map of the zone.

Generation and transmission costs are expected to increase from growing data center demand and will likely affect non-data center customers

Utility costs are likely to increase from the fixed costs of new infrastructure that will need to be built to address data center demand and the increase in prices as energy supply becomes constrained. Costs for the Dominion transmission zone could increase by an estimated $16 billion to $18 billion by 2040 under the unconstrained demand scenario, depending on if VCEA requirements are met. Costs could increase by $8.5 billion to $10 billion under the half of unconstrained demand scenario. In both

scenarios, most of the projected cost increases are attributable to growing data center demand. Costs do not reflect the full up-front capital costs of building new generation and transmission infrastructure, because these costs are amortized and collected from customers over a period of 20 to 40 years. Instead, they reflect the share of capital costs that would need to be recovered from customers each year, plus operating costs and energy purchases.

Building enough generation and transmission infrastructure to meet data center energy demand would be difficult because it requires constructing enormous amounts of new infrastructure. In addition, unconstrained demand scenarios would require building infrastructure faster than has been historically possible. See Chapter 3 for additional details.

Because generation and transmission costs are passed on to customers based on their actual usage, a substantial share of these costs would be recovered from the growing data center industry. However, a share of cost increases would be borne by other customers in three ways. First, a large amount of new generation and transmission would need to be built that would not otherwise be built, creating fixed costs that utilities would recover over the next several decades. A portion of these costs would be paid by non-data center customers. Second, because it would be difficult to provide enough energy supply to keep pace with growing data center demand, energy prices would increase for all customers (sidebar). Third, if utilities are more reliant on importing power to meet demand, they may not always be able to secure lower-cost power and would be more susceptible to spikes in energy market prices. These higher overall costs are likely to affect all customers, proportional to their energy use.

Distribution cost increases are likely to be assigned mostly to data centers and not other customers

Data center loads are typically so large that they are not served from the regular distribution system and are instead connected directly to transmission lines from a substation that serves one or a few data center customers. Consequently, the main distribution costs that data centers incur are for building and maintaining these substations.

Utility rate structures appear to effectively insulate other customers from paying for distribution costs associated with data centers. Dominion recovers data center distribution costs by charging them its standard industrial and large commercial customer class rates, but it also contractually requires data centers to make minimum payments that fully recover the cost of the distribution substations built to serve them. In addition, Dominion charges data center customers directly for any "surplus" equipment (e.g., redundant connections requested by the customer). Co-ops require data centers to directly pay all costs associated with new substations as they are constructed.

There is one way that growing demand from data centers could indirectly increase distribution costs for other customers. As data center demand grows, some transmission lines could be upgraded to higher voltages to meet demand. For example, an existing 115kV transmission line could be upgraded to a 230kV line. This can require distribution-side upgrades to *all* existing substations connecting to the high voltage line, including those that serve and are paid for by non-data center customers. The cost impacts of potential substation upgrades are uncertain because they cannot easily be modeled across the system.

Residential customers could experience cost increases that current utility and regulatory rate reviews cannot fully address

Utilities recover costs, including any future cost increases, through rates charged to customers. Rates are regularly reviewed by utilities, SCC, and the Federal Energy Regulatory Commission (FERC) to ensure costs are being properly assigned to customers (sidebar). Rate reviews ensure that system costs are being allocated in a way that best reflects which customers are responsible for incurring costs. For example, in 2019, Dominion received FERC approval to revise how transmission costs are allocated to utilities within its transmission zone, which effectively assigned a greater share of costs to large customers and reduced residential transmission costs by about 10 percent. While current rate structures will assign a larger portion of costs to data centers over time, rates are not designed to isolate other customers from cost increases driven by the expected system-transforming increase in data center demand.

Utilities regularly review their rates as required by state and federal laws.

SCC reviews and approves changes to generation, transmission, and distribution rates charged by utilities serving Virginia customers, such as Dominion and the co-ops.

FERC reviews and approves changes to how transmission costs are allocated to PJM and how transmission operators allocate cost to utilities.

Residential rates are likely to increase because of costs associated with growing data center demand

JLARC's consultant modeled how residential rates for Dominion customers might be affected by growing demand, assuming utilities and regulators use current practices to regularly reallocate costs. Dominion was chosen because of its large size and concentration of data centers. Residential rate changes were a key focus because they show how Virginia households could be affected and are indicative of how other customers, such as businesses, might be impacted.

Using the consultant's analysis, JLARC staff estimated that a typical residential customer with monthly consumption of 1,000 kWh could experience generation- and transmission-related costs increasing by an estimated $33 per month by 2040 under the unconstrained demand scenario. Factoring in VCEA requirements would increase monthly costs by four dollars. However, building enough infrastructure to meet unconstrained demand would be very difficult. Under the half of unconstrained demand scenario, which is still difficult to achieve, the total cost is estimated to increase by around $14 per month (Table 4-2), whether or not VCEA compliance is assumed.

The rate changes shown here represent the share of generation and transmission rate increases that could be attributed to growing data center demand. Dominion's total residential bill projections, from its integrated resource plan, show much larger overall increases than the numbers reported here. Dominion's projections apply to the whole residential customer bill and include several costs that are not captured in JLARC's analysis, such as distribution costs and the cost of some additional transmission and generation projects that may not be solely attributable to data centers. Dominion's residential bill projections are also in nominal dollars that have been adjusted upward using an inflation assumption, whereas JLARC's are held in constant

(or real) 2024 dollars to show the real growth of costs that consumers will experience, independent of inflation. Dominion used a demand forecast that is similar to JLARC's unconstrained demand forecast and substantially higher than the half of unconstrained demand forecast.

TABLE 4-2
Generation- and transmission-related costs for residential customers would increase by 2040 because of data center demand (Dominion example)

	Projected increase in generation & transmission charges (not including distribution charges & some transmission costs; 2024 constant dollars)	
	2030	**2040**
Typical monthly residential generation and transmission charges (2023)	**$90**	**$90**
Scenario 1: Unconstrained demand		
- VCEA (very difficult to achieve)	+$23	+$37
- No VCEA (very difficult to achieve)	+$22	+$33
Scenario 2: Half unconstrained demand		
VCEA (difficult to achieve)	+$7	+$14
No VCEA (difficult to achieve)	+$6	+$14

SOURCE: JLARC staff analysis of E3 model results and Dominion 2024 integrated resource plan.
NOTE: Typical monthly residential charges are the sum of the amount billed to Dominion residential customers assuming typical use of 1,000 kWh. Does not include potential increases in distribution and several other charges that customers typically pay for. Does not capture the cost of the many intrazonal transmission projects that would be needed or generation projects that are not attributable to data center demand.

Utilities could help insulate customers from systemwide cost increases with new data center customer class and rate-setting approaches

Historically, adding new customers to the energy grid, even large load customers like manufacturers, has not increased costs for other customers because additions have been gradual, and the existing system has had enough capacity to serve them. However, addressing the needs of the fast-growing data center industry, even if only half of unconstrained demand is met, would require increasing generation capacity by 80-to-90 percent and transmission capacity 36 percent by 2040. Current utility rate structures are not designed to account for sudden, large cost increases from new infrastructure construction to serve a relatively small number of very large customers. New approaches would be needed to isolate residential and other customers from cost increases.

Establishing a separate data center customer class is a first step utilities could take to help insulate residential and other customers from the energy cost impacts of the industry. Utilities already have the authority to create separate rate classes with SCC approval. Creating a separate data center customer class would allow costs to be more closely allocated to data centers and provide utilities with more flexibility over how to charge rates. Co-ops essentially treat data centers as their own customer class already,

so this change would only affect Dominion, which groups data centers with other industrial and large commercial customers. The General Assembly could require Dominion to establish a separate data center customer class, although historically the legislature has not set such detailed requirements in statute.

Establishing a separate data center customer class alone would not fully insulate other customers from cost impacts. Utilities, with SCC approval, would also need to establish new cost allocation methodologies that assign a greater share of generation and transmission fixed costs to the new data center customer class. For example, they could design rate structures that *directly* assign some fixed generation or transmission costs to a new data center customer class, or an increased share of those costs to the new class.

Rates may also need to be adjusted more frequently to insulate other customers from data center-driven costs. Currently, rate adjustments occur only every one to two years and can over or underestimate actual cost growth. For example, under Dominion's current biennial rate review, generation costs are reallocated and rates are adjusted every two years, based on forecast energy demand. While forecasts expect data center demand to increase, accurately forecasting the industry's rapid growth is challenging because of the many factors that can affect demand in a given year. Consequently, new rates may not fully account for shifts in how costs are being incurred across customer classes in the years in between biennial reviews. For example, if the company allocates 55 percent of costs to residential customers, but rapidly growing data center demand results in residential customers only being responsible for 52 percent of costs during the biennium, the costs recovered from residential customers could be higher than the costs they incur. This could also potentially work in the other direction, with residential customers being undercharged if costs are under-allocated based on forecasts.

Utility cost allocation and rate design are complex and highly technical, and the practicality and legality of any changes require detailed analysis to be fully understood. For this reason, utilities and SCC are in the best position to address future cost concerns through cost allocation and rate design changes. SCC is proactively looking into cost concerns from the data center industry and has scheduled a technical conference for December 2024 to explore the effects of the increasing number of data centers and other large-load customers on Virginia's utilities, ratepayers, and power grid. The conference will provide participants an opportunity to identify ways to address the cost concerns noted here and throughout this chapter.

Even if new customer classes and rate-setting methodologies are established, it may not be possible to isolate any customers from the cost impacts of higher energy prices (discussed above). In addition, energy prices in Virginia could still be affected by data center demand even if data center growth is slowed in the state, because industry growth could shift to other states in the PJM region, increasing energy prices throughout the region.

Data center growth creates additional financial risks to utilities and their customers

The growth of the data center industry presents several additional, but so far unrealized, financial risks to utilities and their customers. These risks largely result from the sheer size of the data center industry's energy demand relative to all other customers. These risks exist with the current size of the data center industry and will increase as the industry grows. Utilities have several mechanisms they use to manage financial risks from large data center customers, from planning processes to contracts, but these may not always be sufficient to mitigate the risks posed by the industry.

Data center demand could drive generation and transmission infrastructure to be overbuilt, stranding costs with existing customers

One of the main risks posed by the data center industry's rapid growth is that utilities will build more energy infrastructure than is needed if forecast demand does not materialize as expected, or one or more large data centers close. Overbuilding could strand utilities with infrastructure costs that would have to be recouped from their broader customer base. This would drive up costs for all customers, including residential and other non-data center customers. The overbuilding risk is mostly associated with generation and transmission, not distribution (sidebar). It is also more of a concern for Dominion than the co-ops, because Dominion builds generation to meet all customer needs and is responsible for transmission, whereas co-ops *purchase* most energy for their data center customers and are not directly responsible for transmission.

Distribution could be overbuilt but is less of a risk because most of these costs are fully recovered from data centers directly or through contractual minimum payment requirements.

Generation could be overbuilt if a substantial portion of the expected data center demand does not materialize, or if there is a decrease in that demand overtime. As a result, non-data center customers would pay a larger share of the fixed costs for this new generation. While it does not currently appear likely that supply will exceed demand, there is some risk because much of the data center industry is concentrated in a small number of companies. Therefore, business decisions at one company could have a substantial effect on overall demand. For example, if one of the major hyperscaler companies decided not to pursue development of new artificial intelligence (AI) products or has a line of AI products that fails to be commercially viable, then energy demand from that company could decrease substantially.

On the transmission side, there are three types of transmission lines to consider: (1) "backbone" lines that bring power into a region, (2) regional lines that move power to distribution points within the region, and (3) short extension lines that move power from main lines to serve a single distribution point, including extension lines that might be built to serve one or a few data center customers. Because transmission lines serve specific regions and distribution points, they are more at risk of being overbuilt if regional or individual customer demand does not materialize or decreases over time.

Utilities attempt to avoid overbuilding transmission and otherwise ensure costs are recovered. Dominion indicated it tries to avoid overbuilding by making transmission upgrades only as needed to meet the metered load expected from customers. For example, even if data center customers in an area have requested 2,000 MW of capacity, Dominion will only build new transmission to serve 1,000 MW if that is the forecasted metered load. One co-op utility indicated that it contractually requires data center customers to reimburse the utility for any penalties from transmission providers that may be incurred if a data center project is canceled. However, while utility actions reduce the risk of transmission costs being stranded with other customers, they do not eliminate this risk. For example, transmission costs can take up to several decades to recoup, and if a data center ceases operation before then, or it never uses the amount of energy it expected to, costs will be recovered from other customers.

Utilities could take additional steps to reduce the risk of generation and transmission costs being stranded with customers.

- Utilities could obtain contractual agreements from data centers customers to provide minimum payments that ensure the costs of major generation and transmission buildouts are not stranded with other customers. For example, AEP Ohio has proposed requiring any data center with over 25 MW of capacity to pay for at least 85 percent of the energy they expect to need, even if they use less, for at least 12 years.
- Utilities could directly assign some or all costs of smaller projects, such as transmission line extensions, to the customers or customer class for whom the line is primarily being built to serve. For example, if a two-mile transmission extension is primarily being built to serve a data center development, some or all of the project's costs could be assigned to that customer.

The state should direct Dominion to develop a plan for addressing the risk of generation and transmission infrastructure costs being stranded with existing customers. (Dominion is currently the only transmission-owning utility in the state expected to experience rapid demand growth.) The plan could adopt one or more of the approaches described above, or other approaches the utility identifies as more practical and effective. The plan could be included as part of Dominion's biennial rate review filing with SCC, or as a separate filing.

RECOMMENDATION 5

The General Assembly may wish to consider amending the Code of Virginia to direct Dominion Energy to develop a plan for addressing the risk of generation and transmission infrastructure costs being stranded with existing customers and file that plan with the State Corporation Commission as part of its biennial rate review filing or as a separate filing.

Data centers pose particular cost and financial solvency risks to electric co-ops and their customers

Virginia's electric co-ops are not-for-profit companies that are essentially owned by their member customers. Their main purpose is to provide members with reliable power at low costs. Co-ops are much smaller than the state's investor-owned, for-profit utilities—Dominion and APCO—and do not have the same financial resources or reserves as these companies.

An increasing share of data center growth is expected to occur in co-op service territories, and co-ops are statutorily obligated to serve these customers. Based on the half of unconstrained demand forecast, the industry could account for 80 percent or more of annual energy sales in three Virginia co-ops by 2030. This growth creates unique challenges for the co-ops, which must find ways to insulate themselves and other customers from the cost and financial solvency risks associated with taking on a small number of extremely large data center customers.

The main risk co-ops identified is that a data center could potentially delay, dispute, or fail to pay its energy generation bill. Co-ops purchase energy from PJM energy markets and then sell that energy to their data center customers. A weekly data center energy bill can be extremely large under normal circumstances and can be magnified by price spikes from peak load events. For example, one co-op estimated the weekly energy bill for 4,000 MW of power at data center sites expected to soon be built in its service territory could be $20 million to $40 million and could range upward of $100 million under the energy price spikes that were seen in a major winter storm in 2022. PJM bills weekly, and if one or more data center customers dispute or otherwise do not pay on time, a co-op would have to cover its energy costs until they can be recouped. If the co-op was unable to recoup costs from one or more of its data center customers, the costs would ultimately have to be paid by all other co-op members, and a large enough bill could result in the co-op defaulting and going bankrupt.

Some co-ops said they were sufficiently addressing risks through their contracts with data centers, as allowed under current state law. Namely, these co-ops said the contracts allowed them to:

- perform credit checks when establishing service,
- require more frequent weekly payments for energy use, which aligns with PJM's weekly billing cycle, so they do not have to float co-op funds to pay data center bills,
- require upfront payment of deposits and pledges of collateral based on what the co-op expects it would need to cover unpaid data center bills until further action, such as terminating service, can be taken, and
- terminate service for failure to pay.

Other co-ops said they did not believe that the existing contractual and legal tools available were sufficient to fully cover all potential financial risks, especially considering

data centers could soon account for the vast majority of their energy costs. They noted that current termination of service notification and dispute time periods could allow unpaid bills to continue increasing for several weeks (sidebar). They also said it can be challenging to get data center companies to agree to some contractual terms, such as committing to large collateral obligations designed to cover a large peak load event. These contractual and legal issues could be addressed at the SCC technical conference in December.

State law allows utilities to **terminate service after 10 days** of advance notice. However, customers can dispute billing issues that might lead to service termination, and co-ops indicated that **dispute resolution can take as long as 30 to 60 days**.

One co-op indicated that, even with additional contractual protections, they were still at risk if a data center company failed to meet its contractual obligations, such as if the company itself were unable to provide agreed upon payments. To address this, the co-op attempted to get SCC approval to create for-profit subsidiary companies to serve data center customers. Under this arrangement, if a data center did not pay its bills, only the subsidiary company would be affected, and the business continuity of the co-op would be assured. SCC acknowledged the risks the co-op had identified, but did not grant the request because it did not believe it had the legal authority to allow a co-op to serve customers through a separate for-profit legal entity, among other factors. The General Assembly could amend the Code of Virginia to expressly allow co-ops to create for-profit subsidiaries to serve data centers and other large load customers. The customer size could be set at 90 MW to match the statutory threshold that already exists for the retail choice program (discussed in the next section).

POLICY OPTION 2

The General Assembly could consider amending the Code of Virginia to allow electric cooperatives to create for-profit subsidiary companies that could fulfill their legal obligation to provide energy services (retail sales) to customers with load capacity of over 90 MW.

Data center company participation in retail choice program could shift generation costs to other customers

In Virginia, most customers are obligated to purchase generation through their incumbent utility. For example, a customer in Dominion's service territory must purchase power from Dominion. The one major exception is that large load customers, including most data centers, are allowed to participate in retail choice, which allows them to purchase energy through a provider of their choice (sidebar). The goal of the program is to encourage competition and lower energy prices for industrial and other large commercial customers.

The current retail choice program was established in 2007 when Virginia's energy sector became re-regulated. Under the program, a qualifying customer can enter into an agreement to receive power from a third-party competitive service provider, which can purchase energy from the PJM market or enter into power purchase agreements with independent generators in or outside of Virginia to provide power to the customer.

Customers qualify for retail choice if they (a) exceed 5 MW and account for less than 1 percent of the utility's peak load, or (b) exceed 90 MW. The restriction that a customer cannot account more than 1 percent of the utility's load was intended to prevent customers from leaving the utility for retail choice if it could have negative cost impacts on the utility's remaining customers. The 90 MW exception was reportedly added to allow one particular industrial customer to participate in the program. At that time,

very few customers exceeded the 90 MW threshold. Today, many existing data centers, and virtually all planned future ones, exceed 90 MW and are eligible to participate in retail choice.

Now that data centers make up a substantial and growing share of energy use in the state, retail choice creates two financial risks to utilities and their customers.

- Utilities are required to build or secure enough generation to meet all customer demands. If a customer leaves the utility for retail choice, the fixed cost of any recently built generation is divided among the remaining customers. For example, the costs of constructing Dominion's recent Brunswick and Greensville power stations are paid for by all of its customers. If a substantial portion of data centers leave for retail choice, a greater share of those fixed costs will be allocated to remaining customers. The risk for this potential dynamic will be compounded in upcoming years because a lot of new generation is planned to be built to serve growing data center demand.

- Utilities also indicated that, because they are legally obligated to serve any customer in their territory as a provider of last resort, they must plan for the capacity needs of current and future customers. If utilities plan and build infrastructure to serve future data center customers, and some of those customers at some point leave for retail choice, the utility will incur costs for customers who are no longer actively paying generation bills.

It is difficult to model the cost impacts of data center customers shifting to retail choice, because it is unclear how many might pursue this option. However, utilities report that only a small number of data center customers are currently participating in retail choice, so there is the potential for many more to enter the program, especially as the industry grows. Dominion estimated that if all currently eligible customers chose to participate in retail choice, including non-data center customers, the cost-shift to other customers could exceed $600 million annually (a $150 per year cost impact for a typical residential customer). That figure is likely to grow substantially as data centers make up an increasing share of the customer base.

Before returning to their incumbent utility, **a retail choice customer must provide advance written notice of five years.** However, statute allows the customer to return earlier by seeking an exemption from SCC if its energy supplier "has failed to perform, or has anticipatorily breached its duty to perform, or otherwise is about to fail to perform," and the customer is unable to obtain service at reasonable rates from an alternative supplier.

JLARC staff identified several ways the state could manage the financial risks of retail choice to residential and other customers. The General Assembly could direct utilities to determine an overall cap on retail choice participation for their customers, such as a total amount of the utility's customer load that could be obtained through retail choice and require SCC to review and approve the caps. This would provide an avenue for utilities and customers to present their cases and give SCC authority to decide what is appropriate. Other alternatives to this approach include requiring exit fees for customers leaving for retail choice or directing utilities to continue directly charging them for fixed generation costs (i.e., making these "non-bypassable" charges). In addition, the General Assembly should leave in place the existing legal requirement that any customer participating in retail choice must notify the utility five years before returning (sidebar). Requiring advance notice of at least several years is important so that utilities

can appropriately plan for system needs, secure needed capacity, and protect other customers from rate fluctuations.

POLICY OPTION 3

The General Assembly could consider amending the Code of Virginia to require that electric utilities establish caps on participation in retail choice that protect ratepayers from undue costs, and that such caps be approved by the State Corporation Commission through a formal case process.

Data center companies could soon have access to utility market-based pricing options that largely achieve the same goal as retail choice without shifting costs to other customers. Currently, co-ops already provide all their data center customers with market-based energy prices. Dominion has also established a small market-based rates pilot program and recently filed an application with SCC to make the program permanent and widely available to customers. Market-based rates provide customers with potentially lower energy pricing that is similar to what they could expect to obtain through retail choice, but they remain a utility generation customer and therefore continue to help pay for fixed generation costs (instead of having these costs passed on to other customers).

5 Natural and Historic Resource Impacts

Virginia has abundant natural and historic resources, which provide economic, environmental, cultural, and educational benefits to the state. The value of these resources has long been recognized by the federal, state, and local governments. Governments have established regulatory systems intended to protect these resources and reduce the impacts that land development and other human activity have on them. The extent of natural and historic resource protections varies by resource type, with some regulatory systems providing stronger protection than others (Table 5-1). Natural and historic resource protections apply to data center operations and developments just as they apply to other commercial and industrial operations and developments (sidebar).

Data center energy demand, and its related impacts on Virginia's natural and historic resources, is discussed in Chapter 3 and related appendixes.

TABLE 5-1
Federal, state, and local regulations protect natural and historic resources from commercial and industrial operations and developments, such as data centers

	Regulatory protections			
	Federal	**State**	**Local**	**Brief overview**
Air resources				
Pollutant emissions*	●	●	○	Federal and state governments regulate harmful emissions and concentrations
Water resources				
Water withdrawals*	○	●	○	State sets and enforces water withdrawal limits and conditions
Wastewater discharges*	●	●	○	Federal and state governments regulate harmful discharge contents
Stormwater runoff*	●	●	◑	Federal, state, and some local governments regulate runoff rate and quality
Wetland and stream disturbances*	●	●	◑	Federal, state, and some local governments require impact mitigation
Land resources				
Conservation	◑	◑	◑	All government levels set aside lands for conservation, but few regulations, outside voluntary programs, protect private lands
Electronic waste				
Disposal	◑	◑	◑	No regulations require reuse or recycling, but some disposal limitations exist
Historic resources				
Preservation	◑	◑	◑	Federal, state, and some local governments regulate impacts in specific circumstances

SOURCE: JLARC staff summary of federal, state, and local regulations, staff interviews, reports, and websites.
NOTE: ● = stronger mandatory protections, ◑ = partial mandatory protections, ○ = no mandatory protections. * indicates that permits are required for potentially sizeable impacts. The responsibility or authority for a given government level to regulate impacts varies by resource.

Data center backup generators emit pollutants, but their use is minimal, and existing regulations largely curb adverse impacts

To ensure constant operations in the event of a power outage, data centers maintain on-site backup power. Data centers report that providing uninterrupted operations is extremely important to their customers, which can include banks and hospitals, who expect no outages or downtime. In Virginia, nearly all data centers use diesel generators for backup power (Figure 5-1). On average, each data center site has 54 permitted generators, but the number and electrical capacity of these generators vary widely depending on the number of data center buildings at a site, overall power and redundancy needs, and the sizes of generators used (typically one to three megawatts per unit). In total, the industry has approximately 8,000 permitted generators throughout the state.

FIGURE 5-1
Data centers rely on diesel generators for power in the event of an outage



SOURCE: JLARC photo of diesel generators at a data center in Virginia.

Diesel generators emit several harmful pollutants, so their commercial use is regulated by state and federal agencies. The main emissions are nitrogen oxides, carbon monoxide, and particulate matter. When highly concentrated in the air, these emissions can have adverse effects on public health and the environment. Exposure to high concentrations of diesel generator emissions can affect human cardiovascular, respiratory, and central nervous systems. Nitrogen oxides, which diesel generators emit in much larger quantities than other pollutants, can contribute to ground-level ozone pollution (including smog) and acid rain.

To prevent harmful concentrations, Virginia's Department of Environmental Quality (DEQ) is required by federal and state law to regulate sizeable emissions of these pollutants and enforce National Ambient Air Quality Standards (sidebar). DEQ requires

The federal Clean Air Act requires the U.S. Environmental Protection Agency to set **National Ambient Air Quality Standards**. These standards identify safe concentration thresholds for six pollutants—including ozone (which nitrogen oxides may form), carbon monoxide, and particulate matter—based on scientific evidence.

diesel generators used by data centers to be permitted, primarily because of their nitrogen oxides emissions (sidebar). Moreover, DEQ monitors air quality and creates plans to maintain or attain National Ambient Air Quality Standards across the state. For instance, Northern Virginia has historically struggled to meet the standard for ozone, to which nitrogen oxides can contribute, so DEQ has stricter policies for nitrogen oxides emissions in that region.

DEQ permits are required for any new development that may annually emit over 40 tons of nitrogen oxides, 100 tons of carbon monoxide, or 10–25 tons of particulate matter, depending on the particulate matter size. Data centers using diesel generators usually meet the criterion for nitrogen oxides, but not for the other pollutants.

Data center backup generators are rarely run for prolonged periods, and emissions are unlikely to adversely affect regional air quality

Data center operators aim to have backup generator capacity for days-long outages, but in practice, the generators are rarely run for prolonged periods. Most operators reported experiencing zero to two minor outages per site in the last two years, with nearly all outages being between one and five hours long. Otherwise, generators are typically run only for limited amounts of time as part of routine maintenance (sidebar). For example, in 2023, the industry's actual emissions were only 7 percent of what permits allowed, with most emissions coming from maintenance testing.

Data center operators indicated that **maintenance testing** typically involves a short (10–30 minute) monthly test and one long (one- to four-hour) annual test. Testing of generators is staggered across a site on an individual or group basis.

On a regional level, data center emissions from diesel generators have grown substantially in recent years, but they remain a relatively small contributor to regional air pollution. Since 2015, nitrogen oxides emissions from data center diesel generators have more than doubled, carbon monoxide emissions have tripled, and particulate matter emissions are five times larger. However, these emissions make up a small part of overall emissions in the region. Based on National Emissions Inventory data, in Northern Virginia, where most data centers are concentrated, data center emissions make up less than 4 percent of regional nitrogen oxides emissions and 0.1 percent or less of regional carbon monoxide and particulate matter emissions. Overall, air quality in Northern Virginia has improved during the same time that the industry has grown, as reductions in car and other emissions have been greater than data center emission growth.

While emissions from data centers' diesel generators make up a small part of *regional* emissions, understanding whether they have adverse *local* impacts is more difficult. Because the data center industry's large clusters of diesel generators are unique, local air quality impacts are harder to assess. Diesel generators' intermittent use makes their impacts difficult to model, and no other type of development uses nearly as many generators on one site as a data center development. Additionally, air quality monitoring occurs regionally and does not effectively capture localized effects. While DEQ staff believe that data centers' intermittent use and low emissions levels are unlikely to cause adverse impacts, the agency has recently launched a three-year study that will directly monitor data center generator emissions in Northern Virginia to more fully understand their air quality impacts. If the study detects any local air quality impacts, DEQ has the authority to increase protections as needed.

Federal and state regulations limit potential emissions from backup generators, even under worst-case scenarios

The U.S. Environmental Protection Agency has established **generator tiers** based on emission rates, or the amount of a pollutant emitted by a source over a given amount of time. Data centers could use generators that are considered Tier 2 or Tier 4.

DEQ permits limit when data center generators can be run, how long they can be run, and the maximum annual emissions each permitted site is allowed. Nearly all current data centers use "Tier 2" diesel generators, which are only permitted to run in emergencies or as part of routine maintenance testing (sidebar). This restriction prevents data centers from running their generators for any other reason. Permits are issued per data center site, rather than per building or generator, and cap the total emissions allowed per site. For example, a data center campus would not be allowed to run its generators indefinitely, even in an emergency, because it would likely reach its emissions limits within a few days. Because outages are rare, data centers do not often approach their emission limits. (For information on data center generator fuel choice, see Appendix K.)

In the event of a prolonged outage that affects one or more Northern Virginia counties, any affected data centers could reach their emission maximum within a few days and potentially affect regional air quality. For example, under a worst-case scenario where all data centers in Northern Virginia reach their maximum allowed emissions, data centers would emit over 9,000 tons of nitrogen oxides in the region. That is equal to about half of what has typically been emitted annually in Northern Virginia by all sources. Such a large-scale outage could potentially result in violation of air quality standards and contribute to regional air quality issues. However, the extent of any impact would depend on weather patterns and contributions from other emissions. Such large-scale outages are rare, and air quality levels would return to normal after the event is over.

General Assembly could incentivize use of generators with lower emission rates to reduce risk of local and regional impacts during prolonged power outages

To reduce the risk of air quality impacts from data centers during a prolonged outage, the state could incentivize the industry to adopt technologies that reduce potentially harmful emissions. "Tier 4" diesel generators are designed to emit significantly less nitrogen oxides and particulate matter than the "Tier 2" generators most data centers use. Alternatively, Tier 2 generators can be equipped with selective catalytic reduction systems (SCRs). Both technologies can significantly reduce emissions of nitrogen oxides and particulate matter—reportedly by up to 90 percent—over long run times. Some newer data centers in Virginia use SCRs on their generators, and only one uses Tier 4 generators.

Without state incentives, data center companies are unlikely to change their backup power choices. Tier 4 generators and SCRs are more costly, and data center companies have expressed concerns about the extra complexity and the current availability of Tier 4 generators to meet campuswide and statewide backup power needs. The state

could encourage adoption of these technologies by requiring new data centers in the Northern Virginia Ozone Nonattainment Area to use Tier 4 or SCR-equipped Tier 2 generators to be eligible for the state's sales and use tax exemption (sidebar). This requirement could be phased in over time to account for data centers that have already ordered generators or otherwise made investments that would not comply with this requirement.

The Northern Virginia Ozone Nonattainment Area includes Arlington, Fairfax, Loudoun, and Prince William counties and the cities of Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park.

POLICY OPTION 4

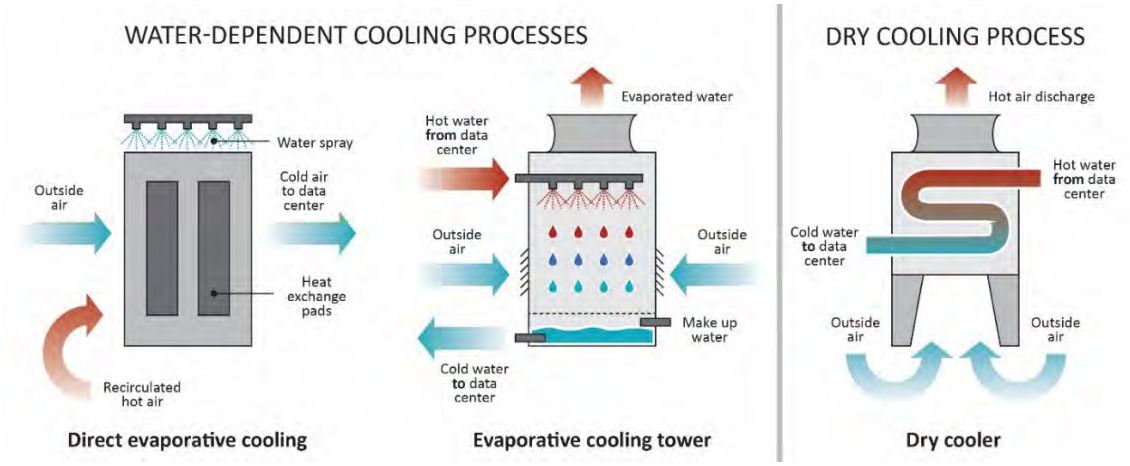
The General Assembly could amend the Code of Virginia to require that, as a condition of receiving the data center sales and use tax exemption, all new data center developments in the Northern Virginia Ozone Nonattainment Area use only Tier 4 generators, Tier 2 generators with selective catalytic reduction systems, or generators with equivalent or lower emission rates.

Data center water use is currently sustainable, but use is growing and could be better managed

Data center water use varies depending on the data center's size, computing density, and type of cooling system. Data centers require industrial-scale cooling to manage the heat generated by their computing equipment. Some cooling systems use water evaporation, and these systems typically require regular water refills to operate (Figure 5-2). Other cooling systems recirculate all or most of their water, similar to a radiator, and use relatively little water. Some data centers use a combination of cooling processes, including processes that do not require any water.

FIGURE 5-2

Evaporative cooling processes require more water than dry cooling processes



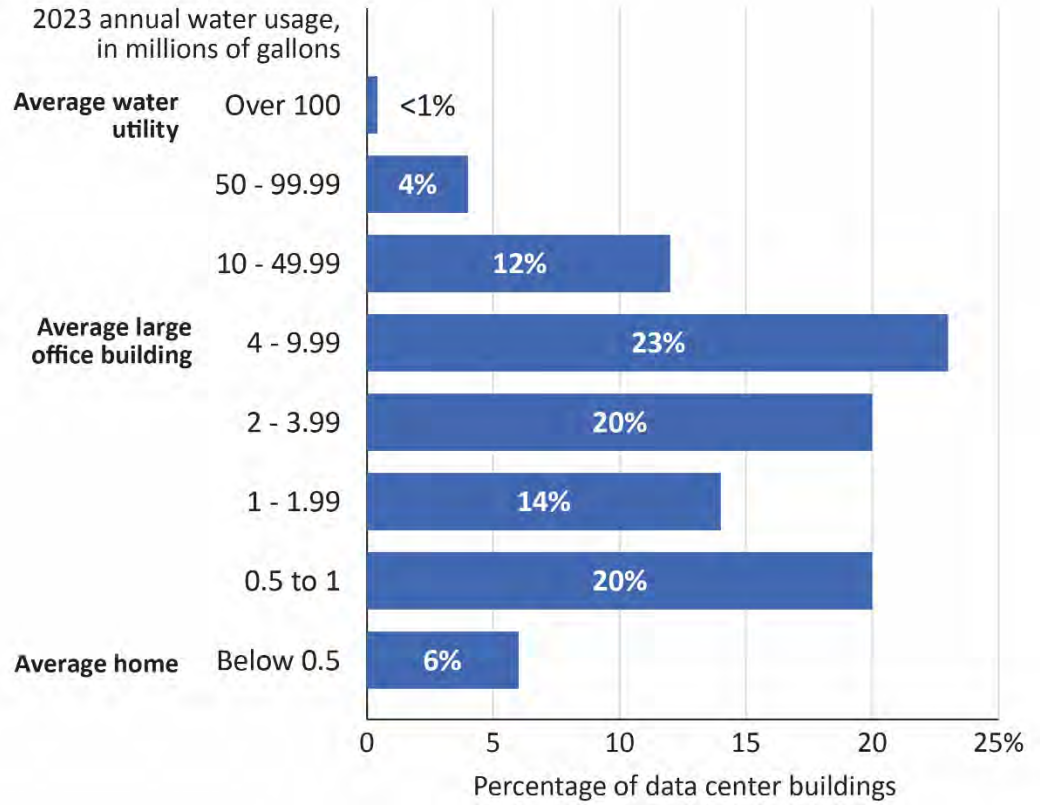
SOURCE: JLARC synthesis of interviews, government reports, and research literature.
NOTE: Depicted examples are generalizations and do not include all data center cooling processes and equipment.

While some data centers use substantial amounts of water, most use similar or less than other large commercial and industrial water users

For comparison, **the state's largest industrial water user in 2023** used about 36.5 billion gallons of water annually.

Based on available data, most data centers use about the same amount of water (or less) as an average large office building (6.7 million gallons per year), although a few require substantially more, and some require less than a typical household (Figure 5-3). In 2023, 11 data center buildings each used over 50 million gallons, including one building that used 243 million gallons (10 percent of the industry's total use) (sidebar).

FIGURE 5-3
Annual data center building water use varied widely, but most used the same amount of water as an average large office building or less (2023)



SOURCE: JLARC staff analysis of data provided by water utilities serving Fairfax, Henrico, Loudoun, Mecklenburg, and Prince William counties and the Town of Wise. Average uses are based on federal and state water use statistics.
NOTE: Data was not available for all data centers in Virginia but was for the large majority. Water use is on a per building, not per campus, basis. Annual usage for some data center buildings is approximate because of data constraints.

Reclaimed water is wastewater that is treated, often to a non-potable standard, and re-used, such as for irrigation and industrial purposes. It reduces the need for additional water withdrawals, diverts wastewater from entering water sources, and reduces demand on potable water systems.

Cumulatively, data centers use a small share of statewide water withdrawals and a moderate share of some region's water withdrawals. In 2023, the data center industry used an estimated 2.1 billion gallons of water, with just over a third coming from reclaimed water instead of new withdrawals (sidebar). Data center water use accounted for less than 0.5 percent of total state withdrawals.

The industry's impact was also limited regionally. Most data centers are served by water utilities, and industry use made up from 0.2 to 21 percent of water use, after excluding reclaimed water use, at the six water utilities JLARC staff reviewed. Data centers were typically one of these water utilities' larger customers, but a data center was the single largest customer for only two utilities.

State regulates water withdrawals to ensure future water availability and to protect water ecology

To protect future water availability and environmental sustainability, DEQ regulates withdrawals from Virginia's water sources, including requiring permits for large-scale withdrawals (sidebar). Withdrawals can reduce the amount of water that is available for future use if it is withdrawn faster than it is naturally replaced. Additionally, they may affect aquatic flora and fauna, such as by reducing available habitat. Most data centers receive their water from local water utilities, which make the withdrawals. In these cases, DEQ ensures that data centers' water use is sustainable through permitting the utility's withdrawals. Only two data centers have their own DEQ withdrawal permits, and any data centers that do make their own withdrawals are subject to the same regulations as water utilities.

Withdrawal permits are required for withdrawals above 10,000 gallons per day from non-tidal surface waters, two million gallons per day from tidal surface waters, and 300,000 gallons per month from groundwaters in a groundwater management area. There are some exceptions for users that pre-date these regulations. Withdrawals that do not require permits may still require annual reporting.

To determine appropriate water withdrawal allowances, DEQ performs scientific modeling that evaluates water withdrawal impacts on future water availability and aquatic flora and fauna in that water source. Permits specify withdrawal limits and set other conditions, such as requiring the permit holder to limit withdrawals during droughts. If a requested withdrawal amount would exceed sustainable levels, DEQ would issue a permit only for a sustainable amount or add conditions to the permit that ensure sustainability. Permits must be renewed at least every 15 years, at which time DEQ reruns the water model with updated water source condition data. If growing data center demand prompted a water utility to seek a larger withdrawal than their permit currently allows, the requested permit withdrawal allowance increase would also have to be modeled by DEQ.

Data center water needs are likely to increase as the industry grows, and state and local governments could help ensure limited water resources are used effectively

While DEQ is responsible for ensuring that permitted water withdrawals are sustainable for the water source, there is less oversight over how available water should be shared across various uses. While the state as a whole is relatively water rich, water is a limited resource for some Virginia localities, such as those that do not have access to major rivers or other surface waters and are in groundwater management areas. Additionally, when local water use demand exceeds current permit or infrastructure thresholds, utilities may need to expend significant resources to meet the additional demand (sidebar). Therefore, localities should fully consider their allocation of available water. For instance, when reviewing a potential new development that may use a

Some **water utilities that serve or will soon serve data centers** have recently expanded their permits and/or infrastructure. For instance, five have requested new or larger withdrawal permits, though these expansions are not fully attributable to data centers. Water utility staff shared that data centers pay their fair share for any additional infrastructure they require.

large amount of water, a locality should consider whether the project could affect the locality's ability to meet future residential demand or pursue other types of economic development.

State could clarify localities' authority to request potential water use information from proposed developments

While any large water user has the potential to affect local water availability, water use information may be particularly helpful for zoning decisions for data center developments. Data centers can use a relatively large range of water amounts compared with other land uses. Some companies will continue to build data centers that use water for cooling, and potentially larger amounts of water as cooling needs increase. While others are moving away from water, the industry's net water use is expected to increase. In addition, because the industry is growing rapidly and typically grows in clusters, data center water use in a given locality can grow suddenly.

Localities have general statutory authority to consider water resources in their land use planning, but state law is not clear on localities' ability to require a proposed data center development to provide a water use estimate or to consider water use in their rezoning and special use permit decisions. (Rezonings and special use permits are discussed more in Chapter 6.) In interviews, local planning staff, government attorneys, and a local elected official conveyed different understandings of the law or reported being uncertain whether a locality could consider water use estimates when evaluating data center development projects. This information could be helpful for assessing a development's potential impacts, but data center developers can be reluctant to share this information because of proprietary concerns. State law should clarify localities' authority to require this information from data center developers and consider water usage in their rezoning and special use permit decisions. This clarification could potentially be extended to other development types, such as other developments with the potential to use large amounts of water.

RECOMMENDATION 6

The General Assembly may wish to consider amending the Code of Virginia to expressly authorize local governments to (i) require proposed data center developments to submit water use estimates and (ii) consider water use when making rezoning and special use permit decisions related to data center development.

Additionally, if local planning officials have this information, they should consult with their local water utility—prior to approving data center developments—on the impact these developments could have on the utility or future water availability. In some data center approvals, this information was not shared between parties. Doing so could help to ensure water use impacts are fully understood prior to approving the development.

Increasing use of reclaimed water may help reduce impacts on water resources

Some utilities offer reclaimed water systems for their customers, and using reclaimed water instead of potable water for cooling, including evaporative cooling, is generally a best practice for data centers. Reclaimed water can reduce a development's impact on water resources because it does not require additional water withdrawals and can decrease wastewater discharges. DEQ currently permits only two water utilities, including Loudoun Water, to provide reclaimed water for evaporative cooling uses.

Reclaimed systems may not be viable or available in all localities, but utilities that serve data centers should consider the option. Smaller utilities may not create enough wastewater for a reclaimed system that could sustain data center operations. Moreover, financial considerations may also limit reclaimed water use, as reclaimed systems have high capital costs. However, because of the potential benefits for water availability, utilities that serve data centers—and other large water customers—should consider the viability of using reclaimed water systems, as well as potential opportunities for data center companies to help with upfront costs.

Some stakeholders, including a data center company and several water utilities, indicated that Virginia's reclaimed water system regulations for evaporative cooling use are difficult to meet or confusing. DEQ indicated that regulatory changes, such as explicitly listing minimum standards for reclaim water use in data center evaporative cooling processes or reducing some treatment and monitoring conditions, could potentially address concerns while maintaining necessary safeguards but would require further review. DEQ is already scheduled to conclude an internal review of these regulations by September 2026 as part of its quadrennial review process, but DEQ could start this review now so that any eventual changes could be implemented a year earlier. Any potential changes DEQ identifies would need to be implemented through the standard regulatory process—including a Notice of Intended Regulatory Action and public comment period.

Data center construction has similar land and water impacts to other large developments, and state and local regulation mitigate most effects

The development of land for industrial, commercial, or residential uses, particularly "greenfield" developments, can affect Virginia's land and water resources (sidebar). Depending on the characteristics of the site being developed, the construction process may change land characteristics and uses, modify stormwater runoff patterns, and/or disturb wetlands and other waterways (Table 5-2). Such impacts can degrade air and water quality, destroy wildlife habitat, and increase flooding and erosion risks.

A development's ability to mitigate its potential impacts depends on the site, development type, and the resource. A development can mitigate overall potential impacts on these resources in three ways:

"Greenfield" development occurs on land that has not previously been developed. In contrast, redevelopment occurs on the site of a former development. A redevelopment is less likely to impact land and water resources, as any potential impacts likely already occurred during the previous development.

State-managed databases, such as the Department of Conservation and Recreation's **Natural Heritage database**, identify on-site resources that may be impacted by development.

- **avoiding** direct impacts to the maximum extent practicable, such as not constructing a building on forested land,
- **minimizing** impacts to the maximum extent practicable, such as using a retaining wall to minimize impacts to an adjacent waterway, or
- **compensating** for any impacts that do occur, such as offsetting impacts to a wetland by restoring or constructing that same type of resource elsewhere.

TABLE 5-2
Constructing new developments can result in loss of undeveloped and agricultural lands, create stormwater runoff risks, and potentially disturb wetlands

	Land resource loss	Stormwater changes	Wetland disturbances
Development action	Undeveloped and agricultural lands may be developed for industrial, commercial, residential, or other uses.	Impervious surfaces may be created to support buildings and ancillary developments.	Wetlands (including streams and other waterways) may be drained, filled, or encroached upon to maximize developable area.
Potential impact	Forests, agricultural lands, and other green spaces are lost.	Less rainwater is absorbed into the ground, increasing stormwater runoff.	Wetland areas are destroyed, diverted, or otherwise disturbed.
Effect without mitigation	Air, water, and soil quality degradation, loss of habitat, and lower agricultural production occur.	Increased flooding and erosion, water pollution, and slower groundwater recharge, occur.	Water source degradation, loss of habitat, and increased flooding and erosion occur.
Effect with mitigation	Losses are avoided, minimized, or offset by preserving, creating, or restoring lands elsewhere. [a]	Predevelopment runoff rate and quality are maintained, minimizing adverse impacts.	Disturbances are avoided, minimized, or offset by funding or implementing wetland creation or restoration. [a]

SOURCE: JLARC synthesis of interviews, government reports, and other information.
NOTE: [a] Offsetting impacts can be difficult and require significant time and space, particularly for replacing lost undeveloped and agricultural lands.

Some regions have seen substantial data center growth, but their construction impacts are similar to other large developments

Data center development has construction impacts that are similar to other large-scale developments' impacts. While comprehensive information on data centers' impacts to natural resources is not tracked, the vast majority of their development is greenfield development—although some redevelopment is also occurring.

The development pressures from data centers on undeveloped and agricultural lands statewide are not more than other fast-growing developments in Virginia. For example, the total land area of currently operating data centers is equal to about 1.4 percent of the farmland lost in Virginia between 2017 and 2022. According to land conservation experts, the current primary threat to undeveloped and agricultural lands is solar energy developments.

On a regional level, however, the share of undeveloped and agricultural land development in Northern Virginia attributable to data centers has been substantial. JLARC staff estimated that the data center industry accounted for between 20 and 30 percent of land development in Loudoun and Prince William counties from 2013 to 2021, and the amount of data center development has already increased 50 percent since then. However, these are some of Virginia's fastest-growing counties, which means that some portion of land developed for data centers likely would have been developed for other uses, such as housing, mixed-use commercial space, or distribution centers.

Data center developments have similar impacts on stormwater and wetlands as other large-scale developments, such as warehouses or shopping centers. The magnitude and significance of impacts depend on site characteristics as much as the development itself (sidebar). Therefore, impacts may be the same whether a site is developed for a data center or another land use.

Magnitude of impact depends on the change to the environment, not the development itself. For example, a small greenfield development may create more impervious surface than a large redevelopment.

Impact significance depends on the resource that is affected. For example, a given amount of water pollution may have a larger effect in a small river than a big river.

State and federal regulations require mitigation of stormwater and wetlands impacts, but land conservation is at local discretion

Federal and state regulations require stormwater management and wetland permits for sizeable impacts, regardless of development type. Stormwater permits for individual developments are usually administered by DEQ or the locality, and wetland permits are typically jointly issued by the U.S. Army Corps of Engineers and DEQ. Most data center developments require a stormwater permit because of their size, but only those that affect a wetland or other waterway require a wetland permit (which is the same for all types of development).

Stormwater management permits require developments to manage their stormwater runoff to meet water quality and quantity requirements to minimize impacts. For instance, a development would be required to install a stormwater management system, such as an on-site stormwater pond, to slow and filter its runoff. Data centers create a relatively large amount of impervious surface, and stormwater permits require management that is proportional to the addition of impervious surface and land cover changes. Some impacts may still occur even if all permit requirements are met, such as less water being absorbed into the ground or water source temperature increases, but these same impacts can occur from any developments that create large impervious surfaces or change land cover, such as a warehouse or shopping center.

Wetland permits require developments to avoid and minimize impacts to wetlands and other waterways to the maximum extent practicable and to compensate for any remaining significant impacts. Because data centers require large building footprints, they may be relatively less able to avoid or minimize impacts. However, any significant impacts that do occur require proportionate compensation, which ensures losses are replaced to the extent possible through the preservation, restoration, or creation of that resource elsewhere.

In Virginia, federal and state regulations do not require mitigation of impacts to undeveloped and agricultural lands. Localities have full discretion through their zoning laws

to determine how lands that are not protected from development can be used. While localities can require, negotiate, or accept offers to conserve a portion of the existing natural landscape as part of a development, data center developments generally use most of land that is practicable and allowed to be developed. Because undeveloped and agricultural lands are difficult to replace, the primary mitigation method to protect them is to avoid or minimize development on these lands. The state could consider imposing land use restrictions to prevent or minimize the land impacts from data center development, but this would be a profound change in the state's involvement in local land use decisions, and, currently, there does not appear to be a basis for distinguishing data centers from other large developments in considering such restrictions.

State could require data centers to meet environmental management standard to receive tax exemption

Even though federal and state regulations already limit most negative natural resource impacts of data centers, the state could encourage them to meet an environmental management standard because of their large and growing presence. Environmental management standards, such as the International Organization for Standardization's (ISO) 14001 standard, require companies to proactively review and reduce their impacts to natural resources (sidebar).

The ISO 14001 standard for Environmental Management Systems is one of the most used environmental management frameworks in the world. The U.S. Environmental Protection Agency believes it helps organizations to systematically identify and reduce their environmental impacts.

Environmental management standards do not set required minimum standards but involve continuous improvement in operational sustainability. Required minimum standards may not be viable for all data center companies and may not be wholistically sustainable (sidebar). Environmental management standards call for companies to evaluate all of their environmental impacts and set and pursue sustainability goals. This process is repeated every few years and encourages a wholistic approach to sustainability. For instance, ISO 14001 seeks to promote organizational improvement in air emissions, water use, water discharge, waste generation, and energy consumption—all of which have been raised as concerns about data centers. (For more information on data center water discharges and waste generation, see Appendix K. For more information on data center energy impacts, see Chapter 3.)

Required minimum standards for specific resources could have unintended consequences, including: 1) not being viable for all data center companies, who have different operational systems and preferences, 2) not ultimately improving sustainability, such as water restrictions leading to more energy-intensive cooling, or 3) not being adaptable as the data center industry evolves, such as if new technologies shift the industry's environmental impacts.

The state could encourage adoption of an environmental management standard by making the state's sales and use tax exemption for both new and existing data centers contingent on adoption. Many data center companies already set sustainability goals and policies, and a well-designed state requirement would encourage other companies to adopt similar goals and policies. At least four other states—Arizona, Illinois, Iowa, and Washington—require data centers to meet a sustainability standard as a condition of their state data center tax incentive program.

POLICY OPTION 5

The General Assembly could amend the Code of Virginia to require that, as a condition of receiving the sales and use tax exemption, data center companies meet and certify to an environmental management standard, such as the International Organization for Standardization's 14001 standard for Environmental Management Systems.

Data center impacts on historic resources are similar to other developments, but current protections could be strengthened

Developments have the potential to negatively affect historic resources, both during and after construction. Historic resources can include sites (e.g., battlefields and cemeteries), structures (e.g., buildings), and objects (e.g., artifacts) (Figure 5-4). Impacts can vary substantially depending on the type of development being proposed, the significance of the historic resources affected, and how those resources will be affected. In many cases, a development will not adversely affect historic resources because there is nothing historically significant on the development site or located nearby.

FIGURE 5-4
Virginia has a wide range of historic resources



SOURCE: Image courtesy of the Virginia Department of Historic Resources (cropped by JLARC).

Data center developments can affect historic resources in the same ways as other large developments

Some data center developments have affected state historic resources. For instance, two data center developments have relocated or damaged cemeteries, and several have been located on historic sites, including a turn of the 19th-century residential site, a historic African American horse showground, and part of a Civil War battlefield. Additionally, several approved but not yet built data center developments have raised concerns of viewshed impacts on historic battlefields around the Northern Virginia region. Like with other development types, the total number and extent of data centers' impacts on historic resources are unknown as not all of these resources—or impacts to them—have been identified and catalogued.

Preservation experts consider data centers' impacts and risk of impact to be similar to those of other large-scale developments. Data centers have less flexibility than some other developments, like housing, to avoid building on parts of the property where resources might be located. Data center developments also require extensive grading, which can destroy buried structures and objects, and tall data center buildings are more likely to have viewshed impacts on nearby resources. However, other large-scale developments, like warehouses and shopping centers, can have the same impact. The rapid growth of data center development increases the likelihood that historic resources will be disturbed by these developments, but the same is true of other commercial and residential construction growth.

Pre-development studies help promote mitigation of impacts to historic resources

Various methods may be used to **mitigate impacts to historic resources**. For instance, developments may avoid or minimize impacts by moving building locations or lowering building heights. If historic resources cannot be avoided, they may be excavated and relocated, studied and documented before their destruction, and/or commemorated with signage. The appropriate strategy can depend on the resource, development type, and the site.

Before site development begins, sites can be studied to identify any potentially significant historic resources and determine mitigation strategies if impacts were to occur. Developers can hire experts or third parties to perform "Phase I" historic resource studies, which could include background research, physical inspection, and remote sensing, to identify historic resources that may be affected by a new development. If a Phase I study finds historic resources, Phase II historic resource studies can determine their significance and, if needed, develop mitigation approaches (sidebar). When needed, Phase III historic resource studies involve carrying out mitigation approaches, such as excavating and relocating a resource or documenting a resource. Once historic resources have been identified, developers can additionally perform viewshed analyses to determine whether a new development would be visible to these resources, potentially affecting their significance.

Phase I historic resource studies and viewshed analyses are relatively inexpensive pre-development tools. Some data center companies reported that they conduct Phase I studies for some or all of their data center developments, and several have conducted and shared viewshed analyses as part of the local zoning approval process. Studies can ultimately save developers time and money by preventing delays or the need for design changes from unexpected discoveries after developments have been approved.

Few legal or regulatory protections exist to protect historic resources, but pre-development studies could be more strongly encouraged

While there are many layers of federal, state, and local protections for natural resources, fewer protections exist for historic resources. For private developments, federal regulations require that historic resource impacts need to be considered—studied and potentially mitigated—only if a wetland or other federal permit is required. State law only requires additional Virginia Department of Historic Resources (DHR) oversight of private developments when human remains need to be removed.

Local regulation of historic resources varies by jurisdiction, depending on local capabilities and priorities. All localities have the authority to restrict development around

historic resources through their zoning ordinances, but some are better able to identify these resources than others. For instance, Loudoun requires Phase I historic resource studies for all non-residential developments and has a county archeologist who evaluates study results and makes recommendations to planning staff if additional action is needed. Most localities do not require pre-development studies and do not have an archeologist on staff. Moreover, when development and historic resource preservation goals conflict, it is up to local elected officials to make zoning decisions.

To ensure that potential impacts to historic resources are identified, the state could encourage Phase I historic resource studies for all new data center developments, as well as viewshed analyses for new developments within a certain distance of a registered historic site. To do this, the state could make eligibility for the sales and use tax exemption contingent on this work being performed for any new data center developments. For example, the state could require that, for any data center that begins construction in 2026 or later, the data center company perform a Phase I study (along with a viewshed analysis, if applicable) before the facility is constructed to be eligible for the exemption. Data center developers would pay for the study and report findings to localities, which would determine if any further action is required.

POLICY OPTION 6

The General Assembly could amend the Code of Virginia to require that, as a condition for receiving the sales and use tax exemption, data center companies conduct a Phase I historic resource study of a proposed development site, as well as a viewshed analysis when a proposed site is located within a certain distance of a registered historic site, and report the study findings to the appropriate locality prior to development.

Some localities may not currently have the time, expertise, or resources to review the Phase I historic resource study submissions. DHR could offer grants for localities to hire consultants or have staff available for consultation, but this would require additional funding or staff to implement. Alternatively, localities would have the option to require data centers to pay for a consultant hired by the locality to perform the review.

Some historic resource preservation experts stated that, while they would appreciate greater protections around historic resources, establishing mitigation requirements at the state level may not allow for site-specific characteristics or local preferences. For instance, prohibiting data center development near historic resources statewide, as was proposed during the 2024 legislative session, may be broader than needed—as impacts do not occur every time a development is on or near a historic resource—or could prove too restrictive given the abundance of historic resources in Virginia.

6 Local Residential Impacts

Local governments are responsible for managing land development in their jurisdictions for different residential, commercial, agricultural, and industrial uses. Localities manage development through planning and zoning to ensure developments conform with state and local laws and are grouped with appropriate types of development.

On the planning side, state law requires localities to create and update long-term comprehensive plans to support "coordinated" and "harmonious" development. These plans provide a strategic vision for development in the county but, while important for guiding local decisions, do not set any legal boundaries.

On the zoning side, localities pass zoning ordinances that set legal restrictions on development. Zoning ordinances establish conceptual *zones* (e.g., rural residential, light industrial), which have their own sets of rules and requirements for new development. For each zone, the ordinance lists *uses* that are allowed. Uses can allow different types of business operations (e.g., data center, brewery), different types of residential construction (e.g., townhouse, single-family house), and other distinct uses. Additionally, zoning ordinances can impose minimum requirements on specific uses or zones, such as maximum heights or mandatory setbacks from property lines.

Within a zone, a use can be allowed by right, allowed by special permit, or prohibited. If a use is prohibited in a zone, then a developer can seek to have the parcel rezoned to allow the use.

- **By right** uses are allowed within a zone without any special approval by the locality. For example, if data center development is a by-right use, a developer can build a data center in the zone without seeking special approval from the locality. Localities cannot require data center developers to do anything not already established in the zoning ordinance. For example, a locality could not require a by-right data center to be set back farther from nearby property lines than the ordinance already dictates.
- **Special permit** uses are allowed if approved by the locality's elected officials, e.g., a county's board of supervisors (unless they delegate this authority to the local board of zoning appeals), often following a public hearing. As part of the special permit process, the locality can make approval conditional on additional restrictions to mitigate negative impacts, such as bigger property line setbacks or lower building heights.

- **Rezoning** changes the conceptual zone a parcel falls under and therefore its allowed uses. Rezoning requests require a public hearing and approval from elected officials. Like with special permits, the locality can consider the developer's willingness to conform to additional restrictions or actions as a condition of rezoning approval.

Growing number of data centers are being built close to residential areas, causing residential impacts

This chapter focuses on data centers' impacts on residential areas. While minimizing impacts on **other sensitive uses** such as schools and parks is important, concerns of negative impacts in Virginia have primarily come from residential areas.

Land use planning principles state that neighboring property uses should be compatible with one another. These principles generally dictate that industrial uses should be far from residential and other sensitive uses because they are often incompatible (sidebar). Residential neighborhoods are generally expected to be safe, quiet, and pleasant places to live, whereas industrial facilities are often large, unsightly, and potentially noisy. For example, Loudoun County ordinances state that "industrial uses […] are incompatible with residential uses due to the prevalence of outdoor storage and emissions of noise, odor, and vibrations."

Data centers are industrial facilities that are largely incompatible with residential uses

The industrial scale of data centers makes them largely incompatible with residential uses. A modern data center site includes one or more large, industrial buildings, similar in size and appearance to a new distribution center or a manufacturing facility, which is an abrupt contrast to a residential home.

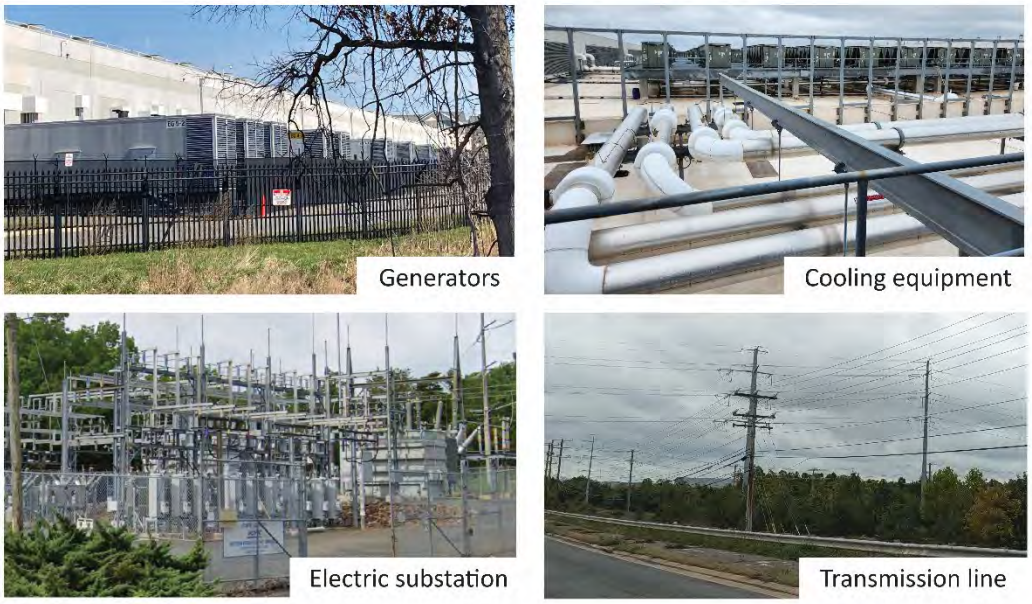
Resident descriptions of nearby data centers include:

— "a giant monolith in the wrong place"

— "a prison"

Other components of data center sites are also industrial in character and unsightly to residents who live close by (sidebar) (Figure 6-1). Trailer-sized generators (a median of 35 per site) are often lined up beside the data center building or housed in large generator sheds. Industrial-scale cooling equipment, such as chillers or water towers, often sit on the roof or outside the main building. Many data center sites are encompassed by security fences and deploy bright security lighting. Data centers also require industrial-scale electrical infrastructure. Sites will often include one or more electrical substations on or adjacent to the site, and some require above ground transmission lines extending from nearby main lines.

FIGURE 6-1
Data center buildings and sites have industrial characteristics and infrastructure



SOURCE: JLARC staff photos and Google Earth.

Homeowners in residential areas close to data centers frequently express concern that having industrial sites nearby will decrease their property values. While it is certainly possible that nearby data centers have affected the resale value of homes, there is not yet evidence of this relationship. In interviews with representatives of neighborhoods opposed to nearby data centers and other informed individuals (sidebar), almost none observed a decline in property value or change in speed of home sales. One commonly cited explanation was that the tight housing market in Northern Virginia decreases buyers' selectiveness and so proximity to data centers has not yet had a noticeable effect on property values.

To assess data centers' impacts on property value, JLARC interviewed representatives of neighborhoods opposed to data centers proposed or recently constructed nearby, local stakeholder groups, county assessor's offices, and a local real estate agent association.

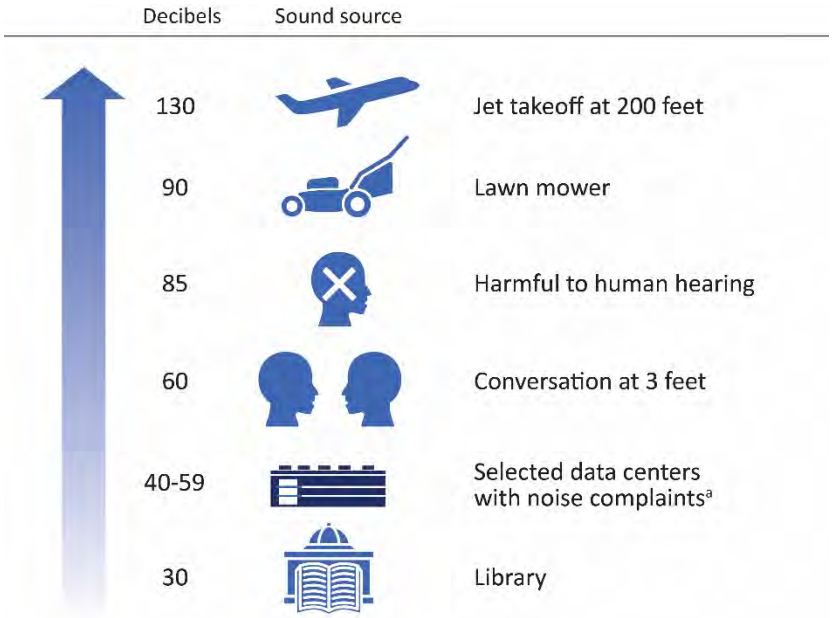
Some nearby residents report that constant noise from data centers affects their well-being

The constant nature of data center noise has been a reported problem when data centers are located near residential areas. Whether data center noise can be heard past the facility's property line depends on its design and its type of cooling system, which can cause noise. In addition, local geography and surrounding buildings can affect how sound travels.

While some data centers have been noisy enough to cause complaints, the noise is not loud enough to damage nearby residents' hearing and rarely loud enough to violate noise ordinances (Figure 6-2). Data center noise that has prompted resident complaints ranges from an estimated 40 to 59 decibels (per JLARC's review of noise measurements of selected data centers that have prompted complaints by residents). This

sound level is typically below the 55 or 60 decibel limit that Loudoun, Prince William, and Fairfax allow in their ordinances for residential areas. Rather than the volume of the noise, it's data centers' constant noise that some residents consider problematic. Data center noise is described as a constant "drone" or "hum," similar to house air conditioning systems but magnified to an industrial scale. The noise can sometimes be heard both in and outside of nearby residences.

FIGURE 6-2
Data center sound is noticeable but quieter than many common sounds



SOURCE: JLARC review of Occupational Safety and Health Administration, U.S. Centers for Disease Control and Prevention, and Federal Aviation Administration websites, and analysis of complaint data from Fairfax and Loudoun.
NOTE: The units are A-weighted decibels. [a] Encompasses measurements at locations where local staff recently measured data center noise using A-weighted decibels. Measurements are a response to complaints, so they are not representative of all data centers. Measurements indicate total sound, not the isolated amount from data centers.

Residents who have reported that data center noise is a problem have indicated that it has adversely affected their well-being. JLARC staff spoke with residents who live near data centers that have been the subject of noise complaints to learn how the noise affects them. Some residents described physical symptoms such as migraines from the facilities' constant noise. Others said that they experience health problems caused by disrupted sleep, and some residents described an inability to concentrate on tasks. A common theme was poorer quality of life, with some residents avoiding their decks and yards because the sound is louder outdoors.

Data centers are not required to reduce their noise if they are not violating local ordinances, which has made it difficult to address noise concerns. Some neighborhoods have attempted to address concerns through the county and engagement with data center companies. Residents of the Great Oak neighborhood in Prince William reported noise to county police from a nearby data center in May 2022, and as of

October 2024, the issue had not been fully addressed by the data center owner to all residents' satisfaction. Residents of the Brook Haven neighborhood in Loudoun contacted the county in 2021 about noise concerns, and the data center completed an attempted solution in November 2023. In both cases, residents observed reductions in noise from the nearby facilities but emphasized it took time and repeated communications from residents to prompt action.

Data center construction sites can be especially disruptive to nearby residential areas

Because of data centers' size and scale, their construction takes a long time and is disruptive to residential areas. Construction activities typically include clearing trees, grading land, laying foundations, erecting buildings, and installing equipment. While these activities are not unique to data centers, the impacts on residents are especially large because of the projects' scope. Each building takes about 12 to 18 months to construct, and with the industry moving toward developing data center campuses, work on additional buildings often begins as soon as one is completed. Therefore, a large site could take as long as seven years to fully complete. This work requires thousands of workers on site and substantial truck deliveries of materials.

Some residents report they have been negatively affected by data centers' construction. Their concerns include loud construction noises and vehicle traffic. For example, one neighborhood's main access road was damaged by frequent use of heavy vehicles, which reportedly sometimes blocked school buses and emergency vehicles.

One-third of data centers are near residential areas, and industry trends make future residential impacts more likely

The majority of data centers are appropriately located in industrial or commercial areas and are not close to residential uses. Over 60 percent are more than 500 feet from residential-zoned properties (as measured from property line to property line, meaning the actual facility and residences are even farther apart) (sidebar). The farther away a data center is from residential areas, the less likely it is to affect nearby residents.

Analysis of the proximity of data center properties to residential zoning used data from eight localities that account for nearly all (93 percent) data centers in Virginia. (See Appendix B.)

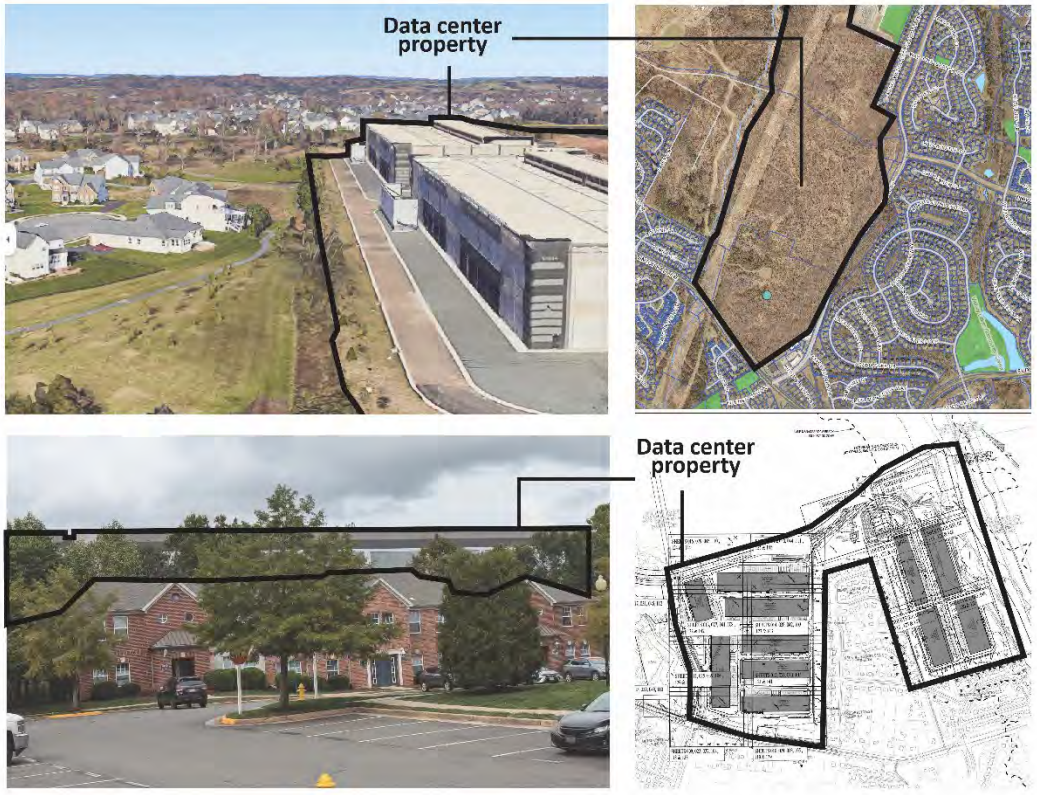
A minority of data centers have generated noise complaints. At least 15 data centers (10 percent of operational data center sites) appear to have generated noise that nearby residents regard as problematic, according to resident groups and government records.

However, the number of data centers being built near residential areas is increasing. Almost one-third (29 percent) of operational data center properties in Virginia are within 200 feet of residentially zoned properties. Currently, there are several data centers being constructed adjacent to single-family homes, townhouses, and apartment complexes. Several recently approved data centers in Loudoun and Prince William will be built on land adjacent to neighborhoods, including at least two proposed developments where the property also abuts an elementary school (Figure 6-3). Other

counties—such as Fairfax, Stafford, and Henrico—have also received proposals for data centers close to residential areas.

Trends in real estate availability and facility design increase the likelihood of future residential impacts. As the industry's footprint in Northern Virginia grows, the amount of land ideal for data center development is decreasing, and developers are more likely to consider locations closer to residential and other sensitive areas. Additionally, the typical data center building is becoming taller, larger, and more power-intensive, which has the potential to make their industrial characteristics more pronounced and, depending on the design, could generate more noise.

FIGURE 6-3
Some recently built or approved data centers are close to residential areas



SOURCE: JLARC site visits, Google Earth, and locality websites.
NOTE: In order, the pictures depict: (1) existing data center from the Loudoun Meadows neighborhood of Loudoun, (2) land approved for Devlin Technology Park in Prince William, (3) an existing data center next to the Regency neighborhood in Prince William, and (4) a proposed site plan for property that was rezoned to allow data centers around the Amberleigh Station neighborhood in Prince William.

Localities have allowed data centers near neighborhoods, sometimes without sufficient mitigation of impacts

Appropriate local planning and zoning decisions can reduce the risk of data center developments affecting residents. Localities need to proactively update their planning and zoning to manage data center development, because the industry is rapidly changing. As recently as 10 years ago, data centers were much smaller facilities that were similar in size and appearance to commercial office buildings. Local ordinances that continue to treat data centers as non-industrial commercial uses, which are often allowed next to residential areas, are outdated and can affect residents.

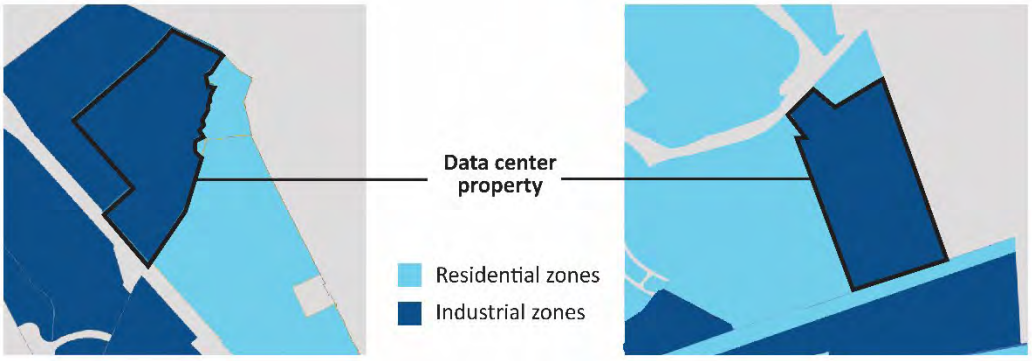
Localities need to consider which areas are appropriate for data center development, classify data centers as industrial uses in zoning ordinances, ensure data centers are not too close to residential zones, and include requirements to mitigate any potential negative impacts from data centers, such as building setbacks and height restrictions. In addition, local elected officials should adequately consider potential residential impacts when considering special permit and rezoning requests.

Inadequate planning and zoning have allowed data centers near residential areas

Data centers have sometimes been built too close to residential and other sensitive areas because local zoning ordinances did not consider them to be an industrial use. For example, until 2021, Fairfax considered a data center to be a telecommunications facility, which allowed data centers to be built in areas zoned for residential and office uses. Loudoun originally treated data centers as an office use and continues to allow by-right data center development in areas zoned for office uses in some parts of the county.

In addition, some localities have zoned industrial areas next to residential areas on their zoning maps, even though land use principles state that industrial uses are ideally separated from residential uses by buffers, such as commercial zones. For example, the Great Oak neighborhood in Prince William and the Bren Mar neighborhood in Fairfax are directly adjacent to industrial zones (Figure 6-4). This has allowed data center development by right despite being close to residences. The likelihood of residences being close to data centers has also increased because of some local decisions to rezone land to residential despite being in primarily industrial areas. If zoning maps are not reviewed and updated, more data centers are likely to be built closer to residential areas.

FIGURE 6-4
Some industrial zones border residential zones, allowing by-right data centers too close to residential zones



SOURCE: JLARC review of Prince William and Fairfax geographical informational systems and planning staff reports.
NOTE: The first picture depicts an existing data center near the Great Oak neighborhood of Prince William. The second picture identifies a planned data center near the Bren Mar neighborhood of Fairfax County. Grey coloring indicates a zone that is (1) neither residential nor industrial or (2) within another locality. "Zones" refers to the official zoning classification in local ordinances.

Zoning ordinances often include requirements intended to mitigate negative impacts from businesses, but these requirements are not always sufficient. Required building height limits and property line setbacks are fundamental ways to reduce a development's impacts. For example, the property on the right side of Figure 6-4 was zoned industrial and is only subject to a setback of at least 40 feet (although the developer is voluntarily planning a larger setback). This zoning would have allowed a new data center to be built close to the property lines of two adjacent townhouse complexes. Landscaping and architectural requirements are other ways to mitigate data center impacts, but their value is limited. Newly planted trees take decades to grow, and the size and proximity of a nearby data center matters more to residents than its architecture.

Some localities' elected officials have granted data centers exceptions to requirements designed to reduce residential impacts

Local officials in Virginia have sometimes approved data center requests to build in locations that prompt resident opposition or are likely to cause impacts. These elected officials are responsible for reviewing applications for special permits and rezonings and ensuring they are compatible with the locality's long-term comprehensive plan (or amending the long-term plan). While there is no objective way to assess if officials made the "right" decision in approving a given project, there are cases where elected officials' decisions have led to impacts on residents or contradicted development strategies laid out in long-term plans. For example,

- Elected officials have approved property rezonings that allow data centers next to sensitive locations. Prince William approved rezoning from mixed residential to industrial for the Devlin Technology Park (second in Figure 6-3), which is adjacent to a school and about 80 feet from residential zoning.

- Elected officials have approved data center requests in areas that are not suitable, according to the locality's long-term comprehensive plan. In Loudoun, the board of supervisors approved the True North development even though staff recommended denial because the county's "transitional" long-term plan classification for the site does not support data centers (sidebar).
- Elected officials have exempted individual data centers from local requirements intended to mitigate negative impacts on residents. For example, Loudoun's board of supervisors allowed Aligned Energy's Relocation Drive project to exceed the zone's maximum height and square footage, despite staff recommending against the exemption because of nearby residential areas.

Local planning staff can recommend denial for several reasons. Sometimes staff may recommend denial because they believe more information from the developer is needed before a decision should be made. Other times staff may recommend denial because the proposed use is not compatible with the proposed site or there are not sufficient mitigations planned to adequately protect nearby residents.

Some localities have taken steps to minimize residential impacts, though success of these efforts rests with elected officials

Residents' opposition to data centers has grown in recent years, especially in Loudoun and Prince William. While data center projects rarely generated citizen opposition in the past, it is now more common for individuals and organized groups to speak against data center proposals at local planning commission and board of supervisor meetings. Some grassroots groups have been created to fight specific proposals for new data centers, joined by existing organizations such as regional environmental groups. These local groups often also advocate for more government restrictions on allowable locations for data centers.

Opposition to data center proposals has also emerged outside of the main Northern Virginia markets. For example, local groups contested recent proposals in Henrico County and the Town of Warrenton. However, some locations such as Mecklenburg have not encountered significant resident opposition.

Several Virginia localities are making or considering zoning ordinance changes to reduce the risk of residential impacts

Most of the Virginia localities with sizable data center markets have taken or are considering steps to better manage future data center development. Since 2019, elected officials in the three localities with the most data centers (Loudoun, Prince William, and Fairfax) have taken some steps to address residential concerns (Appendix L). For example,

- All three localities have increased the requirements for data centers to improve their appearance or reduce their visibility, for example, increasing setback requirements, requiring specific design standards for the building façade, or screening external mechanical equipment.

- Loudoun and Fairfax have reduced the number of zones allowing data centers by right.
- All three localities have taken steps to address noise, such as requiring sound studies for new projects, requiring proactive sound measuring for existing data centers, and eliminating a partial exemption in the local noise ordinance for nighttime noise from businesses (including data centers).
- All three localities recently initiated studies of their data center policies to better manage development. Fairfax's study concluded with elected officials amending their ordinances in fall 2024. Loudoun and Prince William are reviewing potential changes to their long-term comprehensive plans as part of their studies and tentatively plan to vote on study proposals in 2025.

In several of the Virginia localities that are considering or expecting their first data center projects, elected officials have proactively implemented planning and zoning changes to promote appropriate industry development. The goals of these changes are to avoid the types of residential impacts that have occurred in established data center markets. For example, in 2023, Stafford County added data center principles to its comprehensive plan, prohibited data centers in several commercial and light industrial zones, and established industry-specific standards. Culpeper County also coordinated amending its comprehensive plan and zoning ordinance relevant to data centers. Culpeper allows data centers in multiple industrial zones but provides tax incentives to encourage development in a newly designated Technology Zone with more stringent design requirements.

Localities generally have adequate expertise to make data center decisions

For the most part, local government staff possess sufficient expertise to support the review and approval of data center projects. Data centers are one of many types of development that local planning, permitting, and other staff evaluate. Evaluating whether a data center project is in an allowable location, has appropriate setbacks and building height, or is proposing effective landscape screening is similar to evaluating other large commercial or industrial developments. The one exception is noise, a topic where staff from several localities would like more expertise. For example, planning staff from a locality with data center experience are uncertain whether their recently revised ordinances are the right way to prevent data center noise impacts.

Data center applications can be challenging, however, for smaller counties with less experience with the industry, given the complexity, size, and scale of data center projects. These localities have addressed challenges by reaching out to staff in other localities with more industry experience and by contracting for tasks where their expertise may be lacking, such as assessing economic impacts. For some functions, such as reviews of stormwater management plans, the Department of Environmental Quality

may perform the review instead of the locality. Larger counties have sometimes used consultants as well, such as Prince William for a noise study.

Effectiveness of local efforts to minimize residential impacts ultimately depends on elected officials

The effectiveness of local efforts to minimize the residential impacts from data center development ultimately depends on elected officials. Local staff can propose well-designed zoning ordinance changes and provide sound advice on whether a special permit or rezoning request should be approved based on local development standards and the locality's comprehensive plan, but elected officials make the final decisions. As described above, elected officials in Fairfax, Loudoun, and Prince William have recently taken actions to minimize residential impacts of data centers, and several localities considering data center projects are taking actions proactively. While these actions do not guarantee elected officials will always make the "right" decisions to address impacts, they do indicate that elected officials are actively responding to residents' concerns.

State intervention does not appear warranted, but localities should consider using key practices in data center ordinances and decisions

Land use decisions are traditionally a local responsibility in Virginia, because they directly affect local residents. Land use decisions are also very site specific, and local governments are better positioned than the state to evaluate what is appropriate for a given site.

Nature of data center impacts does not appear to merit state intervention, and localities appear to be taking needed actions

Although some stakeholders have advocated for greater state involvement in land use decisions, there is not currently a compelling reason for a state role in setting local requirements for data centers or intervening in local approval decisions. State intervention should be considered only if local policies are causing significant threats to residents' health and safety or other significant harm, but that is not the case with data centers.

Furthermore, only a minority of data centers in Virginia have been reported to impose negative impacts on residents. While some localities have allowed data centers to be built in areas incompatible with residential uses, those localities now appear to be taking actions to avoid future impacts by reviewing and changing local zoning ordinances. Other localities that have not experienced negative impacts on residents yet appear to be taking proactive action to minimize impacts.

Localities should implement several practices to minimize residential impacts

Localities should implement several practices to protect residents and ensure data center development proceeds appropriately and with minimal impacts. Namely, localities should:

- classify data centers as an industrial use in their zoning ordinances;
- review the locations of zones allowing data centers by right, and adjust the zoning map if needed, considering proximity to residential areas;
- ensure that minimum requirements in the zoning ordinance adequately mitigate negative impacts on residential or other sensitive areas (e.g., setbacks, building heights), and add requirements specific to data centers as needed;
- identify optimal areas for data center development in the locality, including locations that are suitable from the county's perspective (e.g., far from residential areas) as well as the industry's perspective (e.g., large parcels, access to transmission);
- reduce the likelihood of noisy data centers (including through limiting allowable locations and requiring sound modeling) and prohibit the constant low-frequency noise of data centers from reaching residential areas; and
- require commitments from data centers making zoning requests to sufficiently mitigate negative impacts on any nearby residential areas.

Localities can take steps to mitigate data center noise, but some are unsure of authority to do so

Although only a few data centers have caused impacts to residential areas, noise is reported to be one of the most disruptive problems for residents, and data center noise concerns can be difficult to resolve. Noise impacts can be reduced by siting data centers away from residential areas and by modeling data centers' potential noise impact before they are built. Localities also need to be able to address noise that occurs after data centers are operational.

Noise concerns can be reduced by modeling data center sound impacts before a data center is built

In addition to having zoning ordinances that prevent data centers from being located close to residential areas, localities should require sound modeling for data centers proposed close to residential areas. Sound modeling predicts the sound a facility will generate once operational and provides an opportunity for building designers to assess the need for, and effectiveness of, sound reduction strategies. Localities could review study results to determine if any further action, such as sound barrier construction, should be required before approving a development project.

Sound modeling studies can also be used to establish the baseline level of noise already occurring around the proposed data center site, which can later be used to determine whether a data center has contributed to noise in the area. Many data center companies are now doing sound modeling studies for all or some of their projects, and companies explained that sound modeling prior to construction is worthwhile because reducing noise after a building is operational can be difficult and expensive.

Some localities were unsure whether Virginia law allows them to require sound modeling studies. Given this uncertainty, the Code of Virginia should be amended to clarify that local governments have the authority to require sound modeling studies by data center developers and to review and consider the results in their land use decisions.

RECOMMENDATION 7

The General Assembly may wish to consider amending the Code of Virginia to expressly authorize local governments to require sound modeling studies for data center development projects prior to project approval.

The state could incentivize sound modeling by making eligibility for the sales and use tax exemption contingent on this work being performed for any new data center developments proposed near residential areas. For example, the General Assembly could amend the law to require any data center company with a data center that is proposed to be constructed in 2026 or later near a residential area or area zoned for residential development perform a sound modeling study and provide the results to the appropriate locality in order to qualify for the exemption.

POLICY OPTION 7

The General Assembly could amend the Code of Virginia to require that, as a condition for receiving the sales and use tax exemption, data center companies conduct a sound modeling study prior to the development of a proposed data center that is to be located within a certain distance of a residential development or area zoned for residential development and provide the study findings to the appropriate locality.

Localities also need the ability to address noise issues that occur once a data center is operational

Localities also need to be able to address data centers' noise once they are operational, but local ordinances have been largely ineffective at addressing data center noise concerns. Most local noise limits are defined using "A-weighted" decibels (sidebar). This metric is designed to target excessively loud noise from sources such as parties and barking dogs. The lower frequency noise data centers emit is not fully captured in "A-weighted" decibels. Therefore, data center noise rarely exceeds the allowable limits set in ordinances, despite the constancy of the sound being problematic for residents. To effectively address data center sounds that cause resident complaints, localities could

"Decibels" are a pure unit of measurement of sound's volume. When measuring sound, different modifications can be used to account for various frequencies. For example, "A-weighted" decibels prioritize frequencies perceived loudest by humans and therefore reduce particularly low frequencies. "C-weighted" decibel measurements account more for low frequencies.

develop a supplemental noise limit defined using a metric that better accounts for low frequency sounds, such as "C-weighted" decibels.

Another challenge is that most localities address excessive noise in *noise ordinances*, and state law limits civil penalties for noise ordinance violations to $500 after the first offense. Stakeholders have expressed concern that this small penalty is not sufficient to affect the behavior of the large companies that own data centers. Addressing noise limits through localities' *zoning ordinances* would allow localities to better address data center noise. For example, the zoning ordinance could prescribe a process for measuring potential noise violations and penalties for not addressing them.

Some localities were unsure whether state law allows them to (i) establish maximum sound levels in alternative low frequency sound metrics and (ii) set noise rules and enforcement mechanisms in their zoning ordinances. The state should clarify that local governments have the authority to use these approaches to address data center noise.

RECOMMENDATION 8

The General Assembly may wish to consider amending the Code of Virginia to expressly authorize local governments to establish and enforce maximum allowable sound levels for data center facilities, including (i) using alternative low frequency noise metrics and (ii) setting noise rules and enforcement mechanisms in their zoning ordinances, separate from existing noise ordinances.

7 Potential Changes to Data Center Sales Tax Exemption to Address Policy Concerns

Virginia's data center retail sales and use tax exemption is a valuable incentive to data centers (providing $928 million in savings in FY23), and about 90 percent of the industry (as measured by megawatts of power) uses the exemption. The General Assembly could therefore use the exemption to incentivize the industry to take actions that help address many of the concerns discussed throughout this report.

If consideration is given to amending the exemption, two factors should be considered. The exemption was adopted primarily to attract data centers to Virginia for economic development purposes, so any changes to advance other policy goals could make it a less effective economic development tool. The exemption is also consistent with tax policy principles that generally exempt businesses' production-related inputs (in this case computer and related equipment) and therefore provides equitable tax treatment with other capital-intensive industries that have business input exemptions.

Exemption changes could encourage continued data center growth, reduced energy demand, or a balance of these priorities

The data center industry provides positive economic benefits to Virginia (Chapter 2). However, a primary concern about the growing industry is the immense increase in energy demand it will require (Chapter 3), which could increase costs to other customers (Chapter 4). The state could consider changes to the exemption to maintain data center industry growth, reduce energy demand by reducing industry growth, or attempt to balance these two competing priorities.

Extending the exemption could help Virginia maintain industry growth and associated economic and local tax revenue benefits

The data center industry provides moderate economic benefits to Virginia and can provide localities that have them with substantial tax revenues. While economic benefits are concentrated in Northern Virginia, other regions of the state also benefit. For example, data center construction benefits equipment manufacturers and material suppliers in Tidewater, Southwest, and Southside Virginia. While historically only a few localities have benefited from data center tax revenues, the industry is rapidly growing. Data center projects are under development in at least 15 localities, most of which did not previously have data centers. Therefore, from an economic development perspective, the state may want to continue attracting the industry and maintain Virginia's position as a top global data center market.

The state's data center sales tax exemption is scheduled to expire in 2035, and data center representatives unanimously reported that expiration of the exemption would have a negative impact on the state's ability to attract new data centers and keep existing ones. Some companies indicated the expiration date could start to affect site selection and expansion decisions made in the next few years, because companies typically consider the costs of data center ownership over a 15- to 20-year period when making location decisions. Companies indicated that, without the exemption, the total cost of data center ownership and operation would significantly increase. Virginia is currently competing for new data center development with several other primary U.S. markets, almost all of which have data center exemptions. Without an exemption, data center representatives indicated any new development in Virginia would be limited to only what is "absolutely necessary," and development would likely shift to other markets.

To help Virginia remain competitive, the state could extend the exemption's expiration date. To influence future site selection decisions, an extension would need to be in place well before 2035. A reasonable new expiration year would be 2050, which would match the special extension that has already been created for companies that meet certain additional criteria (sidebar). The exemption should continue to have an expiration date, because this is considered an effective practice to ensure periodic scrutiny of its need and effectiveness.

The 2023 General Assembly passed **a special data center sales tax exemption extension to 2040 or 2050** for companies that create 1,000 or 2,500 jobs (100 of which must meet above average wage requirements) and make a capital investment of at least $35 billion or $100 billion, respectively. So far, this extension applies to only one data center company, but several others may be interested in qualifying for this extension.

POLICY OPTION 8

The General Assembly could amend the Code of Virginia to extend the expiration date for the state's sales and use tax exemption for data centers from 2035 to 2050.

Extending the expiration date for the exemption, without making any other changes to it, would not address one structural issue with the exemption. Most of the economic benefits of the exemption occur during data center construction, but the exemption provides companies with substantial tax benefits in subsequent years after economic benefits have declined.

Allowing the exemption to expire could help reduce industry growth and associated energy demand

Virginia's utilities have historically been able to keep up with energy demand, but even if data center energy use grows at only half the forecasted rate, the state will need to make enormous investments in energy infrastructure. While data centers will incur much of the cost of new infrastructure investments, energy rates for all users are likely to increase. Growing energy demand could also make it more difficult for the state to meet goals set forth in the Virginia Clean Economy Act.

If the General Assembly wishes to slow down the data center industry's growth in Virginia because it determines that energy concerns outweigh the industry's economic benefits, it could allow the sales tax exemption to expire in 2035. While it is difficult to gauge the exact effect this would have, it is likely industry growth would slow and

could eventually stop or even contract. If the industry contracts, it would reduce the need for future generation and transmission infrastructure but would actually increase energy costs paid by other ratepayers, who would have to share a larger portion of current systemwide costs. While the state could allow the exemption to expire only in certain localities or regions, like Northern Virginia, that approach would be less effective in reducing overall growth in energy demand. Industry growth is occurring in several counties outside of the Northern Virginia region and is expected to continue, so allowing the exemption to expire in Northern Virgina while extending it elsewhere would not address the energy impacts where much of the future industry growth is likely to occur (sidebar).

Outside of the Northern Virginia planning district, data center projects are currently under development in the counties of Caroline, Chesterfield, Culpeper, Fauquier, Hanover, Henrico, Louisa, Mecklenburg, Pittsylvania, Powhatan, Spotsylvania, and Stafford. Dominion Energy expects the Stafford area to "become another super large market" like Loudoun and Prince William counties.

If the General Assembly allowed the exemption to expire in 2035, it would need to determine how to treat the large subset of data centers that will likely qualify for the special 2040 or 2050 extension. This extension currently pertains only to Amazon Web Services, but other companies may be interested in developing agreements to use the extension. Disallowing Amazon Web Services from using the extension would likely affect its custom performance grant agreement with the state to develop multiple data center facilities throughout Virginia, which was negotiated under the assumption the company would receive the extension, and could be subject to legal challenges.

POLICY OPTION 9

The General Assembly could allow the sales and use tax exemption for data centers to expire in 2035.

Exemption could be changed to balance industry growth with energy impacts

By either extending the exemption or allowing it to expire, the state would be choosing either economic benefits or reduced energy impacts. An alternative approach is to try and balance these competing objectives. The state could do this by allowing the *full* exemption to expire in 2035 (or ending it before then) and applying a *partial* tax exemption to 2050.

The size of a partial exemption could depend on whether the state wants to emphasize economic benefits or reduced energy impacts. For example, under the current exemption, qualifying companies are exempt from paying the full 4.3 percent state share of the retail sales and use tax and local and regional portions (sidebar). Focusing on the state share, a partial exemption could require qualifying companies to pay a 1 percent sales tax, which would keep much of the exemption's value intact and would likely remain somewhat effective at promoting industry growth (but would do less to reduce energy use). Alternatively, qualifying companies could be required to pay a higher 3 percent sales tax, which would likely be less effective at promoting industry growth and so would reduce future energy use more. By choosing a higher partial tax rate, the state could risk losing some of its existing data centers, particularly in Northern

The statewide retail sales and use tax includes a 4.3 percent state share, a 1 percent local option share, and an additional 0.7 percent to 1.7 percent regional share, depending on the region.

Virginia, although this risk may be diminished by the region's many attributes that make it so attractive to the industry.

The state would need to determine if the partial exemption would apply to data centers that qualify for the existing special 2040 or 2050 extension. This extension currently pertains only to Amazon Web Services, but other companies may be interested in developing agreements to use the extension. To be most effective at addressing energy impacts, and to maintain a level playing field for competitors, the same or a similar partial exemption could also be applied to these data centers.

POLICY OPTION 10

The General Assembly could amend the Code of Virginia to extend a partial sales and use tax exemption for data centers from 2035 to 2050.

A partial exemption would also better align the economic benefits the state receives with the exemption's value. Most economic benefits occur during construction, and switching to a partial exemption in 2035 would reduce the value of the exemption in later years when the economic impacts of current and planned data centers could be expected to slow. A partial exemption would also generate more revenue for the state. For example, a 1 percent partial sales tax would have generated approximately $160 million in state tax revenue in FY23.

Exemption changes could address other policy concerns related to the data center industry

Virginia's sales tax exemption currently requires...

50 new jobs located at the data center, associated with operations or maintenance.

Jobs pay at least 150% of the prevailing annual average wage of the locality where the data center is located.

$150 million in capital investment.

Requirements are lower for data centers in economically distressed localities (10 jobs and $75 million capital investment).

If the decision is made to extend the exemption, this report provides several options the General Assembly could enact to modify it and address concerns in specific policy areas (Table 7-1). These policy options would add new requirements, in addition to the existing requirements, for data centers to be eligible to receive the exemption (sidebar). These options could be phased in gradually to give data center companies enough time to implement them, and the General Assembly could decide to enact some but not others.

The General Assembly will need to determine its primary policy goals for the industry to determine whether to add new requirements to the exemption. If some or all of these policy options were adopted, it would likely make the exemption harder to use and more complex to administer. Alternatively, the General Assembly could pass legislation *requiring* the industry to take these actions, regardless of whether they qualify for the exemption, but this approach could lead to some data centers choosing to either shut down or operate in violation of the law.

The policy options in Table 7-1 would require changes to the Memoranda of Understanding (MOUs) all data center companies are required to enter into with the Virginia Economic Development Partnership (VEDP) to receive the exemption. Current law allows all of a company's data centers in a specific locality to collectively qualify for

the exemption. Therefore, the company reports data to VEDP for all of its data centers in each locality where it operates rather than by each individual data center. Policy options that apply only to new data centers might require changing MOUs to apply to each individual data center or to have addenda to the MOUs that identify the individual eligible data centers. VEDP would need to determine exactly how MOUs would need to be restructured.

VEDP would also need to determine the evidence data center companies would need to provide to qualify for the exemption, which would likely add to the complexity of administering the exemption. For example, companies could be required to provide appropriate documentation before a new data center becomes operational to qualify for the exemption. Alternatively, companies could be allowed to self-certify under the condition that documentation must be provided if requested by VEDP or Virginia Tax. VEDP would need to develop guidelines for how to implement any new compliance requirements and set forth new terms in the MOUs.

TABLE 7-1
General Assembly could modify the sales tax exemption to address energy, natural resource, historic resource, and residential impacts

Change	Issue Addressed	Policy option
Options that could apply to *all* Virginia data center operations		
Implement ISO-50001 Energy Management standard or equivalent	Energy impacts and costs	1
Implement ISO-14001 Environmental Management Systems standard or equivalent	Natural resource impacts	5
Options that could apply to *new* data centers built after a certain date		
No Tier 2 diesel generators in Northern Virginia Ozone Non-Attainment area without SCR systems	Natural resource impacts	4
Phase 1 historic resources study required, viewshed study required if near registered historic site	Historic resource impacts	6
Sound modeling (noise) study required	Residential impacts	8

SOURCE: JLARC staff analysis.
NOTE: ISO = International Organization for Standardization. SCR = Selective Catalytic Reduction systems that reduce emissions of nitrogen oxides, a major contributor to smog-forming ozone, and other harmful emissions.

Appendix A: Study resolution

Resolution of the Joint Legislative Audit and Review Commission directing staff to review data centers

Authorized by the Commission on December 11, 2023

WHEREAS, there has been substantial growth in the data center industry in Virginia, particularly Northern Virginia which has the largest concentration of data centers in the world, Southern Virginia, the Greater Fredericksburg region, and the Greater Richmond region; and

WHEREAS, growth in the data center industry is expected to continue with increasing demand from deployment of advanced and innovative technologies used by individuals, business of all sizes across all industries, government agencies, and other organizations that require the digital infrastructure that data centers provide; and

WHEREAS, data centers can bring economic benefits to localities because they can create significant economic activity during construction, they can increase property tax revenue for local governments without placing high demands on government services like schools, and the clustering of data centers can make a region more attractive to other high tech businesses and help support ecosystems of vendors, service providers, and suppliers; and

WHEREAS, concerns exist over data centers because they require large amounts of energy, which can affect the broader energy market; they may have impacts on natural, historical, and cultural resources; and some citizens have expressed opposition to having data centers located near residential areas due to concerns over issues such as noise and the adverse visual impact: and

WHEREAS, the data center sales tax exemption is Virginia's largest economic development incentive, and JLARC conducted an in-depth review of the exemption in 2019; now, therefore, be it

RESOLVED by the Joint Legislative Audit and Review Commission that staff be directed to review the overall impacts of the data center industry in Virginia and state and local policies regarding the industry. In conducting its study staff shall (i) research recent and expected trends in factors impacting data center industry growth and forecast future growth of Virginia's data center industry, taking into account how various factors may affect these projections; (ii) assess impacts of the data center industry on Virginia's natural resources, as well as historic and cultural resources, and identify potential technologies that could reduce their impacts on these resources; (iii) assess the impacts of the data center industry on current and forecasted energy demand and supply in Virginia, including how data centers will likely affect future energy infrastructure needs, energy rates paid by customer classes and whether cost allocation methods ensure no single customer class is unreasonably subsidized by other customer classes, and the state's ability to transition from fossil fuels to renewable energy sources; (iv) estimate the impact of the data center industry on local revenue and assess how local tax policies may affect data centers; (v) identify how data centers may impact local residents, including concerns such as noise pollution, decreasing property values, and

the adverse visual impact; (vi) identify considerations around the construction and siting of data centers, and review how zoning and regulatory restrictions and requirements can affect data center deployment; (vii) identify guidance and assistance state agencies could provide to local governments for use in making decisions about the location and expansion of data centers; (viii) assess whether more geographically diverse data center industry growth would provide greater economic benefits to the Commonwealth, and if so, identify obstacles to attracting data centers to other areas, particularly economically distressed or rural regions of the state, and policy changes that could increase geographic diversity, such as changes in electricity policy, tax policy, and broadband infrastructure policy; (ix) compare Virginia's competitiveness in attracting data centers with other states; and (x) determine if Virginia's data center tax exemption could be improved, including whether the exemption could be better targeted, the level of benefit is appropriate given the cost, or other changes should be considered.

JLARC may make recommendations as necessary and may review other issues as warranted.

All agencies of the Commonwealth, including the Virginia Department of Energy, the Virginia Department of Environmental Quality, the State Corporation Commission, the Virginia Economic Development Partnership Authority, the Virginia Department of Taxation, and Virginia local governments shall provide assistance, information, and data to JLARC for this study, upon request. JLARC may use consultants as necessary to complete the study. JLARC staff shall have access to all information in the possession of agencies pursuant to § 30-59 and § 30-69 of the Code of Virginia. No provision of the Code of Virginia shall be interpreted as limiting or restricting the access of JLARC staff to information pursuant to its statutory authority.

Appendix B: Research activities and methods

Key research activities performed by JLARC staff for this study included:

- structured interviews with local residents and stakeholder groups, data center companies and developers, state and local officials, electric and water utility companies, and subject-matter experts;
- contracts with consultants to produce an independent energy demand forecast for Virginia and its utilities, and model how future data center growth in Virginia is likely to impact energy supply, demand, emissions, and cost;
- site visits to data centers and nearby communities;
- development of inventories of (i) operational and (ii) planned data centers;
- economic impact analysis of the data center industry (see Appendix D);
- data collection and analysis, including on data center water usage, emissions, capital expenditures, employment and tax benefits amongst users of the data center tax exemption, and data center proximity to residential areas;
- review of state and local laws, ordinances, reports, and policies relevant to energy, natural and historic resources, land use, and noise;
- review of research literature relevant to data centers, energy, natural and historic resources, and noise; and
- review of other documents, literature, and media sources.

Structured interviews

Structured interviews were a key research method for this report. JLARC staff conducted over 250 interviews with 165 different stakeholders.

Residents and stakeholder groups

JLARC staff conducted interviews with nearly 20 local residents and resident stakeholder groups, such as neighborhood associations, including those in Fairfax, Fauquier, Henrico, Loudoun, and Prince William counties. These interviews focused on the impact of data centers on local residents and communities, such as viewshed and noise issues.

JLARC staff also conducted roughly 20 interviews with state and regional stakeholders groups, including those that represent data center companies, electric cooperatives, construction tradespeople, land conversation and preservation, battlefield preservation, sustainability and the environment, and local and tribal interests. Staff interviewed the American Battlefield Trust, Clean Virginia, Cultural Heritage Partners, Data Center Coalition, Friends of the Rappahannock, Northern Virginia Technology Council, Preservation Virginia, Sierra Club, Southern Environmental Law Center, Virginia Association of Counties, Virginia Association of Soil and Water Conservation Districts, Virginia Chapter of the American Planning Association, Virginia Clinicians for Climate Action, Council of Virginia Archaeologists, Virginia Data Center Reform Coalition, Virginia Farm Bureau Federation, and Virginia, and Maryland & Delaware Association of Electric Cooperatives. Staff also interviewed

representatives of the Pamunkey tribe. These interviews covered a range of topics related to the impact of data centers.

Data center companies and developers

JLARC staff conducted nearly 40 interviews with 12 data center companies and developers. These companies operate colocation and hyperscale data centers in Virginia and include industry leaders. These interviews covered a range of topics, including their data center operations in Virginia, the economic impact of data centers, data center site selection, energy issues and sustainability, and the impact of data centers on natural and historic resources, local planning, and community impacts.

State agency staff

JLARC staff conducted more than 30 interviews with state agency staff, including staff from the Virginia Department of Environmental Quality (DEQ), State Corporation Commission, Virginia Economic Development Partnership, Virginia Department of Taxation, Virginia Department of Conservation and Recreation, Virginia Department of Historic Resources, Virginia Department of Forestry, Virginia Department of Agriculture and Consumer Services, Virginia Department of Energy, Virginia Department of Housing and Community Development, and Virginia Department of General Services. These interviews covered a range of topics related to the impact of data centers, including energy issues, issues related to natural and historic resources, and economic development.

Local government staff

JLARC staff conducted more than 50 interviews with local government staff and elected officials in Caroline, Chesterfield, Culpeper, Fairfax, Fauquier, Frederick, Henrico, Loudoun, Mecklenburg, Prince William, Stafford, and Wise counties, and the town of Warrenton. These interviews covered a range of topics, including planning and zoning, economic development, environmental services, public works, historic resources, and local tax and revenue impacts.

Federal government staff

JLARC staff conducted interviews with staff at the U.S. Army Corps of Engineers, U.S. Department of Agriculture, and U.S. Environmental Protection Agency. These interviews generally focused on the impact of data centers on natural resources.

Electric companies and cooperatives in Virginia and Virginia's regional transmission organization

JLARC staff conducted more than 20 interviews with electric companies and cooperatives in Virginia, including Dominion Energy, Appalachian Power Company, and the Central Virginia, Mecklenburg, Old Dominion, Northern Virginia, and Rappahannock electric cooperatives. These interviews focused on the impact of data centers on energy demand, supply, and rates. Interviews with Dominion Energy also focused on energy transmission and generation issues.

JLARC staff also interviewed the PJM regional transmission organization, which serves Virginia. These interviews focused on energy transmission and generation in the region, as well as the impact of data centers on energy demand and supply.

Water utilities

JLARC staff conducted 15 interviews with local water utilities, including those in Caroline, Fairfax, Fauquier, Henrico, Loudoun, Mecklenburg, Prince William, Stafford, and Wise counties. These interviews focused on the impact of data centers on water utilities, planning, and availability.

Subject-matter experts

JLARC staff conducted more than 25 interviews with subject-matter experts across a range of topics related to data centers. These experts included researchers at the Cooling Technologies Research Center at Purdue University, Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, Occoquan Watershed Monitoring Laboratory, and Rutgers Noise Technical Assistance Center; experts at engineering, law, and real estate firms with experience working with data centers; and leading data center construction materials and equipment manufacturers, such as a steel fabricator and generator manufacturer.

Contracts with consultants

JLARC contracted with faculty from the Weldon Cooper Center for Public Service at the University of Virginia (Weldon Cooper Center) to develop an independent energy demand forecast for Virginia and its utilities. JLARC also contracted with consulting firm Energy + Environmental Economics (E3) to model how data center growth in Virginia is likely to affect future generation and transmission needs and whether the associated costs of system changes could be passed on to residential ratepayers. E3's work was divided into two projects: (1) grid modeling and (2) cost of service and rate impacts.

Additionally, JLARC contracted with Terance Rephann and Joao Ferreira, regional economists at the Weldon Cooper Center, to assist in the economic impact analysis. The methods used for the economic impact analysis are described in Appendix D.

Weldon Cooper Center energy demand forecast

WCC was contracted to develop an independent energy demand forecast for Virginia that accounts for the expected growth of the data center industry. WCC collected data on historical retail energy sales for Dominion Energy, Appalachian Power Company (APCO), and utilities serving the rest of Virginia. WCC collected additional data on retail energy sales to *data center* customers for the utilities that currently serve most of the Virginia data center industry: Dominion, Northern Virginia Electric Cooperative (NOVEC), and Mecklenburg Electric Cooperative (MEC). WCC also collected data on metered load forecasts for data center customers in the Rappahannock Electric Cooperative (REC). REC does not currently have any operational data center customers, but a substantial number of new, large data center campuses are planned to be built in REC's distribution service territory.

Using historical energy sales data, WCC applied advanced statistical methods to develop an *unconstrained energy demand* forecast for Virgina. The unconstrained demand forecast shows what demand would be before accounting for constraints like the ability to build enough energy infrastructure to meet demand. WCC also developed a forecast for *half of unconstrained demand* to provide a lower-growth scenario for analysis purposes. Finally, WCC developed a *no new data center demand* forecast so that the effects of the industry on energy demand could be isolated for analysis purposes. WCC's forecast

made several projections, including baseload demand growth from all non-data center customers, demand growth from data center customers, and demand growth from electric vehicles. Additional details on the data and statistical methods used to develop the forecast are detailed in WCC's final report to JLARC staff.

WCC's forecasts cover the period from 2025 to 2050, because VCEA requires carbon emitting generation owned by Dominion and APCO to be retired by 2045 and for the utilities to have all energy from non-carbon emitting sources by 2045 (Dominion) or 2050 (APCO). However, because forecasts become more speculative the farther out they go, this report shows energy demand forecasts up to 2040. The energy demand forecasts for later years are detailed in WCC's final report to JLARC staff.

One of the limitations of the WCC forecasts is that historical data does not fully capture some of the trends that are likely to drive future data center growth, such as how artificial intelligence (AI) will be developed and deployed. However, the unconstrained demand forecast is within the bounds of what can be expected in the next five-plus years based on the electric service and construction agreements that utilities report having in place with data center customers. It is important to note that because forecasts were developed using actual, historical energy sales, they are not subject to distortion by speculative capacity requests from developers or data center companies.

Energy + Environmental Economics grid modeling (project 1)

E3 developed a model of the regional PJM generation and transmission grid. E3 then converted the WCC *energy* demand forecasts into *peak load* demand forecasts that estimate the highest overall power demand that would be placed on the grid each year, under different scenarios. The peak load forecast considered daily and seasonal energy use trends and weather patterns. E3 then modeled three main demand scenarios. For each of the demand scenarios, the model considered the most feasible and economical approaches to meeting infrastructure needs with and without the requirements of the Virginia Clean Economy Act (VCEA).

- Scenario 1: unconstrained demand, with and without VCEA. E3 also modeled variations where unconstrained demand and VCEA requirements could be met by using high levels of nuclear and renewable generation or by better regional coordination across PJM.
- Scenario 2: half of unconstrained demand, with and without VCEA.
- Scenario 3: no new data center demand, with and without VCEA.

E3's modeling used industry standard approaches and tools used for electric utility and state energy planning purposes. The model applied constraints on the amounts of infrastructure that could be built by 2030 using historical build rates, relaxed those constraints for 2035, and removed most constraints for 2040 and following years. Modeling was based on state and federal laws and regulations in place in 2024. For VCEA scenarios, the model followed the "letter of the law" and assumed that certain requirements—such as the Renewable Portfolio Standards and associated Renewable Energy Certificate requirements for investor-owned utilities—would not apply to electric cooperatives. This assumption has a significant impact because a majority of future data center growth is expected to occur in the electric cooperatives' distribution service territories. Societal costs, such as the social cost of carbon, were not explicitly included in the model. Additional details on the exact methods and assumptions used to develop the model are detailed in E3's final report to JLARC staff.

For each scenario, the model predicted the mix of generation and transmission capacity that would be needed to meet demand, the resulting mix of generation energy sources (including energy imports), and their associated emissions. Outcomes were developed for the Dominion transmission zone, Virginia, and the PJM region. The model also predicted system costs for the Dominion transmission zone, where most data center growth is expected to occur. Each scenario outcome was tested to ensure that the system being built would be functional and meet industry standard reliability requirements.

E3's grid modeling covers the period from 2025 to 2050 because VCEA requires all carbon emitting generation owned by Dominion and APCO to be retired by 2045 and for the utilities to have all energy from non-carbon emitting sources by 2045 (Dominion) or 2050 (APCO). However, because energy demand forecasts and generation options become more speculative in further out years, this report only shows model results up to 2040. The model's results for later years are detailed in E3's final report to JLARC staff.

Energy + Environmental Economics cost of service and rate impact analysis (project 2)

For the cost-of-service analysis, E3 examined how costs were being incurred and allocated to different customer classes under the rate structures in place at Dominion Energy, NOVEC, and MEC. The purpose of this analysis was to determine if the current rate structures were wholly recovering costs from the customers who are incurring those costs. E3's cost-of-service analysis was done using industry standard approaches and tools for electric utility planning purposes. Additional details on the exact methods and assumptions used in this analysis are detailed in E3's final report to JLARC staff.

For the rate impacts analysis, E3 focused on how changing demand could affect generation and transmission costs for residential ratepayers in Dominion's distribution service territory. Dominion was chosen because of its large size and concentration of data centers. Residential rate changes were a key focus because they show how Virginia households could be affected by growing data center demand and are indicative of how other customers, such as businesses, might be affected.

E3's analysis of rate impacts followed three steps. First, E3 estimated total costs that would be attributable to the Dominion transmission zone, under the different energy demand scenarios discussed above, using its grid model. Second, for the Dominion distribution service territory, E3 estimated how costs would be allocated to residential customers, assuming that the company regularly reallocated costs to its different customer classes using current state- and federally approved allocation methodologies. Third, E3 translated these costs into the incremental cost per kilowatt-hour that would be passed on to residential ratepayers.

E3's rate impact analysis was limited to generation and transmission cost increases that could be attributed to growing data center demand. The analysis captures the cost of transmission needed to increase capacity into the Dominion transmission zone (interzonal transmission) and to interconnect with new generation sources. A significant portion of potential future transmission costs, associated with transmission projects *within* the Dominion transmission zone (intrazonal transmission), were not captured because these projects and their costs cannot easily be predicted. The analysis did not consider potential changes to distribution rates because most increases in distribution costs from the data center industry are effectively allocated to and recovered from these customers. E3's analysis also did not consider how Dominion's allowable profit margin would factor into rate impacts.

JLARC staff converted E3's rate impact data to show how a typical residential customer, using 1,000 kilowatt-hours of energy per month, could be affected. JLARC staff's conversion included an adjustment to account for Dominion's allowable profit margin but did not incorporate several other costs that affect the total residential bill. Consequently, Dominion's total residential bill projections, from its integrated resource plan, show much larger overall increases than the numbers presented in this report. Dominion's projections apply to the whole residential bill and include several costs that are not captured in JLARC's analysis, such as distribution costs and the cost of some additional transmission and generation projects that may not be solely attributable to data centers. Dominion's residential bill projections are also in nominal dollars that have been adjusted upward using an inflation assumption whereas JLARC's are held in constant (or real) 2024 dollars to show the real growth of costs that consumers will experience, independent of inflation. The demand forecast that Dominion uses in its rate projections is similar to the WCC unconstrained demand forecast but substantially higher than the half of unconstrained demand forecast.

Site visits

JLARC staff conducted site visits to two operational data centers in Virginia, including one in Loudoun and one in Henrico. Staff conducted these site visits to better understand how data centers are designed and operated. For example, staff observed the data halls, power and cooling systems, and backup generators, and listened to noise levels throughout the facilities. Staff also spoke with a variety of personnel at the data centers, including facility operations managers and operational and maintenance staff.

Additionally, JLARC conducted multiple site visits to observe areas with data center development and neighborhoods with nearby data centers. Two of these site visits were led by stakeholder groups with extensive participation in local zoning processes and studies of data centers. JLARC visited eight neighborhoods close to operational data centers or data centers in various stages of development. At all but one of those locations, JLARC staff spoke with residents about their perspectives on the data centers. Additionally, JLARC visited a commonly used trail adjacent to a data center and visited land within Manassas National Battlefield next to property rezoned for a data center.

Data center inventories

JLARC staff developed an inventory of the operational data centers in Virginia. This inventory was used to map the presence of the industry in Virginia. The inventory was based on data provided by DEQ listing data center sites with active air emissions permits (which all Virginia data centers have for their diesel generators). This data was as of August 2024. Staff used the address field in this data to search county real estate assessment records, using these records to (i) confirm the address was associated with a data center and (ii) identify the size of the site (in terms of acres), the number of buildings on the site, when they were built, and their size (in terms of square feet). In a few instances, county records did not list the size of the building. In these instances, JLARC staff estimated the size of the building(s) on the site based on the total capacity (megawatts) of the generators permitted by DEQ.

Staff cross-referenced this information where possible, using publicly available information from data center company websites, the Existing and Proposed Data Centers map developed by the Piedmont

Environmental Council, and other websites that track the data center industry, such as Datacenter-Hawk. From this cross-referencing, JLARC staff identified a few sites that appeared to be data centers but were not associated with a DEQ permit. In these instances, JLARC staff estimated the capacity of the site (megawatts) based on the size of the building(s) listed on the site's real estate assessment record.

JLARC staff also developed a list of data center sites currently under construction, planned, or proposed in Virginia. This information was used to assess where data center growth is expected to occur in the state. To develop this inventory, staff monitored media articles announcing new and proposed data center development, such as those published by Data Center Dynamics and local news outlets. Staff also identified information about proposed data center sites by reviewing local data center-related zoning and permitting requests.

Data collection and analysis

Local data center tax revenue

JLARC staff calculated the proportion of local revenue that comes from data centers by collecting data center tax revenue from localities and comparing it to their total local revenue reported in the Auditor of Public Accounts' Comparative Report of Local Government Revenues and Expenditures for FY23.

Data center generator permit, emissions, and violations data

DEQ provided JLARC staff air permit data for Virginia data centers (who were identified by DEQ), including data center permitted generator numbers and energy capacities, maximum allowed annual emissions, and actual emissions from 2015–2023. Additionally, JLARC staff used DEQ annual point source emission data, enforcement action data (including notices or violations and any charges assessed), and National Emissions Inventory data for Northern Virginia in 2017 and 2020.

JLARC staff created summary statistics of data center permit information (such as generator numbers and maximum allowed emission) and actual emissions and examined trends across time, regions, and localities. Using a map generated through JLARC's data center inventory, JLARC staff also examined clusters of data centers and cumulative local emissions from data centers.

To understand how data center emissions compare to other industries and contribute to overall emissions, JLARC staff compared data center emission and violation data to that of other Virginia air permit holder groups from 2015–2023. Additionally, JLARC staff estimated the current and potential portion of Northern Virginia air emissions resulting from data centers using 2020 National Emissions Inventory data.

Data center water use

JLARC staff received 2023 data center water usage information from water utilities serving Fairfax, Henrico, Loudoun, Mecklenburg, and Prince William counties as well as the town of Wise. Usage was typically reported for anonymous, individual data center buildings. However, one utility shared combined data for all of their data centers buildings, and one shared all water meter data for data center companies but did not combine use by building. (Some data centers have multiple water lines.) Reclaim

water use amounts were identified in the data. Two utilities shared annual usage data; three shared monthly usage data; and one shared daily usage data. Five utilities were able to share some amount of information related to data center water use trends since 2019 or later. All utilities shared their total annual customer base water usage for 2023.

JLARC staff used this data to calculate individual and cumulative data center water usage amounts, including the portion of a local utility's water that goes to data centers. JLARC also examined data center water usage seasonal trends and trends in recent years. JLARC analyzed data center water usage relative to other industries and water users in Virginia based on DEQ's 2023 Annual Water Resources reports; non-agricultural, non-public utility withdrawal data shared by DEQ; and the U.S. Energy Information Administration's 2012 Commercial Buildings Energy Consumption Survey water use statistics.

Land conversion due to data centers

JLARC estimates of land conversion due to data centers are based on data center development land area summary statistics calculated in JLARC's data center inventory. These land area amounts were compared to statewide and locality natural land losses recorded in the U.S. Department of Agriculture's 2022 Census of Agriculture state-level data and the federal Multi-Resolution Land Characteristics Consortium's National Land Cover Database Enhanced Visualization and Analysis tool.

Proximity of data centers to residential zones

JLARC staff analyzed the distance between operational Virginia data center sites and residential zoning. This analysis was limited to eight localities that account for the vast majority (93 percent) of data center sites in the state. JLARC measured the distance between each operational data center site and the nearest residential zoning using the interactive maps on localities' websites. This measurement indicates the distance between property lines, but the distance between data center buildings and homes is greater because data center buildings tend to be located away from the property line. JLARC staff captured the smallest distance to residential zoning across the multiple parcels that comprise a single data center site. JLARC focused on residential zoning because the zoning classification reflects uses of a property permissible under current local ordinances. However, this approach sometimes *overstates* the distance between a data center site and residences in situations where land is zoned residential but contains no homes. The reverse is also true; this approach sometimes *understates* the distance between data center sites and residences in situations where land contains homes but is not zoned residential. JLARC summarized the proportion of data center sites very close to residential zoning (defined as within 200 feet, which is approximately half the length of a football field) and somewhat close to residential zoning (defined as within 500 feet, which is approximately 1 ½ times the length of a football field) (Table B-1).

JLARC also analyzed the change over time in the proportion of data center sites near residential zoning. For each data center site in the analysis, JLARC identified whether the site existed in 2015 using annual DEQ data about air emission permits, which Virginia data center sites have for their diesel generators. For the group of data center sites with any generators reported to DEQ in 2015, JLARC calculated the proportion within 200 and 500 feet of residential zoning. JLARC then compared those

proportions to the proportions of all data center sites within those specified distances to examine whether data center proximity to residential zoning has increased over time.

TABLE B-1
Proportion of data center sites near residential zoning varies by Virginia locality

	Proportion of data center sites within specified distance of residential zoning		Total data
Locality	**200 feet**	**500 feet**	**center sites**
Loudoun	24%	34%	71
Prince William	21%	21%	24
Fairfax	55%	70%	20
Henrico	38%	38%	8
Chesterfield, Culpeper, Fauquier, Virginia Beach [a]	25%	38%	8
Total	29%	37%	131

SOURCE: JLARC analysis of localities' interactive map websites and JLARC inventory of operational data centers.
NOTE: Six data center sites were excluded from the analysis because data on proximity to residential zoning was not available or reliable.
[a] These four localities are combined because the number of data center sites in each locality is very small.

Document and research literature review

JLARC staff reviewed numerous documents and literature pertaining to data centers, such as:

- Virginia state laws, regulations, and policies relevant to energy, natural and historic resources, land use, and noise;
- studies, reports, data, and other information on data center market size and forecasting data center industry growth;
- reports, presentations, and regulatory filings from Dominion Energy, electric cooperatives, and the PJM regional transmission organization, including those related to energy load, load forecasts, and transmission, generation, and distribution projects;
- research literature and stakeholder reports on natural and historic resources; data center backup power and cooling technologies; and data center, other land use, and technology impacts on natural and historic resources;
- federal, state, and local government reports, assessments, webpages, and other documents on natural and historic resources, data center, other land use, and technology impacts on these resources, land use best practices;
- local comprehensive plans, ordinances, and policies relevant to land use and noise;
- local government presentations and reports relating to data centers including documents prepared by staff, consultants, and workgroups;
- summaries of local approaches to data center regulation and recommended practices;
- documents and journal articles describing the science of sound waves, sound modeling processes, ways to reduce sound levels, and government approaches to regulating sound; and
- local, national, and international news media coverage of the data center industry.

Review of local ordinances and specific data center requests

JLARC staff conducted an in-depth examination of the way nine localities in Virginia govern data centers. The review included localities with the most existing data centers in Virginia (Loudoun, Prince William, Fairfax, Henrico, Mecklenburg), as well as several localities that have recently approved their first data centers (Caroline, Fauquier, Stafford, Warrenton). JLARC staff searched for ordinances specific to data centers, as well as other ordinances applicable to data centers due to their location or use category. The review focused on local rules regarding density (e.g., height, lot coverage), architecture (e.g., building materials), site layout (e.g., building setbacks), landscaping, and equipment screening. When specific to data centers, local rules related to environmental, water use or cooling systems, and electricity infrastructure were also identified.

Additionally, JLARC reviewed staff reports for 19 specific data center requests to local elected officials. These reports provided elected officials with information about requests for rezonings, special permits, and exceptions to local ordinances. JLARC staff reviewed reports from Caroline, Fairfax Henrico, Loudoun, and Prince William counties and the town of Warrenton. The purpose of reviewing these staff reports included learning about the types of potential positive and negative impacts from data centers, the types of conditions beyond minimum requirements that developers committed to, the standards against which local staff evaluated data centers, the frequency of data center development that was not by right, and the alignment between staff recommendations and the decision of elected officials.

Appendix C: Agency responses

As part of an extensive validation process, the state agencies and other entities that are subject to a JLARC assessment are given the opportunity to comment on an exposure draft of the report. JLARC staff sent relevant portions of the exposure draft to the State Corporation Commission (SCC), Virginia Economic Development Partnership (VEDP), Virginia Department of Environmental Quality, Virginia Department of Historic Resources, Dominion Energy, Northern Virginia Electric Cooperative, and Rappahannock Electric Cooperative.

Appropriate corrections resulting from technical and substantive comments are incorporated in this version of the report. This appendix includes response letters from SCC and VEDP.

JEHMAL T. HUDSON
COMMISSIONER

SAMUEL T. TOWELL
COMMISSIONER

KELSEY A. BAGOT
COMMISSIONER

COMMONWEALTH OF VIRGINIA

STATE CORPORATION COMMISSION

BERNARD LOGAN
CLERK OF THE COMMISSION
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November 22, 2024

Mr. Hal E. Greer, Director
Joint Legislative Audit and Review Commission (JLARC)
919 East Main Street, Suite 2101
Richmond, VA 23219

Dear Mr. Greer:

The State Corporation Commission appreciates the opportunity to review the draft of relevant portions[1] of the JLARC report, *Data Centers in Virginia* provided to Staff on November 13, 2024. The Commission Staff provided its high level feedback to JLARC Staff during a meeting held on Friday, November 22, 2024.

Please let us know if we may be of further assistance.

Respectfully submitted,

Jehmal T. Hudson
Chairman, State Corporation Commission

[1] Sections 3 and 4, and Appendices F, G, I, and J.

VEDP | Virginia Economic Development Partnership

November 21, 2024

Mr. Hal E. Greer, Director
Joint Legislative Audit & Review Commission
919 East Main Street, Suite 2101
Richmond, VA 23219

Re: VEDP response to the draft JLARC report, *Data Centers in Virginia*

Dear Mr. Greer:

Thank you for providing an opportunity for us to review relevant sections of chapters 1, 2 and 7 of the Joint Legislative Audit & Review Commission's (JLARC's) draft report, *Data Centers in Virginia*.

The content we reviewed provides a helpful overview of the data center industry and its importance to the Commonwealth. As the report highlights, data centers are key hubs of the world's digital infrastructure, and their concentration in Virginia has helped establish the Commonwealth as a global tech hub. We particularly appreciate your meticulous survey of the data center industry's presence in Virginia, which accounts for over 63 million square feet of data center space across 150 sites and directly employs more than 8,000 people, in addition to supporting tens of thousands of additional jobs.

Since your last comprehensive review of the industry in 2019, the geographic distribution of data centers across Virginia has changed considerably. Although many of the legacy assets are still concentrated in Northern Virginia, the industry has become an important opportunity for the entire Commonwealth. This expansion, particularly into rural areas, has been facilitated by technologies such as Artificial Intelligence, which are less constrained by latency requirements compared to other applications. Reflecting this trend, seven localities that previously lacked data centers have either approved new campuses or have pending applications, including several rural and "distressed" areas. VEDP's current project pipeline suggests that the spread of data centers across more localities is expected to continue, provided that Virginia continues to offer a competitive sales and use tax exemption.

Your report also demonstrates the significant and far-reaching impact of the data center industry. Notably, the analysis estimates that the data center industry supports an impressive 74,000 jobs, $5.5 billion in labor income, and $9.1 billion in Virginia GDP overall to the state economy annually. In particular, we appreciate that your report shines a spotlight on the significant knock-on effects of the industry that extend to virtually every corner of the Commonwealth.

VEDP strongly agrees with the report's finding that the sales and use tax exemption has been an important part of the industry's growth and continues to drive site selection and expansion

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decisions. VEDP has responsibility for administering, in cooperation with the Department of Taxation, this important program on behalf of the Commonwealth and is pleased to see that new data collected by VEDP is serving to strengthen transparency. Your analysis adeptly leverages this data to demonstrate the significant state and local tax revenues generated by the industry.

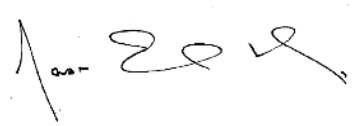
This valuable report comes at a critical juncture for the data center industry. Coming on the heels of significant growth in recent years, the industry is expected to see continued, strong growth driven by demand for digital services and the emergence of new technologies, like Artificial Intelligence. These trends raise important questions about the implications of this growth.

Your report underlines various considerations that legislators will need to balance as they think about the future of the state's support for the data center industry. You correctly point out that sustaining the growth of the industry and its critical contribution to Virginia's economy will require action on the current 2035 sunset of the data center sales and use tax exemption. Allowing the existing exemption to sunset would result in development shifting to competing markets, and those effects are likely already beginning to be felt given the long timeframes the industry uses to analyze their investments.

Nonetheless, VEDP recognizes that balancing competing interests may prompt legislators to seek out a new paradigm for support that navigates a challenging middle ground. The report is helpful in providing a number of different policy options for them to consider. In the context of thinking about these different options, we strongly agree with the report's warning that saddling an incentive program with competing policy priorities is not sound economic development practice. Furthermore, VEDP would caution against any action that could constitute a legal or moral failure to deliver on commitments to companies that have chosen to invest in Virginia and have entered into performance agreements or memoranda of understanding with the Commonwealth. This could expose the Commonwealth to legal risks and seriously undermine our credibility with prospective investors in the future.

As always, we appreciate the professionalism and engagement of JLARC staff during the project and compliment your team on its insightful analysis and reporting.

Sincerely,



Jason El Koubi
President & CEO

Appendix D: Economic impact modeling of the data center industry

Weldon Cooper Center staff conducted economic impact analyses of Virginia's data center industry using IMPLAN (IMpact analysis for PLANning) software. IMPLAN has been used in many economic impact studies and is one of the most common tools used in economic impact analysis. Models here were built using 2022 IMPLAN Pro data released in November 2023 that utilizes a 546-sector IMPLAN sector scheme (IMPLAN® model. n.d.). Tables were customized for Virginia and two of its regions using the software.

Input-output analysis using the model produces industry-specific multipliers that indicate how economic activity in one sector of the economy affects the overall state or regional economy. For this study, we were interested in how changes in the data center industry affect the state and regional economy. Outcome variables examined include total employment, state GDP, and labor income.

For estimating the impact of the industry net of the state data center exemption, the opportunity cost of state funds was accounted for by increasing government spending, equivalent to the exemption amount.

Analysis included customization of IMPLAN sector for data centers to better reflect nature of the industry

Tracking the size and growth of the data center industry is challenging because of the absence of a specific industrial classification in government statistics. Data center activity often appears merged with the primary business operations of their parent firms, making their identification difficult[i].

The North American Industrial Classification System (NAICS) code 518210—Data Processing, Hosting, and Related Services—is typically used as a proxy for data centers, but this approach introduces what is usually referred to as "aggregation bias," as this category encompasses various unrelated activities that have a far higher representation in the sector than only data centers. For instance, an analysis of Virginia's 2016 employment data for that sector (518210) reveals that only 15 percent of the total employment in the sector was data center employment, with other data centers, cloud computing, and cybersecurity-related support services making up perhaps 2–5 percent more. Indeed, most employment in this sector involves other IT services, such as document scanning and software development, particularly in federal IT contracting in Northern Virginia. (See *Data Centers and Manufacturing Incentives*, JLARC 2019).

Data center employment is also dispersed across other industries. An examination showed that only 41 percent of data center jobs were classified under data processing, hosting, and related services. Significant portions were found in sectors like "wired telecommunications carriers" (30 percent), "telecommunications resellers" (10 percent), and "all other telecommunications carriers" (4 percent). This analysis excluded many enterprise data centers and colocated firms, whose employment is often reported under other business functions, further complicating efforts to track the industry accurately.

The IMPLAN sector for data centers that corresponds to the 518210 NAICS code for data centers is "436 - Data processing, hosting, and related services." However, using this sector introduces significant bias, as data centers represent only a small portion of its total activity. More importantly, the

expenditure patterns of this IMPLAN sector do not reflect the specific characteristics of data center operations. Because of this, there is a substantial mismatch between the commodity demand and value-added characteristics of the IMPLAN sector 436 and what we know of data center expenditure patterns. For instance, in 2020, IMPLAN data showed that less than 1 percent of gross output is spent on "electricity transmission and distribution" (0.68 percent) and water, sewage, and other systems (0.02 percent) even though data center industry reports estimate that electricity alone accounts for 40 percent of data center operating expenditures[ii]. Data center representatives also estimated energy accounts for about 40 percent of their operating costs during structured interviews. Similarly, employee compensation is overestimated in the IMPLAN model, accounting for 24 percent of output compared with 15 percent in industry-specific studies. This may lead to an inflation of induced economic impacts by overstating the income distributed to households.

In income distribution, little is known about other aspects of data center value added that are important for estimating activity impact, such as profit generation, distribution, and taxes paid. Indeed, data centers have the potential to contribute to local economies through tax payments, which are then reinvested via local government spending. However, IMPLAN's tax estimation methodology is quite generic and may not accurately reflect county- and state-level tax structures and exemptions. Therefore, modeling alternative tax scenarios with more realistic assumptions can help better estimate the local economic impacts of data centers.

The reliance on conventional and standardized IMPLAN sectors, particularly when key inputs are significantly misrepresented, leads to biased results in economic impact studies. Best practices in economic analysis suggest customizing expenditure patterns to more accurately reflect the unique characteristics of data center operations. Therefore, the expenditure patterns for IMPLAN sector 436 regarding electricity were increased to 40 percent and employee compensation was reduced to 15 percent. Sensitivity analysis was performed to see how changing these percentages affected results. For operational impacts, for example, customizing the IMPLAN sector to include 40 percent of electricity consumption lowers the employment multiplier for data center operations approximately 20 percent.

Analysis includes two modeling phases

This analysis was split into two phases, the construction phase (capital spending for initial development of the data center) and the operations phase (ongoing) to help policymakers better understand the industry's short-term and long-term impacts. The construction phase corresponds to the initial years of data center development and what must be put in place before a data center "works." The operations phase accounts for the impact of all the expenditures after the data center opens independent of whether they are considered capital or operational expenditures in their budget.

Construction phase

Information collected by VEDP from data centers using the exemption was used to determine amounts of capital spending by data centers to include in the analysis (Table D-1). The percentages of spending by capital spending category are consistent with other research[iii].

TABLE D-1
Initial capital spending of data centers using the exemption (by year)

Year	Land acquisition	Building and site improvements	Exempt equipment or software	Other
2021	$865 M	$3,927 M	$14,333 M	$940 M
2022	1,030	2,264	9,614	1,615
2023	1,689	5,309	16,009	1,002
Total	**$3,585 M**	**$11,501 M**	**$39,957 M**	**$3,557 M**
%	6.1%	19.6%	68.2%	6.1%

SOURCE: VEDP.

The VEDP data includes only data centers that benefited from the tax exemption. These data centers correspond to 92 percent of the data center activity in Virginia, according to DEQ records and JLARC staff analysis of locality real estate records to obtain data center square footage. Statewide, 8 percent of data centers were not included in those numbers. By region, it is estimated that only 5.45 percent of the data centers in Northern Virginia are nonexempt (94.55 percent are exempt) and 21 percent in other regions of Virginia are nonexempt. Capital spending was increased to account for the nonexempt data centers, and this new amount was assumed to be the direct impact of the industry (Table D-2).

TABLE D-2
Initial capital spending of data centers using the exemption (by region)

Year	Land acquisition	Building and site improvements	Exempt equipment or software	Other
Northern Virginia	$3,316 M	$10,638 M	$36,955 M	$3,290 M
Other regions	632	2,027	7,041	627
Virginia total	**$3,948 M**	**$12,664 M**	**$43,997 M**	**$3,917 M**

SOURCE: Weldon Cooper Center.

However, not all of this spending affects Virginia's economy, and a critical assumption of economic impact analysis is the share of capital expenditures that are generated locally. Land acquisition is not traditionally included in impact models since this represents a monetary flow or transfer of funds that will not necessarily translate into a shock in local production. The acquisition of computer and related IT equipment is not necessarily done locally, so it should be assumed that part of this equipment comes from outside the region. This is even more true as we examine smaller geographical areas that might not include the entities associated with wholesale, transportation, and production of this type of equipment. Only building and site improvements (construction) should be included as local production. To estimate the indirect impacts, the model included 100 percent of the building and site improvements as construction (specifically IMPLAN industry sector "51 – construction of new manufacturing structures") and 25 percent of the exempt equipment and software expenditures.

The assumptions described above were used to generate indirect and induced impacts of data center capital investment in Virginia, according to average annual capital investment between FY21 and FY23

(Table D-3). Impact estimates were also produced for Northern Virginia and other regions of the state. Analysis of the results indicates that most of the impacts are construction-related (for example 80 percent of the direct employment is construction-related) rather than from manufacturing and installation of IT equipment.

TABLE D-3
Impacts of initial capital investment in Virginia and by region, annual average FY21–FY23

Impact	Employment	Labor income	Virginia GDP	Total output
Statewide				
Direct	35,110	$2,646.6 M	$3,342.1 M	$7,887.7 M
Indirect	9,945	843.8	1,504.2	2,806.8
Induced	13,992	791.9	1,570.9	2,596.8
Total	**59,047**	**$4,282.4 M**	**$6,417.2 M**	**$13,291.3 M**
Northern Virginia				
Direct	27,703	$2,368.5 M	$2,957.6 M	$6,625.6 M
Indirect	5,577	585.4	1,30.1	1,733.3
Induced	7,510	490.3	963.7	1,488.2
Total	**40,790**	**$3,444.2 M**	**$4,951.4 M**	**$9,847.0 M**
Other regions of the state				
Direct	5,761	$406.5 M	$517.0 M	$1,262.5 M
Indirect	1,584	116.6	212.5	418.0
Induced	2,106	107.3	219.6	373.4
Total	**9,451**	**$630.4 M**	**$949.2 M**	**$2,053.9 M**

SOURCE: Weldon Cooper Center economic impact analysis using IMPLAN.

The statewide results do not match the sum of the results for Northern Virginia and other regions of Virginia because, for the sake of simplicity, a multi-regional input-output model was not used. Data center investment in other regions of the state affects Northern Virginia, and vice versa, but they are not accounted for because the model accounts for the impacts in one region only.

Operation phase

As explained above, to accurately describe the impacts of the ongoing operation, the model was customized to include a better perspective of energy and labor costs. For this analysis, the model assumed that 40 percent of operational expenditures are associated with electricity consumption, and that 15 percent of the industry spending was direct labor costs.

Several adjustments were made to VEDP employment information collected from data centers. The employment information VEDP collected from data centers was used to estimate data center direct employment, statewide, in Northern Virginia, and in other Virginia regions. This number was adjusted in several ways. First, the employment number was reduced by half because the VEDP information on employment tends to boost the number of jobs as data centers can account for the jobs associated with contractors or the employees of contractors in addition to data center employees. In input-output

terminology, this is an indirect impact of the industry. Several data center representatives stated that 50 percent of their jobs were associated with third-party hiring and the other 50 percent with direct jobs. Because the jobs reported by VEDP were all full time (or full-time equivalents), a factor was applied to transform these jobs to full-time and part-time employment as required by the model. Like for capital spending, employment was increased to account for the nonexempt data centers. This new amount was assumed to be the direct impact of the industry (Table D-4).

TABLE D-4
Model was adjusted to incorporate data center operating characteristics

Region	Employment	Labor income	Total output
Northern Virginia	3,426	$357.4 M	$2,382.7 M
Other regions of Virginia	947	62.0	413.1
Virginia statewide	**4,373**	**$419.4 M**	**$2,795.8 M**

SOURCE: Weldon Cooper.

The results obtained for the impacts of ongoing operation for Virginia are far less than the impacts of capital spending (Table D-5). For example, total employment impacts from a year of data center operations are estimated to be 14,817 jobs compared with total employment impacts of 59,047 jobs for a year of initial capital spending.

TABLE D-5
Impacts of data center operations in Virginia and by region, annual average FY21–FY23

Impact	Employment	Labor income	Virginia GDP	Total output
Statewide				
Direct	4,373	$419.4 M	$1,051.1 M	$2,795.8 M
Indirect	6,615	552.2	1,217.8	2,188.1
Induced	3,830	216.8	430.2	711.1
Total	**14,817**	**$1,188.4 M**	**$2,699.0 M**	**$5,695.0 M**
Northern Virginia				
Direct	3,426	$357.4 M	$956.2 M	$2,382.8 M
Indirect	4,333	441.8	963.9	1,552.5
Induced	1,966	128.4	252.5	389.9
Total	**9,725**	**$927.6 M**	**$2,172.5 M**	**$4,325.1 M**
Other regions of the state				
Direct	947	$62.0 M	$116.5 M	$413.1 M
Indirect	1,106	78.3	185.6	356.9
Induced	556	28.3	58.0	98.6
Total	**2,609**	**$168.6 M**	**$360.0 M**	**$868.5 M**

SOURCE: Weldon Cooper Center economic impact analysis using IMPLAN.

Data center industry impact

Mostly because of the impact associated with initial capital expenditures, data centers in Virginia generate 73,864 jobs per year, corresponding to almost $5,471 million of labor income, $9,166 million of Virginia GDP, and an increase in output of $18,986 million (Table D-6).

TABLE D-6
Summary of initial capital spending and operations impact statewide, annual average FY21–FY23

Impact	Employment	Labor income	Virginia GDP	Total output
Direct	39,483	$3,066 M	$4,393 M	$10,684 M
Indirect	16,560	1,396	2,722	4,995
Induced	17,822	1,009	2,001	3,308
Total	**73,864**	**$5,471 M**	**$9,116 M**	**$18,986 M**

SOURCE: Weldon Cooper Center economic impact analysis using IMPLAN.

Another aspect is that the state government could also opt to spend the exemption money on alternative sources. The alternative scenario was modeled to estimate impacts if the state would use the annual average exemption amount between FY21 and FY23 ($573 million per year) in alternative expenditures (Table D-7). These impacts were used to determine the impact of the industry accounting for the cost of the exemption. Accounting for this alternative use of the exemption amount (or opportunity cost), reduces additional jobs by about 5,000 (to 69,000 additional jobs on net) and reduces additional income and Virginia GDP by $0.4 billion and $0.5 billion, respectively, which are a small fraction of their total impacts (Table D-6).

TABLE D-7
Impacts to the state if the exemption amount was used instead for alternative government expenditures, annual average FY21–FY23

Impact	Employment	Labor income	Virginia GDP	Total output
Direct	3,534	$277.4 M	$359.1 M	$448.0 M
Indirect	403	27.7	48.3	88.5
Induced	1,197	67.8	134.5	222.4
	5,134	**$372.9 M**	**$542.0 M**	**$758.9 M**

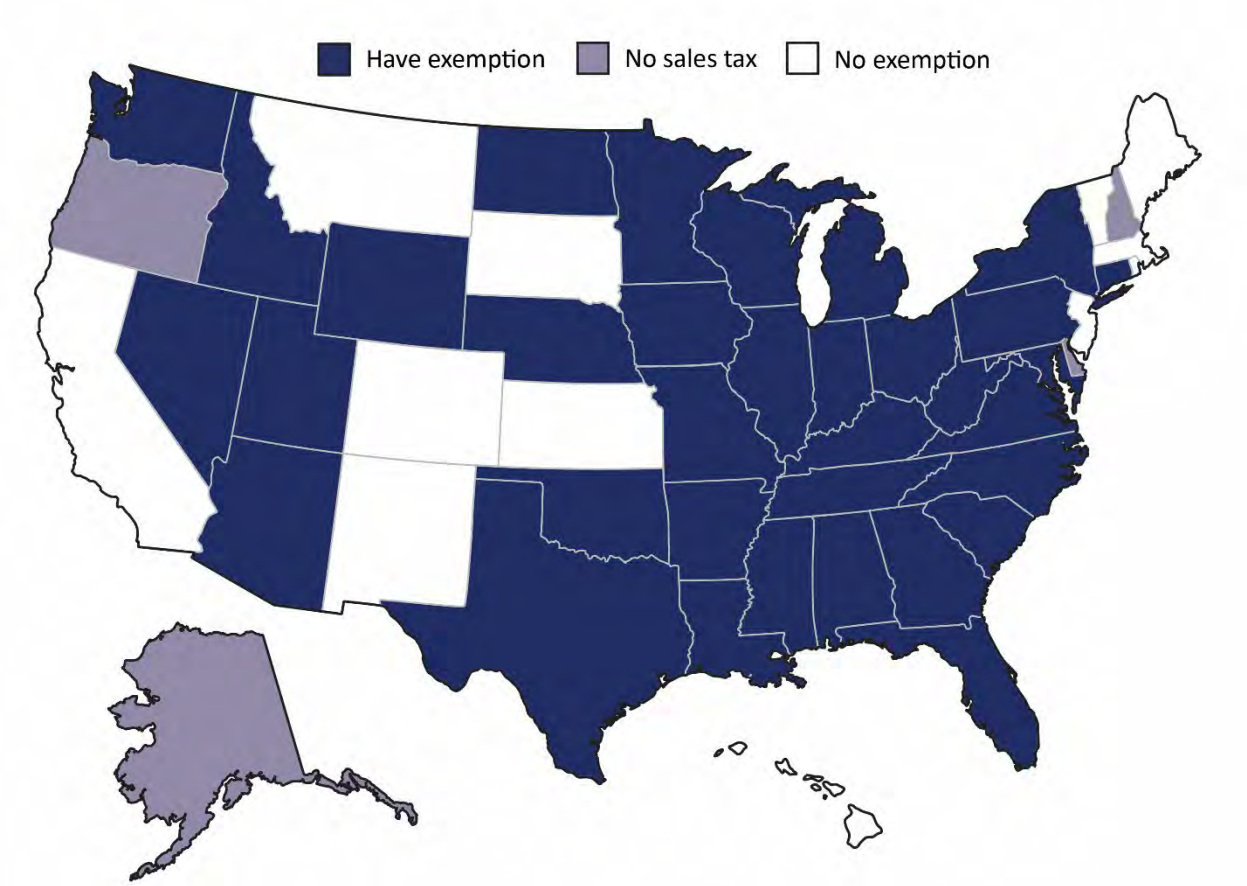
SOURCE: Weldon Cooper Center economic impact analysis using IMPLAN.

[i] Byrne, David, Carol Corrado, and Daniel E. Sichel. 2018. The rise of cloud computing: Minding your p's, q's and k's. NBER Working Paper 25188.
[ii] Day, Tim and Nam D. Pham. 2017. *Data centers: Jobs and opportunities in communities nationwide.* U.S. Chamber of Commerce Technology Engagement Center.
[iii] Day, Tim and Nam D. Pham. 2017. *Data centers: Jobs and opportunities in communities nationwide.* U.S. Chamber of Commerce Technology Engagement Center.

Appendix E: States with data center sales tax exemptions

Most states either have a sales tax exemption for data centers (34) or do not have a sales tax (Figure E-1). All states bordering Virginia provide a sales tax exemption to data centers.

FIGURE E-1
Nearly all states offer a sales tax exemption for data centers (2024)



SOURCE: State Tax Notes and JLARC staff review of state websites.

Appendix F: Energy infrastructure project impacts and regulation

Construction of new generation and transmission infrastructure can affect the communities and environments where they are built. The extent of any impacts will vary substantially for generation and transmission projects. State and local governments regulate these projects, through review and approval processes. Regulatory processes seek to minimize negative impacts but do not necessarily avoid them altogether. Utilities can implement several grid enhancing technologies to help reduce the need for major new generation and transmission projects, but this does not eliminate the need for new projects.

Construction of new generation and transmission infrastructure can have environmental impacts and is often opposed by local communities

On the generation side, a significant portion of new generation is expected to be solar, and solar facilities have large land demands that can have widespread impacts. For example, a modest 100 MW solar facility would require about 5,000 to 1,000 acres of land in Viriginia. (The rule of thumb is that five to 10 acres of solar can generate up to 1 MW of power.) Because of the large land demands, most solar facilities are built in rural areas. Constructing solar facilities typically involves clearing forest land or converting agricultural land to this use, which can have several environmental impacts from habitat loss to affecting stormwater runoff.

Some communities in rural Virginia have been increasingly opposed to new solar facilities, with several counties placing restrictions on solar development or outright denying projects. Community opponents site environmental concerns, impacts on local agriculture, and the effects of solar facilities' industrial appearance on the rural character of their counties. Opponents also often assert that solar facilities do not offer significant economic or other benefits to their communities.

The extent to which a solar project affects the environment and generates community opposition depends on the project. For example, a project that involves clearing 5,000 acres of forest land with multiple streams would have a more substantial environmental impact than a project that is installed on 2,000 acres of fallow pastureland. Similarly, a development located near a residential area or that is visible from the surrounding area could generate more community opposition than one that is hidden from view.

On the transmission side, new transmission lines can fragment forest habitats, create water quality risks at stream and wetland crossings, and reduce scenic quality of nearby historic and recreational resources. Communities are sometimes opposed to new or expanded transmission lines for these reasons. Communities also sometimes oppose new transmission lines because of their undesirable appearance, effect on the use of private properties that are under or adjacent to the lines, effect on the value of nearby properties, and health concerns.

Similar to the generation side, the potential environmental and community impacts of a transmission project can vary greatly from one project to the next. Generally, a "green field" project that involves acquisition of new right-of-way and construction of transmission lines where none currently exist is going to have the highest impact. A project where new lines are built in or adjacent to an existing

transmission line will be less impactful, and a project where an existing line is "wrecked and rebuilt" would be the least impactful.

State and local regulation is intended to minimize the impacts of new generation and transmission projects on communities and the environment

Construction of major new generation and transmission facilities is regulated by the state to minimize impacts. Many of these projects are approved by the SCC through a formal case process to determine if a Certificate of Public Convenience and Necessity (CPCN) should be granted. The SCC considers several factors before approving a project and granting a CPCN. These factors include the potential impacts of the project on property owners, the environment, and cultural and historic resources (Table F-1). While these impacts may not be completely avoided, the process encourages the selection of projects and options that best minimize impacts without placing large cost burdens on ratepayers.

Smaller renewable generation projects (<150 MW) can be reviewed and approved by the Department of Environmental Quality through a separate "Permit by Rule" process. While this is not a litigated case process like an SCC approval, projects are reviewed to ensure they conform with the state's requirements.

Localities have some authority over generation projects and transmission and distribution substations but minimal authority over transmission lines. Generation facilities and substations are subject to the same types of local zoning processes as other land uses. Local zoning ordinances specify which zoning districts allow them, whether they require a special permit from elected officials, and whether any design standards (such as landscaping) apply. Additionally, state law requires local reviews of certain entities—including substations—before development to evaluate their alignment with the local comprehensive plan. For transmission lines, CPCN approval deems the transmission line to be in compliance with local comprehensive plans and ordinances. In effect, this means localities do not have any direct authority over most transmission line project approvals or routes. (Although localities can play a role in approving 138 kilovolt transmission lines, which exist in a few parts of the state.)

Solar and similar projects are required to attempt to coordinate an agreement with their host locality. State law requires applicants for solar or energy storage projects to notify localities of their intent to develop and to meet with the locality to negotiate a "siting agreement." This siting agreement can include conditions such as mitigating negative impacts, and if created, must receive a public hearing. However, there is no requirement for this process to culminate in a siting agreement. Failure to achieve a siting agreement does not prevent a developer from initiating the usual local zoning processes for new developments.

Localities do not have approval authority over transmission line projects but can participate in SCC cases either as respondents or public witnesses. As a public witness, a locality can submit written comments, or local representatives can provide comments in person at commission hearings. As a respondent, a locality becomes a participant in the case and can take several additional actions, such as filing for discovery (e.g., to obtain copies of utility analysis or documents supporting the application for a project), filing briefs, providing expert witnesses, and participating in cross examination of

witnesses (e.g., utility staff). No matter which approach is followed, the SCC is required to hear and weigh all evidence equally.

TABLE F-1
Criteria that the SCC must evaluate before approving a project and granting a CPCN

Criteria that must be met

- Is not against the public interest [a]
- Will have no material adverse effect on system reliability
- Will have no material adverse effect on rates
- For transmission projects,
    a. the line is needed, [b]
    b. proposed method of installation is justified, [b]
    c. will avoid or minimize adverse impact on (a) scenic assets, (b) historic and cultural resources, (c) the environment, and (d) human health and safety, and
    d. why existing rights-of-way cannot adequately serve the need (presumably only applies when an expanded or new right-of-way acquisition is being requested as part of the project)

Criteria that must be considered

- Environmental impacts
- Human health and safety impacts
- Historical and cultural resource impacts
- Economic impacts, including job creation
- Improvement to service reliability
- Environmental justice considerations

Criteria that are considered, if requested

- Conformance with local comprehensive plans (locality must request) [c]
- Costs, economic benefits, and effect on construction timeline of undergrounding transmission lines (locality must request)

SOURCE: The Code of Virginia § 2.2-235, § 56-265.2, § 56-580, and § 56-46.1.
NOTE: SCC regulations provide additional information on what must be submitted to meet requirements and details what must be provided for transmission projects. SCC guidance also includes a planning and design attachment that provides detailed guidelines to applicants on how to ensure facilities protect natural and historic resources. SCC guidance provides additional information on when a transmission project requires a CPCN, based on specific characteristics. SCC guidance notes that certain transmission projects, such as reconductoring, do not require a CPCN.
[a] This is a general criterion that can be interpreted as the cumulation of all the other criteria weighed against each other. The Code declares some projects meet this goal—such as small renewable generation projects and projects in VCEA—and so do not require SCC to make a determination.
[b] Based on applicant's load flow modeling, contingency analysis, and presented reliability needs.
[c] Localities are explicitly granted right to present evidence that shows existing corridors, as designated in the comprehensive plan, can serve the identified need.

Localities also have three additional authorities under Code. First, localities can request that the SCC consider the costs, economic benefits, and effects on construction timelines of undergrounding transmission lines. Second, localities can establish transmission corridors in their comprehensive plans and provide evidence that new lines should be within those corridors, but it appears this latter

authority has been rarely (if ever) used. Third, localities can establish special tax districts that pay for the additional costs of undergrounding transmission lines, although it appears this authority has never been used.

Some stakeholders have said that local governments should have more authority to determine transmission routes and, especially, when transmission lines should be buried underground. While this would make transmission projects more responsive to local needs, undergrounding transmission lines is substantially more expensive and those added costs are currently spread across all utility ratepayers. Any changes to give localities more authority to require undergrounding of transmission lines would need to be accompanied by a change in how costs are allocated to prevent local government decisions from affecting rates paid by customers who do not benefit from undergrounding projects.

Utilities can use grid enhancing technologies to help reduce the need for new generation and transmission infrastructure

Utilities use grid enhancing technologies (GETs), such as reconductoring existing transmission lines, to increase capacity of the transmission system and more effectively use existing generation. For example, Dominion reports that it uses advanced conductors for all its 230 kV reconductor and new build projects, which can increase line capacity by 50 percent. Dominion reported adding or replacing 800 miles of line with advanced conductors as of the end of 2023. Dominion also reports deploying and piloting several other GETs to improve system stability and efficiency. Utilities have an economic incentive to deploy GETs so that they can provide enough transmission capacity to serve fast-growing demand.

SCC staff indicated that, before approving a new transmission line project, they consider whether a quicker and lower-cost approach, such as reconductoring, could be used instead. Staff make this determination by looking at the project proposal, the state need, and whether reconductoring will address the need. SCC staff carry out their own power flow studies and verify thermal issues, voltage issues, and generator deliverability (if applicable).

Appendix G: Virginia Clean Economy Act

The Virginia Clean Economy Act (VCEA) was enacted in 2020 and was intended to drive investment in renewable resources and phase out carbon-emitting generation in the state by 2050. VCEA was passed when energy demand in Virginia was projected to remain relatively flat. Now that demand is growing, largely because of data centers, it will be more challenging to meet these goals than originally contemplated.

The main way VCEA intends to decarbonize generation is by requiring an increasing share of energy sold by Dominion and APCO to come from renewable sources. The share of generation from renewables—the Renewable Portfolio Standard (RPS) requirement—increases each year until it reaches 100 percent (Table G-1). The utilities can meet the RPS requirement by directly building and claiming credit for new renewable generation facilities (mainly solar and wind) and entering into power purchasing agreements with third parties that operate renewable facilities. Utilities receive Renewable Energy Certificates (RECs) for energy from these sources, which are then credited toward their RPS requirement. Utilities can also purchase RECs from the PJM market and use purchased RECs to offset energy produced through carbon generation. Starting in 2025, 75 percent of Dominion's RECs must be from in-state generation sources. VCEA financially penalizes utilities that do not comply with in-state renewables requirements by levying deficiency payments, but in practice utilities may choose to pay those deficiency payments if it is more economical or feasible than securing new renewable generation. The cost of deficiency payments is recovered from utility customers. VCEA sets aside nuclear power as a third category of generation, which in effect can be used to reduce the total amount of renewable energy required.

TABLE G-1

VCEA requires growing share of energy sold in Virginia to come from renewable generation sources, with full decarbonization by 2050

	Percentage of total power sold required to come from renewables (excluding nuclear)	
	Dominion	APCO
2021 (year one)	14%	6%
2025	26	14
2030	41	30
2035	59	45
2040	79	65
2045	100	80
2050	-	100%

SOURCE: The Code of Virginia § 56-585.5.

NOTE: Percentages are the RPS program requirements for selected years; statute sets a percentage for every year. Nuclear power is excluded from the RPS calculation. For example, if one-third of Dominion power is nuclear, then the RPS percentage applies only to the remaining two-thirds of power that is not nuclear. Renewable energy is credited toward meeting RPS requirements through the purchase and retirement of Renewable Energy Certificates (RECs). RECs can be used to offset carbon emissions.

The VCEA's RPS requirements, and their associated REC requirements, do not apply to electric co-operatives (co-ops). This has significant implications because a majority of future energy demand growth is expected to occur in the co-ops' service territories, where many new data center campuses are expected to be built. (This is based on JLARC's consultant forecasts, and is corroborated with utility forecasts, utility construction and service agreements, and JLARC staff's review of data center projects that are actively under development). Unlike Dominion and APCO, state law allows co-ops to secure energy to meet their growing demand from non-renewable and out-of-state generation sources.

VCEA directs the Virginia Air Pollution Control Board to develop regulations to gradually reduce carbon emissions. VCEA states the board "may establish, implement, and manage an auction program" or "utilize an existing multistate trading system" to achieve this purpose. Initially the state entered into the Regional Greenhouse Gas Initiative (RGGI) to reduce carbon emissions. The state has since withdrawn from RGGI, although the legality of that withdrawal is being challenged in court. A recent state circuit court decision ruled that the regulatory actions the state took to remove Virginia from RGGI were unlawful, but this decision could be appealed to a higher court.

Finally, VCEA requires carbon-emitting generation in Virginia owned by Dominion and APCO to be retired by 2045. However, VCEA allows these utilities to continue operating carbon-emitting generation plants in Virginia past 2045 if taking the plant off-line "would threaten the reliability or security of electric service to customers." Utility decisions to keep plants operating past 2045 must be approved by SCC.

VCEA also has a presumption against the SCC approving new carbon-emitting generation plants, which applies to investor-owned utilities and co-ops. However, new carbon-emitting plants can be built if SCC determines they are needed to address threats to the reliability or security of electric service to the utility's customers.

Appendix H: Grid modeling generation capacity and energy source results

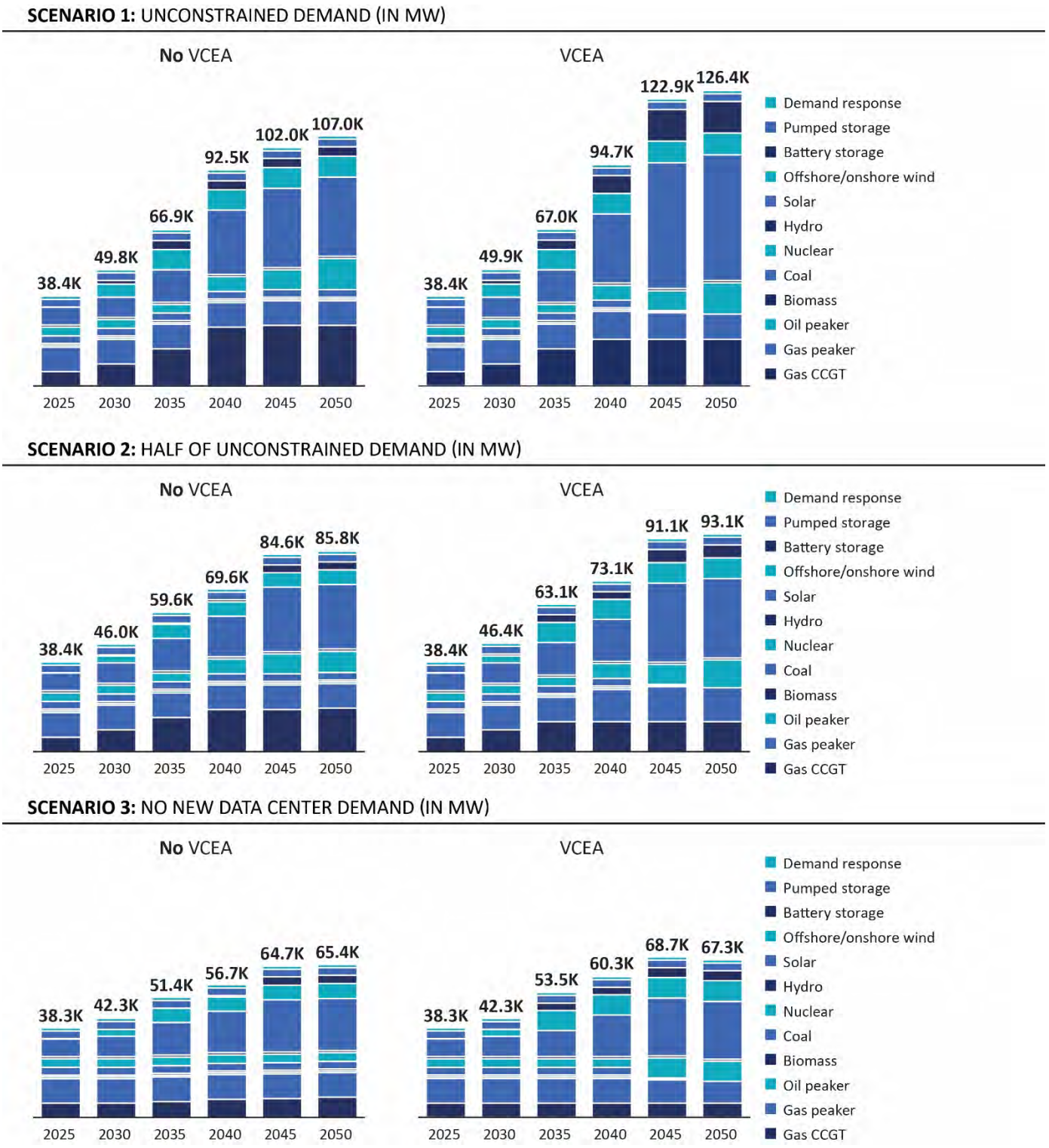
JLARC staff commissioned Energy + Environmental Economics (E3) to develop an independent grid model and project the future generation and transmission infrastructure that would be needed to meet three different demand scenarios. For each of the demand scenarios, the model considered the most feasible and economical approaches to meeting infrastructure needs with and without the requirements of the Virginia Clean Economy Act (VCEA).

- Scenario 1: unconstrained demand, with and without VCEA. E3 also modeled variations where unconstrained demand and VCEA requirements could be met by using high levels of nuclear and renewable generation or by better regional coordination across PJM (not shown in this report).
- Scenario 2: half of unconstrained demand, with and without VCEA.
- Scenario 3: no new data center demand, with and without VCEA.

This appendix provides E3's grid modeling Virginia-level results for the (a) in-state generation capacity that would be needed to meet each demand scenario, by type of generation source and (b) the amount of energy that would be used from each type of generation source. Generation capacity is given in megawatts (MW) of nameplate capacity that would be needed, which can be significantly higher than the firm amount of capacity available from a resource. For example, Virginia solar facilities produce around 25 percent of nameplate capacity. Generation energy is given in annual tera-watt hours (TWh) of energy used. E3's grid model assumes natural gas plants would be converted to hydrogen fuel in each scenario when VCEA compliance is assumed, starting in 2045. The model assumes that new nuclear generation will not be available until 2035. For additional discussion of E3's grid modeling methodology, see Appendix B.

Results begin on next page.

FIGURE H-1
Generation capacity required 2025 to 2050



SOURCE: E3 grid modeling analysis.
NOTE: Capacity shown is nameplate capacity.

TABLE H-1
Generation capacity required 2025 to 2050, Scenario 1: Unconstrained demand (MW)

No VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	6,141	9,391	15,891	25,149	25,937	25,937
Gas peaker	10,499	10,499	10,499	10,499	10,499	10,499
Oil peaker	813	813	813	813	813	813
Biomass	765	765	765	765	765	765
Coal	3,230	3,230	3,230	3,230	3,230	3,230
Nuclear	3,708	3,708	3,708	6,388	8,532	13,356
Hydro	929	929	929	929	929	929
Solar	7,596	8,673	13,939	27,503	33,880	33,880
Offshore/onshore wind	-	5,580	8,656	8,756	8,856	8,956
Battery storage	116	1,608	3,835	3,835	4,008	4,008
Pumped storage	3,241	3,241	3,241	3,241	3,241	3,241
Demand response	1,354	1,354	1,354	1,354	1,354	1,354
Total	**38,393**	**49,792**	**66,861**	**92,462**	**102,043**	**106,967**

VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	6,141	9,391	15,891	19,945	19,945	19,945
Gas peaker	10,499	10,499	10,499	11,976	11,342	10,863
Oil peaker	813	813	813	813	316	-
Biomass	765	765	765	765	15	-
Coal	3,230	3,230	3,230	3,230	630	-
Nuclear	3,708	3,708	3,708	6,388	8,532	13,356
Hydro	929	929	929	929	929	929
Solar	7,596	8,673	13,939	29,622	53,880	53,880
Offshore/onshore wind	-	5,580	8,656	8,756	9,216	9,316
Battery storage	116	1,667	4,014	7,645	13,511	13,511
Pumped storage	3,241	3,241	3,241	3,241	3,241	3,241
Demand response	1,354	1,354	1,354	1,354	1,354	1,354
Total	**38,393**	**49,851**	**67,040**	**94,665**	**122,911**	**126,394**

SOURCE: E3 grid modeling analysis.
NOTE: Capacity shown is nameplate capacity.

TABLE H-2
Generation capacity required 2025 to 2050, Scenario 2: Half of unconstrained demand (MW)

No VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	6,141	9,391	14,626	18,021	18,021	18,605
Gas peaker	10,499	10,499	10,499	10,499	10,499	10,499
Oil peaker	813	813	813	813	813	813
Biomass	765	765	765	765	765	765
Coal	3,230	3,230	3,230	3,230	3,230	3,230
Nuclear	3,708	3,708	3,708	6,388	8,532	9,119
Hydro	929	929	929	929	929	929
Solar	7,596	8,673	13,939	17,340	27,589	27,589
Offshore/onshore wind	-	2,940	6,016	6,116	6,216	6,316
Battery storage	116	494	494	892	3,375	3,375
Pumped storage	3,241	3,241	3,241	3,241	3,241	3,241
Demand response	1,354	1,354	1,354	1,354	1,354	1,354
Total	**38,393**	**46,038**	**59,615**	**69,589**	**84,565**	**85,835**

VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	6,141	9,391	12,856	12,856	12,856	12,856
Gas Peaker	10,499	10,499	10,499	13,709	15,013	14,534
Oil Peaker	813	813	813	813	316	-
Biomass	765	765	765	765	15	-
Coal	3,230	3,230	3,230	3,230	630	-
Nuclear	3,708	3,708	3,708	6,388	8,532	11,854
Hydro	929	929	929	929	929	929
Solar	7,596	8,673	13,939	17,883	33,880	33,880
Offshore/onshore Wind	-	2,940	8,576	8,676	8,776	8,876
Battery Storage	116	878	3,216	3,231	5,590	5,590
Pumped Storage	3,241	3,241	3,241	3,241	3,241	3,241
Demand Response	1,354	1,354	1,354	1,354	1,354	1,354
Total	**38,393**	**46,422**	**63,126**	**73,075**	**91,132**	**93,114**

SOURCE: E3 grid modeling analysis.
NOTE: Capacity shown is nameplate capacity.

TABLE H-3
Generation capacity required 2025 to 2050, Scenario 3: No new data center demand (MW)

No VCEA

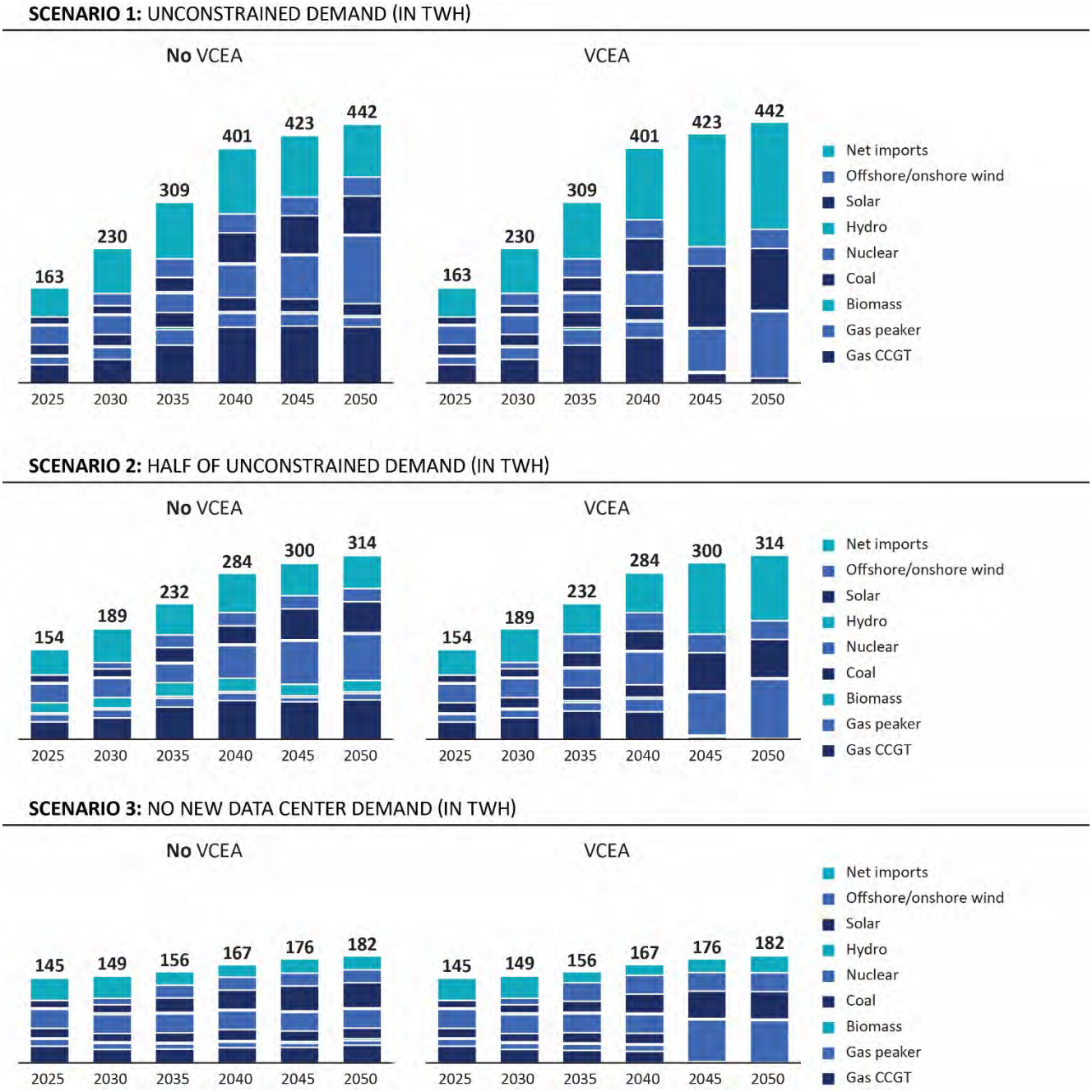
Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	6,042	6,042	6,759	7,728	8,016	8,642
Gas peaker	10,499	10,499	10,499	10,499	10,499	10,499
Oil peaker	813	813	813	813	813	813
Biomass	765	765	765	765	765	765
Coal	3,230	3,230	3,230	3,230	3,230	3,230
Nuclear	3,708	3,708	3,708	3,708	3,708	3,708
Hydro	929	929	929	929	929	929
Solar	7,596	8,673	13,939	17,733	22,340	22,340
Offshore/onshore wind	-	2,940	6,016	6,116	6,216	6,316
Battery storage	116	116	116	609	3,583	3,583
Pumped storage	3,241	3,241	3,241	3,241	3,241	3,241
Demand response	1,354	1,354	1,354	1,354	1,354	1,354
Total	**38,293**	**42,310**	**51,369**	**56,725**	**64,695**	**65,421**

VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	6,042	6,042	6,042	6,042	6,042	6,042
Gas peaker	10,499	10,499	10,499	10,499	9,865	9,386
Oil peaker	813	813	813	813	316	-
Biomass	765	765	765	765	15	-
Coal	3,230	3,230	3,230	3,230	630	-
Nuclear	3,708	3,708	3,708	3,708	8,532	8,532
Hydro	929	929	929	929	929	929
Solar	7,596	8,673	11,092	17,783	24,669	24,669
Offshore/onshore wind	-	2,940	8,576	8,676	8,776	8,876
Battery storage	116	116	3,216	3,216	4,313	4,313
Pumped storage	3,241	3,241	3,241	3,241	3,241	3,241
Demand response	1,354	1,354	1,354	1,354	1,354	1,354
Total	**38,293**	**42,310**	**53,465**	**60,256**	**68,682**	**67,341**

SOURCE: E3 grid modeling analysis.
NOTE: Capacity shown is nameplate capacity.

FIGURE H-2
Energy sources 2025 to 2050



SOURCE: E3 grid modeling analysis.

TABLE H-4
Energy sources 2025 to 2050, Scenario 1: Unconstrained demand (TWh)

No VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	31	40	65	96	98	96
Gas peaker	14	20	27	23	21	16
Oil peaker	-	-	-	-	-	-
Biomass	3	3	3	3	3	3
Coal	18	19	26	24	22	21
Nuclear	32	32	32	56	74	116
Hydro	3	3	3	3	3	3
Solar	13	14	25	52	66	66
Offshore/onshore wind	-	21	32	32	32	33
Battery storage	(0)	(0)	(0)	(0)	(1)	(1)
Pumped storage	(0)	(0)	(0)	(0)	(0)	(0)
DR	0	0	0	0	0	0
Net Imports	50	77	97	112	105	90
Total	**163**	**230**	**309**	**401**	**423**	**442**

VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	31	40	65	77	16	8
Gas peaker	14	20	27	27	1	-
Oil peaker	-	-	-	-	-	-
Biomass	3	3	3	3	0	-
Coal	18	19	26	24	2	-
Nuclear	32	32	32	56	73	114
Hydro	3	3	3	3	3	3
Solar	13	14	25	57	105	106
Offshore/onshore wind	-	21	32	32	33	33
Battery storage	(0)	(0)	(0)	(1)	(2)	(1)
Pumped storage	(0)	(0)	(0)	(1)	(3)	(3)
DR	0	0	0	0	0	0
Net imports	50	77	97	123	194	183
Total	**163**	**230**	**309**	**401**	**423**	**442**

SOURCE: E3 grid modeling analysis.

TABLE H-5
Energy sources 2025 to 2050, Scenario 2: Half of unconstrained demand (TWh)

No VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	30	37	55	66	64	67
Gas peaker	13	14	15	13	7	11
Oil peaker	-	-	-	-	-	-
Biomass	3	3	3	3	3	3
Coal	17	18	23	22	19	20
Nuclear	32	32	32	56	74	79
Hydro	3	3	3	3	3	3
Solar	13	14	25	32	53	53
Offshore/onshore wind	-	11	22	22	23	23
Battery storage	(0)	(0)	(0)	(0)	(1)	(1)
Pumped storage	(0)	(0)	(0)	(0)	(1)	(1)
DR	0	0	0	0	0	0
Net imports	44	57	54	67	56	56
Total	**154**	**189**	**232**	**284**	**300**	**314**

VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	30	37	48	47	4	2
Gas peaker	13	14	15	22	1	-
Oil peaker	-	-	-	-	-	-
Biomass	3	3	3	3	0	-
Coal	17	18	23	22	3	-
Nuclear	32	32	32	56	73	101
Hydro	3	3	3	3	3	3
Solar	13	14	25	33	66	66
Offshore/onshore wind	-	11	32	32	32	32
Battery storage	(0)	(0)	(0)	(0)	(1)	(1)
Pumped storage	(0)	(0)	(0)	(0)	(1)	(1)
DR	0	0	0	0	0	0
Net imports	44	58	53	68	123	112
Total	**154**	**189**	**232**	**284**	**300**	**314**

SOURCE: E3 grid modeling analysis.

TABLE H-6
Energy sources 2025 to 2050, Scenario 3: No new data center demand (TWh)

No VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	29	23	23	26	26	30
Gas peaker	11	10	9	10	7	8
Oil peaker	-	-	-	-	-	-
Biomass	3	3	3	3	3	3
Coal	16	14	16	19	18	18
Nuclear	32	32	32	32	32	32
Hydro	3	3	3	3	3	3
Solar	13	14	25	33	43	43
Offshore/onshore wind	-	11	22	22	22	22
Battery storage	-	(0)	(0)	(0)	(1)	(1)
Pumped storage	(0)	(0)	(0)	(0)	(1)	(1)
DR	0	0	0	0	0	0
Net imports	38	38	23	21	24	24
Total	**145**	**149**	**156**	**167**	**176**	**182**

VCEA

Resource	2025	2030	2035	2040	2045	2050
Gas CCGT	29	23	21	20	0	0
Gas peaker	11	10	11	10	0	0
Oil peaker	-	-	-	-	-	-
Biomass	3	3	3	3	0	-
Coal	16	14	17	18	2	-
Nuclear	32	32	32	32	71	72
Hydro	3	3	3	3	3	3
Solar	13	14	19	33	47	47
Offshore/onshore wind	-	11	32	32	32	32
Battery storage	-	(0)	(0)	(0)	(1)	(1)
Pumped storage	(0)	(0)	(0)	(0)	(1)	(1)
DR	0	0	0	0	0	0
Net imports	38	38	19	19	23	29
Total	**145**	**149**	**156**	**167**	**176**	**182**

SOURCE: E3 grid modeling analysis.

Appendix I: Data center on-site generation

Instead of relying on utilities, many data center companies are looking at ways to generate their own power using on-site power generation. On-site generation can take a variety of forms, including utility-owned generation on or adjacent to a data center site, "behind the meter" generation that is owned by the data center, or a "microgrid" where the site operates its own generation and may not be connected to the larger grid. Of the current technologies available, only natural gas appears viable for on-site generation, and it can be deployed only close to pipeline infrastructure that has sufficient capacity to serve generation needs. Other technologies, such as small modular nuclear reactors, are being actively pursued by the industry as a potential future power source, but most stakeholders believe these will not realistically be available until 2035.

On-site generation is most likely to be used at new data center sites, where they can be incorporated into the site design. It appears unlikely existing sites, especially those that are fully built out, could be switched to on-site generation because of space constraints and financial considerations. Additionally, data center companies may have regulatory and public relation challenges trying to place some technologies, such as nuclear reactors, in suburban localities like Loudoun and Prince William.

On-site generation could help solve data center companies' power problems, but they may not substantially reduce generation and transmission infrastructure needs. Several data center companies indicated that they were pursuing on-site generation as a primary power source but planned to rely on the main grid for backup. Because electric utilities have an obligation to serve all customers in their service territory, they would still need to build the infrastructure necessary to provide power to these sites, even if they are only serving in a backup capacity.

On-site generation could also shift new infrastructure costs to other customers, because infrastructure costs are recaptured through utility billings, and a data center using an on-site generation would not be regularly billed for services. It is possible that utilities could reach agreements with data center companies to provide reduced or non-firm levels of service if only serving in a backup capacity, which would reduce the need for additional utility infrastructure and cost impacts on other customers. However, it is not clear whether data centers would enter into such agreements. State law could be changed to address the potential issue of stranded costs from data centers that use on-site generation, but as of today, this is not occurring and only one data center site in Virginia appears to actively rely on on-site generation for a substantial share of its energy needs.

Appendix J: Power usage effectiveness (PUE) ratios

The efficiency of cooling and other building systems in data centers is commonly measured using a Power Usage Effectiveness (PUE) ratio. For example, a PUE of 1.3 indicates that 1.0 of energy is used for computing activity, and 0.3 is used for all other building systems. A PUE of 1.0 would indicate perfect efficiency, where all energy is used for computing activity, and none is used for any other purpose. Importantly, PUE does not measure how energy efficient a data center's computing is, because energy used for computing is always set equal to 1.0. Consequently, a lower PUE does not indicate if a data center is energy efficient as a whole. PUE only measures the efficiency of cooling and other building systems that support facility operations.

The data center industry has a strong market incentive to be energy efficient because energy is one of data centers' largest operating costs. Data centers regularly upgrade their computing equipment to take advantage of newer, more powerful and energy-efficient computer chips. Computer chips' performance per watt has improved annually for decades. Data centers have also made big efficiency gains with their building systems. As recently as 10 years ago, PUEs of 1.9 or above were common across smaller enterprise and colocation data centers. With the consolidation of the industry into large hyperscale facilities, large companies now report fleetwide average PUEs of 1.1 to 1.4. However, some companies may continue to have less efficient building systems because there are also strong market incentives to avoid changes that could disrupt operations, such as installing more efficient cooling systems.

At least one European country, Germany, has passed legislation requiring data centers to achieve lower PUE in the near future (1.2 to 1.3, depending on when the data center was constructed), and similar legislation has been proposed in Virginia. A PUE requirement could have two unintended consequences: (1) it could encourage more water use by the industry, because water-dependent cooling uses less energy, and could make it harder for companies that use dry cooling systems to comply, and (2) companies that operate colocation data centers may be less able to comply because they do not control operational decisions that can affect PUE calculations, such as how much computing space tenants use. A PUE requirement for existing data centers would also create fairness issues, because companies that have chosen to use cooling systems that are more water efficient but less energy efficient may be unable to comply with the requirement, solely based on the type of cooling they chose before a PUE requirement was established.

Appendix K: Additional natural resource considerations

Additional concerns about data center operations' impacts on natural resources, including their wastewater discharges, disposal of electronic waste, and diesel fuel carbon footprint, have also been raised. While significant adverse impacts to Virginia's natural resources may not occur from these, an environmental management standard, such as ISO 14001, could encourage data centers to reduce their impacts where possible. (See Chapter 5 for more information on environmental management standards.)

Because of existing regulations, data center wastewater discharges do not appear to pose ecological harms

Data centers that use water in their cooling systems typically discharge only a small portion of it, but when discharges do occur, the discharges may contain relatively large concentrations of salts, other dissolved solids, and chemical additives. Some stakeholders expressed concern that data centers and/or wastewater treatment plants do not filter out the salts and any other chemicals before discharging the water to a Virginia surface water source, contributing to the degradation of water quality.

Federal and state wastewater regulations appear to protect against these risks. DEQ requires permits for wastewater discharges from utilities and other large dischargers. These permits set limitations on the contents of discharges and require water quality monitoring to ensure that discharges do not degrade water sources. Some data centers have their own discharge permits, but most send their discharges to a wastewater utility. In either case, the permit holder must ensure any wastewater is appropriately treated before discharging it into a water source. If a wastewater utility is not capable of adequately treating discharge from a data center customer, the utility can require the data center to pretreat its discharges.

Some stakeholders were concerned that existing wastewater regulations were not sufficient to protect water resources, but any potential shortcomings would be true for other development types, so data center-specific standards are not necessary. However, a certification to ISO 14001, which requires companies to meet all environmental regulations, may encourage additional voluntary commitments from data centers to reduce any wastewater impacts.

Electronic waste faces little regulation, but existing practices divert some servers from landfills

Data centers are packed full of thousands of servers, and these servers are replaced every three to five years. Servers can contain rare and toxic materials. The process to procure these materials for use in servers can be environmentally harmful, as can improper disposal of the toxic materials. The reuse or recycling of servers and server parts can minimize environmental impacts.

Data centers, like other businesses, are not required by federal or state law to reuse or recycle electronic waste, but existing practices divert some servers from Virginia landfills. Many data center companies have sustainability goals related to electronic waste, including reusing, recycling, or donating old servers or old server parts. Additionally, not all local waste management services and landfills in Virginia

accept commercial waste and/or electronic waste, which would force data centers to seek other alternatives to dispose of their old servers.

Requiring data centers to meet an environmental management standard, such as ISO 14001, would require data centers to consider any environmental impacts caused by their waste generation. This could complement existing practices and discourage disposal of data center servers in Virginia landfills, if, and where, it does occur.

Few data centers currently use diesel fuel alternatives because of supply limitations

Use of diesel fuel—the fuel commonly found in data centers' backup generators—leads to greenhouse gas emissions. Data center operators are interested in expanding the data center industry's use of alternative fuels, such as hydrotreated vegetable oil (HVO), to lower data centers' carbon footprints. These alternatives can be used in most existing diesel generators. However, while these fuel alternatives are available for and used by data centers in Europe and California, the East Coast does not have a supply chain for these fuels. This makes it more expensive and logistically challenging for Virginia data centers to use these fuel alternatives.

Some data center companies are making efforts to expand the use of alternative fuels. For instance, some have requested DEQ permit approval to use HVO in their generators—as DEQ approval of fuel choice is needed as part of emission regulations—and the industry has reached out to the Virginia Economic Development Partnership about exploring ways to attract the fuel alternative industry to Virginia to increase local availability. While a requirement to use a fuel alternative may not currently be feasible, an ISO 14001 requirement could further encourage industry efforts to review and seek opportunities to limit their carbon footprints where possible.

Appendix L: Data center planning and zoning changes in Fairfax, Loudoun, and Prince William

In recent years, the three Virginia localities with the most data centers have revised their approaches to regulating the industry and initiated studies to consider additional changes. Sites in Loudoun, Prince William, and Fairfax account for 80 percent of data centers in the state. Since 2019, all three localities have adopted changes to their ordinances or other policies relating to data centers. For example, all three localities added minimum requirements for data centers to their zoning ordinances. Additionally, all three localities began official studies of their data center policies, with Loudoun and Prince William planning votes in 2026 by their boards of supervisors in response to study findings. Table L-1 summarizes key changes by Fairfax, Loudoun, and Prince William related to data center planning and zoning processes since 2019.

TABLE L-1
Fairfax, Loudoun, and Prince William have updated data center policies since 2019

Locality	Planning and zoning actions
Fairfax	**Comprehensive zoning update with changes specific to data centers (effective 7/1/2021)** • Recognized data centers as distinct use instead of being considered a type of telecommunications facility • Prohibited data centers in residential and certain commercial zones; requires special permit in certain commercial and industrial zones if exceeds specified size • Established county's first design standard specific to data centers: requiring enclosure of equipment in certain zones **Data center study (initiated 5/9/23)** • Process included public meetings and stakeholder interviews • Produced two staff reports and a consultant report **Zoning changes (effective 9/11/24)** Board of Supervisors considered study's recommendations and implemented several rules to better manage data center development • Prohibited data centers in additional zone; converted several zones from allowing data centers by right to allowing by special permit; expanded requirement for special permit if exceeding specified size to another industrial zone • Required 200 feet between data center building and residential property; required 300 feet (or a building) between equipment and residential property • Required 1 mile between data center and Metro station • Required sound studies at two stages of new projects • Required several architectural standards (e.g., façade differentiation) of by right development, with more flexibility but the same goals for special permit developments
Loudoun	**Rewrite of comprehensive plan (adopted 6/20/2019)** Items for priority future action included performance standards for data centers **Series of meetings about data center policies by legislative committee (2022)** Initiated to review county staff research and develop process for considering changes to data center policies **Comprehensive zoning update includes changes specific to data centers (effective 12/13/2023)** [a] Goal to align zoning ordinances relevant to data centers with comprehensive plan

	• Converted two zones from allowing data centers by right to allowing by special permit; permitted data center in an additional industrial zone • Expanded applicability of data center standards (e.g., façade architecture, screening of mechanical equipment) from four zones to all locations • Created standards for data centers regardless of location including windows, main entrance features, loading bay location, and proactive sound measuring • Created standards for data centers adjacent to residential areas including separation of mechanical equipment, minimum 200-foot setback between buildings and property border, parking setbacks, time limits on generator testing, and acoustic barriers around mechanical equipment **Study of potential changes to comprehensive plan and zoning ordinances for data centers and substations (initiated 2/6/2024)** • First phase focusing on appropriate locations for data centers per the comprehensive plan and zoning ordinance, expected to conclude early 2025 • Second phase to focus on policies and zoning ordinances to implement data center standards (e.g., aesthetics, natural resources), expected to conclude 2026
Prince William	**Additional standards required in data center overlay district (adopted 6/18/2019)** • Created requirements for data centers in the data center overlay district, including for building façade and fence design, screening mechanical equipment and substations near residential areas and certain roads, and buffer yards of data centers near residential areas • To encourage data center development in the overlay, increased density allowed by right within the overlay • Adjusted borders of data center overlay on map **Comprehensive review of data center overlay (initiated 3/2/2021)** • Scope included zoning ordinance, comprehensive plan, and other formal county policies • Products included reports by county's economic development office and two consultants regarding data center industry trends, appropriate land in Prince William, and recommended standards for development • Process included public meetings and stakeholder interviews **Data center ordinance advisory workgroup (created 2/28/2023)** Responsible for continuing review of county's data center policies. Draft timeline includes Board of Supervisors vote on noise ordinance amendments in spring 2025 and vote on policy changes relevant to other topics later in 2025. **Expanded noise ordinance applicability to data centers (adopted 2/28/2023)** • Limited exemption for nighttime cooling systems to residential homes • Originally planned to sunset in a year but extended to provide time to "assess the noise impacts associated with data centers"

SOURCE: JLARC review of local ordinances, review of planning and zoning department documents, and interviews with local staff.
NOTE: Table describes significant changes since 2019 and is not a summary of current ordinances. Table focuses on planning and zoning processes and excludes changes to economic development and tax policy. Table excludes requirements limited to particular projects (e.g., rezoning commitments). "Special permit" is used for consistency, but the terminology for this process depends on the locality.
[a] Updates do not apply to certain parts of the county, which are administered under an older zoning ordinance.



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Communities Are Raising Noise Pollution Concerns About Data Centers

By Miguel Yañez-Barnuevo (/authors/miguel-yanez) (mailto: myanez@eesi.org)

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Key Takeaways:

- Data centers emit sounds from the humming of cooling systems, rumbling of diesel generators, and whirring of fans, which can be heard for hundreds of feet around them.
- Noise pollution is regulated at the local and state levels through zoning ordinances, but for a time in the 1970s, the Environmental Protection Agency oversaw noise pollution and conducted noise-control investigations. It still has the legal authority to do so.
- Because there is a lack of reliable data from sound level meters and because most county or community noise ordinances are written to address noisy block parties (rather than data centers), most noise complaints go nowhere, leading to frustration and lower property values.

EESI Data Center Resources

See all of our articles on the impacts of data centers, including their energy needs, water usage, noise pollution, and contribution to higher energy bills:
The Environmental Impacts of Data Centers (Article Series) (https://www.eesi.org/data-center-impacts)

All EESI Data Center Resources (https://www.eesi.org/page/Data+Centers)

Brittany Heights in Chandler, Arizona, was a quiet neighborhood (https://noisefree.org/wp-content/uploads/2019/10/end-of-silence.pdf) until late 2014, when a data center moved in. Residents living around the data center complained of a constant humming noise coming from the facility that never stopped, even at night. They tried blocking (https://www.azcentral.com/story/news/local/chandler/2018/04/15/chandler-tech-company-hums-along-and-noise-annoying-residents/504641002/) the acoustic nuisance with noise-cancelling headphones and earplugs, to no avail. Complaints (https://www.chandlernews.com/news/residents-skeptical-about-noise-declines-at-data-center/article_c7300e30-593b-11ed-a088-cb76499dd165.html) were filed with the local authorities, but the constant humming from the equipment needed to cool the data center continued. In 2022, the city adopted a zoning code amendment that makes it harder to site a data center in Chandler, a reaction to almost a decade of resident pushback. In 2025, the city council unanimously voted against a new proposed data center; noise concerns (https://www.azfamily.com/2025/12/12/chandler-unanimously-votes-against-proposed-ai-data-center/) played a big role in local opposition.

Data centers are industrial facilities housing thousands of servers and chips to process billions of operations daily and store vast amounts of data. Heat produced by these processes can damage the chips. To avoid this, data centers employ cooling systems to regulate temperature and humidity in server rooms. On average, cooling systems account for about 40% (https://www.researchgate.net/figure/Analysis-of-power-consumption-proportionality-in-data-center-8-24_fig4_355862079) of a data center's electricity usage. Data centers that use cooling systems, rather than water cooling, tend to be noisier. Noisy jet engine-like diesel generators are increasingly powering data centers (https://insideclimatenews.org/news/12112025/data-center-diesel-generators-noise-pollution/) (for example in Texas), and not just as emergency backup power. Mobile gas turbines (https://grist.org/energy/data-centers-natural-gas-methane-behind-the-meter/) are also being used to provide baseload power to data centers behind the meter, or to provide power when centers are forced off the grid during periods of peak demand. Both diesel generators and gas turbines create noise and air pollution.

Humans are no strangers to noise pollution. Cities, in particular, are noisy—filled with cars, trucks, construction sites, barking dogs, and emergency vehicles. While sounds above 85 decibels are considered harmful to a person's ears, studies have shown that noises above 65 decibels (https://www.businessinsider.com/noise-pollution-effects-human-hearing-health-quality-of-life-2018-1) are enough to cause an increase in stress and blood pressure. High noise levels, particularly at night, can cause sleep deprivation and decreased cognitive performance (https://www.who.int/europe/news-room/fact-sheets/item/noise#:~:text=Noise%2520is%2520an%2520underestimated%2520threat,health%2520effects%2520from%2520night%2520noise.), which shows up in poor school or work performance. The elderly, children, shift workers, the less affluent, and people with chronic illnesses are most likely to be impacted by noise pollution.

Data Centers and Decibels

Data center noise impacts vary by facility, time of day, proximity to residential areas, and technology use. Like other industrial facilities, data centers emit high- and low-frequency sounds (https://invc.com/noise-control/data-center-noise-attenuation/#:~:text=What%2520are%2520the%2520causes%2520of%2520data%2520center%2520hum?,)%2520figure%252C%2520not%2520low%2520f In an interview with EESI, Kyle Hart of the National Parks Conservation Association stated that because data center noise spans multiple frequency ranges, particularly in the low-frequency range, it is difficult to measure with a decibel meter and without reliable measurements it is difficult to enforce local noise ordinances for nearby residents.

When operating, data centers emit sounds from the humming of cooling systems and air chillers, the rumbling of diesel generators, and the whirring of fans. Together, these sounds can be heard for hundreds of feet around the facilities. Data center neighbors (https://www.wsp.com/en-me/insights/beyond-power-and-cooling-air-qualitys-role-in-data-center-resilience) have reported headaches, vertigo, nausea, sleep disturbances, ear pain, and hypertension. Hart adds that people who live near these data centers can hear the noise day and night as a ringing in the ears. Complaints about data center noise tend to focus on its 24/7 consistent presence (https://gerrymcgovern.com/data-centers-are-noisy-as-hell/) rather than on its volume.

Data centers are becoming noisier as developers stack more information technology (IT) equipment and servers into smaller spaces. While individual servers are not especially loud, the compounding effect of thousands or tens of thousands of servers in a computing warehouse can raise noise levels to 96 decibels (https://pmc.ncbi.nlm.nih.gov/articles/PMC12273412/). This is a problem because some data centers are close to where people live, sometimes within 50 feet (https://www.washingtonpost.com/dc-md-va/2024/04/30/data-centers-regulations-northern-virginia-georgia-arizona/?ref=hackernoon.com) of homes.

Backup diesel generators (https://www.techtarget.com/searchdatacenter/tip/Understanding-the-impact-of-data-center-noise-pollution) are another source of noise pollution from data centers. Because data centers need to operate 24/7, 365 days a year, they need backup power during grid outages. To ensure this power is available when needed, the generators are tested at least once a month (https://www.techtarget.com/searchdatacenter/tip/Understanding-the-impact-of-data-center-noise-pollution). During non-emergency situations (https://www.epa.gov/system/files/documents/2025-05/rice-memo-on-duke-energy-regulatory-interpretation-04_17_25.pdf), such as equipment testing, the EPA allows emergency generators to operate for up to 50 hours per calendar year. Data centers are not held to a federally-enforceable time limit (https://insideclimatenews.org/news/12112025/data-center-diesel-generators-noise-pollution/) when running diesel generators during unforeseen emergencies such as grid failures, fires, and floods (https://www.epa.gov/stationary-engines/understanding-stationary-engines-rules), provided the operator reports and logs the hours and the emergency.

The number of generators per facility depends on the data center's size. As data centers grow larger, the number of generators per center increases, along with their generation capacity and size. With more and larger generators comes a louder rumbling, which can be disruptive to residents and wildlife living near these facilities. Noise levels from industrial-sized diesel generators can reach up to 105 decibels (https://www.midamericaengine.com/what-are-noise-and-dba-in-diesel-generators/#:~:text=When%2520it%2520comes%2520to%2520the,What%2520are%2520Sound%252DAttenuating%2520Enclosures?), as noisy as a jet flying overhead.

A third source of noise from data centers are dedicated onsite power plants. As more data centers come on line or existing ones expand and need more power, developers are increasingly installing jet-engine gas turbines (https://grist.org/energy/data-centers-natural-gas-methane-behind-the-meter/) inside the perimeter of these facilities to provide dispatchable baseload power. In some data centers, like an xAI facility in Southaven, Mississippi, the roar from 27 natural gas-powered turbines (https://www.nbcnews.com/news/us-news/musks-ai-power-plant-generates-sound-fury-mississippi-rcna258594) is disturbing the sleep of nearby neighbors, who have publicly express concerns about air and noise pollution from these engines.

In the United States, 46 planned, permitted, or under-construction data centers will use off-grid gas turbines (https://cleanview.co/content/power-strategies-report) for power rather than connect to the grid. Unlike emergency diesel generators that run only during testing or emergencies, off-grid turbines operate 24/7 to power the data center, which leads to uninterrupted noise in surrounding areas. Cooling towers, a major source of noise from gas-fired power plants, can emit up to 70 dBA within 400 feet (https://www.powermag.com/major-noise-sources-and-mitigation-cost-estimates-for-gas-fired-power-facilities/).

Local Trade-offs: Economic Growth Versus Public Health

Today, noise pollution is regulated at the local and state level through zoning ordinances and other regulations. The *Clean Air Act of 1970* gave the Environmental Protection Agency (https://www.epa.gov/clean-air-act-overview/clean-air-act-title-iv-noise-pollution#:~:text=The%2520Role%2520of%2520EPA,the%2520public%2520health%2520and%2520welfare.) (EPA) oversight of noise pollution and the power to carry out noise control investigations through the Office of Noise Abatement and Control. The *Noise Control Act of 1972* (P.L. 92-574 (https://www.congress.gov/bill/92nd-congress/house-bill/11021)) and the *Quiet Communities Act of 1978* (P.L. 95-609 (https://www.congress.gov/bill/95th-congress/senate-bill/3083/summary/00#:~:text=3083%2520%25E2%2580%2594%252095th%2520Congress%2520(1977%252D,of%2520the%2520Noise%2520Control%25) empowered the EPA to provide grants to localities to mitigate noise. In 1981, (https://www.epa.gov/clean-air-act-overview/clean-air-act-title-iv-noise-pollution) the Reagan Administration defunded the Office of Noise Abatement and Control and shifted regulatory oversight and noise control to state and local governments. The EPA retains the legal authority to study noise and its effects on public health.

Data centers generate billions of dollars (https://www.datacenterknowledge.com/regulations/how-are-data-centers-taxed-and-how-much-do-they-actually-pay-) for localities through property, sales, and income taxes, which help fund schools, roads, and parks. Kyle Hart described data centers as the “goose that lays the golden eggs.” Due to a lack of reliable data from sound level meters and because most county or community noise ordinances are written to address noisy block parties rather than data centers, most noise complaints go nowhere. Hart added that as data center neighbors see that nothing changes in response to their complaints and frustration, they start to move away.

Impacts on Local Communities

Data center developments in Virginia, Arkansas, and Texas illustrate the impacts of noise pollution on local residents. Northern Virginia is the epicenter of the U.S. and worldwide data center boom. With nearly 300 operating data centers (https://www.governing.com/infrastructure/the-data-center-capital-of-the-world-is-in-virginia), Northern Virginia is home to about 14% (https://novatoday.6amcity.com/data-centers-northern-virginia) of all data centers worldwide. The 2024 Virginia Joint Legislative Audit Review Commission (https://jlarc.virginia.gov/pdfs/reports/Rpt598-2.pdf) report on data centers notes that almost one-third of the state's data centers are located within 200 feet of residentially zoned properties (this is possible because zoning ordinances consider data centers to be in the same non-industrial category as office space). Residents in Prince William County have complained that data center noise levels (https://www.nbcwashington.com/news/local/northern-virginia/as-data-centers-proliferate-neighbors-knock-the-noise/3155887/) routinely exceed 60 decibels. While the county noise ordinance exempts air conditioning units, Amazon, the owner of some of the facilities, has decided to retrofit its data centers with acoustical shrouds (https://www.nbcwashington.com/news/local/northern-virginia/as-data-centers-proliferate-neighbors-knock-the-noise/3155887/) as part of its noise-reduction efforts.

In May 2023, a Bitcoin mining center—a type of energy-hungry data center—popped up in Greenbrier, Arkansas, not far from a residential area. Nearby residents have complained about the 24/7 (https://www.nytimes.com/2024/02/03/us/bitcoin-arkansas-noise-pollution.html?unlocked_article_code=1.K1A.mpwN.hFo2VWIaMbfN&smid=url-share) noise coming from the center, which is leading to health problems, including increased blood pressure and anxiety. The high-velocity fans used to cool computers inside the mine generate a constant hum that can be heard miles away in such a rural setting.

Since the arrival of a nearby bitcoin mining center, dozens of residents of Granbury, Texas, have also complained (https://time.com/6982015/bitcoin-mining-texas-health/) of medical ailments, including vertigo, nausea, high blood pressure, migraines, fluid coming from the ears, and insomnia. Neighbors attribute this spike in health issues to excessive noise pollution from the bitcoin mine. Sitting less than 100 yards (https://www.texastribune.org/2025/10/09/texas-hood-county-crypto-noise-incorporate-city/#:~:text=But%2520residents%2520say%2520it's%2520done,the%2520measurement%2520and%2520monitoring%2520period.%25E2%2580%259D) av from a mobile home park, the sprawling facility hosts 60,000 computers and associated cooling and power systems, emitting noise at all hours of the day and night.

Noise Reduction Solutions for Data Centers

There are steps that data center developers and operators can take to reduce the noise generated by data centers and its impact on neighbors. State and local governments also have a role to play in updating regulations to address this increasingly widespread source of noise pollution. Solutions fall into four general categories: soundproofing specific equipment, soundproofing the overall building envelope, alternative cooling technologies, and better site planning.

Equipment Soundproofing

- Basic soundproofing measures (https://www.datacenterknowledge.com/sustainability/why-data-centers-are-loud-and-how-to-quiet-them-down), such as enveloping server racks with foam and sound-deadening mats, can help reduce noise levels in data centers. Noise-absorbing materials (https://future-bridge.us/noise-control-in-data-centers-key-design-strategies/#:~:text=Double%252Dlayered%2520walls%2520with%2520insulating,of%2520the%2520plant%2520is%2520less.), such as acoustic tiles and foam panels, can be installed indoors on walls and ceilings to absorb sound from IT equipment.
- Compressor sound blankets (https://www.enoisecontrol.com/data-center-noise-control/), fan silencers, and sound curtain barriers can help absorb noise emanating from chillers and cooling equipment, particularly those located outside the data center.
- Sound attenuators (https://www.enoisecontrol.com/data-center-noise-control/) and acoustical silencers can help muffle noise from air intakes in the diesel engine generators.

Building Soundproofing

- Erecting conventional acoustic barriers (https://invc.com/resources/technical-notes-environmental-noise/data-center-noise-control/), such as insulated, modular metal walls around the perimeter of the data center and on roofs, can mitigate high-frequency noise from cooling units, generators, and chillers.
- Placing acoustic shields (https://invc.com/noise-control/data-center-noise-attenuation/#:~:text=What%2520are%2520the%2520causes%2520of%2520data%2520center%2520hum?,)%2520figure%252C%2520not%2520low%2 which are generally smaller and more portable than barriers, around the data center also creates a noise barrier that captures low-frequency noise and the annoying hum from cooling systems.
- Planting bushes, shrubs, and trees (https://future-bridge.us/noise-control-in-data-centers-key-design-strategies/?) around data centers can help reduce noise by creating a natural shield around the facility. Natural barriers can also enhance data centers' visual appeal and provide environmental benefits.

Quieter Cooling Technologies

- Immersion cooling (https://www.datacenterdynamics.com/en/analysis/an-introduction-to-liquid-cooling-in-the-data-center/), which bathes the servers in synthetic liquid-cooling fluid, eliminates the need for large, noisy fans and cooling equipment and is also more energy-efficient.
- Low-noise coolers (https://www.stulz.com/newsroom/detail/low-noise-chillers-for-data-centers-peace-and-quiet-for-your-cooling-needs-1/) for industrial facilities are designed to operate at lower decibel levels than traditional systems.

Better Site Planning

- Communities can create "quiet places" where loud data centers are prohibited.

- Data centers can be located far from residential areas, with zoning ordinances changing to classify them as industrial facilities.

If more data centers test different combinations of these potential solutions, communities, governments, and companies will learn what works to comprehensively address the health and environmental impacts of noise pollution from data centers.

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The Data Heat Island Effect: Quantifying the Impact of AI Data Centers in a Warming World

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Abstract

The strong and continuous increase of AI-based services leads to the steady proliferation of AI data centres worldwide with the unavoidable escalation of their power consumption. It is unknown how this energy demand for computational purposes will impact the surrounding environment. Here, we focus our attention on the heat dissipation of AI hyperscalers. Taking advantage of land surface temperature measurements acquired by remote sensing platforms over the last decades, we are able to obtain a robust assessment of the temperature increase recorded in the areas surrounding AI data centres globally. We estimate that the land surface temperature increases by 2°C on average after the start of operations of an AI data centre, inducing local microclimate zones, which we call the *data heat island effect*. We assess the impact on the communities, quantifying that more than 340 million people could be affected by this temperature increase. Our results show that the data heat island effect could have a remarkable influence on communities and regional welfare in the future, hence becoming part of the conversation around environmentally sustainable AI worldwide.

Keywords: Artificial intelligence sustainability, data centres, power consumption, heat dissipation, land surface temperature.

1 Introduction

When considering the impact of anthropogenic activities on climate change and global warming in the last few decades, the urban heat island (UHI) effect plays a key role. UHI results from the concentration of industrial activities and heavy use of synthetic construction material, as well as solid increase in energy consumption in densely populated urban areas [1–6]. When discussing UHI effects, it is paramount to consider the impact they have on local communities and regional welfare. In this respect, it has been studied and demonstrated how UHI would affect healthcare, energy consumption, air quality, and water quality. It is therefore crucial to understand their causes [7].

Specifically, the main drivers for UHI are classified in terms of geometry of the anthropogenic spaces (e.g., urban canyons dictate the concentration of particulates); lack of vegetation and water bodies; generation of air pollutants and water vapour; heat retention and low albedo building [1, 3, 6, 8, 9]. On top of these categories, the type of human activities established and operating dramatically influence the impact of UHI on environment and communities. These anthropogenic activities are characterized by their spatial concentration, functional type (e.g., residential, industrial), cooling requirements, fuel sources, and thermal efficiency [1, 7, 8].

With global data volumes growing rapidly [10], data centres are expected to be one of the most power-hungry activity in the next decade [11–14]. In fact, it has been estimated that in 3 to 5 years the power consumption for data processing will exceed the amount budgeted for manufacturing [15–17]. As such, it is possible to expect that the impact of data centres and AI hyperscalers activities on climate might not be negligible [18–20], indeed being further exacerbated by the use of AI in the next decades [15, 16, 21].

In fact, AI data centres are in vast majority relying on fossil fuel use [15, 19–22]. Therefore, the steep growth of AI training and use for various applications would directly translate into high net impact on emissions. Also, the inefficiencies and nonidealities of AI hyperscalers operations would cause their emissions to rise even more under the expected projections of AI model scaling [19].

However, studying in detail the actual impact of AI hyperscalers environmental footprint would entail several uncertainties and unknowns [19]. Indeed, there are no credible indicators that can help determine and quantify the impact of existing AI applications. Moreover, predicting the characteristics of future AI applications, particularly their energy consumption and computing requirements, remains challenging. The fluctuations on forecast scenarios that could be drawn are further amplified by a lack of both consistency in methodologies and comprehensive data, even in historic estimates of environmental footprint from the ICT sector [19, 20, 23, 24]. In this paper, we aim to provide a novel perspective on the impact of AI hyperscalers on environment and sustainability under various climate scenarios for the next decades. By a multiscale multimodal analysis of records collected from various sources of information and sensors, we quantify the contribution of AI hyperscalers worldwide on land surface temperature increase (see Figure 1). Specifically, we integrate land surface temperature data from remote sensing platforms with the locations of AI hyperscalers that have been established in the last twenty years in order to assess the change in atmospheric heat induced by the data centres. To make our study less prone to uncertainties, we harmonise, arrange and filter the data from seasonality effects, influence from various nonidealities (e.g., missing data), and influence from factors (e.g., other types of anthropogenic activities in the surrounding of AI hyperscalers) which might contaminate our study. In this way, we are able to identify the impact of AI hyperscalers on environment as a consistent gradient in temperature between the area of data centres and their surrounding regions, so much so that could form a "*data heat island effect*". Our analysis moves in order to address three main objectives:

- Quantification of the land surface temperature increase connected to the establishment of an AI hyperscalers;
- Assessment of the region of influence of this increase;
- Estimation of the population affected by the temperature increase.

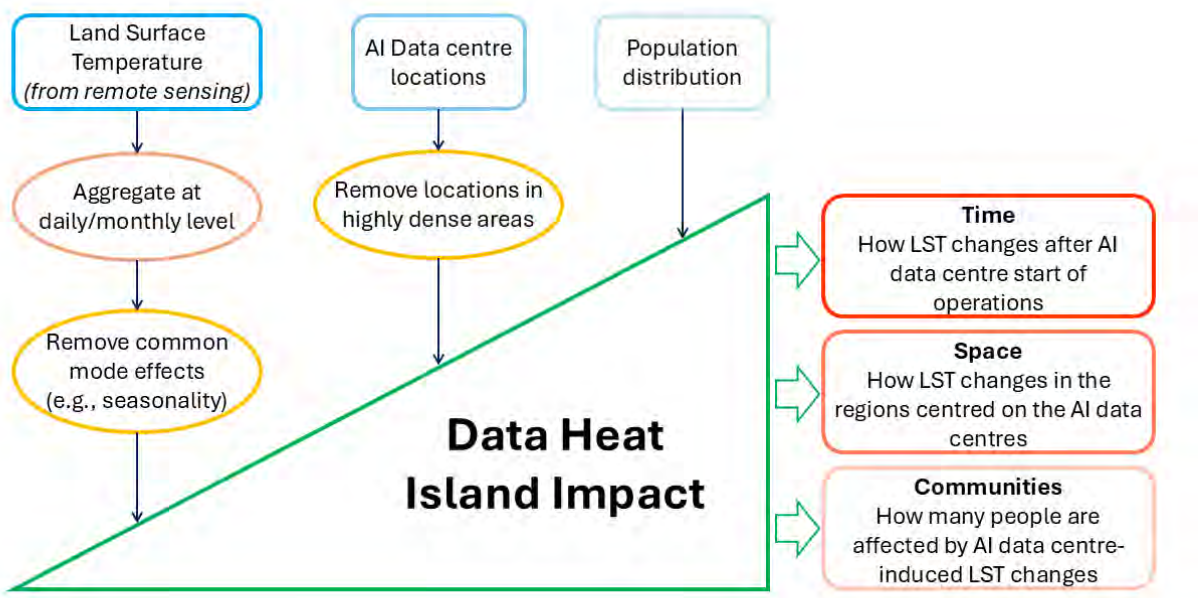


Fig. 1 Graphical abstract of this work: the proposed multiscale multimodal architecture for data analysis integrates records of land surface temperature trends from year 2004 to 2024, gridded population maps, and AI data centres locations worldwide, to achieve a thorough understanding of the impact of *data heat islands* in time, space and over communities.

The paper is organised as follows. Section 2 introduces the datasets and the methodology used to extract information on the land surface temperature increase induced by the AI data centres in twenty years worldwide. Section 3 reports the results we achieved with respect to the aforementioned indicators. Section 4 provides a few best practice guidelines for software and hardware solutions that could help to reduce the impact of the data heat island effect. Finally, Section 5 draws the final remarks and conclusions.

2 Data and methods

Our analysis of the environmental footprint of AI hyperscalers relies primarily on land surface temperature (LST) measurements (see Figure 1). We used a reconstructed MODIS LST dataset (produced by NASA) acquired worldwide from 2004 to 2024 over an enhanced 500m resolution grid [25]. To address data limitations (e.g., missing acquisitions, cloud cover), we aggregated the results at daily and then monthly scale, and removed seasonality effects, as well as outliers. Then, we focused our attention on the locations of the main AI hyperscalers that have been built in the same time interval, collecting information from resources such as [26]. This database contains more than 11000 locations worldwide, of which 8472 have been detected to dwell outside of highly dense urban areas. We thus used the latter locations to quantify the effect of the establishment of data centres on the environment in terms of the LST gradient that could be measured on the areas surrounding each data centre. In fact, LST profiles in urban and densely built-up areas can be affected by various activities, e.g., manufacturing, house heating, road networks. Considering only the AI data centres located outside of highly dense regions allows us to provide a solid connection between the LST trends that we can measure and the presence of AI data centres in the area. In particular, we assess mean LST trends over time within circular regions centered on each AI hyperscaler. In practice, our analysis counts

over 6733 data points, when considering LST trends cleared out of problematic data points and outliers for AI data centres located outside of highly dense urban areas. Finally, to assess the impact of LST change on population, we downscale the 100m x 100m demographic maps from Worldpop Global Project [27] over the considered to 1km resolution, so to enable a robust statistical analysis of the population affected the temperature increase induced by AI data centres.

This study relies on the assumption that AI hyperscalers might have an impact on the LST of their locations because of the heat that they would release as a result of the high power demanding applications that they would be used for [28]. To assess this, we first quantify the normalised temperature increase that could be observed in the months right after the start of operations of the AI hyperscalers we considered. To assess this impact we draw inspiration from the quantification approach used to estimate the urban heat island effect [6, 8, 9]. Specifically, we compute the monthly average LST of the area centred on each AI hyperscaler, and we calculate the difference between the mean monthly LST and average LST that is recorded across a period of k months on that region. In other terms, let us define T_i^r as the mean LST for month i at a distance of r km from a given data centre. Then, for every AI data centre location, we can write the normalised temporal temperature increase centred over the data centre location as $\Delta_i^{r=0}(k) = \Delta_i^0(k)$, which is defined follows:

$$\Delta_i^0(k) = T_i^0 - \frac{1}{k}\sum_{j=1}^{k} T_{i-j}^0, \tag{1}$$

where T_i^0 identifies the mean LST for month i for each AI data centre location. For completeness, this quantity is typically computed over 10 years, which translates into setting $k = 120$ in (1).

To focus our attention on the impact of AI data centres on LST increase, we centre the origin of the i-axis on the date of start of operations of each data centre under exam. Therefore, $\Delta_0(k)$ identifies the average LST increase that is measured over each AI data centre with respect to the mean of the LST that was recorded over the k months before their start of operations.

With this in mind, we assess the spatial influence of AI data centres on LST increase by focusing our attention on the LST distribution at r km from the given data centres over the k months prior to the start of operation of each data centre, that is:

$$\Delta_0^r(k) = \overline{T}_0^r - \frac{1}{k}\sum_{j=1}^{k} \overline{T}_{0-j}^r, \tag{2}$$

where $\overline{T}_0^r$ and $\overline{T}_{-j}^r$ identify the average of the LST of all the points at r km from the given AI data centre on the month of start of operation and at j months prior, respectively. In other terms, assuming that R points are at r km from the given data centre, and that $T_u^r|_l$ identifies the LST that we estimate for the l-th point at r km from the given data centre and u months from the start of operations, we can write $\overline{T}_u^r = \sum_{l=1}^{R} T_u^r|_l \,/R$.

As mentioned, we compute the quantities in (1) and (2) for each data centre under exam. The following Section reports the results we achieved building up on these metrics.

3 Results and discussion

The results we obtained conducting the analysis described Section 2 across all AI hyperscalers analysed during the 2004-2024 period are aggregated and displayed in Figure 2. Specifically, we focus our attention on the LST increase induced over the AI data centres under exam with respect to the average LST recorded over those regions for the 5 years prior to each AI data centre start of operations. For sake of visualisation, we concentrate 10 months before the start of operations of each date centre, and the 10 months after it. In other words, we compute $\Delta_i^0(k)$ as in (1) with $k = 5 \times 12 = 60$,

and for $i \in \{-10, -9, ..., -1, 0, 1, ...9, 10\}$. In particular, we align the temporal analysis results over the x-axis, where the trends are centred over the time of start of operations of each data centre. The aggregate average of the LST difference is shown in red solid line. The shaded areas show the interval between the maximum and minimum value of LST increase that has been recorded across the considered AI hyperscalers. Finally, the bar across the average line identifies the limit of the 95th percentile of the distribution we compute. Figure 2 shows a clear increase of LST coinciding with the start of

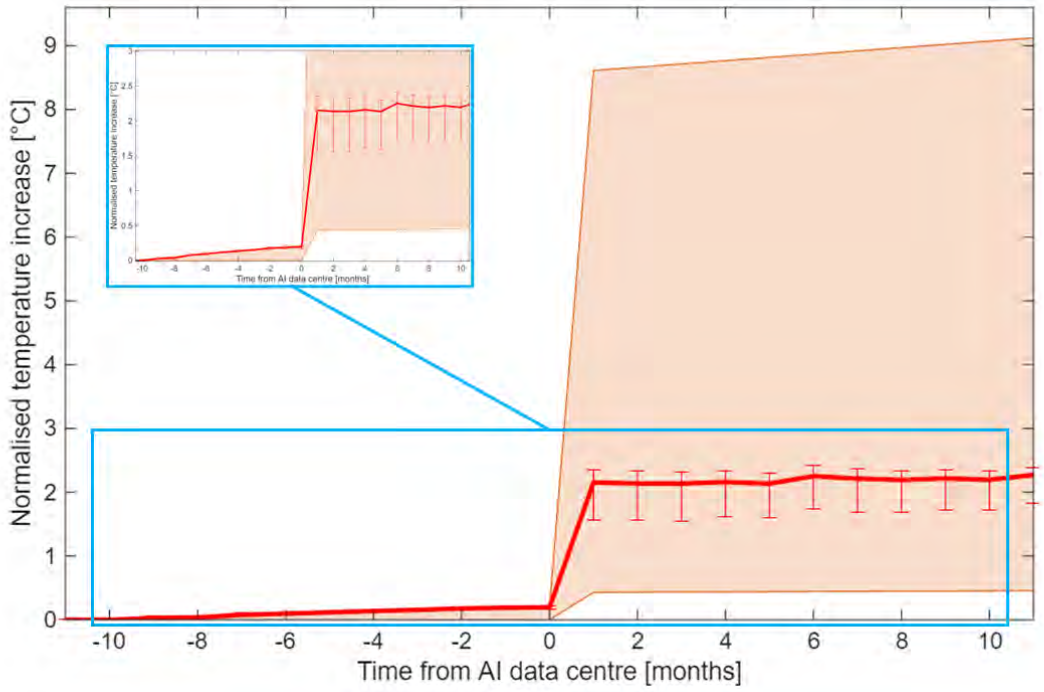


Fig. 2 Temperature increase through time over the AI hyperscalers locations centred around the time of start of operations ($i = 0$), according to the procedure described in Section 3 - equation (1). The aggregate average of the LST difference is shown in red solid line. The shaded areas show the interval between the maximum and minimum value of LST increase that has been recorded across the considered AI hyperscalers. The bar across the average line identifies the limit of the 95th percentile of the distribution we compute.

operations of the AI hyperscalers that have been monitored in this study. Indeed, the average LST increase across the data centres is 2.07°C, whilst its minimum and maximum can be found at 0.3 °C and 9.1 °C, respectively. The 95th percentile of the LST increase after the AI data centres start of operations is concentrated between 1.5°C and 2.4°C. These results are dramatically impressive, especially considering that the typical LST increase caused by the quintessential example of compound of anthropogenic activities – the urban heat island effect – has been estimated in the 4 and 6 °C interval [1, 6, 8]. This apparent step function emphasize the clear effect of AI hyperscalers on their surrounding areas, so much that it can match the impact of "islands" of higher temperatures: therefore, we call this the *data heat island* effect. This terminology is further supported when computing monthly LST differences as in Equation (1) over various time intervals (12 months to 10 years). Table 1 reports these results: across all the intervals that have been considered, the LST increase over the AI hyperscaler regions over the start of operations of the data centre seems consistent. The influence of AI hyperscalers apparently is not limited to the immediate proximity of their locations. In fact, we computed the temperature increase over wider regions circularly arranged around the data centres, following the same procedure that we previously described. Figure 3 displays the results of this analysis. Taking a look to these results, it is evident that the impact of LST increase reaches up to 10 km

Table 1 Temperature increase (in °C) as defined in Equation (1) at AI hyperscalers start of operation (i=0) as a function of k.

$\Delta_0(k)$	**k=12**	**k=24**	**k=36**	**k=120**
average	2.03	2.05	2.06	2.12
minimum	0.30	0.31	0.32	0.37
maximum	9.02	9.09	9.14	9.24

distance from the AI hyperscalers. The data heat island effect seems to reduce its intensity to 30% within 7 km around the data centres. In particular, an average monthly LST increase of 1 °C can be measured up to 4.5 km from the AI hyperscalers. This spatial extent is comparable to that observed in urban heat island effects [1, 6, 8]. The LST increase that is recorded in the area surrounding AI

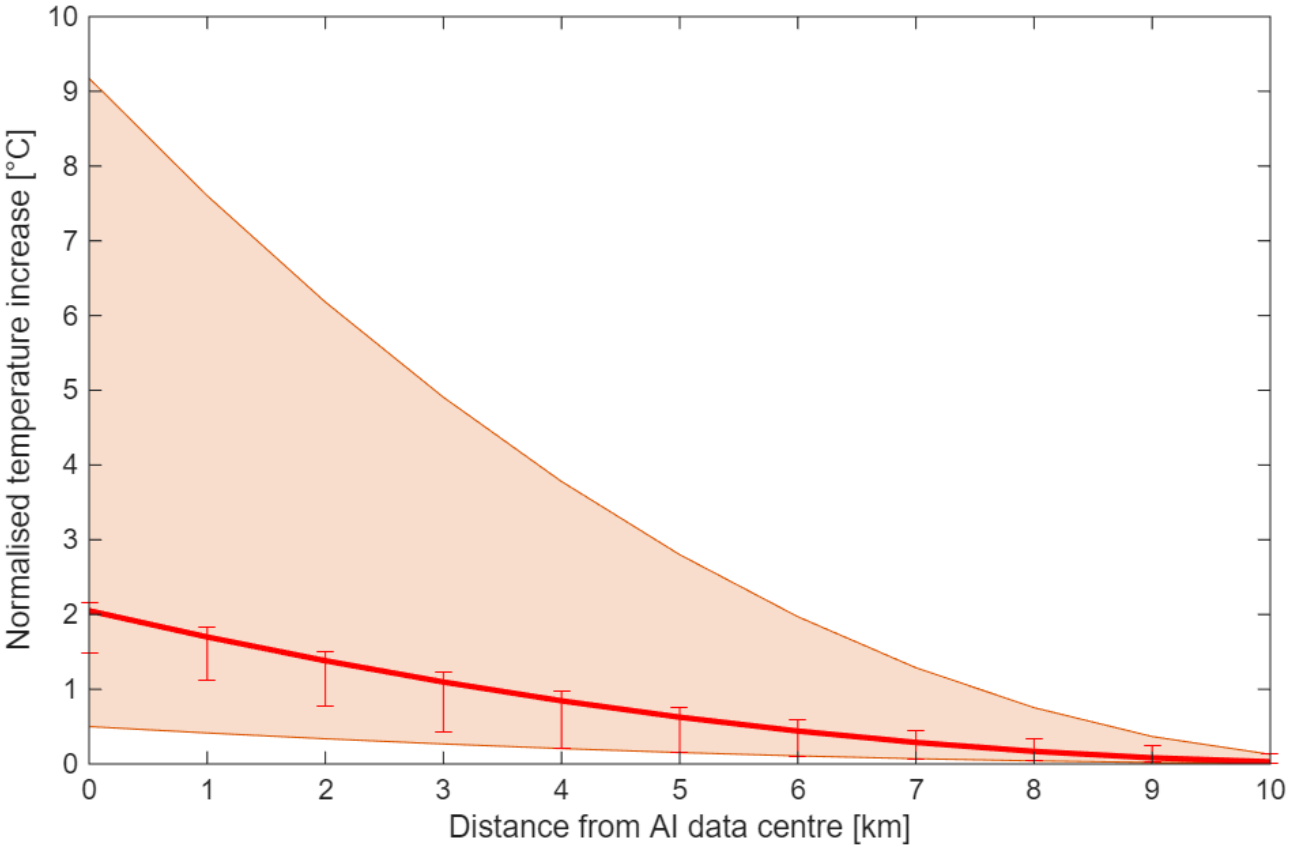


Fig. 3 Temperature increase through space as a function of the distance from the AI hyperscalers locations, according to the procedure described in Section 2 - equation (2). The same color policy as in Figure 2 applies here.

data centres seem consistent across various regions of the world, even if under diverse climatic conditions. As an example, we mention three situations that show the consistency of our study. In fact, in the following case studies, our LST increase assessment fit some anomalous trends of LST increase that have been recorded in the last decades, so that our approach could eventually be used to explain these non-typical temporal LST profiles:

- *Bajio region, Mexico*: the Bajio region in Mexico records a very high density of data centres managed by various providers that started operations approximately twenty years ago. The stable climate,

low seismic activity, and proximity to North American markets made the Bajío region a great hub for AI data centres. Nevertheless, it has been recorded a serious LST increase trend (in the order of 2°C) in the last twenty years in the region, which was not identified in proximal areas [29];

- *Aragon province, Spain*: Aragón has emerged as a major European hub for hyperscale AI data centres. The region is becoming a critical node for AI, cloud computing, and, increasingly, specialized server manufacturing. At the same time, the region has recorded an anomalous increase of approximately 2°C, which stands out with respect to the trends of the neighboring provinces of Spain, as well as to the global temperature increase that has been monitored in Europe [30];
- *Ceara' and Piauí states, Brazil*: The north east region of Brazil identifies one of the areas in the country (together with the greater urban areas of Rio de Janeiro and Sao Paulo) with a very high concentration of data centres. The surroundings of the city of Teresina, Piauí, are in particular dedicated for AI service hub. At the same time, the states of Ceara' and Piauí have shown a peculiar LST increase trend centred in Teresina in the range of 2.8°C, projected to reach more than 3.5°C in the next five years, that is quite unusual with respect to other areas in the north Brazil and equatorial Brazil [31].

These results become more significant when considering the population exposed to data heat island effects. We report in Figure 4 the amount of people that were resident within 10 km radius from the AI hyperscalers with respect to the LST increase that they would have experienced after the start of operations of each data centre. Figure 4 displays the result of this analysis. Although the object of the analysis has been focused on data centres outside of densely populated areas (as mentioned in Section 2), it is possible to appreciate how many people (up to 343 millions in total for a LST increase up to 9°C) could be affected by the data heat island effects worldwide. This makes the data heat island effect a phenomenon that is very hard to consider negligible, as it may lead (like the urban heat island effect) to dramatic impact on welfare, healthcare and energy systems [2, 6, 19, 24, 32].

Given these findings, mitigation measures for data heat island effects warrant urgent consideration: a set of strategies that can be implemented in this respect are introduced in the next Section.

4 A way forward

Although the impact of data heat islands can be intense (as it has been previously discussed), advances in technology in the semiconductor and energy material industries, as well as methodological developments in computer science and electrical engineering, can be used to mitigate their effects. We categorise these possible strategies in two main classes, software- and hardware-based. We report in the following examples of realistic approaches that can be employed to alleviate the data heat island effect (although in most cases these strategies have not been designed to address LST increase in the context of climate transformation). Beyond technological interventions, addressing the environmental impact of AI hyperscalers also highlights the need for a new theory of intelligence that explicitly incorporates energy, information, and physical constraints. Traditional AI theories often treat intelligence as abstract computation or symbolic manipulation, ignoring the thermodynamic costs of information processing. The Matryoshka model of intelligence [33], for instance, proposes a hierarchical, physically grounded framework in which cognitive, sensory, and motor processes are coupled with energy and material constraints across nested levels of complexity. By recognizing intelligence as a thermodynamically instantiated phenomenon, this framework not only provides deeper insight into natural and artificial cognition but also offers a principled foundation for designing more energy-efficient and sustainable AI systems, which could substantially reduce the heat and carbon footprint of large-scale data centers. Integrating such theory-driven principles into AI architecture and operations could complement hardware and software strategies, offering a holistic approach to mitigating the data heat island effect.

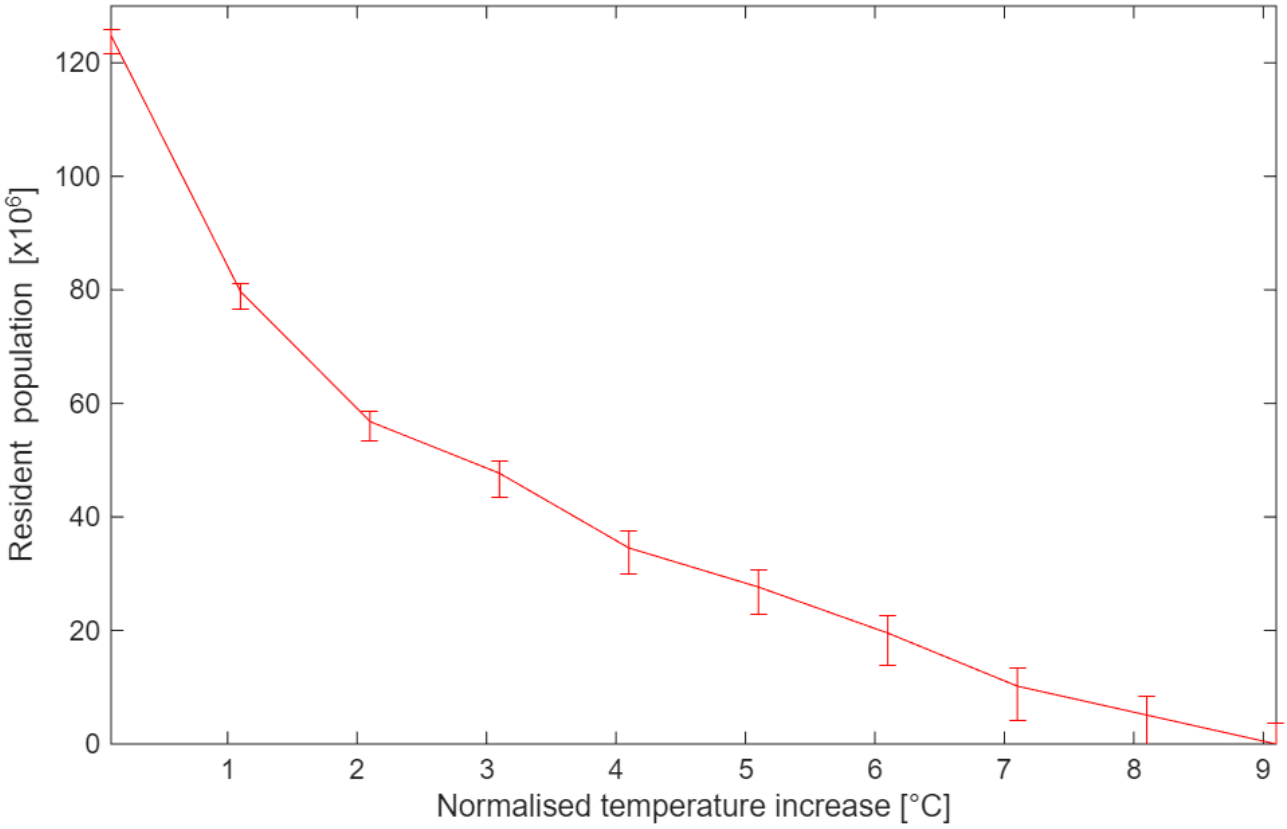


Fig. 4 Distribution of population as a function of the LST increase they are affected by within $r = 10$ km radius from the AI hyperscalers considered in this study with respect to the LST trend of the 5 years prior to the start of operations of the data centres, i.e., $\Delta_0^{10}(60)$ in (2) in Section 2.

4.1 Software-based solutions

The strategies in this category pertain to the design, development and implementation of computational methods that would make the data processing in AI hyperscalers more efficient, hence reducing their inherent power consumption. In order to provide a complete overview of the directions that could be explored for limiting the impact of data heat island effect in this respect, we divide the strategies in this category according to the main phases for data data analysis, i.e., preprocessing, processing, and usage for decision making:

- *how data are arranged*: the preprocessing operations in data analysis frameworks must not be underestimated. In the vast majority of operational scenarios, data analysis has to be performed onto records that show several nonidealities (e.g., missing, corrupted, unbalanced data, high variability in the records, low informativity of the data samples). This affects the quality of data analysis, as classic AI models would aim to reduce this uncertainty by implementing transformations (e.g., interpolation, smoothing) on the data, which could lead to artificial bias and hallucinations [24]. In this respect, considering the records as realizations of propagation and advection forces that can be used to model the properties of the data samples in the feature space can help [34]. In fact, this choice enables the identification of the actual relevance of the data samples and features, hence supporting efficient computational procedure by removing the negligible connections across samples and focusing the algorithms' attention on the significant and informative components of the datasets only. Core datasets can be selected from their original datasets to improve training efficiency in deep learning, without loss of performance accuracy [35].

- *how data are processed*: one of the greatest challenges of classic AI algorithms is convergence to unacceptably inferior local minima during the loss minimization or training process [23, 24, 36–38]. This leads to extreme difficulties for AI algorithms to guarantee any level of predictive accuracy without allowing AI models to use a large amount of energy, e.g., to identify all the possible solutions across the feature space [16, 18, 39, 40]. Seminal concepts such as the universality of deep, feed-forward neural networks and empirically encouraging results, although the degree of improvement in terms of power efficiency is most of the times very limited. Also, hierarchical learning based on functional learning (e.g., isogeometrical networks [41]) can be used to mitigate training and convergence issues, and can increase the accuracy of the classic AI strategies whilst guaranteeing a sustainable use of the computing resources. Also, pruning and compression of deep learning based models [42, 43] can benefit the definition and development of solution for hardware-aware AI models.
- *how data are used*: as other anthropogenic activities, data centeres emissions can be quantified in terms of carbon footprint, i.e., the the amount of greenhouse gas emissions (gCO2) generated [1, 2, 7, 9]. In this respect, novel strategies for innovative carbon-aware generative language model inference framework have been designed to reduce carbon footprint: the primary method for this relies on the strategic use of token generation directives while maintaining high-quality outputs [20, 23, 44, 45]. To achieve these goals architectures proposed in technical literature employ numerical programming for system-level optimization, balancing carbon savings with generation quality.

4.2 Hardware-based solutions

In this category, we summarise some viable options to improve data centres efficiency (hence their heat release in the atmosphere) by enhancing their operational framework. As for the previous case, we list these novel approaches according to the stage of functional deployment in the AI hyperscalers, i.e., at signal processing, power management, and infrastructure level.

- *how data are translated into signals*: recent progresses in integrated circuitry have enabled the development of technologies able to reduce the power consumption of AI accelerators and indeed recover the energy used for computing [23, 24, 46]. Adiabatic circuitry plays a key role in this respect [47]. This class of low-power integrated circuits rely on reversible logic and energy recovery, so that reduction of energy loss during computation can be achieved. This directly leads to reduction in heat dissipation, therefore potentially reducing the data heat island effect. Indeed, in adiabatic circuitry, power is recycled mainly through transistor switching. Although very promising, this technology show consistent limits for speed and scaling to AI models, hence requiring very complex systems (e.g., sinusoidal/trapezoidal clocks) to be implemented.
- *how signals are translated into power*: AI workloads are characterized by high computational intensity over long timeframes; high degree of variability, unpredictability, and nonlinear scalability of computational power usage; sensitivity to algorithmic design and implementation [11–13, 15, 16, 18]. This leads to major problems for demand and supply of AI hyperscalers within the energy grids that they are embedded in, e.g., affecting the grid stability and the accuracy of the AI models that are run onto their structures. These issues are a direct byproduct of the inability of AI hyperscalers power infrastructures to track the high variability of AI models usage. However, when power resources are set up to provide dynamic power response [48] (e.g., by intelligent battery energy support systems paired with power-load-temperature optimisation systems for resource and job allocation), the efficiency of data centres could dramatically improve, e.g., showing solid reduction of data centre downtime; protection of the infrastructure by power fluctuations, drops and spikes; and higher resilience towards irregular and unstructured AI platform usage.
- *how power is managed in infrastructure* The electronic components in AI hyperscalers are characterised by extremely high-power densities, often reaching magnitudes on the order of 107 W/m^2 [49]. These extreme thermal loads, exacerbated by non-uniform workload distributions and the emergence of localized hotspots across chips, demand sophisticated thermal management strategies

[50]. One key approach involves multiscale coordinated cooling schemes that combine localised liquid cooling at the chip level with system-wide air cooling across the facility. This hybrid method targeted heat extraction from critical hotspots while maintaining overall thermal balance throughout the infrastructure [51]. In addition to active cooling methods, passive cooling technologies offer complementary benefits by alleviating structural thermal load without increasing operational energy demand. Among these, passive radiative cooling has garnered particular interest. This technique engineers the optical properties of outdoor-exposed surfaces, such as building envelopes, by incorporating high solar reflectivity to suppress solar heat gain and strong thermal emissivity in long-wave infrared spectrum to enable radiative heat dissipation, thereby reducing the overall thermal load on infrastructure [52–54]. Recent advancements have translated this passive cooling technology into practical applications. In particular, passive radiative cooling coating based on polymer–nanoparticle composite has been applied across various real-world scenarios, including residential structures, urban infrastructure, and agricultural storage facilities [55]. Reported results indicate cooling load reductions ranging from 10% to 40% after applying the coating, contingent on site-specific factors such as surface albedo, orientation, and geographic climate conditions. In the context of AI hyperscalers, where thermal loads are not only intense, but spatially heterogeneous, such passive approaches can play a structural role in limiting the baseline thermal burden imposed on active cooling systems.

5 Conclusions

The increasing demand for AI-based services, processes and operations led to the proliferation of data centres worldwide that are extremely power hungry. In this paper, we provide the first assessment of the environmental impact of AI hyperscalers. We focus our attention on the heat dissipation of data centres, which is directly connected to the energy consumption required for the operations of the AI hyperscalers. We investigate, by means of a multimodal multiscale architecture, the land surface temperature change occurred as a consequence of the start of operations of the data centres. Our analysis spans over the last decades (from 2004 to 2024), taking advantage of the plethora of remotely sensed temperature measurements acquired by satellites worldwide. Our study shows a non negligible and rather remarkable impact of the AI data centres on their local regions, which is consistent across the data centres worldwide and extends for several kilometers around the AI hyperscalers. The consistency, scale and extent of these effects lead to think that the creation of local climate zones induced by data centres - that we call the *data heat island effect* - is real and significant, especially in the context of global warming and climate transformation.

Consequently, the data heat island effect could affect the welfare, healthcare, energy, and demographic systems. Since the trends of data centre energy consumption are expected to show a steep growth in the foreseeable future, the data heat island effect could solidly become an additional factor for environmental and industrial sustainability in the changing climate, hence having a robust impact on communities at local, regional, and international level, thus demanding to be studied in complex multi-hazard systems. To this aim, in this paper we provide an overview of potential solutions to alleviate the data heat island effect, which could be further expanded into mitigation policies for future climate and socioeconomic scenarios.

References

[1] Filonchyk, M., *et al.*: Greenhouse gases emissions and global climate change: Examining the influence of co2, ch4, and n2o. Science of The Total Environment **935**, 173359 (2024)

[2] UNEP: Emissions Gap Report 2025: Off Target. Available at https://www.unep.org/resources/emissions-gap-report-2025 (2025)

[3] Gunawardena, K.R., M.J.Wells, Kershawa, T.: Utilising green and bluespace to mitigate urban heat island intensity. Science of The Total Environment **584-585**, 1040–1055 (2017)

[4] Tan, J., *et al.*: The urban heat island mitigation potential of vegetation depends on local surface type and shade. Urban Forestry and Urban Greening **62**, 127128 (2021)

[5] Yuan, Y., et al.: Surface urban heat island effects intensify more rapidly in lower income countries. npj Urban Sustainability **5**(11) (2025)

[6] ECMWF: Urban heat islands and heat mortality. Available at https://stories.ecmwf.int/urban-heat-islands-and-heat-mortality (2025)

[7] UN: World Urbanization Prospects 2025. Available at https://www.un.org/development/desa/pd/world-urbanization-prospects-2025 (2025)

[8] EPA: What Are Heat Islands? Available at https://www.epa.gov/heatislands/what-are-heat-islands (2025)

[9] Nastrana, M., Kobala, M., Elerb, K.: Urban heat islands in relation to green land use in european cities. Urban Forestry and Urban Greening **37**, 33–41 (2019)

[10] Cambria, E., Chattopadhyay, A., Linn, E., Mandal, B., White, B.: Storages are not forever. Cognitive Computation **9**, 646–658 (2017)

[11] Li, Y., Mughees, M., Chen, Y., Li, Y.R.: The Unseen AI Disruptions for Power Grids: LLM-Induced Transients. Preprint at https://arxiv.org/abs/2409.11416 (2024)

[12] Chen, M., *et al.*: Power for ai and ai for power: The infinite entanglement between artificial intelligence and power electronics systems. IEEE Power Electronics Magazine **12**(1), 37–43 (2025)

[13] Luccioni, A.S., Jernite, Y., Strubell, E.: Power hungry processing: Watts driving the cost of ai deployment? In: ACM (ed.) Proceedings of Conference on Fairness, Accountability, and Transparency (2024)

[14] Choukse, E., et al.: Power Stabilization for AI Training Datacenters. Preprint at https://arxiv.org/abs/2508.14318 (2025)

[15] McKinsey: How data centers and the energy sector can sate AI's hunger for power. Available at https://www.mckinsey.com/industries/private-capital/our-insights/how-data-centers-and-the-energy-sector-can-sate-ais-hunger-for-power (2024)

[16] McKinsey: Scaling bigger, faster, cheaper data centers with smarter designs. Available at https://www.mckinsey.com/industries/private-capital/our-insights/scaling-bigger-faster-cheaper-data-centers-with-smarter-designs (2025)

[17] Masanet, E., Shehabi, A., Koomey, J.G.: Characteristics of low-carbon data centres. Nature Clim Change **3**(7), 627–630 (2013)

[18] Desislavov, R., Martínez-Plumed, F., Hernández-Orallo, J.: Trends in ai inference energy consumption: Beyond the performance-vs-parameter laws of deep learning. Sustainable Computing: Informatics and Systems **38**, 100857 (2023)

[19] IEA: Energy and AI. Available at https://www.iea.org/reports/energy-and-ai (2025)

[20] Masanet, E., *et al.*: Recalibrating global data center energy-use estimates. Science **367**(6481), 984–986 (2020)

[21] Nicoletti, L., Malik, N., Tartar, A.: AI needs so much power, it's making yours worse. Available at https://www.bloomberg.com/graphics/2024-ai-power-home-appliances/ (2024)

[22] Steele, K.: Global data center demand surges despite supply and power constraints. Available at https://www.jll.com/en-us/newsroom/global-data-center-demand-surges-despite-supply-and-power-constraints (2025)

[23] Wu, C.-J., *et al.*: Sustainable ai: Environmental implications, challenges and opportunities. In: Proceedings of Machine Learning and Systems (2022)

[24] Engineering, R.A.: Engineering responsible AI: foundations for environmentally sustainable AI. Available at https://nepc.raeng.org.uk/policy-work/engineering-responsible-ai-foundations-for-environmentally-sustainable-ai/ (2025)

[25] Metz, M., Rocchini, D., Neteler, M.: Surface temperatures at the continental scale: Tracking changes with remote sensing at unprecedented detail. Remote sensing **6**(5), 3822–3840 (2014)

[26] DataCenterMap: (2025). https://www.datacentermap.com/

[27] Catalog, E.E.D.: WorldPop Global Project Population Data: Estimated Residential Population per 100x100m Grid Square. Available at https://developers.google.com/earth-engine/datasets/catalog/WorldPop_GP_100m_pop (2025)

[28] Verne: Harnessing Data Center Waste Heat. Available at https://www.verneglobal.com/blog/data-center-waste-heat (2024)

[29] Rettie, F., *et al.*: Historical trends reveal significant increase in hot-dry extremes in mexico's bajío region. Environ. Monit. Assess. **198**(3), 228 (2026)

[30] Tejedor, E., *et al.*: Recent heatwaves as a prelude to climate extremes in the western mediterranean region. npj Clim Atmos Sci **7**, 218 (2024)

[31] Souza, A., et al.: Analyzing maximum temperature trends and extremes in brazil: A study of climate variability and anthropogenic influences from 1960 to 2020. Aerosol Sci Eng (2025)

[32] Council, U.G.B.: Climate resilience roadmap. Available at https://ukgbc.org/our-work/topics/resilience-roadmap/ (2024)

[33] Chen, M., Cambria, E., Laschi, C., Mengaldo, G.: Intelligence is physical: Energy, information, and a thermodynamically grounded theory of minds and machines. https://philsci-archive.pitt.edu/27741 (2025)

[34] Marinoni, A., Liò, P., Barp, A., Girolami, M.: Improving embedding of graphs with missing data by soft manifolds. IEEE Transactions on Pattern Analysis and Machine Intelligence **48**(3), 2221–2235 (2026)

[35] Nema, A., Zhu, H., Lin, W.: Holistic coreset selection for data efficient image quality assessment. In: Proceedings IEEE International Conference on Impage Processing (2025)

[36] Amodei, D., et al.: AI and compute. Available at https://openai.com/index/ai-and-compute/ (2025)

[37] Pandelea, V., Ragusa, E., Young, T., Gastaldo, P., Cambria, E.: Toward hardware-aware deep-learning-based dialogue systems. Neural Computing and Applications **34**, 10397–10408 (2022)

[38] Pandelea, V., Ragusa, E., Gastaldo, P., Cambria, E.: Selecting Language Models Features Via Software-Hardware Co-Design. In: Proceedings of IEEE ICASSP (2023)

[39] Schneider, I., et al.: Life-Cycle Emissions of AI Hardware: A Cradle-To-Grave Approach and Generational Trends. Preprint at https://arxiv.org/abs/2502.01671 (2025)

[40] Patel, P., *et al.*: Characterizing power management opportunities for llms in the cloud. In: ACM (ed.) Proceedings of 29th ACM International Conference on Architectural Support for Programming Languages

and Operating Systems (2024)

[41] Gasick, J., Qian, X.: Isogeometric neural networks: A new deep learning approach for solving parameterized partial differential equations. Computer Methods in Applied Mechanics and Engineering **405**, 115839 (2023)

[42] Wu, K., *et al.*: Efficient distortion-minimized layerwise pruning. IEEE Transactions on Pattern Analysis and Machine Intelligence **47**(10), 9298–9315 (2025)

[43] Zhang, X.: Learning grouped lattice vector quantizers for low-bit llm compression. In: Proceedings of NeurIPS (2025)

[44] d'Orgeval, A., *et al.*: Generative ai impact assessment through a life cycle analysis of multiple data center typologies. Applied Energy **406**, 127288 (2026)

[45] Mytton, D.: Data centre water consumption. npj Clean Water **4**(1) (2021)

[46] Butt, M.A., Janaszek, B., Piramidowicz, R.: Lighting the way forward: The bright future of photonic integrated circuits. Sensors International **6**, 100326 (2025)

[47] Pal, A.: Adiabatic Logic Circuits, pp. 303–321. Springer, New Delhi (2015)

[48] Marinoni, A., Shivareddy, S., Lio', P., Lin, W., Cambria, E., Grey, C.: Improving AI Efficiency in Data Centres by Power Dynamic Response. Preprint at https://arxiv.org/abs/2510.11119 (2025)

[49] Du, Y.H., *et al.*: Dynamic thermal environment management technologies for data center: A review. Renewable and Sustainable Energy Reviews **187**, 113761 (2023)

[50] He, Z.Q., *et al.*: Thermal management and temperature uniformity enhancement of electronic devices by micro heat sinks: A review. Energy **216**, 119223 (2021)

[51] Cao, K., *et al.*: Comprehensive review and future prospects of multi-level fan control strategies in data centers for joint optimization of thermal management systems. Journal of Building Engineering **94**, 110021 (2024)

[52] Raman, A.P., *et al.*: Passive radiative cooling below ambient air temperature under direct sunlight. Nature **515**(7528), 540–544 (2014)

[53] Fan, S., Li, W.: Photonics and thermodynamics concepts in radiative cooling. Nature Photonics **16**(3), 182–190 (2022)

[54] Lin, K., *et al.*: Hierarchically structured passive radiative cooling ceramic with high solar reflectivity. Science **382**(6671), 691–697 (2023)

[55] i2Cool: i2Cool Powers Green Event Management at Hong Kong Coliseum with Electricity-free Cooling Technology. Available at https://www.prnewswire.com/apac/news-releases/i2cool-powers-green-event-management-at-hong-kong-coliseum-with-electricity-free-cooling-technology-302342933.html (2025)

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Data Center Waste Heat as an Emerging Urban Thermal Hazard: First Field Measurements of Neighborhood-Scale Air Temperature Impacts

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Data centers are among the fastest-growing sources of concentrated anthropogenic heat in urban environments. Despite heat flux densities that exceed peak solar irradiance by a factor of 2–6, their thermal impacts on adjacent communities have never been directly measured or reported in the peer-reviewed literature. This short communication addresses that gap by presenting the first vehicle-based traverse measurements of air temperature in residential neighborhoods downwind of operational data centers. Five traverses at four facilities in the Phoenix, Arizona metropolitan area, ranging from a 36 MW single-building data center in Mesa to a 169 MW colocation campus in Chandler, reveal downwind air temperature warming as high as 2.2 °C, with average downwind air temperatures 0.7–0.9 °C warmer than corresponding upwind areas. Thermal signatures were detectable at distances up to 500 m from facility perimeters. The 36 MW Mesa facility rejects waste heat equivalent to the electricity consumption of approximately 40,000 households, while the 169 MW Chandler campus is equivalent to over 180,000 households, both concentrated into footprints smaller than a single residential subdivision. With U.S. data center capacity projected to more than double by 2030, these findings establish data center anthropogenic waste heat as a previously undocumented urban thermal hazard demanding attention from the data center and urban planning communities. [DOI: 10.1115/1.4071922]

Keywords: data centers, anthropogenic heat, urban heat island, vehicle traverse, thermal plume, Phoenix, building energy, cooling, environment, heat transfer, measurement

1 Introduction

Anthropogenic heat (Q_f) is the thermal energy released into the environment by human activities—principally fuel combustion, industrial processes, and building heating and cooling systems [1]. In cities, Q_f compounds the urban heat island effect, with city-wide fluxes in major United States metropolitan areas typically ranging from 10 to 75 W/m^2 [2–5]. The existing literature documents temperature elevations of 0.5–3.0 °C associated with urban anthropogenic heat fluxes, with an estimated air temperature sensitivity of approximately 1 °C for each 100 W/m^2 [6] at the neighborhood scale. However, data centers generate heat fluxes of thousands of W/m^2, far exceeding any previously studied urban source.

The data center industry is expanding at an unprecedented rate. Global electricity consumption by data centers reached approximately 415 TW h in 2024, about 1.5% of worldwide electricity demand, and is projected to double to 945 TW h by 2030 [7]. The United States data center infrastructure consumed 183 TW h in 2024, over 4% of national electricity, with more than 5000 facilities nationwide [8,9]. The Phoenix, Arizona metropolitan area, is among the fastest-growing hyperscale markets, hosting facilities by NTT, CyrusOne, EdgeCore, Iron Mountain, Stream, and Apple, with hundreds of megawatts of operational capacity and thousands more proposed [10].

For example, the NTT PH1 facility measured in this study has a 36 MW critical IT load housed within 11,700 m^2 of floor space in a two-story building [11]. Because newer data centers in Phoenix generally rely on sensible air-based cooling, virtually all electrical energy consumed by Information Technology (IT) equipment is ultimately converted to sensible heat; this yields a heat rejection density of approximately 3100 W/m^2, exceeding peak solar irradiance (~1000 W/m^2) by a factor of three, concentrated near the ground level. For context, the average U.S. household consumes ~10,500 kW h/year, an average draw of ~1.2 kW (electricity only) [12]. A single 36 MW data center with a power usage effectiveness (PUE) of ~1.3 [13], drawing ~47 MW in total, therefore rejects heat equivalent to that emitted by approximately 40,000 households. The CyrusOne colocation campus in Chandler (PHX1–PHX8), another site measured in this study, comprises eight facilities totaling 186,000 m^2 with 169 MW of critical IT capacity [14]; at the same industry-average PUE, the campus draws approximately 220 MW in total, rejecting heat equivalent to over 180,000 households from a single 34-ha site.

Despite this extraordinary thermal footprint, the localized air temperature impacts of data center waste heat on surrounding communities have never been directly measured or reported in the peer-reviewed literature. This gap is significant because many facilities are sited adjacent to residential neighborhoods (Fig. 1), and their air-cooled condenser arrays discharge air at temperatures 8–14 °C above ambient—often exceeding 50 °C during Phoenix summers—with air velocities of 2–4 m/s [15,16], creating thermal plumes that are advected downwind over inhabited areas. For example, the Iron Mountain Data Center (Fig. 1(*c*)) has

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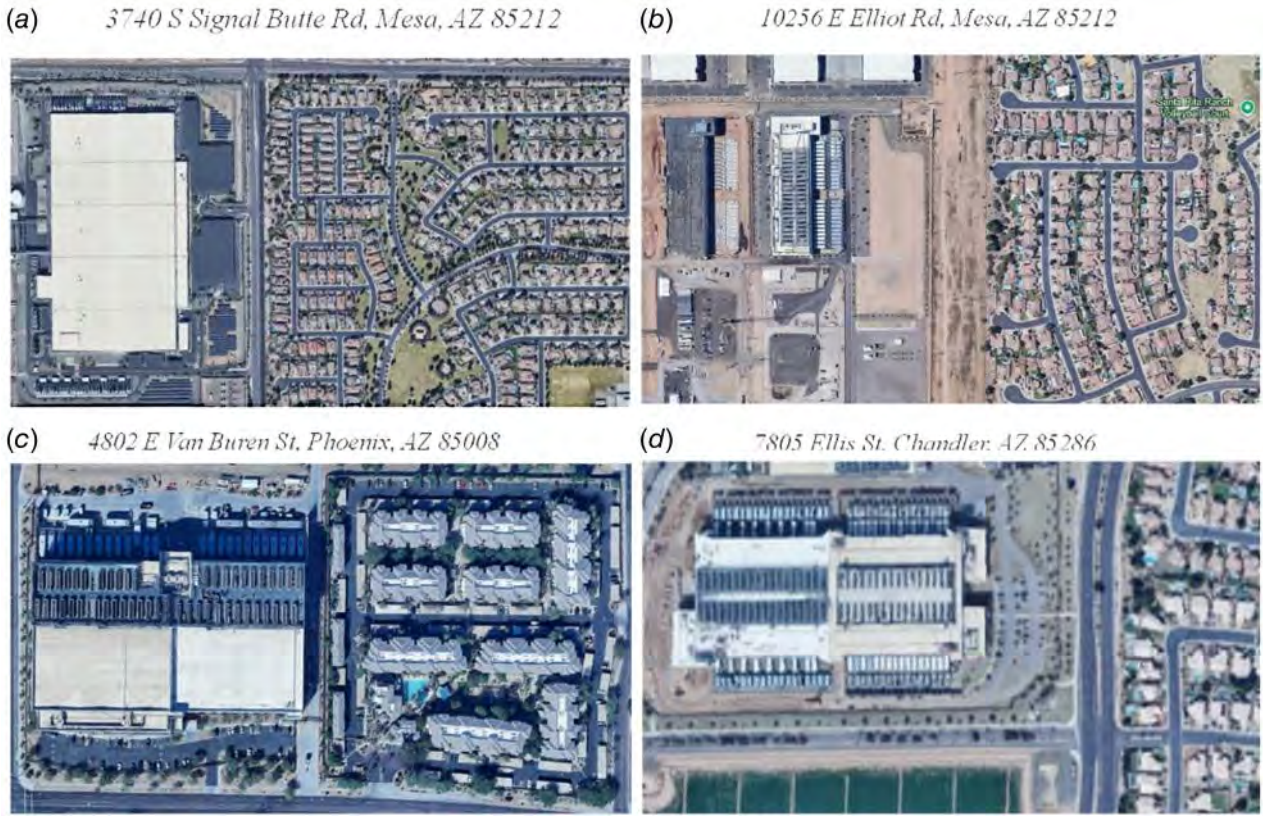


Fig. 1 Aerial imagery of four data center sites in the Phoenix metropolitan area, each situated adjacent to residential neighborhoods: (*a*) Apple Data Center, Mesa; (*b*) NTT PH1 Datacenter, Mesa; (c) Iron Mountain Data Centers (AZP-2), Phoenix; and (*d*) CyrusOne Price Road Tech Corridor (PHX1–PHX8), Chandler. The proximity of rooftop cooling infrastructure to surrounding communities illustrates the potential for thermal plume dispersion into residential areas

cooling equipment located less than 50 m from the nearest three-story apartment building.

The specific contributions of this short communication are (1) we present the first field measurements of air temperature elevations in residential neighborhoods attributed to data center waste heat rejection; (2) we quantify the magnitude (as much as 2.2 °C, with averages of 0.7–0.9 °C) and spatial extent (>250 m) of these thermal impacts at four facilities; and (3) we contextualize data center heat flux relative to other urban anthropogenic heat sources, establishing it as a previously unrecognized dimension of the urban heat challenge that is relevant to building energy, thermal comfort, and public health.

2 Methods

Vehicle-based traverses using established instrumentation and techniques [17–19] were conducted at four data center sites in the Phoenix metropolitan area. The first is the CyrusOne colocation complex (PHX1–PHX8) along the Price Road Technology Corridor in Chandler, Arizona, featuring dense rooftop condenser fan arrays located 130–150 m from the nearest residential neighborhood. The second and third sites, Aligned and Digital Realty, are also located along the Price Road Technology Corridor in Chandler, each situated adjacent to residential neighborhoods. The fourth is the NTT PH1 data center in Mesa (10256 Elliot Rd.), with 36 MW critical IT load across 11,706 m^2 of floor space, using air-cooled chillers with airside economizers [11]. NTT PH1 sits immediately south of the Santa Rita Ranch residential neighborhood, separated by 200 m of undeveloped land. These four data centers are highly representative of modern, hyperscale data center infrastructure. Together, they reflect the industry's shift toward massive multibuilding campuses with primarily air-based cooling systems.

Air temperature was measured using vehicle-mounted, aspirated, and shielded precision 4-wire Resistance Temperature Detectors (RTD with accuracy of 0.1 °C; time constant <3 s) sensors at 1.6–2.2 m height and a data logginging Global Position System (GPS) recorder (~2.5 m circular error probability), both logging at 2-s intervals. These instruments were mounted on multiple vehicles, which simultaneously drove on public roadways adjacent to data centers and throughout nearby neighborhoods. Measurements were obtained using established mobile urban temperature sensing protocols [18,20,21]. Thermal assessments upwind and downwind of data centers relied on averages of large areas (in each case representing >10 datum points) such that locational uncertainty and sensor time lags were not consequential. Wind speed and direction data were obtained from the Chandler Municipal Airport (KCHD) NWS station for the June 18 CyrusOne and October 25 Digital Realty traverses, from a portable weather station positioned near the facility perimeters for the August 8 CyrusOne and Aligned traverses, and from the Phoenix–Mesa Gateway Airport (KIWA) NWS station for the NTT PH1 traverse. Multiple traverses were conducted across different dates, times of day, and conditions from June 18 to October 25, 2025.

3 Results

Vehicle-based traverse measurements were conducted at four data center sites across three dates in the Phoenix metropolitan area (Fig. 2). All traverses captured clear thermal gradients that appear to be associated with data center waste heat rejection. The

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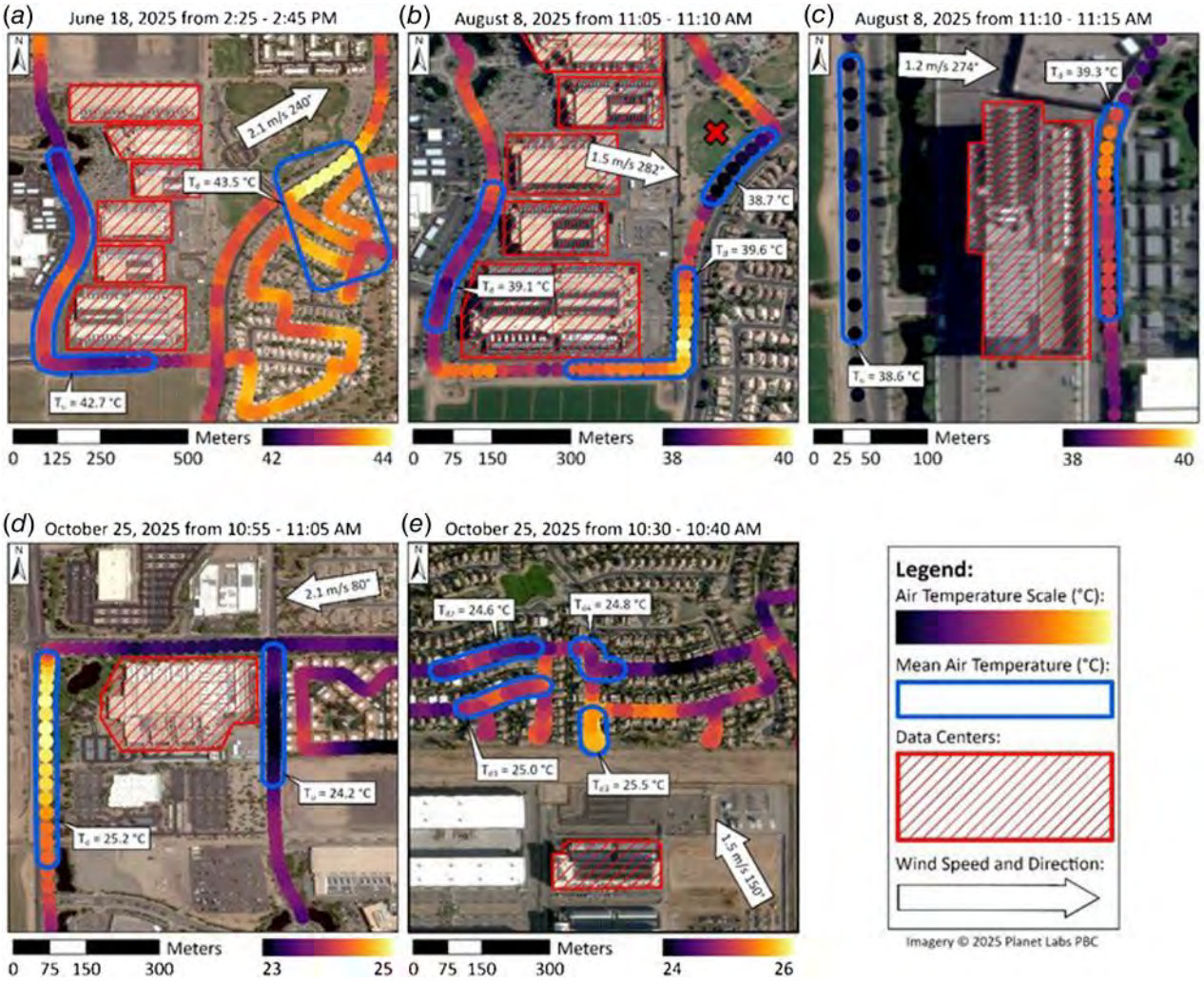


Fig. 2 Vehicle-based air temperature traverse results at four data center sites in the Phoenix metropolitan area: (*a*) CyrusOne, Chandler, June 18, 2025 (2:25–2:45 p.m.); (*b*) CyrusOne, Chandler, August 8, 2025 (11:05–11:10 a.m.); (*c*) Aligned, Chandler, August 8, 2025 (11:10–11:15 a.m.); (*d*) Digital Realty, Chandler, October 25, 2025 (10:55–11:05 a.m.); (*e*) NTT, Mesa, October 25, 2025 (10:30–10:40 a.m.). Small filled circles represent 1.6 m air temperature collected every 2 s. Outlined polygons denote the averaging areas for mean air temperature. Hatch-filled polygons indicate data center facilities. Wind speed and direction are shown for each traverse. Basemap imagery: PlanetScope, © Planet Labs PBC [22]

magnitude and spatial extent of warming vary by facility size, cooling system configuration, and meteorological conditions.

3.1 Cyrusone, Chandler. The CyrusOne colocation campus was measured on two dates. The first traverse (Fig. 2(*a*)), conducted on June 18, 2025 (2:25–2:45 p.m.), captured afternoon conditions with winds from 240 deg (WSW) at 2.1 m/s, advecting the thermal plume toward the residential neighborhoods east and northeast of the campus.

The mean air temperature on the upwind side of the facility was approximately 42.7 °C, increasing to 43.5 °C in the neighborhood near the eastern boundary of the data center campus on the downwind side. The observed ΔT of approximately 0.8 °C extended roughly 500 m downwind.

A second traverse at CyrusOne (Fig. 2(*b*)) on August 8, 2025 (11:05–11:10 a.m.), under winds from 282 deg (WNW) at 1.5 m/s, confirmed the thermal signature under different meteorological conditions. Mean air temperatures of 39.1 °C on the upwind side of the data center increased to 39.6 °C in the downwind residential area to the southeast, yielding a ΔT of 0.5 °C. This traverse also revealed an apparent downwind cooling signal near the northeast boundary of the figure. Upon further investigation, this region of apparent cooling is immediately adjacent to a water detention basin in Chuparosa Park (marked with an X on the figure), situated between the data center and the street upon which downwind measurements were made. Chuparosa Park uses a combination of sprinkler irrigation of sports fields and flood irrigation around treed areas of the park. As a result, it is not surprising that the measurements downwind of the park during summer reveal an apparent cooling relative to the areas upwind of the data center, suggesting a possible mitigation strategy to address the effects of data center waste heat.

3.2 Aligned, Chandler. On the same morning as the second CyrusOne traverse, measurements were conducted at the Aligned data center in Chandler (Fig. 2(*c*); August 8, 2025, 11:10–11:15 a.m.) under westerly winds (274 deg) at 1.2 m/s. The traverse recorded a mean air temperature of 39.3 °C near the eastern border of the facility, where condenser exhaust is discharged, compared with 38.6 °C in the upwind area to the west, yielding a ΔT of approximately 0.7 °C.

3.3 Digital Realty, Chandler. A traverse at the Digital Realty facility in Chandler (Fig. 2(*d*); October 25, 2025, 10:55–11:05

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Table 1 Ranges and averages of air temperatures (°C) measured in the upwind (T_u) and downwind (T_d) boxes depicted in Fig. 2

	(a)		(b)		(c)		(d)		(e)			
	T_u	T_d	T_u	T_d	T_u	T_d	T_u	T_d	T_{d1}	T_{d2}	T_{d3}	T_{d4}
Min	42.1	42.8	38.8	39.4	38.5	39.2	24	25	24.8	24.4	25.4	24.5
Max	43.4	44.3	39.5	40	38.6	39.5	24.4	25.4	25.3	25	25.8	25.1
Mean	42.7	43.5	39.1	39.6	38.6	39.3	24.2	25.2	25	24.6	25.5	24.8

a.m.) was conducted under winds from 80 deg (ENE) at 2.1 m/s. The traverse revealed elevated mean air temperatures downwind, reaching 25.2 °C, compared with 24.2 °C in the upwind (east) area of the facility. The resulting mean and maximum temperature differences between the upwind and downwind areas were 1.0 °C and ~2 °C, respectively.

3.4 NTT, Mesa. A traverse at the NTT PH1 facility in Mesa (Fig. 2(*e*); October 25, 2025, 10:30–10:40 a.m.) was conducted under winds from 150 deg (SSE) at 1.5 m/s, placing the Santa Rita Ranch residential neighborhood directly downwind. Mean air temperatures of 25.5 °C and 25.0 °C were recorded near the data center boundary, decreasing to 24.8 °C and 24.6 °C with increasing distance northward (80–100 m) into the neighborhood. The resulting air temperature signal ($\Delta T \approx 0.9$ °C) 300–500 m downwind from the data center is consistent with plume dilution and vertical mixing downwind of the condenser arrays.

Across the four data centers observed in this study, the apparent downwind air temperature warming effect was as large as 2.2 °C, with average downwind air temperatures being 0.7–0.9 °C warmer than the corresponding upwind temperatures (Table 1). Temperature elevations were detectable at distances of 100–500 m from the facility perimeter, depending on facility size, wind conditions, and campus layout.

4 Discussion

The measurements presented here are, to our knowledge, the first field evidence that operational data centers produce measurable increases in air temperature in adjacent residential neighborhoods. While it should be emphasized that these are initial observations, the measured elevation of air temperature by as much as 2.2 °C at 100–500 m downwind is physically consistent with the extraordinary heat flux densities involved. The attribution of this warming to data center waste heat is supported by the consistent alignment of the temperature signal with the prevailing wind direction across multiple sites, dates, and meteorological conditions. While the sensitivity relationship of ~1 °C per 100 W/m^2 from Ref. [6] would suggest much larger warming, data center heat is emitted as a buoyant plume that partially disperses before reaching pedestrian level in downwind neighborhoods. Nevertheless, the measured air temperature elevations represent a nontrivial warming effect, especially in a region where extreme heat already poses serious public health risks. It is important to note that these measurements represent a relatively small sample of initial observations from only four data centers and a few measurement periods. A more exhaustive field campaign is being planned to collect data for a much wider range of times and weather conditions. These data will then support the development of a validated microscale atmospheric model that can be used to explore design alternatives to lessen the downwind thermal impacts of data centers. Nevertheless, these initial data are consistent with expectations from decades of research on anthropogenic heat and support the hypothesis that data centers may result in substantial warming of proximate downwind neighborhoods.

The magnitude of data center heat rejection is remarkable relative to other urban sources [23]. City-wide Q_f in Phoenix averages ~13 W/m^2 in summer, with peaks of ~50 W/m^2 in commercial areas [4]. Tokyo's central business district has peak Q_f emissions of ~1600 W/m^2 [24], but these emissions are distributed vertically across high-rise buildings exceeding 100 m. A single 36 MW data center rejects 2800–6200 W/m^2 at ground or rooftop level from one building footprint—far exceeding emissions from dense urban areas. With hundreds of megawatts of data center capacity currently operational in Phoenix and thousands more proposed [10], the aggregate thermal impact on the urban atmosphere could be substantial, leading to many pockets of data center heat islands, and potentially having wider-scale implications for the urban climate system.

These findings have implications for many aspects of urban operations, including increases in air conditioning energy demand for neighborhoods warmed by nearby data centers [25]. Prior modeling for Phoenix has shown that waste heat from residential air conditioning alone increases summertime nighttime temperatures by more than 1 °C [26]. In Phoenix, where cooling exceeds 50% of household electricity use, even 1–2 °C of additional ambient warming can meaningfully increase peak cooling demand and annual energy consumption in downwind homes, creating a feedback loop where data center operations raise the energy burden on surrounding neighborhoods, precisely during the extended summer cooling season when temperatures already routinely exceed 43 °C.

There are many factors that influence the downwind thermal impacts from data centers. Some, such as background weather conditions, are mostly out of our control. However, the design and configuration of cooling equipment used in data centers may offer some control over these impacts. Exhaust height, velocity, discharge angle, equipment density, and parapet walls all influence plume buoyancy and dispersion. Strategic design informed by high-resolution microclimate modeling now feasible at 1–2 m resolution [27] could substantially reduce the thermal footprints of data center impacts without compromising cooling performance. Such considerations should be integrated into siting and permitting processes, particularly in hot climates.

5 Conclusions

This communication presents the first field evidence that operational data centers produce measurable warming in adjacent residential neighborhoods, with the downwind warming effect as large as 2.2 °C and average downwind air temperatures 0.7–0.9 °C warmer than upwind temperatures, extending more than 250 m downwind. These impacts arise from heat flux densities of 2000–6000 W/m^2, magnitudes 2–6 times peak solar irradiance, equivalent to the heat emitted by thousands of residential buildings concentrated on a single site. As global data center capacity is projected to double by 2030, we establish data center anthropogenic heat as a previously unrecognized urban thermal hazard with implications for residential building energy, outdoor thermal comfort, and public health. With facilities increasingly sited in hot-climate markets across the American Southwest, the Middle East, and Southeast Asia, and a growing reliance on sensible air-based cooling systems, the thermal externality documented here is poised to become a recurring feature of 21st-century urbanization.

Future research should include systematic observational campaigns that integrate additional traverse observations with

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temporary fixed weather stations and remote-sensed land surface temperature data. These studies should characterize the sensitivity of the observed warming to wind speed, atmospheric stability, and time of day, connect the warming to impacts on residential energy and water use, and translate the resulting temperature elevations into outdoor thermal comfort metrics. The resulting empirical datasets will be important for informing more systematic statistical analyses of the downwind thermal effects of data centers. They will also be essential for developing and validating microscale models, which can then be used to evaluate design interventions aimed at mitigating the downwind thermal impacts of data centers.

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Conflict of Interest

There are no conflicts of interest.

Data Availability Statement

The datasets generated and supporting the findings of this article are obtainable from the corresponding author upon reasonable request.

References

[1] Oke, T. R., Mills, G., Christen, A., and Voogt, J. A., 2017, *Urban Climates*, Cambridge University Press, Cambridge.
[2] Sailor, D. J., and Lu, H., 2004, "A Top-Down Methodology for Developing Diurnal and Seasonal Anthropogenic Heating Profiles for Urban Areas," Atmos. Environ., **38**(17), pp. 2737–2748.
[3] Sailor, D. J., Georgescu, M., Milne, J. M., and Hart, M. A., 2015, "Development of a National Anthropogenic Heating Database With an Extrapolation for International Cities," Atmos. Environ., **118**, pp. 7–18.
[4] Chow, W.T.L., Salamanca, F., Georgescu, M., Mahalov, A., Milne, J. M., and Ruddell, B. L., 2014, "A Multi-method and Multi-scale Approach for Estimating City-Wide Anthropogenic Heat Fluxes," Atmos. Environ., **99**, pp. 64–76.
[5] Smith, C., Lindley, S., and Levermore, G., 2009, "Estimating Spatial and Temporal Patterns of Urban Anthropogenic Heat Fluxes for UK Cities," Theor. Appl. Climatol., **98**(1–2), pp. 19–35.
[6] Wang, L., Sun, T., Zhou, W., Liu, M., and Li, D., 2023, "Deciphering the Sensitivity of Urban Canopy Air Temperature to Anthropogenic Heat Flux With a Forcing-Feedback Framework," Environ. Res. Lett., **18**(9), p. 094005.
[7] International Energy Agency (IEA), 2025, "Energy and AI: Special Report," IEA, Paris.
[8] Pew Research Center, 2025, "What We Know About Energy Use at US Data Centers Amid the AI Boom," https://www.pewresearch.org/short-reads/2025/10/24/what-we-know-about-energy-use-at-us-data-centers-amid-the-ai-boom/, Accessed March 27, 2026.
[9] Data Center Map, 2025, "Number of Data Centers Worldwide," https://www.datacentermap.com/datacenters/, Accessed November 2025.
[10] CBRE, 2025, "North America Data Center Trends H2 2024," CBRE Research.
[11] NTT Global Data Centers, 2013, "Phoenix PH1 Data Center Fact Sheet," NTT DATA Inc., Mesa, AZ.
[12] U.S. Energy Information Administration, 2024, "Energy Use in Homes," https://www.eia.gov/energyexplained/use-of-energy/electricity-use-in-homes.php, Accessed March 27, 2026.
[13] Shehabi, A., Newkirk, A., Smith, S. J., Hubbard, A., Lei, N., Siddik, M. A. B., Holecek, B., Koomey, J., Masanet, E., and Sartor, D., 2024, "2024 United States Data Center Energy Usage Report," Lawrence Berkeley National Laboratory, LBNL-2001637, https://eta.lbl.gov/publications/2024-lbnl-data-center-energy-usage-report
[14] CyrusOne, 2026, "Chandler, AZ: PHX1-PHX8," https://www.cyrusone.com/data-centers/north-america/chandler-arizona, Accessed March 27, 2026.
[15] Kennedy, H., and ASHRAE, 2024, *ASHRAE Handbook—HVAC Systems and Equipment*, H. E. Kennedy, ed., SI ed., American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA, Ch. 39, pp. 741–760.
[16] ASHRAE, 2025, "Climatic Design Information," *ASHRAE Handbook—Fundamentals*, H. E. Kennedy, ed., SI ed., American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA, Ch. 14, pp. 14.1–14.18.
[17] Hart, M., and Sailor, D. J., 2008, "Quantifying the Influence of Land-Use and Surface Characteristics on Spatial Variability in the Urban Heat Island," Theor. Appl. Climatol., **95**(3–4), pp. 397–406.
[18] Molla, A., Sailor, D. J., and Flores, A. B., 2025, "Exploring Air Temperature Variability and Socio-demographic Inequalities in Heat Exposure Through Machine Learning: A Case Study of Maricopa County, Arizona," Urban Clim., **59**, p. 102276.
[19] Molla, A., Lamer, K., and Sailor, D. J., 2026, "Citizen Science Coupled With Machine Learning to Quantify Green-Blue Infrastructure Cooling Potential in Maricopa County, Arizona," Sustain. Cities Soc., **139**, p. 107211.
[20] Rajkovich, N. B., and Larsen, T. T., 2016, "A Bicycle-Based Field Measurement System for the Study of Thermal Exposure," Int. J. Environ. Res. Public Health, **13**(2), p. 159.
[21] Schneider, F. A., Ortiz, J. C., Vanos, J. K., Sailor, D. J., and Middel, A., 2023, "Evidence-Based Guidance on Reflective Pavement for Urban Heat Mitigation in Arizona," Nat. Commun., **14**(1), p. 1467.
[22] Planet Labs PBC, 2026, "PlanetScope Imagery Documentation," https://docs.planet.com/data/imagery/planetscope/, Accessed March 31, 2026.
[23] Sailor, D. J., 2011, "A Review of Methods for Estimating Anthropogenic Heat and Moisture Emissions in the Urban Environment," Int. J. Climatol., **31**(2), pp. 189–199.
[24] Ichinose, T., Shimodozono, K., and Hanaki, K., 1999, "Impact of Anthropogenic Heat on Urban Climate in Tokyo," Atmos. Environ., **33**(24–25), pp. 3897–3909.
[25] Santamouris, M., Cartalis, C., Synnefa, A., and Kolokotsa, D., 2015, "On the Impact of Urban Heat Island and Global Warming on the Power Demand and Electricity Consumption of Buildings—A Review," Energy Build., **98**, pp. 119–124.
[26] Salamanca, F., Georgescu, M., Mahalov, A., Moustaoui, M., and Wang, M., 2014, "Anthropogenic Heating of the Urban Environment Due to Air Conditioning," J. Geophys. Res. Atmos., **119**(10), pp. 5949–5965.
[27] Mortezazadeh, M., Wang, L. L., Albettar, M., and Yang, S., 2022, "CityFFD—City Fast Fluid Dynamics for Urban Microclimate Simulations on Graphics Processing Units," Urban Clim., **41**, p. 101063.

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NEWS

Data Centers, Urban Heat, and AI Growth

As AI fuels data center expansion, communities are pushing back. What's driving the opposition, and what are the real environmental and economic trade-offs? YSE experts weigh in.

As proposals to build data centers to meet the computing demands of artificial intelligence grow, so too does the pushback.

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managed to block or delay more than $60 billion in data center investments in roughly a year. The concerns around data centers are immediate and local: urban heat, water consumption, electricity grid strain, but the drivers are global and economic. Understanding the science, the political landscape, and the underlying economics is critical to understanding how this technology will shape communities.

Here, Karen Seto, the Frederick C. Hixon Professor of Geography and Urbanization Science and Director of the Hixon Center for Urban Sustainability, explains what data centers actually do to urban heat. Daniel Esty, the Hillhouse Professor of Environmental Law and Policy, maps the cross-spectrum opposition and what it reveals about how society should approach AI's costs and benefits. Kenneth Gillingham, the Grinstein Class of 1954 Professor of Environmental and Energy Economics, breaks down the economic and energy realities driving the data center boom, and Yuan Yao, the Manufacturer's Association Professor of Industrial Ecology and Sustainable Systems, explains the environmental costs of data centers and what solutions exist to minimize their impact.

Q. How do data centers actually affect urban heat? What does the science show?

Seto: Because nearly all of the electricity consumed by a data center ends up as heat, servers and other equipment require continuous cooling. These cooling systems remove the heat generated by computing and release it into the surrounding environment as waste heat. Recent research conducted in Phoenix, Arizona, estimates that a large data center can emit

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nearby neighborhoods by up to 4°F. These effects have been observed as far away as half a kilometer, or about five city blocks!

While more research is needed, these findings suggest that data centers can worsen heat exposure in neighborhoods that are already impacted by the urban heat island effect. Given that cities are typically 1-7°F warmer than surrounding areas, additional warming from data center waste heat can further increase air conditioning energy demand and human health risks in nearby communities. In order to mitigate these impacts, cities and industry leaders should work together on better facility design and neighborhood cooling strategies, including parks and reflective surfaces.

Q. Communities are pushing back on data centers across the political spectrum. What are they actually opposing — and why?

Esty: Reactions to the growth of data centers represent something of a Rorschach Test — perhaps telling us more about the economic confidence of those offering opinions than anything else.

Every week we see new AI-enabled tools emerging that might allow us to reconfigure our food, transport, building management, and energy systems for much greater efficiency and thus

NEWSLETTER

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speed and scale, which might allow us to ramp up the global response to shared challenges such as climate change, biodiversity conservation, chemical exposures, and pollution.

the Environment.



But AI also poses significant risks related to growing electricity demand that could cause a spike in greenhouse gas emissions as well as air and water pollution if the new power requirements are met by fossil fuels rather than clean power generation and improved energy efficiency.

What has become evident is that society needs a more clear-eyed approach to the potential losses from AI as well as a strategy for sharing the benefits. Simply put, only with ongoing policy-guided investments and concerted effort can we be confident that AI will move society toward a sustainable future.

Q. What's the actual economic and energy reality driving data center growth?

Gillingham: The main driver of data center expansion today is the race to train better AI models. In addition to training large language models, data centers are also used to run generative AI queries. They are also used simply to store all of the data that we all have in the cloud. But the primary driver of the growth really is generative AI.

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Yale's peak demand. We are beginning to see substantial anxiety about generative AI in the polls, as well as substantial pushback from some politicians. Regardless, energy policy will have to accommodate the first new growth in electricity demand in a couple of decades. Electricity prices are already rising, and they are likely to continue to increase in the near future. Higher electricity prices can help the adoption of renewables, but so far, the new electricity demand has largely been met with natural gas generation. This means increased emissions. We don't know how many new data centers will be built, but it is clear already that the next few years will be a very dynamic time for electricity markets and energy policy.

Q. What are the real environmental impacts of data centers, and what solutions are there?

Yao: The environmental impacts of data centers are real, but they are also highly context-dependent. The most visible impact is electricity use, which can translate into greenhouse gas emissions depending on when and where the power is consumed. A data center located on a coal- or gas-heavy grid can have a very different carbon footprint from one using low-carbon electricity. Water use is another major concern, especially for cooling and for electricity generation upstream, and it matters greatly whether a facility is located in a water-stressed region.

A life-cycle perspective is important because impacts do not come only from day-to-day operations. Data centers also require servers, chips, cooling equipment, buildings, backup

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manufacturing, construction, and replacement.

The solutions that work best are not single fixes, and they may differ across locations, technologies, and operating models. Energy efficiency and improved cooling remain important, but efficiency gains can be offset if total demand grows rapidly. Clean electricity procurement is essential, but it should be evaluated by location and time, not just annual averages. More broadly, solutions need to consider siting and infrastructure decisions, operational strategies, and the full life cycle management of hardware and equipment. Transparent reporting and metrics that capture carbon, water, reliability, and life cycle environmental impacts together are also critical.

best are not single fixes, and they may differ across locations, technologies, and operating models. Energy efficiency and improved cooling remain important, but efficiency gains can be offset if total demand grows rapidly."

Yuan Yao Manufacturer's Association Professor of Industrial Ecology and Sustainable Systems

My group is currently working on sustainability metrics for data centers, with the goal of helping companies, policymakers, and the public more clearly compare impacts across technologies, locations, and operational choices.

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ENVIRONMENT

Why data centers pose an outsized threat to Eastern Oregon's air quality



By April Ehrlich (OPB)
July 22, 2026 6 a.m. **Updated:** July 23, 2026 12:50 p.m.

Under an unstable grid, diesel pollution could threaten communities with large clusters of data centers.

00:00 / 05:01

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HIGHLIGHTS

- Data centers use train car-sized diesel generators for backup power during blackouts.
- The Pacific Northwest's unstable grid is at risk of longer, more frequent blackouts, making some areas more vulnerable to harmful diesel exhaust from large data centers.
- An hour-long, region-wide power outage in the Lower Umatilla Basin — where there are 14 large data centers — could generate as much pollution as 38,000 semi-trucks driving for an hour.
- Air pollution is a risk that some local officials say is worth bearing, as their small towns see growing economies for the first time in decades.

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A cow on Josh Walton's property walks in front of a data center in Umatilla, Ore., in April 2026. The Waltons' home was once surrounded by cornfields and farms. Now, a large swath of their property looks out onto an Amazon data center. Many of the data centers across Oregon rely on diesel generators to provide backup power —which, if used, could release massive amounts of diesel pollution into nearby communities.

Saskia Hatvany / OPB

When the Waltons built their lemon-colored ranch home outside Umatilla in northeast Oregon, they were drawn to the area’s rolling hills.

“All of our neighbors were farmers,” Josh Walton said on a sunny afternoon this spring. “So, all this used to be a cornfield.”

The landscape has changed a lot in the last 15 years. Instead of overlooking crop fields and the Columbia River in the distance, the Waltons’ backyard view is now the towering white walls of a data center operated by Amazon.

This complex of four boxy buildings is roughly the size of nine Walmart Supercenters. At night, its stadium-level lighting shines into the Waltons’ bedroom windows, making sleep difficult for Walton, his wife and their two teenage sons. Most summer days, the data center’s cooling fans drone like low-flying passenger jets.

“Except it’s constant and doesn’t fade away,” Walton said.

The family could face another intrusion from their super-sized neighbors: diesel pollution.

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Mason Walton, 14, does chores at his family's home in Umatilla, Ore., in April 2026.

Saskia Hatvany / OPB

Across the country, Amazon, Google and other tech companies have stocked up on diesel generators to keep their data centers humming during power outages. Like diesel-powered buses, these generators chug out black exhaust full of air pollutants that can cause cancer, asthma and heart disease.

At a time when the risk of major blackouts is growing, that could add massive air pollution to Oregon and the Northwest. Yet Oregon air regulators haven't modeled the potential risk from Oregon's growing data center market, and policymakers haven't asked them to.

While the precise risk to the public is unknown, it could be enormous.

Related: How we reported the story about emissions from data center generators

To measure the potential harm, OPB used pollution permits to calculate emissions based on a possible blackout scenario and then checked those estimates with regulators

and industry analysts for accuracy.

OPB focused on the Lower Umatilla Basin because that is where Oregon's largest, most power-hungry data centers are clustered. All are owned by Amazon. We found the company has amassed enough diesel generators to cloud the nearby cluster of small, rural towns along the Columbia River with smog. For each hour that an outage lasts, they would emit about twice as much pollution as all of the exhaust from cars and trucks on Oregon's roads over the same hour.

Data centers in the Lower Umatilla Basin

Amazon owns 14 data center complexes in the Lower Umatilla Basin in Northeast Oregon.



Source: Oregon Department of Environmental Quality pollution permits

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If a region-wide blackout forced Amazon to run its generators for an hour, it would create more diesel pollution than 38,000 semi-trucks driving through town over the same period.

That extreme level of pollution would only occur during a blackout stretching across a 30-mile-wide region, which Amazon says is highly unlikely.

OPB's "calculation relies on a scenario in which the entire Umatilla Electric Cooperative territory loses power simultaneously," Amazon spokesperson Adrienne Talbot said in an email. "This has never happened in the utility's 89 years of operation and would be an extraordinarily rare event anywhere in the United States."

But widescale power outages are not unheard of. In 2021, an ice storm knocked out power for more than 300,000 Oregonians in the Willamette Valley. Some were without power for hours. Others were in the dark for days. And two weeks after Talbot said Umatilla Electric had never experienced a large-scale outage, a neighboring utility — the Oregon Trail Electric Cooperative — did experience a territory-wide power failure across about 4 million acres for about an hour. The outage was triggered by a wildfire.

Amazon has cleaner alternatives it could use for backup power. It could replace its current generators with new ones that have pollution controls. A company spokesperson said its new data centers will all have generators with pollution controls. But that won't help the Watsons if the power goes out today.

If electrical grids become increasingly unstable, the chances of a region-wide outage increase. The Western Electricity Coordinating Council projects that by 2034, Pacific Northwest residents could see more than 700 hours of potential power failures annually.

"It's certainly something that could happen," said Jay Dietrich, research director of sustainability at Uptime Institute, a data center consultancy. "You have to be aware that it could happen and you have to plan for it."

Other parts of the country are already experiencing grid strain during extreme weather events, like storms and heatwaves, prompting data center operators to run their generators nonstop for multiple days, even when their local permits expressly prohibit that.

Five times this year, the Trump administration used a 1930s law originally written for wartime to allow data centers to tap their diesel generators and stop drawing power from the electrical grid. These emergency orders enabled data center operators to run their generators for multiple days, forgoing local pollution regulations.

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Potential air pollution is one of the tradeoffs Oregon's city and county leaders are making as they welcome data centers. These high-tech projects have brought public revenue and jobs. For the first time in years, these small farming towns are seeing their budgets and populations grow.



An Amazon data center is seen from Oregon Trail Boulevard, in a neighborhood of Boardman, Ore., in April 2026.

Saskia Hatvany / OPB

Some officials in these communities say they trust the state to keep the air clean.

"We're not air quality experts and don't have to really deal with it in any other circumstance," said Hermiston Assistant City Manager Mark Morgan.

Morgan said they rely on the state's environmental regulators to ensure air quality is safe. Those regulators say they're concerned about air pollution from data centers' generators, but they're limited in what they can do.

This year, Gov. Tina Kotek convened a data center advisory committee to address issues from data center growth and recommend policy solutions. Air quality was added to the

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committee's to-discuss list on Friday, after OPB contacted the governor's office for this story. It will be on the agenda on July 31.

In a statement to OPB, the governor's office said the committee will "certainly be considering diesel generator impacts in their deliberations."

"The Governor believes there should be intentional statewide planning on data centers to ensure Oregon is effectively mitigating adverse impacts while maintaining strong economic growth and responsible stewardship of local tax revenues," Press Secretary Luke Harkins said. "That's why she convened the Data Center Advisory Committee and looks forward to their recommendations later this year."

Backbone of the internet



A data center in Umatilla, Ore., in April 2026. Data centers often have power stations built adjacent to them to meet their extensive energy needs.

Saskia Hatvany / OPB

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Just about everything on the internet runs through data centers. Their computer servers host streaming movies, video games and business documents, and they train and host artificial intelligence models.

Processing all of that data requires an exorbitant amount of electricity. The data center behind the Waltons' home is part of a class of massive data centers called "hyperscale." It uses more than 100 megawatts of electricity at once, enough to power about 80,000 homes.

That energy must be constant. Over the last three years, one in five data center operators experienced a loss of more than $1 million — some of them from power outages, according to an analysis by Uptime Institute.

"If my airline reservation system goes down, I can't sell new tickets. I can't put people on planes, right?" Dietrich of Uptime Institute said. "There are different ways those losses materialize, but they can easily get into the millions of dollars if it's a really critical system."

Meta, Apple and other tech companies own dozens of data centers across Oregon, varying in size and power load.

It's difficult to gauge the scale of data centers in Oregon compared to other states, partly because multiple buildings might be clumped together as a single campus sharing the same address. The Pew Research Center lists Oregon among the ten states with the highest number of operating data centers, though its figures don't consider their size or capacity.

Hillsboro, outside Portland, is home to about 40 individual data center buildings, but many of those have a small footprint. Prineville in Central Oregon has about 13 hyperscale buildings.

The Lower Umatilla Basin — which includes the towns of Boardman, Hermiston and Umatilla — has about 45 hyperscale buildings. Those structures dwarf most other data centers in the state.

Where life is sweet

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A Google Earth image, southwest of Hermiston, shows crop circles between Morrow and Umatilla counties.

Maps data: Google Earth/Airbus

Satellite images of Umatilla and Morrow counties show a grid of circular crop fields, like a collection of verdant coins, where farmers grow potatoes, onions and watermelons. Hermiston is "where life is sweet," as the city motto goes, with murals of watermelons painted around town.

Farmers across the country have been struggling in recent decades due to rising costs and market consolidation. Some Oregon farmers have sold or leased their land to make ends meet. Over time, some of those verdant coins have given way to solar panel farms, wind turbines and hyperscale data centers.

The Lower Umatilla Basin is now a web of industrial power lines.

Those power lines are partly what has brought data centers to this area. Data center operators want affordable power, lots of water, vast stretches of land — and friendly local governments.





First image: A hyperscale data center owned by Amazon can be seen on the outskirts of Hermiston, Ore., in April 2026. Second image: A train makes its way through Umatilla County in April 2026.

All images: Saskia Hatvany / OPB.

In Hermiston, Amazon has hired hundreds of employees and contractors to staff its two hyperscale data center campuses. Hermiston has given the company 15-year tax breaks for each campus. So instead of property taxes, Amazon pays annual fees amounting to about $9.5 million. Amazon also pays annual franchise fees, which businesses pay when their power lines or cables encroach on public rights-of-way. Hermiston's revenues from franchise fees have more than tripled since Amazon came to town, from $1 million in 2024 to a projected $3.4 million by the end of this year.

Amazon also contributed about $25 million toward water and other utility infrastructure, so the city can deliver water to Amazon. Another $9 million helped the city build an RV park for Amazon's construction workers.

That money has funded new city buildings, services and infrastructure. City staff say these financial exchanges are not quid-pro-quo deals, and that each agreement between the city and Amazon stands on its own.



Assistant City Manager Mark Morgan poses for a portrait at Hermiston's City Hall in April 2026 in Hermiston, Ore.

Saskia Hatvany / OPB

"This is paid for by Amazon," said Morgan, Hermiston's assistant city manager, waving toward the city's newly constructed City Hall.

The building's front overhang is made of green glass circles, a tribute to the region's farming industry.

An analysis by city staff estimated about 4,200 people in the Lower Umatilla Basin work at data centers — about 9% of this region's total population. These locations hire technicians to install, maintain and repair hardware and network infrastructure, as well as contractors for security, building maintenance and construction.

Between these jobs and the public fees Amazon pays, Morgan said, the benefits of becoming a data center hub have outweighed the costs.

"We're just comfortable in the discussions we've had that they can operate safely," Morgan said.

'The cumulative impact … is going to be incredibly high'



Generators and their exhaust pipes are visible outside of an Amazon data center in Umatilla, Ore., in April 2026.

Saskia Hatvany / OPB

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When a power outage strikes, large data centers first switch to their battery backups. Those run out of juice in about 10 minutes, according to Uptime Institute. Operators then fire up dozens — sometimes hundreds — of train car-sized diesel generators to keep the power flowing.

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Diesel exhaust is part gas, part soot. It's what creates smog around freeways and traffic-heavy cities like Los Angeles. Its most harmful pollutants include nitrogen oxides, or NOx, and particulate matter. The World Health Organization has classified both as carcinogens.

Oregonians might already be familiar with the term particulate matter, or PM 2.5, from wildfire smoke. Similar to smoke, tiny particles from diesel exhaust can lodge in people's lungs and enter their bloodstream, elevating their risk of heart attacks and lung disease. Severe health effects can occur within a day of exposure.

Hospitals, grocery stores and large corporate buildings commonly rely on diesel generators for backup power. They're sturdy, reliable and relatively cheap. But those buildings use a small fraction of the electricity of hyperscale data centers, so they only need a few diesel generators to power their essential services.

At OHSU, Oregon's only public academic hospital system, much smaller generators can cumulatively generate 18 megawatts of electricity.

The backup diesel generators at Amazon's 14 data centers in the Lower Umatilla Basin are collectively rated for about 3,700 megawatts of power. That's over 200 times more than OHSU's backups.

Last year, data centers in Oregon had about 6,000 megawatts of backup electrical generating capacity — double the average power usage of all the homes in the state.

An Amazon spokesperson declined an on-the-record interview with OPB, but in background conversations, staff said the company is investing in alternative energy sources — including nuclear, solar and wind — to help ease local grid strain.

In a statement, Kerry Person, Amazon's vice president of global operations and data center delivery, said the company's generators aren't currently high polluters.

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Generators and their exhaust pipes are visible outside of an Amazon data center in Umatilla, Ore., in April 2026.

Saskia Hatvany / OPB

"Our emergency generators run approximately 12 hours per year, almost entirely for brief compliance testing," Person said. "These systems exist solely to protect continuity of essential services during rare power interruptions."

When there isn't an emergency or a blackout, data centers have to maintain their generators by running each of them at low capacity for a minimum of 30 minutes a month. State environmental regulators say that maintenance doesn't release a concerning amount of pollution.

What does worry them, though, is what would happen during a summer heatwave or wildfire-induced blackout, when multiple data centers might crank up many of their generators at once.

"The cumulative impact, in terms of NOx emissions, in terms of PM 2.5, is going to be incredibly high," DEQ air quality administrator Ali Mirzakhalili said.

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Nitrogen oxides emissions

If the Umatilla Basin experienced a 24-hour blackout, Amazon's data centers would turn on their back-up diesel generators. Those generators release pollutants called nitrogen oxides, or NOx. This chart shows how much these data centers could release compared to other major polluters.

Amazon's potential NOx emissions, tons per day	Oregon's 2022 statewide NOx emissions, tons per day
Amazon's data centers	216
On-road vehicles	107
Industrial boilers & combustion engines	25
Rail transportation & equipment	16
Marine vessels	12
Construction equipment	9

Oregon isn't tracking data center air pollution risks

On paper, Oregon limits how much diesel fuel a data center can use in a year — around 700,000 gallons for each campus. Amazon would likely exceed those limits during an extended blackout, Mirzakhalili said.

"Is that fuel sufficient to satisfy a long-duration emergency? I don't think so," Mirzakhalili said. "Should that happen, they're going to use more fuel than that, and we're not going to stop that."

Amazon didn't directly respond when asked about the possibility it might exceed state limits. It stressed the importance of preparing for severe weather or other disruptions to the electrical grid.

Data center operators can reduce their diesel pollution by installing generators that include pollution controls, like filters. Those generators can cut emissions by about 90%, but they are pricey. Just one pollution-controlled generator could cost upwards of $1 million, almost twice as much as a standard industrial generator.

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Amazon is the fifth most valuable company in the world, valued at $2.6 trillion, with $78 billion in profits last year.





First image: An Amazon data center in Boardman, Ore. Second image: A data center is under construction in Umatilla, Ore.

All images: Saskia Hatvany / OPB.

Staff with Amazon told OPB that they plan to equip their new data centers entirely with pollution-controlled generators going forward. They did not directly respond when asked if the company had plans to replace its current generators that don't include filters.

DEQ now offers fast-tracked air pollution permits to operators who primarily use pollution-controlled generators, but no companies have taken up the offer in the last year.

Staff with the agency say they're worried about data centers releasing concentrated plumes of diesel exhaust.

"It's a carcinogen," Mirzakhalili said. "That's an additional load to the environment that we don't want to see."

Other than its fast-tracked permits, Oregon doesn't have statewide laws or policies specifically addressing diesel generators at data centers.

"It's a risk we have to understand," said Shaolei Ren, an engineering professor at University of California, Riverside, who has studied the health impacts from data centers.

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Ren has advocated for state governments across the country to take a closer look at how data center emissions could impact the towns where they are concentrated.

California, Virginia, Illinois and Washington have strictly limited data centers from using generators without pollution controls. Washington regulators are also tracking and modeling diesel pollution in regions with large numbers of data centers, so lawmakers can eventually develop policies that can protect people from pollution.

Oregon isn't tracking how much air pollution data center generators could release during a major power outage.

Pausing environmental laws for data center power

The risk of air pollution from data centers' diesel generators goes beyond the Pacific Northwest.

Diesel generator capacity at data centers in the U.S. nearly tripled from 2018 to 2024, according to a report by the Better Data Center Project, an organization that advocates for cleaner data centers. If they were all turned on at once, diesel generators at data centers across the country could provide enough electricity to power roughly 20 million American homes.

That's a lot of potential power — and a lot of potential exhaust.

Trump administration policies may be increasing that potential health risk.

Four researchers who spoke to OPB say they are worried about something called "demand response." That's when electric utilities request data centers stop pulling from the grid when overall electrical demand is high, like during heat waves or snowstorms. When that happens, most data centers turn to their backup power supplies.

Oregon's air pollution permits don't allow industrial businesses like data centers to participate in demand response. They can only use their generators if they unexpectedly lose power.

But those regulations can be cast aside by the federal government. During a winter storm that stretched across southern and northeastern states, three electric utilities serving 97 million customers asked the federal government to waive environmental limitations on data centers in order to prevent blackouts for residential customers.

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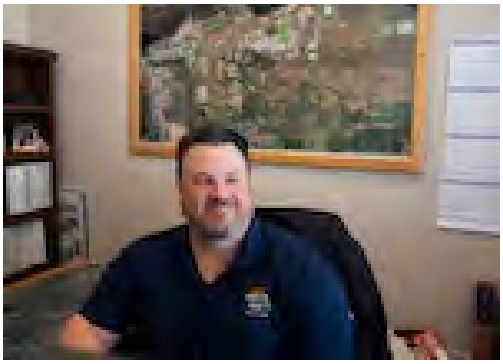
The U.S. Department of Energy granted their requests under a section of the Federal Power Act, a 1935 statute originally created to compel utilities to cooperate during war. The Trump administration has used these emergency powers to allow coal plants to continue operating past their retirement dates — and to allow data centers to use their backup diesel generators — regardless of environmental restrictions.

During this year's winter storms, the Energy Department's emergency orders allowed data centers in 14 states and the District of Columbia to rely on their backup power instead of the electrical grid. The orders specifically excluded other businesses and agencies that have backup power — including hospitals, first responders, air traffic controllers, and facilities treating water and waste — from using those backups without environmental limitations.

Looking for alternatives

Not far from Hermiston, Umatilla has also seen financial benefits thanks to data centers. It has four in city limits, and three others in the works. All but one belong to Amazon.

Umatilla has seen a seven-fold increase in its overall budget since Amazon started building more data centers here around 2018, according to city manager David Stockdale. Umatilla is now one of the few cities in Oregon with growing revenues. That's helped the city repair roads and old buildings at a time when many Oregon communities are facing budget cuts.



Umatilla City Manager David Stockdale in his office in April 2026. Stockdale says the arrival of the industry has provided much-needed cash flow to the town, and also acknowledges the environmental costs of data centers.

Saskia Hatvany / OPB

"Prior to data centers arriving here, quite literally everything was deferred maintenance," Stockdale said. "Prior to 2018, it had been about 25 years since there had been even a road construction project in the whole city."

Amazon has also brought people. Housing construction is at an all-time high, Stockdale said, with around 100 new homes entering the market every year — significant for a town with around 2,200 households.

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But Stockdale also acknowledges data centers' environmental impacts, including the potential for increased air pollution. He's helping spearhead an effort to build a battery storage facility on about 1 million square feet, which could help power data centers during blackouts. Stockdale said the project is stalled by slow-moving negotiations with state land use regulators.

Umatilla city officials are also hopeful that a business could turn carbon dioxide from diesel exhaust into clean, restaurant-quality carbon dioxide for carbonating sodas. They're in the early stages of helping the company find suitable land in city limits.

Stockdale sees this as an example of the city doing its best to mitigate environmental harms that could come from data center pollution.

"We've tried to take a proactive approach rather than reactive," Stockdale said.



Josh Walton and his son Blake Walton talk to neighbors at their home in Umatilla, Ore., in April 2026. The Waltons say the new data center adjacent to their property emits bright lights at night and a loud humming, especially on hot days — both of which disrupt their sleep.

Saskia Hatvany / OPB

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Even so, Josh Walton — whose home now sits in the shadow of that hyperscale data center near Umatilla — feels like he's on the losing side of an industry that's rapidly transformed his community.

"It seems like it happened so quickly," Walton said of the data center behind his home. "We were never notified. We never received a letter."

Walton's property is 450 feet from the data center site — far enough that officials weren't required to tell him of the plans.

To Walton, it feels like his health, and that of his family, depends on the economic whims of local politicians.

"There's noise pollution, there's light pollution, there's increased traffic," Walton said. "We just hope that the people that are in charge are doing the best for the community."

This story was written and reported by April Ehrlich, edited by Courtney Sherwood, Tony Schick and Gillian Flaccus, with photos by Saskia Hatvany and visual editing by Kristyna Wentz-Graff, and digitally produced by Sukhjot Sal.

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***Editor's note**: This story has been updated to clarify the time span during which diesel generator capacity at U.S. data centers climbed. That capacity nearly tripled from 2018 to 2024. This story has also been updated to clarify the nature of data center financial losses included in an Uptime Institute analysis.*

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Localized Air Pollution Impacts from Data Centers in Northern Virginia

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Modeling Localized Air Pollution Impacts from Data Centers in Northern Virginia

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1. Background

The goal of this research is to examine the extent of current and potential future air pollution emissions from data centers in Northern Virginia. As has been well documented, Northern Virginia has the largest concentration of data centers in the world, which is greatly increasing electricity demand and associated greenhouse gas (GHG) emissions and other forms of air pollution from fossil-fuel power plants. However, this study does not examine the implications of data centers' electricity consumption. Rather our focus is on the direct criteria air pollution emissions (i.e., pollutants such as carbon monoxide and nitrous oxides that directly harm human health) resulting from the data centers' use of backup diesel and natural gas generators.

This project addresses the following research questions about the total current criteria emissions from Northern Virginia data centers, as well as the much larger amount that is allowed under the data centers' air pollution permits from the Virginia Department of Environmental Quality (DEQ):

- What are the total current criteria air pollutant emissions from data centers in Northern Virginia, how much have those emissions increased from 2015 - 2023, and what percentage do they represent of total criteria air pollution in the region?
- How does the total criteria air pollution from data centers compare to the amount of air pollution emitted by other notable facilities in the region (electric power plants, etc.)?
- How much additional criteria air pollution would Northern Virginia's data centers emit, if they were to reach the total level of emissions allowed by their DEQ air permits?

Additionally, given that many of Northern Virginia's data centers are concentrated in certain parts of the region, our research addresses the following additional questions about the localized air pollution exposure from data centers in Northern Virginia:

- What is the total cumulative exposure to criteria air pollution from data centers in individual Northern Virginia neighborhoods?
- What is the potential cumulative exposure to criteria air pollution from data centers in Northern Virginia neighborhoods, if they emit the total amounts allowed by their permits?
- To what degree does the current and potential neighborhood-level air pollution exposure from data centers compare to that from other notable facilities in the region?
- To what degree do the current and potential neighborhood-level air pollution levels in Northern Virginia correlate with demographic characteristics such as race, income, etc.?

2. Data Sources and Methodology

[*Note: See Appendix A for a more detailed discussion of this report's methodology*]

To answer the first set of research questions, about current air pollution emissions from data centers, we utilized back-end data provided directly by the Virginia DEQ. Additional contextual data about air pollution in the region was sourced directly from the National Emissions Inventory (NEI) website maintained by the U.S. Environmental Protection Agency (EPA).

To evaluate potential future emissions from data centers, we downloaded all available data center air pollution permits from the Virginia DEQ website on Issued Air Permits for Data Centers, as of June, 2025, identified those within our Northern Virginia study area, and built a database of the key details from those permits including their annual emission limits.

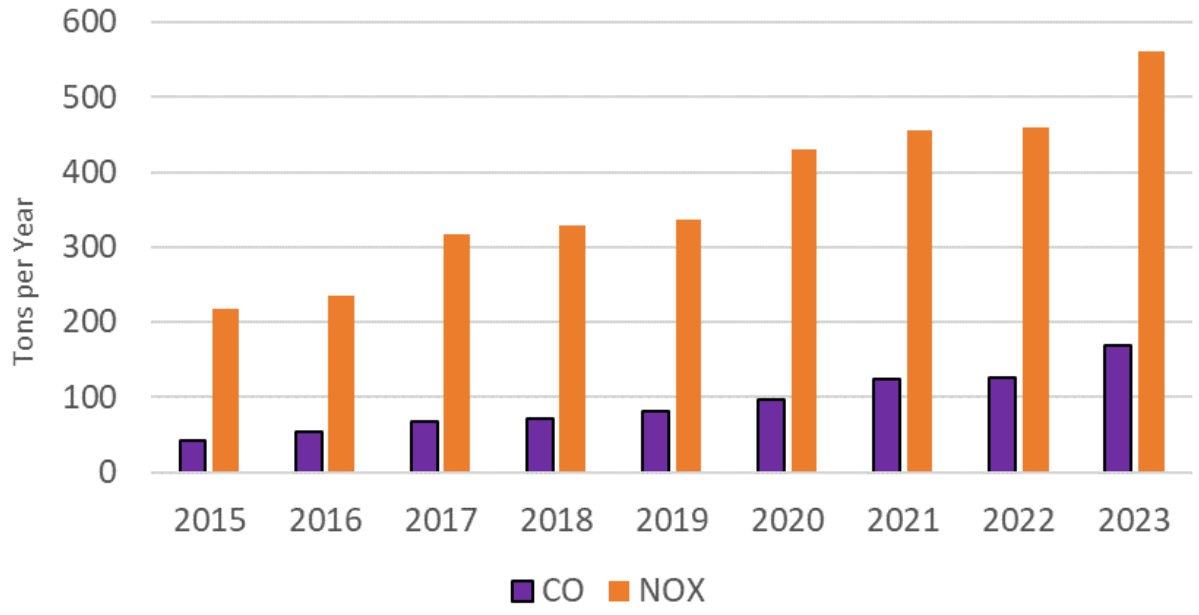
The study area for this project is the four counties in Northern Virginia (Arlington, Fairfax, Loudoun, Prince William), and the five independent cities contained within those counties (Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park). This is a more narrowly defined area than the Virginia DEQ's "Northern" region, which also includes an outer perimeter of localities such as Fauquier County, Culpepper, etc. This study area includes 138 of the 170 data centers with air pollution permits identified on the DEQ website, as of June 2025, of which 106 have actual criteria air pollution emissions data available from DEQ and/or NEI. While no data centers requiring air pollution permits currently operate in Arlington County or Alexandria, these localities were included in our study area for the sake of regional comparison.

For the second set of research questions we imported the actual and potential air pollution emissions data into GIS. Using this software we modeled the diffusion of air pollution emissions from Northern Virginia's data centers and other notable facilities, to estimate total emissions exposure at the Census Block Group level. We then downloaded Census data for these same block groups, in order to analyze the correlations between data center air pollution emissions exposure and demographic characteristics such as race, income, and education level.

3. Current Air Pollution Emission Totals from Data Centers in Northern Virginia

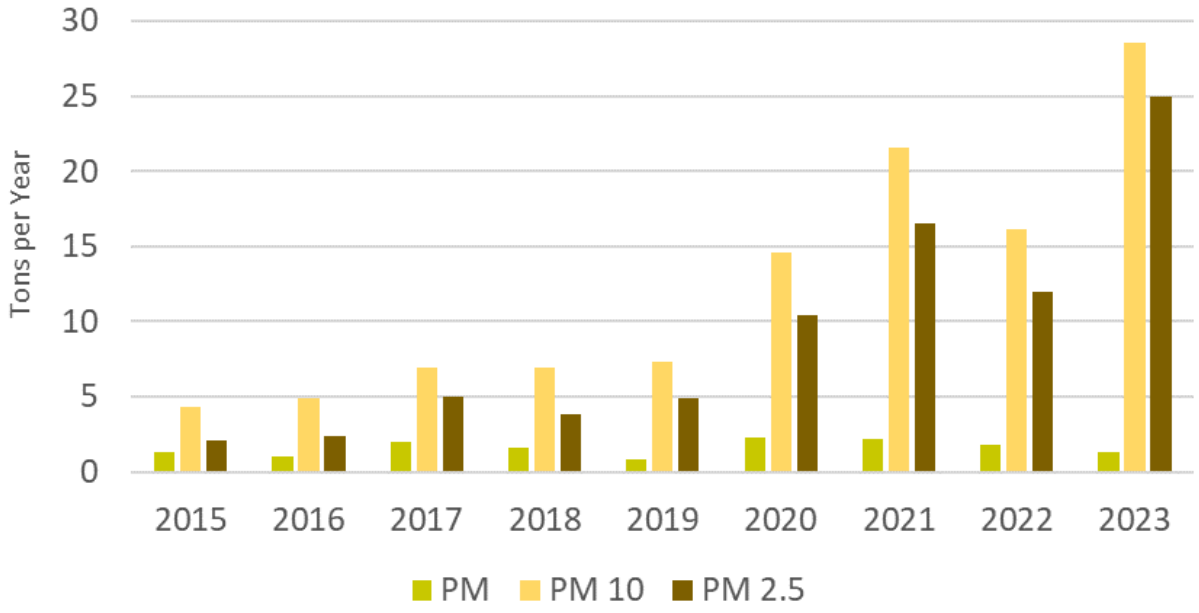
Total criteria air pollution emissions from Northern Virginia have increased substantially since 2015, as shown in Figures 1 and 2 below.

Figure 1. CO and NOx Emissions from Northern Virginia Data Centers, 2015-2023



Source: Virginia Department of Environmental Quality (DEQ)

Figure 2. Particulate Matter Emissions from Northern Virginia Data Centers, 2015-2023



Source: Virginia Department of Environmental Quality (DEQ)

As indicated in Figure 1 above, the total reported carbon monoxide (CO) and nitrous oxides (NOx) emissions from Northern Virginia data centers increased substantially between 2015 and 2023. Emissions of CO increased 196% over that time, from 42.91 tons in 2015 to 169.29 tons in 2023. Emissions of NOx increased 111%, from 218.03 to 562.01 tons. These increases are due in part to the growth of data centers themselves, as the data provided by DEQ included 50 reporting facilities in 2015, increasing to 92 reporting facilities by 2023. (While our data set includes 106 facilities, some have shut down since 2015, while others have not reported emissions every year).

Analysis of particulate matter (PM) emissions is more complicated, as permitting and reporting standards have evolved over the years, and there is some overlap in the data between PM, PM 10, and PM 2.5. Nevertheless, Figure 2 demonstrates a clear increase in particulate matter emissions overall, with PM 2.5 emissions – the most dangerous form of particulate matter, from a public health perspective – increasing 139% from 2020 to 2023.

The actual current emissions from data centers represent a small percentage of total criteria air pollution emissions within the Northern Virginia region. For example, as of 2022 the NEI data shows over 187,000 tons of CO and over 21,000 tons of NOx. Much of these emissions comes from onroad sources (i.e., vehicles), and other "mobile" or "non-point" sources. "Point sources" such as power plants, factories, etc. make up less than 5% of Northern Virginia's CO, SO2, and VOC emissions, but much higher percentages of NOx (19%) and SO2 (50%) emissions. (See here for an explanation of how the NEI defines these emissions source categories. This information is summarized in Table 1 below. [Note that the data provided by DEQ does not include SO2 and VOC emissions for 2015 - 2022, but does include those for 2023].

Table 1. Emissions from Data Centers Compared to NOVA Region Totals (tons)

Emissions Type	CO	NOx	PM 2.5	SO2	VOC
Regional Emissions - All Sources (2022)	187,427	21,070	9,734	1,170	62,494
Regional Emissions – Point Sources (2022)	4,432	4,061	368	581	762
Data Center Emissions (Actual, 2022)	127	460	12	No Data	No Data
Actual DC Emissions as Pct of All Sources	0.1%	2.2%	0.1%	No Data	No Data
Actual DC Emissions as Pct of Point Sources	2.9%	11.3%	3.2%	No Data	No Data

Sources: Virginia DEQ, U.S. EPA National Emissions Inventory 2022 v2 Emissions Modeling Platform.

Note that the percentage of total regional emissions coming from data centers will likely be higher for 2023, once the baseline NEI data for that year becomes available, as the DEQ data shows significant increases in data center emissions from 2022-2023.

4. Permitted Air Pollution Emission Totals from Data Centers in Northern Virginia

While current air pollution emissions from Northern Virginia data centers is not insignificant, Table 2 shows that the total emissions allowed under the DEQ data center permits are far higher.

Table 2. Permitted Data Center Emissions Compared to NOVA Region Totals (tons per year)

Emissions Type	CO	NOx	PM 2.5	SO2	VOC
Permitted Data Center Emissions (Totals)	4,105	9,995	351	45	1,102
Actual DC Emissions (2022) as Pct of Permitted	3.1%	4.6%	3.4%	No Data	No Data
Permitted DC Emissions as Pct of All Sources*	2.1%	32.7%	3.5%	3.7%	1.7%
Permitted DC Emissions as Pct of Point Sources*	48.8%	73.5%	49.6%	7.2%	59.1%
Permitted DC Emissions as Increase in All Sources**	2%	45%	3%	4%	2%
Permitted DC Emissions as Increase in Point Sources**	90%	235%	92%	8%	145%

Sources: Virginia DEQ, U.S. EPA National Emissions Inventory 2022 v2 Emissions Modeling Platform.

** These percentages are calculated by adding the additional permitted data center emissions to the total 2022 emissions, then dividing the total permitted data source emissions by those new regional totals*

*** These percentages are calculated as the difference between the actual 2022 emissions (both point sources and all sources) and the total emissions once the additional permitted emissions are added*

The key takeaways from the data summarized in Table 2 are as follows:

- The actual data center emissions from 2022 were between 3% - 5% of total permitted data center emissions. While not shown in the tables above, the actual data center emissions from 2023 are significantly higher (see Figures 1 and 2 on p. 3), and represent between 3% (VOC) and 10% (SO2) of total permitted data center emissions.
- If Northern Virginia data centers were to emit their total allowed pollution, per their DEQ permits, this would significantly increase the region's total point source air pollution, for all pollutants other than SO2. Point-source emissions would increase by about 90% for CO and VOC, 145% for VOC, and 235% for NOx. Total emissions (including mobile, etc.) would only increase by less than 5% for most pollutants, but would increase 45% for NOx.
- After adding the additional permitted emissions, data centers would represent about 50 - 75% of the new point source pollution totals for all pollutants, except SO2 (only 8%). The permitted data center emissions would then represent about 2% - 4% of regional totals for most air pollution emissions, but would be 33% of total regional NOx.

5. Comparison of Data Center Air Pollution to Other Facilities in Northern Virginia

To further contextualize the air pollution emissions from data centers, we compared those totals to the reported air pollution emissions from the NEI (2022) for other notable facilities in the Northern Virginia region, focusing on visible and easily comprehensible facilities such as electric power plants, natural gas compressor stations, and municipal facilities, as shown in Table 3.

Table 3. Emissions (tons) from Data Centers (2023) and Other Notable Facilities (2022)

Facility Name	Facility Type	Locality	CO	NOx	PM 2.5	SO2	VOC
Dominion - Leesburg Compressor Station	Compressor Station	Loudoun County	6.8	10.1	1.3	0.1	3.9
Michigan Cogeneration Systems Inc	Landfill Gas Power Plant	Fairfax County	64.9	32.1	7.5	2.6	14.8
Prince William County Sanitary Landfill	Municipal Landfill	Prince William Co.	328.6	61.0	20.8	42.6	36.2
Covanta Alexandria/ Arlington	Municipal Waste Combustor	Alexandria City	51.4	275.5	6.7	4.5	0.2
Covanta Fairfax	Municipal Waste Combustor	Fairfax County	73.3	1,030.2	148.0	304.0	5.8
Dominion - Possum Point Power Station	Natural Gas Power Plant	Prince William Co.	73.0	100.0	55.9	8.0	4.8
Panda Stonewall / Potomac Energy	Natural Gas Power Plant	Loudoun County	29.2	64.8	44.0	1.1	3.7
Norman M Cole Jr Pollution Control Plant	Wastewater Treatment Plant	Fairfax County	98.1	35.9	0.0	0.4	3.8
Current Total: All Data Centers in NoVA Study Area (2023)			169.3	562.0	24.9	4.4	35.5
Permitted Total: All Data Centers in NoVA Study Area			4,105	9,995	351	45	1,102
Actual Data Center Emissions (2023) as percent of Total Permitted Data Center Emissions			4.1%	5.6%	7.1%	9.8%	3.2%

Sources: Virginia DEQ, U.S. EPA National Emissions Inventory 2022 v2 Emissions Modeling Platform.

Following are some observations from the comparisons shown in Table 3:

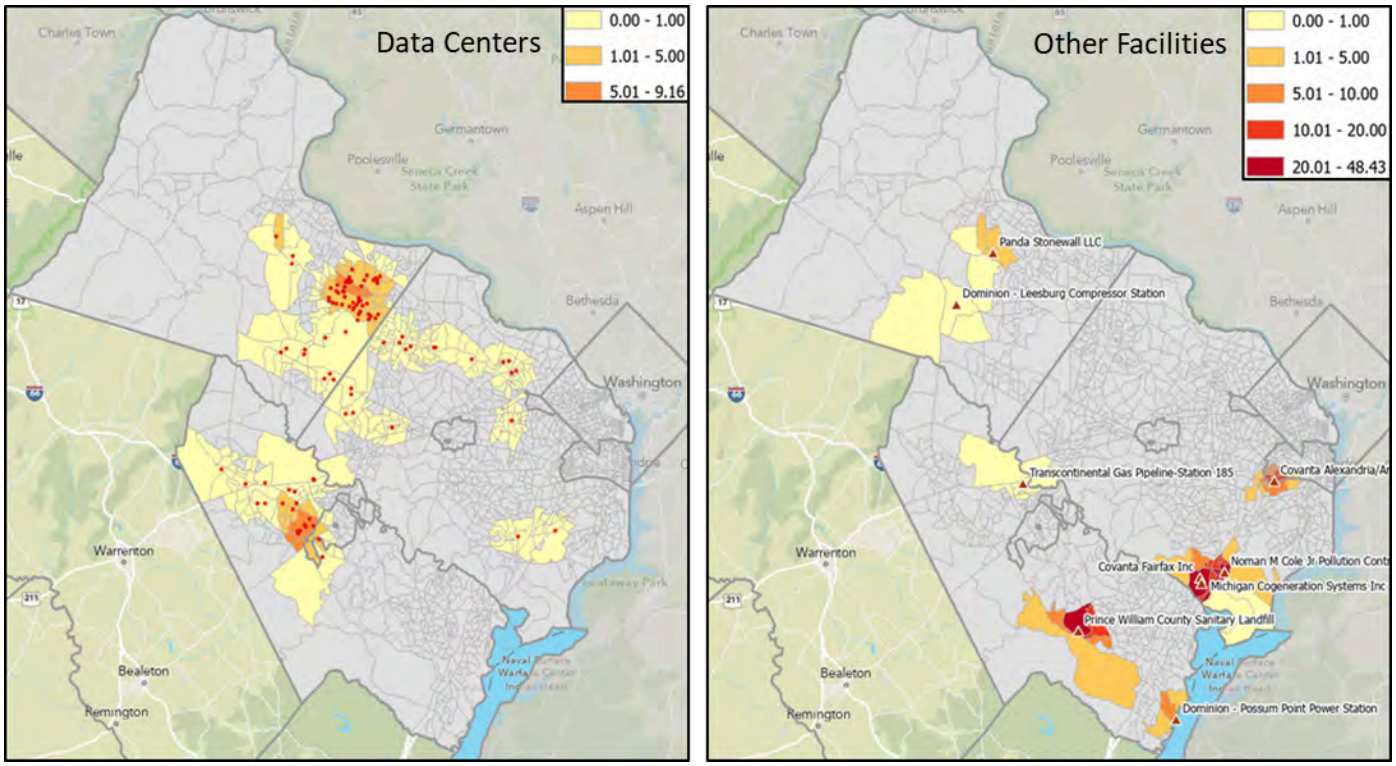
- Current data center emissions of CO and NOx are far higher than in most of these other facilities, while the data center PM 2.5 and VOC emissions are comparable in many cases.
- The current data center emissions of CO, NOX, and VOC are substantially higher than the corresponding emissions from the Dominion Possum Point Power Station.
- Permitted data center emissions would be orders of magnitude higher than those from these other facilities, particularly for CO, NOx, and VOC.

6. Localized Air Pollution Emissions from Data Centers in Northern Virginia

The next step in this research was to analyze the actual current neighborhood-level exposure to criteria air pollution from data centers, at the Census block group level. Our study area includes 1,565 block groups, of which 338 are located within one mile of a data center identified in the 2023 data center emissions data set from DEQ. First, we used Geographic Information Systems (GIS) tools to convert the tons of emissions from each data center facility into diffusion maps, which illustrating how each facility's emissions would spread into nearby neighborhoods, including the combined effects where multiple data centers are clustered near each other (See figures B-1A, B-2A, etc., in the Appendix). From these diffusion maps we were able to derive block-group-level estimates of the emissions concentrations from these data centers, as can be seen in Figures 3 - 5 below. (See also full-sized versions of each map in Appendix B).

We used this same process to estimate the block-group-level emissions exposure from the other notable facilities in the study area, listed above in Table 3. Those facilities are far enough apart that we could isolate each one's individual emissions impacts. However, three of the facilities are in the same industrial complex in the Lorton area of South Fairfax County, requiring us to model the combined block-group level emissions exposure from those facilities.

Figure 3. Concentrations of Carbon Monoxide (CO) Emissions (tons / sq. mi.) from Northern Virginia Data Centers (2023) versus Select Other Facilities (2022)



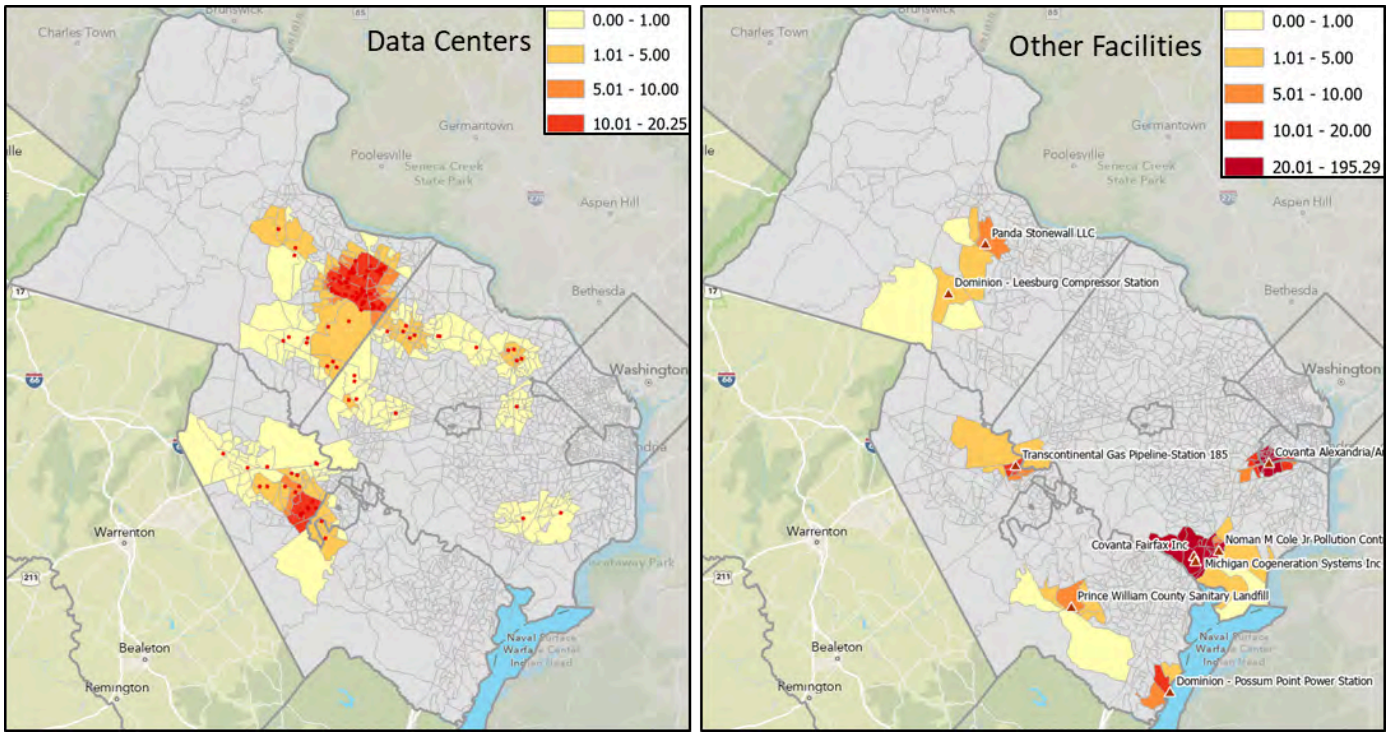
Sources: Virginia DEQ data and U.S. EPA National Emissions Inventory [2022 v2 Emissions Modeling Platform](). Analysis by Virginia Commonwealth University research team.

Comparing the data center (left) and non-data center (right) images in Figure 3 (above) reveals the following takeaways:

- Current data center operations result in small amounts of CO exposure across much of eastern Loudoun County, western Prince William County, and parts of Fairfax County.
- In the areas with large clusters of data centers, CO pollution exposure can be equal to, or higher, than that from natural gas power plants and compressor stations.
- Data center CO exposure is much lower than that from some other notable facilities, including the Prince William County landfill, the Arlington / Alexandria municipal waste combustor, and the cluster of facilities – a municipal waste combustor, a landfill gas plant, and a wastewater treatment plant – in southeast Fairfax County.

Figure 4 compares nitrous oxide (NOx) exposure from current data center operations to those of the other notable facilities in the region.

Figure 4. Concentrations of Nitrous Oxides (NOx) Emissions (tons / sq. mi.) from Northern Virginia Data Centers (2023) versus Select Other Facilities (2022)



Sources: Virginia DEQ data and U.S. EPA National Emissions Inventory [2022 v2 Emissions Modeling Platform]. Analysis by Virginia Commonwealth University research team.

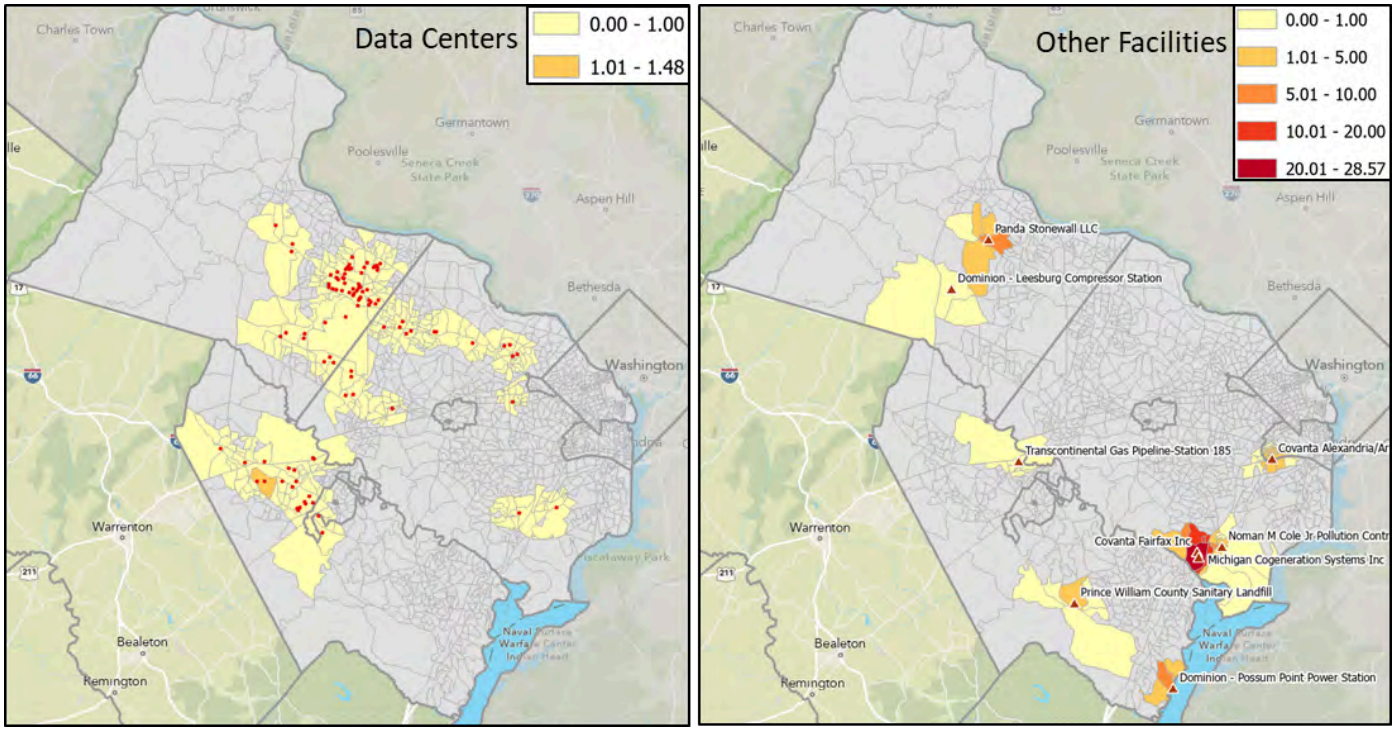
Key observations from Figure 4 are as follows:

- Data center pollution exposure, in tons per sq. mi., is generally higher for NOx than for CO.

- NOx exposure from data centers meets or exceeds that from the natural gas power plants and compressor stations in Northern Virginia.
- Data center NOx emissions exposure also exceeds that from the Prince William Co. landfill, but remains much lower than the highest concentrations of NOx from the Alexandria / Arlington municipal waste combustor and the cluster of facilities in SE Fairfax County.

Figure 5 provides the same side-by-side comparison for particulate matter (PM 2.5) exposure.

Figure 5. Concentrations of Particulate Matter (PM 2.5) Emissions (tons / sq. mi.) from Northern Virginia Data Centers (2023) versus Select Other Facilities (2022)



Sources: Virginia DEQ data and U.S. EPA National Emissions Inventory 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.

Comparing the PM 2.5 exposure from data centers (left image) and non-data-center facilities (right image) in Figure 5 results in similar patterns as the other two pollutants shown in Figures 3 and 4:

- Exposure to PM 2.5 pollution, in total tons per sq. mi., is generally lower than those from the other two pollutants, for both the data centers and other non-data-center facilities.
- The highest concentrations of PM 2.5 are also found around the wastewater treatment plant and municipal waste facilities in southeast Fairfax County.
- PM 2.5 is the only pollutant for which the highest levels of emissions exposure from data center operations is lower than that from the two natural gas power plants in the study area.

Table 4 below identifies the ten Census Block Groups in the study area with the highest current emissions impacts from data centers, per our analysis of the 2023 DEQ data. These totals range as high as 9.16 tons / sq. mi. of CO and 20.25 tons / sq. mi. of NOx. Several other block groups not shown in Table 4 have higher PM 2.5 exposure, up to a maximum of 1.48 tons / sq. mi., but lower exposure to CO and NOx. (See additional descriptive statistics in the Appendix, Table B-1).

The block groups with the highest NOx and/or CO exposure are all in the Sterling / Ashburn areas of east Loudoun Co., or in the area of Prince William Co. just west of Manassas (e.g., around the Broad Run Industrial Park), both of which are home to large clusters of active data centers. These areas correspond to the two large "hot spots" of data center emissions shown in Figures 3 - 5.

Table 4. Census Block Groups with Highest Data Center Emissions Exposure (tons per square mile, 2023)

Block Group	Location	CO	NOx	PM 2.5
51-153-901409-6	Prince William County, west of Manassas	9.16	19.83	0.66
51-107-611006-1	Loudoun Co. / Sterling / Ashburn, w. of Route 28	5.55	20.25	0.35
51-153-901409-1	Prince William County, west of Manassas	7.09	16.45	0.52
51-107-611020-3	Loudoun Co. / Sterling / Ashburn, w. of Route 28	4.93	18.76	0.34
51-107-611601-2	Loudoun County / Sterling, east of Route 28	4.93	17.79	0.31
51-107-611502-1	Loudoun County / Sterling, east of Route 28	4.58	17.90	0.34
51-107-611601-1	Loudoun County / Sterling, east of Route 28	5.00	16.95	0.38
51-153-901409-3	Prince William County, west of Manassas	6.06	12.85	0.43
51107-611018-2	Loudoun Co. / Sterling / Ashburn, w. of Route 28	4.25	14.31	0.24
51153-901409-8	Prince William County, west of Manassas	3.91	12.58	0.33

Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.

Comparing Table 4 with Table 5 (next page), one can see that the maximum block group level exposures from the other non-data-center facilities can be much higher in some cases.

(See Tables B-1 and B-3 of the Appendix for additional descriptive statistics on emissions exposure from data centers and non-data-center facilities in the study area).

Table 5. Census Block Groups in Study Area with Highest Emission Exposure from Select Non-Data Center Facilities (tons / sq. mi., 2022)

Block Groups	Location	CO	NOx	PM 2.5
Norman M Cole Jr Pollution Control Plant (Wastewater Treatment Plant), Covanta Fairfax Inc (Municipal Waste Combustor), Michigan Cogeneration Systems Inc (Landfill Gas Power Plant)				
51-059-422202-2	Lorton / Southeast Fairfax County	26.82	195.29	28.57
51-059-422202-1	Lorton / Southeast Fairfax County	14.25	115.92	16.65
51-059-422102-2	Lorton / Southeast Fairfax County	19.85	91.29	13.21
Covanta Alexandria / Arlington Inc. (Municipal Waste Combustor)				
51-510-200408-3	Southwest Alexandria	15.31	82.09	1.99
51-510-200408-2	Southwest Alexandria	12.87	68.98	1.67
51-510-200403-1	Southwest Alexandria	12.61	67.59	1.63
Prince William County Sanitary Landfill (Landfill)				
51-153-901234-2	Manassas area / SE Prince William County	48.43	9.00	3.07
51-153-901234-1	Manassas area / SE Prince William County	13.80	2.56	0.87
51-153-901306-3	Manassas area / SE Prince William County	9.26	1.72	0.59
Dominion - Possum Point Power Station (Natural Gas Power Plant)				
51-153-900904-2	Dumfries / SE Prince William County	9.20	12.60	7.04
51-153-901101-3	Dumfries / SE Prince William County	4.60	6.30	3.52
51-153-900904-4	Dumfries / SE Prince William County	2.92	4.00	2.24
Panda Stonewall LLC / Potomac Energy Center (Natural Gas Power Plant)				
51-107-611004-1	Leesburg area / Loudoun County	3.88	8.62	5.85
51-107-610604-4	Leesburg area / Loudoun County	3.11	6.91	4.69
51-107-610604-2	Leesburg area / Loudoun County	1.31	2.91	1.97
Transcontinental Gas Pipeline - Station 185 (Natural Gas Compressor Station)				
51-153-901602-4	Manassas area / Prince William County	0.46	15.50	0.28
51-153-901602-3	Manassas area / Prince William County	0.45	15.00	0.28
51-153-901602-5	Manassas area / Prince William County	0.31	10.37	0.19
Dominion - Leesburg Compressor Station (Natural Gas Compressor Station)				
51-107-611029-3	Leesburg / Loudoun County	0.77	1.13	0.15
51-107-611029-2	Leesburg / Loudoun County	0.06	0.09	0.01
51-107-610900-2	Leesburg / Loudoun County	0.02	0.04	0.00

Source: U.S. EPA, NEI 2022 v2 Emissions Modeling Platform. Analysis by VCU research team.

The following are some key observations from the comparison of the highest block-group level air pollution emissions exposure from data centers (Table 4) and notable non-data-center facilities (Table 5) in the study area:

- Some of the Census block groups near the cluster of facilities in southeast Fairfax County (wastewater treatment plant, municipal waste combustor, and landfill gas power plant) have a much higher cumulative emissions exposure from those facilities – across all three pollutants – than anything seen in the areas of clustered data centers.
- The block groups around the Covanta Alexandria / Arlington municipal waste combustor also receive higher emissions exposure from that facility, across all three pollutants, than any block group receives from data center emissions.

However, comparing Tables 4 and 5 also reveals instances in which the cumulative data centers exposure for certain block groups is greater than the emissions exposure from some of these other notable facilities. For example:

- The block groups shown in Table 4 experience levels of carbon monoxide exposure from data centers that are much higher than the CO emissions from the Dominion - Leesburg or Transcontinental Gas natural gas pipeline compressor stations.
- The peak block-group level NOx emissions from data centers also far exceed the local NOx impacts from the Dominion - Leesburg compressor station, and are about equal to those from the Transcontinental Gas compressor station. Likewise the local PM 2.5 impacts from data centers are at times higher than those from either compressor station.

Perhaps more notably, the combined local emissions exposure from clusters of data centers can sometimes even exceed the pollution exposure associated with a natural gas power plant:

- The highest levels of CO exposure from data centers are generally similar to those found in the block groups receiving the highest emissions from Possum Point.
- Some block groups receive much more NOx exposure from data centers, compared to the highest block group NOx exposures from Dominion - Possum Point.
- The highest amount of block-group level PM 2.5 exposure from the Dominion - Possum Point power plant (7.04 tons / sq. mi.) far exceeds any PM 2.5 exposure from data centers.
- The highest levels of local block-group-level CO and NOx impacts from data centers exceeds those associated with the Panda Stonewall / Potomac Energy Center natural gas power plant, but that gas plant has higher PM 2.5 impacts.

7. Permitted Localized Air Pollution Emissions from Data Centers In Northern Virginia

In this next phase of the research we evaluated the potential localized air pollution emissions from data centers in Virginia, based on the total allowed emissions of CO, NOx, and PM 2.5 from their use of back-up generators, as per the requirements of each data center's respective air pollution permits issued by the Virginia Department of Environmental Quality (DEQ).

As noted in Table 3 above, the actual emissions from data centers in 2023 was only about 4 - 7% of the total permitted emissions for the three pollutants evaluated in this study. However, in comparing the actual versus permitted emissions of individual data centers, we find that 14 out of 104 facilities emitted 20% or more of their allotted totals in 2023, for at least one of the three pollutants. In some cases the data centers emitted more than 40% of their total permitted emissions for a given pollutant. Table 6 shows some examples of data centers for which the tons of emissions reported in 2023, per the data provided by DEQ, equaled at least 30% of the allowed tons / year of a given pollutant on the applicable air permit issued by DEQ for that facility.

Table 6. Data Centers with Reported Emissions (2023) at 30% or Greater of Permitted Level

DEQ Air Permit Registration Number	Location	2023 Emissions as % of Permitted		
		CO	NOx	PM 2.5
74167	Manassas area, Prince William County	78%	78%	76%
72367	Ashburn area, Loudoun County	39%	39%	NA
73158	Sterling area, Loudoun County	41%	49%	NA
74109	Sterling area, Loudoun County	34%	34%	0%
74112	Manassas area, Prince William County	30%	22%	19%

Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.

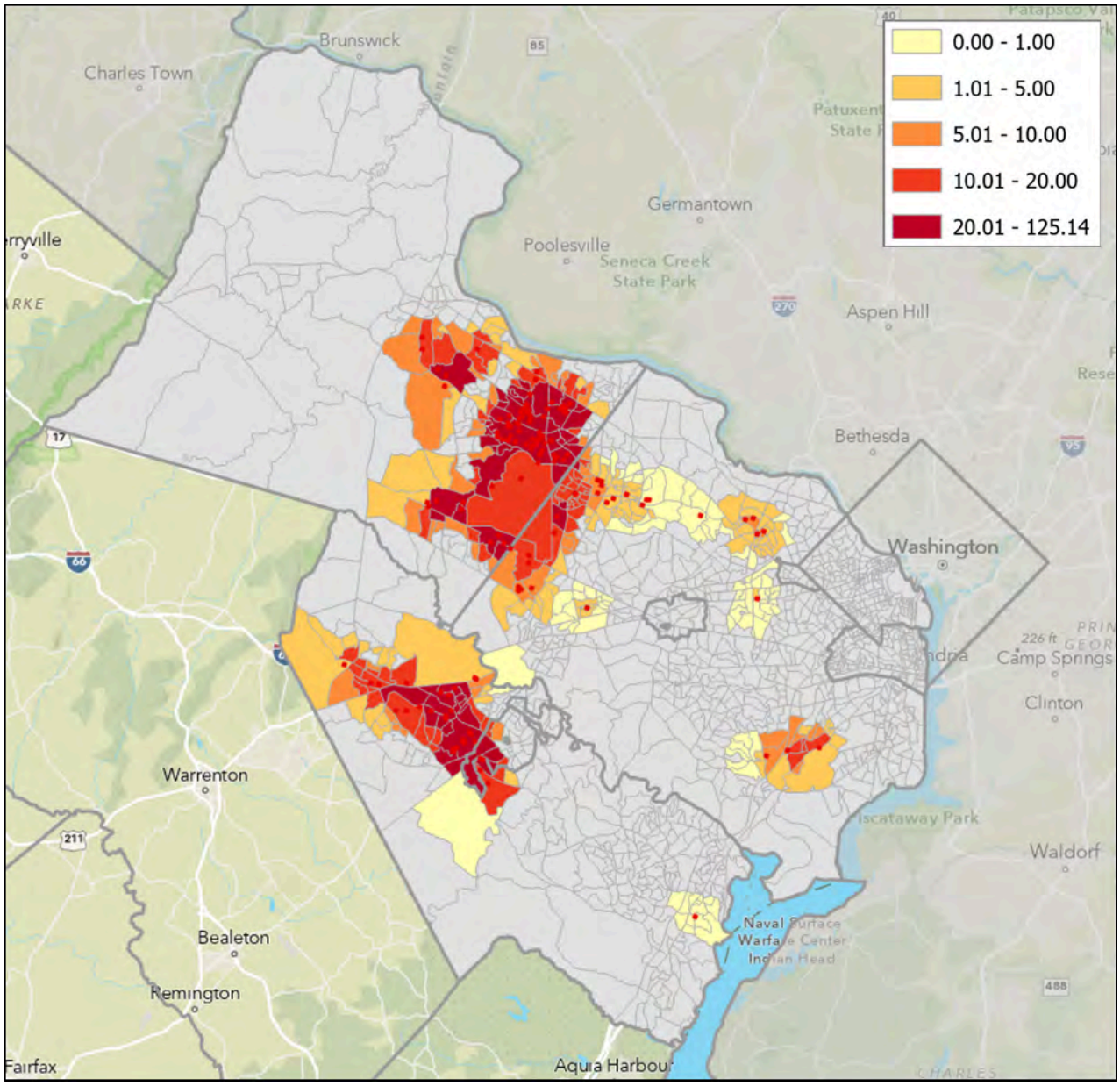
Note: "NA" indicates that the data center had no permitted or reported 2023 emissions for PM 2.5.

Given that the data center facility permits allow much higher levels of pollution than the current totals, and that some facilities are already emitting far more than the average of 4 - 7% of their allotment, we therefore find it instructive to model the potential pollution exposure from these facilities, in the event that data center emissions were to reach their maximum allowed levels.

Following the same methodology as used for the actual emissions from data centers and non-data center facilities, we converted the total permitted emissions levels for each data center in the study area into diffusion maps, shown in Figures C-1A, C-2A, and C-3A of the Appendix, which show how the potential criteria air pollution emissions from each data center would spread across a 1-mile radius. From those diffusion maps we derived the potential emission concentrations for each block group, in tons / year / sq. mi., thus creating the maps shown in Figures 6 - 8 below.

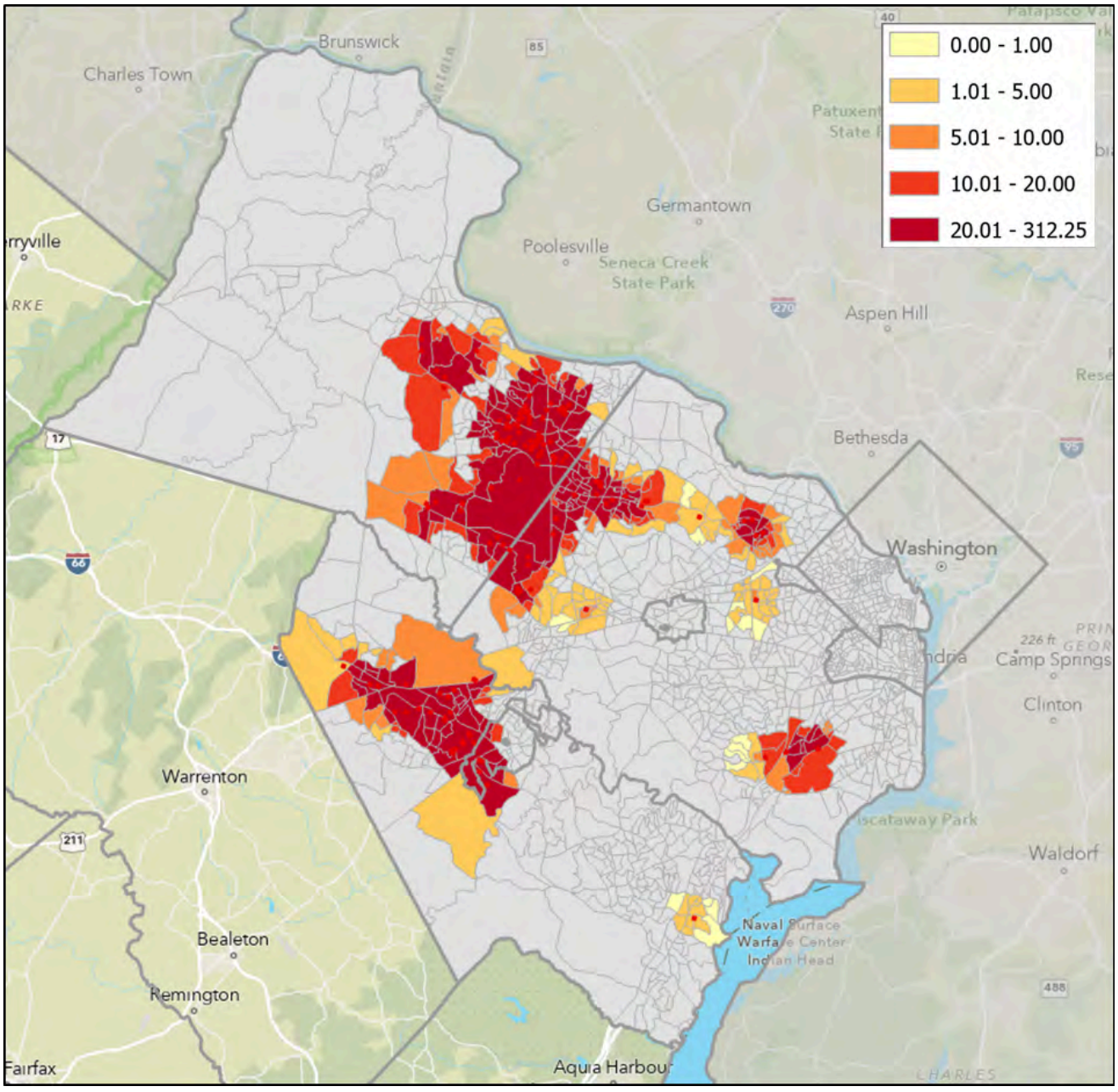
It is important to note that the potential emissions concentrations shown in Figures 6 - 8 are mapped at the same scale as the actual reported 2023 emissions shown in Figures 3 - 5 above. Thus it is possible to visually compare these maps and understand the relative differences in actual or potential pollution concentrations. In doing so, one can see that the potential emissions concentrations from Northern Virginia data centers far exceed both the actual emissions concentrations from current data center operations, and the concentrations associated with any of the other notable facilities evaluated in this report (landfills, natural gas power plants, etc.)

Figure 6. Potential Carbon Monoxide (CO) Emission Concentrations from Northern Virginia Data Centers (Maximum Allowed under DEQ Permits)



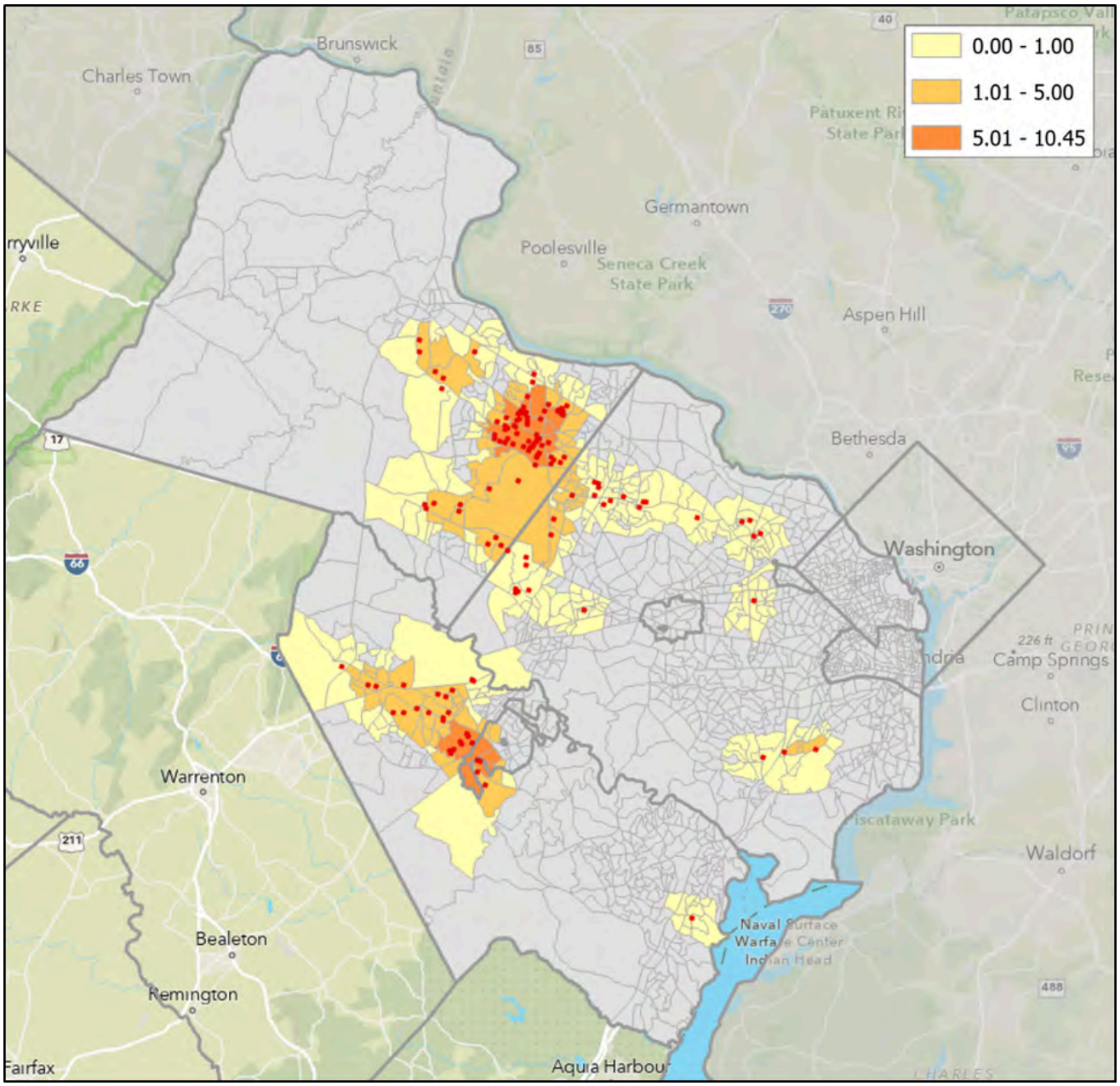
Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Figure 7. Potential Nitrous Oxides (NOx) Emission Concentrations from Northern Virginia Data Centers (Maximum Allowed under DEQ Permits)



Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Figure 8. Potential Particulate Matter (PM 2.5) Emission Concentrations from Northern Virginia Data Centers (Maximum Allowed under DEQ Permits)



Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Table 7 below identifies the ten Census Block Groups in the study area with the highest levels of potential data center emission concentrations, per our analysis of the DEQ air permits for those facilities. All of these block groups are in the "data center alley" area of Loudoun County, in the Sterling and Ashburn areas on either side of Route 28. Many of these block groups are also identified in Table 4 as having the highest estimated current (2023) data center pollution.

Table 7. Census Block Groups with Highest Potential Data Center Emission Concentrations (tons per year per sq. mi.), per DEQ Air Permits

Block Group	Location	CO	NOx	PM 2.5
51-107-611006-1	Loudoun Co. / Sterling / Ashburn, w. of Route 28	122.28	312.25	8.46
51-107-611020-3	Loudoun Co. / Sterling / Ashburn, w. of Route 28	125.14	307.38	10.45
51-107-611601-2	Loudoun County / Sterling, east of Route 28	95.05	236.57	7.71
51-107-611018-2	Loudoun Co. / Sterling / Ashburn, w. of Route 28	89.30	236.66	6.78
51-107-611601-1	Loudoun County / Sterling, east of Route 28	81.61	213.57	6.54
51-107-611019-3	Loudoun County / Ashburn, west of Route 28	78.90	194.36	4.32
51-107-611502-1	Loudoun County / Sterling, east of Route 28	68.56	192.07	5.13
51-107-611018-3	Loudoun Co. / Sterling / Ashburn, w. of Route 28	67.81	171.91	5.31
51-107-611020-6	Loudoun County / Ashburn, west of Route 28	56.35	164.95	4.81
51-107-611020-2	Loudoun County / Ashburn, west of Route 28	52.64	165.43	4.93

Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Comparing these potential block-group-level emissions concentrations in Table 6 to the actual estimated emissions concentrations in Tables 4 and 5 leads to the following observations:

- The highest potential data center emission concentrations are roughly 10 - 20 times greater than the highest actual data center emissions concentrations, across all three pollutants.
- The highest potential emissions concentrations from data centers also far exceed, in most cases, the highest actual estimated concentrations from the other non-data-center facilities.
- The potential CO and NOx concentrations shown in Table 6 dwarf the highest estimated concentrations from any of the natural gas compressor stations or power plants in the study area. The highest potential concentration of CO (125 tons / year / sq. mi.) is about 14 times greater than the highest estimated CO concentration (9.2 tons / year / sq. mi.) from the Possum Point Power Station. Likewise, the potential 312 tons / year / sq. mi. of NOx is nearly 25 times the highest estimated NOx (12.6 tons / year / sq. mi.) from Possum Point.
- The potential CO and NOx concentrations shown in Table 6 also exceed, to varying degrees, the estimated emissions exposure from other facilities such as landfills, wastewater treatment plants, and municipal waste combustors, including the estimated combined exposure from multiple such facilities in southeast Fairfax County.
- The potential PM 2.5 concentrations from data centers remains below the estimated combined exposure from the facilities in southeast Fairfax County, but significantly exceeds the estimated actual concentrations from any of the other non-data-center facilities, including the Possum Point and Potomac Energy Center natural gas power plants.

8. Demographics of Data Center Emissions In Northern Virginia

For the final step of this research, we investigated the potential for inequitable environmental impacts from data center emissions, across various demographic categories. To do this, we analyzed the correlations between estimated data center emissions exposure and key socioeconomic indicators such as race, income, and education, among all Census block groups within the Northern Virginia study area.

The results of these analyses are shown in Tables 8 and 9 below. The values shown in bold indicate statistically significant correlations between the corresponding demographic characteristics and estimated concentrations of data center emissions. These statistically significant correlations can be summarized as follows:

- In Table 8, the estimated actual concentrations of CO and NOx, as reported in the 2023 DEQ data, are negatively correlated with Median Household Income and Higher Education (percentage of residents with a college degree). Estimated NOx concentrations are also negatively correlated with home ownership percentage.
- In other words, Census block groups with higher estimated (2023) concentrations of CO and NOx from data centers tend to have lower household income levels, fewer residents with college degrees, and fewer owner-occupied housing units (in the case of NOx) than block groups in the study area that experience lower estimated data center emissions.
- In Table 9, the estimated potential emissions concentrations, from the DEQ data center air permits, are negatively correlated across all three pollutants (CO, NOx, and PM 2.5), for both median household income and higher education percentage. Estimated potential CO and NOx concentrations are also negatively correlated with home ownership percentage.
- This means that Census block groups with higher concentrations of potential CO, NOx, and PM 2.5 emissions tend to have lower household income levels, fewer residents with college degrees, and fewer owner-occupied housing units (in the case of CO and NOx) than block groups in the study area that experience lower estimated data center emissions.
- There are no statistically significant correlations between data center emission concentrations and non-white population percentage, neither with estimated actual (Table 8) nor potential (Table 9) data center emissions.
- Population density is for the most part not correlated with any of the estimated actual or potential data center emissions metrics. The only exception is a statistically significant negative correlation with estimated actual PM 2.5 emission concentrations (Table 8), which would suggest that areas with lower population density tend to have higher estimated concentrations of PM 2.5 emissions from data centers.

Table 8. Correlations: Estimated Actual (2023) Data Centers Emissions Concentrations and Select Demographic Characteristics

Pollutant	Correlation Statistics	Population Density	Non-White Percent	Median HH Income	Higher Ed Percent	Home Owner Percent
CO / sq. mi.	Pearson Corr.	-0.104	0.047	**-.114***	**-.160****	-0.108
	Sig. (2-tailed)	0.06	0.39	0.041	0.004	0.051
NOx / sq. mi.	Pearson Corr.	-0.059	0.061	**-.133***	**-.158****	**-.156****
	Sig. (2-tailed)	0.287	0.265	0.017	0.004	0.005
PM 2.5 / sq. mi.	Pearson Corr.	**-.121***	0.02	-0.008	-0.098	0.022
	Sig. (2-tailed)	0.028	0.719	0.888	0.077	0.692
** Correlation is significant at the 0.01 level (2-tailed).						
* Correlation is significant at the 0.05 level (2-tailed).						

Source: Virginia DEQ data (2023). Analysis by Virginia Commonwealth University research team.

Table 9. Correlations: Estimated Potential Emissions Concentrations from Data Center Permits and Select Demographic Characteristics

Pollutant	Correlation Statistics	Population Density	Non-White Percent	Median HH Income	Higher Ed Percent	Home Owner Percent
CO / sq. mi.	Pearson Corr.	-0.051	0.064	**-.117***	**-.175****	**-.111***
	Sig. (2-tailed)	0.327	0.219	0.027	<.001	0.032
NOx / sq. mi.	Pearson Corr.	-0.018	0.051	**-.154****	**-.162****	**-.160****
	Sig. (2-tailed)	0.724	0.326	0.003	0.002	0.002
PM 2.5 / sq. mi.	Pearson Corr.	-0.074	0.056	**-.113***	**-.185****	-0.081
	Sig. (2-tailed)	0.154	0.282	0.032	<.001	0.119
** Correlation is significant at the 0.01 level (2-tailed).						
* Correlation is significant at the 0.05 level (2-tailed).						

Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Appendix A. Detailed Methodology

To answer the first set of research questions, about current air pollution emissions from data centers, we utilized back-end data provided directly by the Virginia DEQ. Additional contextual data about air pollution in the region was sourced directly from the National Emissions Inventory (NEI) website maintained by the U.S. Environmental Protection Agency (EPA).

To evaluate potential future emissions from data centers, we downloaded all available data center air pollution permits from the Virginia DEQ website on Issued Air Permits for Data Centers, identified those within our Northern Virginia study area, and built a database of the key details from those permits including their annual emission limits.

The study area for this project is the four counties in Northern Virginia (Arlington, Fairfax, Loudoun, Prince William), and the five independent cities contained within those counties (Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park). This is a more narrowly defined area than the Virginia DEQ's "Northern" region, which also includes an outer perimeter of localities such as Fauquier County, Culpepper, etc. This study area includes 138 of the 170 data centers with air pollution permits as identified on the DEQ website, of which 106 have actual criteria air pollution emissions data available from DEQ and/or NEI. While no data centers requiring air pollution permits currently operate in Arlington County or Alexandria, they were included in our study area for the sake of regional comparison.

For the second set of research questions we imported the actual and potential air pollution emissions data into GIS. Using this software we modeled the diffusion of air pollution emissions from Northern Virginia's data centers and other notable facilities, to estimate total emissions exposure at the Census Block Group level. As shown in the subsequent figures, each pollutant's emissions was interpolated to create a continuous surface of emission levels using ArcGIS Pro's Diffusion Interpolation with Barriers tool. (See diffusion maps in Figures B-1A, B-2A, etc.). The resulting surface was then processed to derive the total emission in tons per year (TPY) for each block group. To adjust for varying geographic areas, block group level TPYs were further divided by their areas measured in square miles. (See derived emissions in Figures B-1B, B-2B, etc.).

We then downloaded Census data for these same block groups, in order to analyze the correlations between data center air pollution emissions exposure and demographic characteristics such as race, income, education level, and home ownership. We obtained this demographic data from the following 2023 American Community Survey (ACS) 5-Year Estimates data tables: B02001 (race), B19013 (median household income), B15003 (educational attainment), and B25003 (housing tenure).

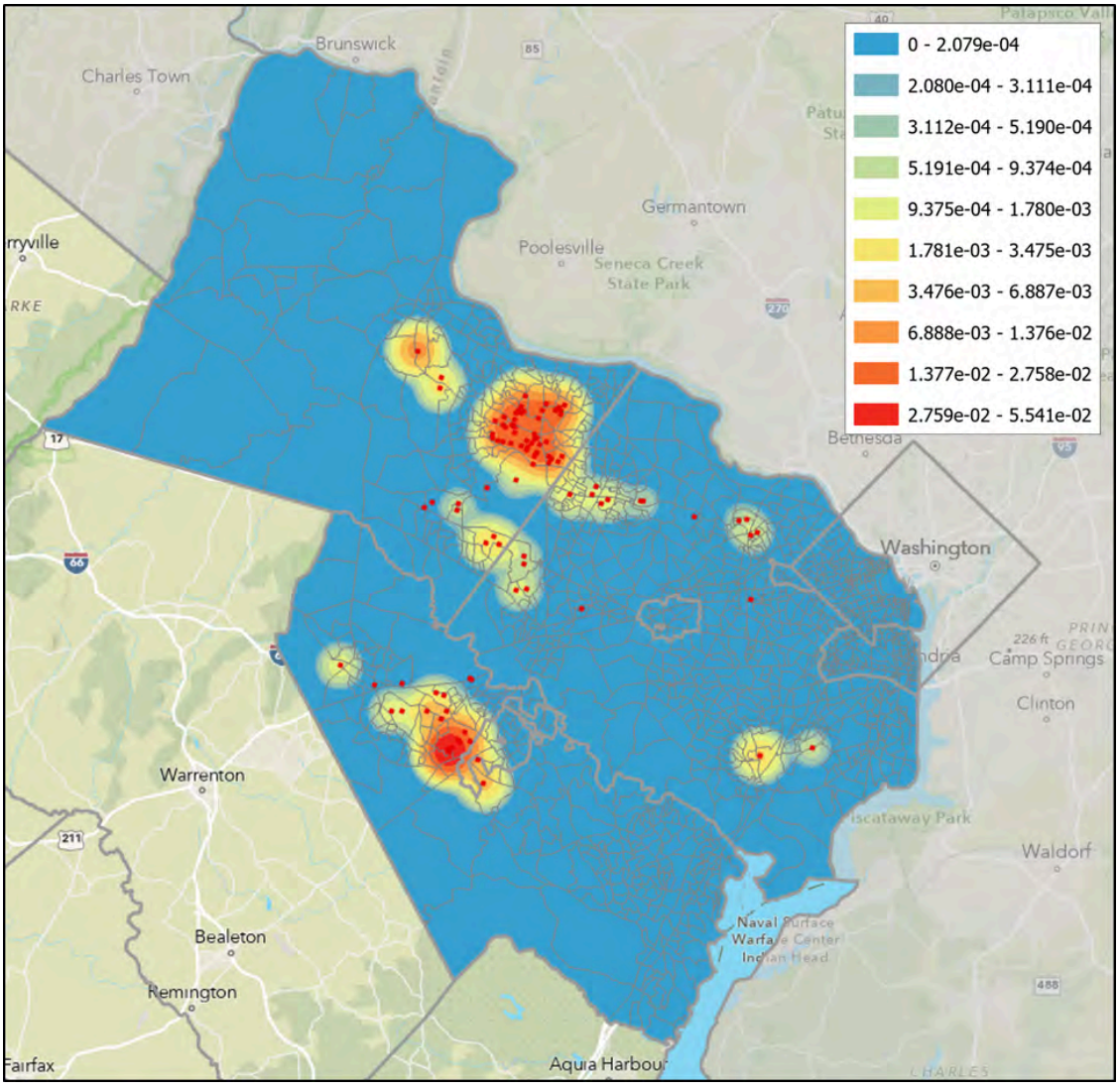
Finally, we used SPSS to compute the descriptive statistics of emissions exposure (Tables B-1 and C-1), as well as the correlation coefficients to examine the strength and direction of relationships between emissions exposure and demographic characteristics (Tables B-2 and C-2).

Appendix B. Detailed Results for Analysis of Localized Air Pollution Emissions from Data Centers and Other Representative Facilities

The “diffusion maps” in Figures B-1A, B-2A, etc. show the interpolation of the criteria air pollution emissions (CO, NOx, and PM 2.5) from each data center (2023 data from Virginia DEQ) and other non-data center facility (2022 NEI data) in the Northern Virginia study area, to illustrate how those emissions would spread over a one-mile distribution radius.

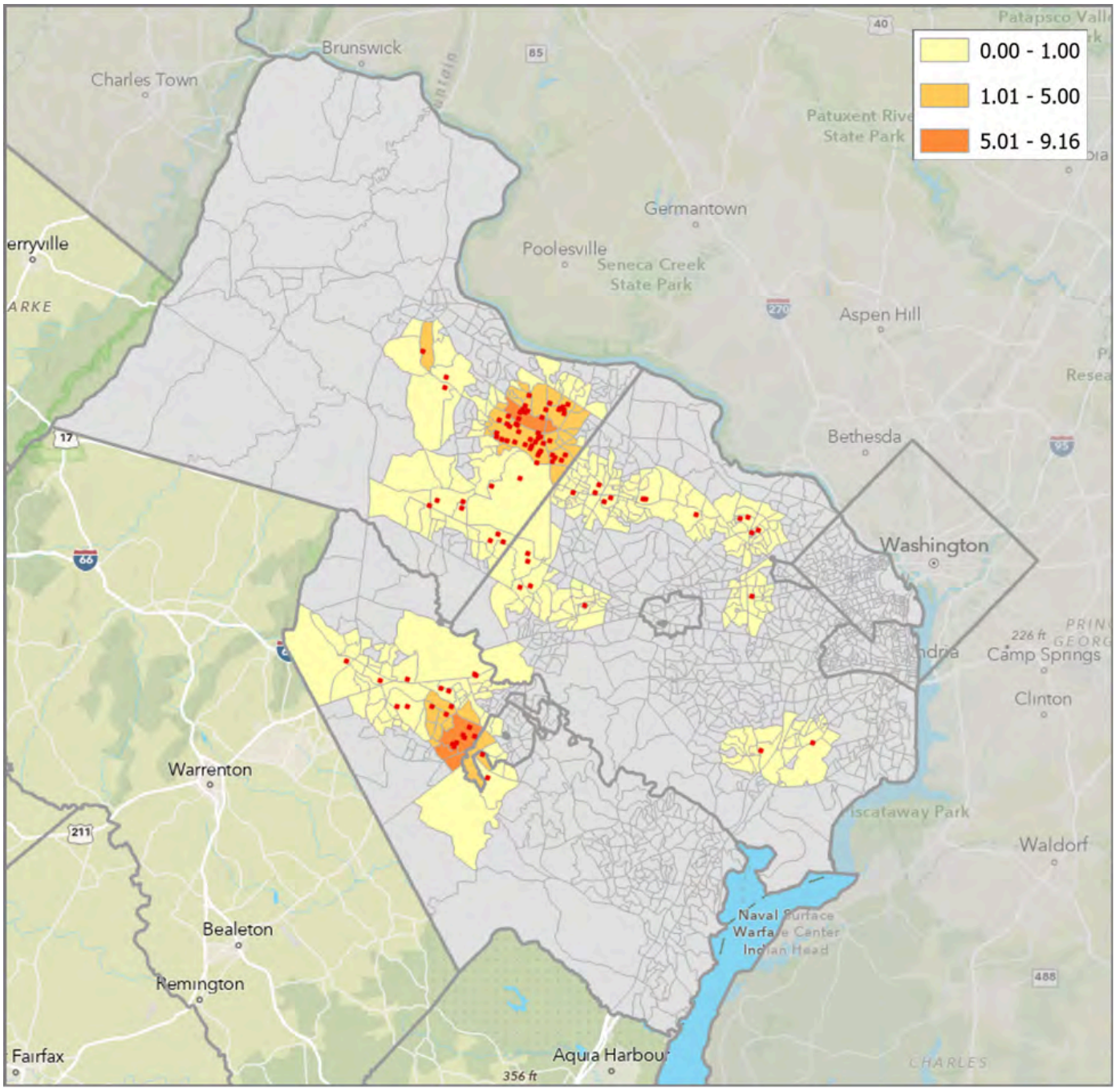
Note that these diffusion maps are provided for graphical representation purposes only, and are on different scales; thus, they should not be compared against one another. For an accurate comparison of the total emissions impacts of these facilities, refer to the “derived emissions” maps (B-1B, B-2B, etc.), both in this appendix and in the main body of this report.

Figure B-1A. Diffusion Map of Carbon Monoxide (CO) Emissions from Northern Virginia Data Centers (2023), tons per year by raster grid cells (330’ x 330’ resolution)



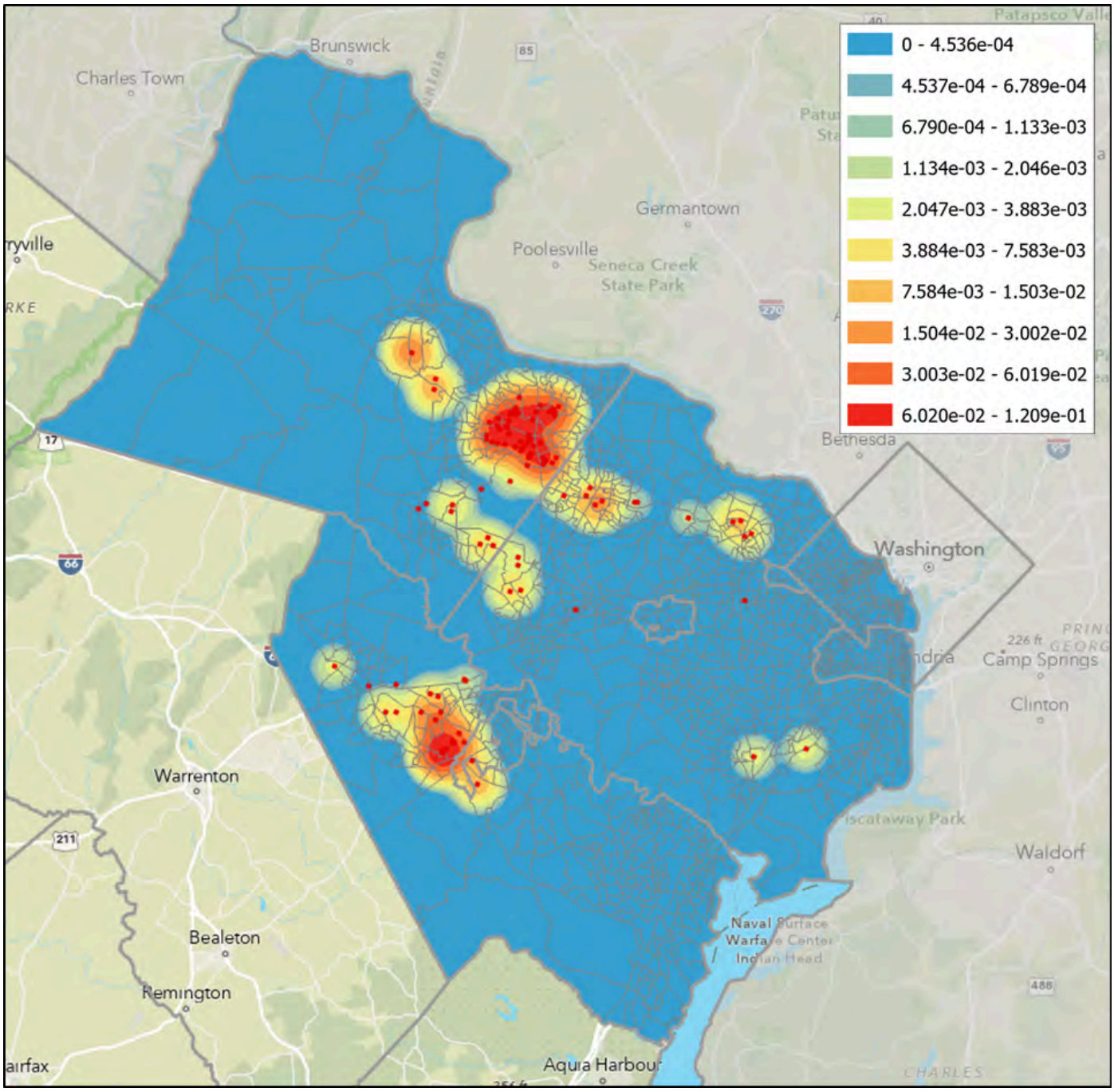
Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.

Figure B-1.B. Map of Derived Total Carbon Monoxide (CO) Emission Concentrations from Northern VA Data Centers (2023), by Census Block Group, tons per year per square mile



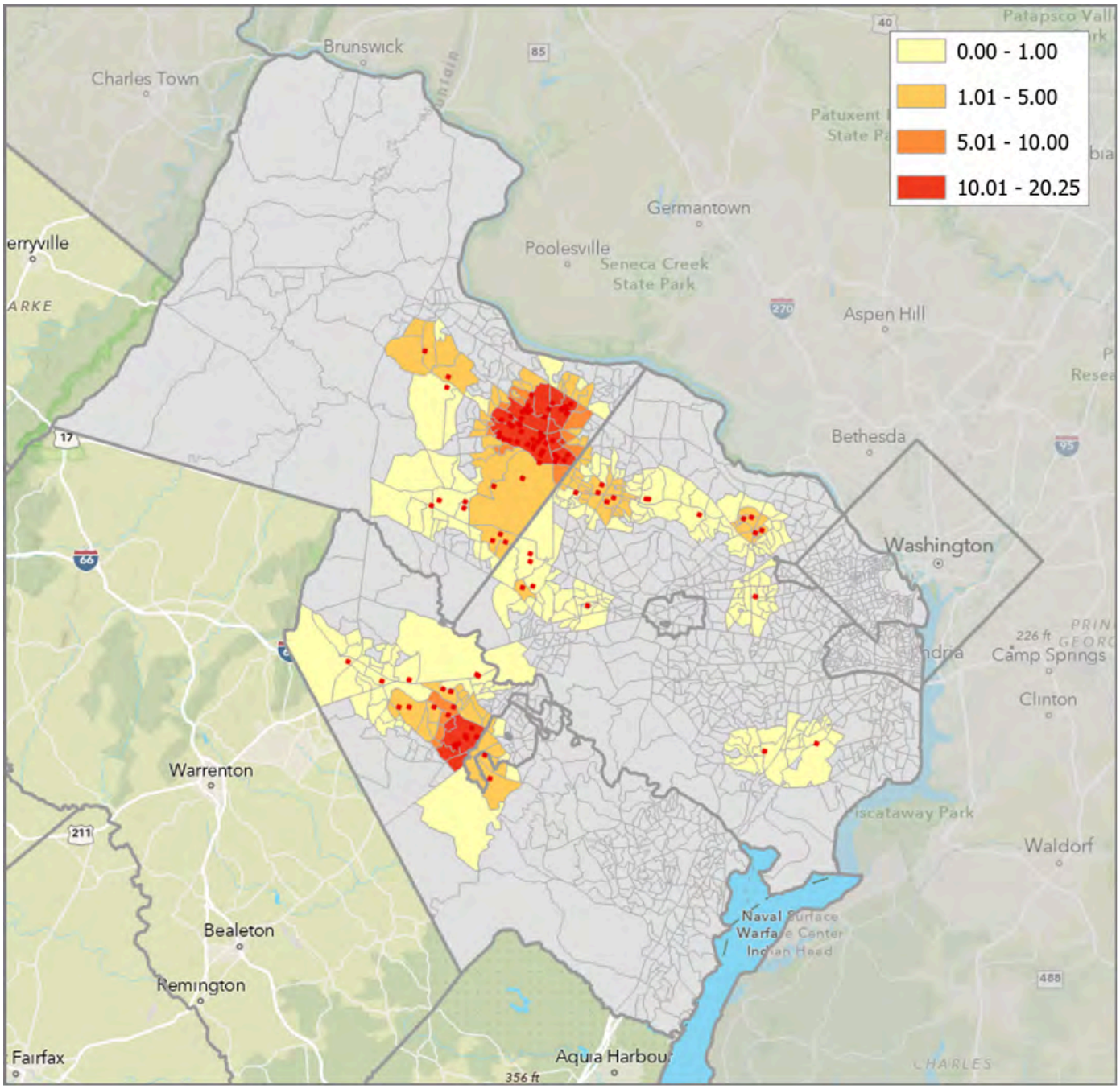
Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.

Figure B-2A. Diffusion Map of Nitrous Oxides (NOx) Emissions from Northern Virginia Data Centers (2023), tons per year by raster grid cells (330’ x 330’ resolution)



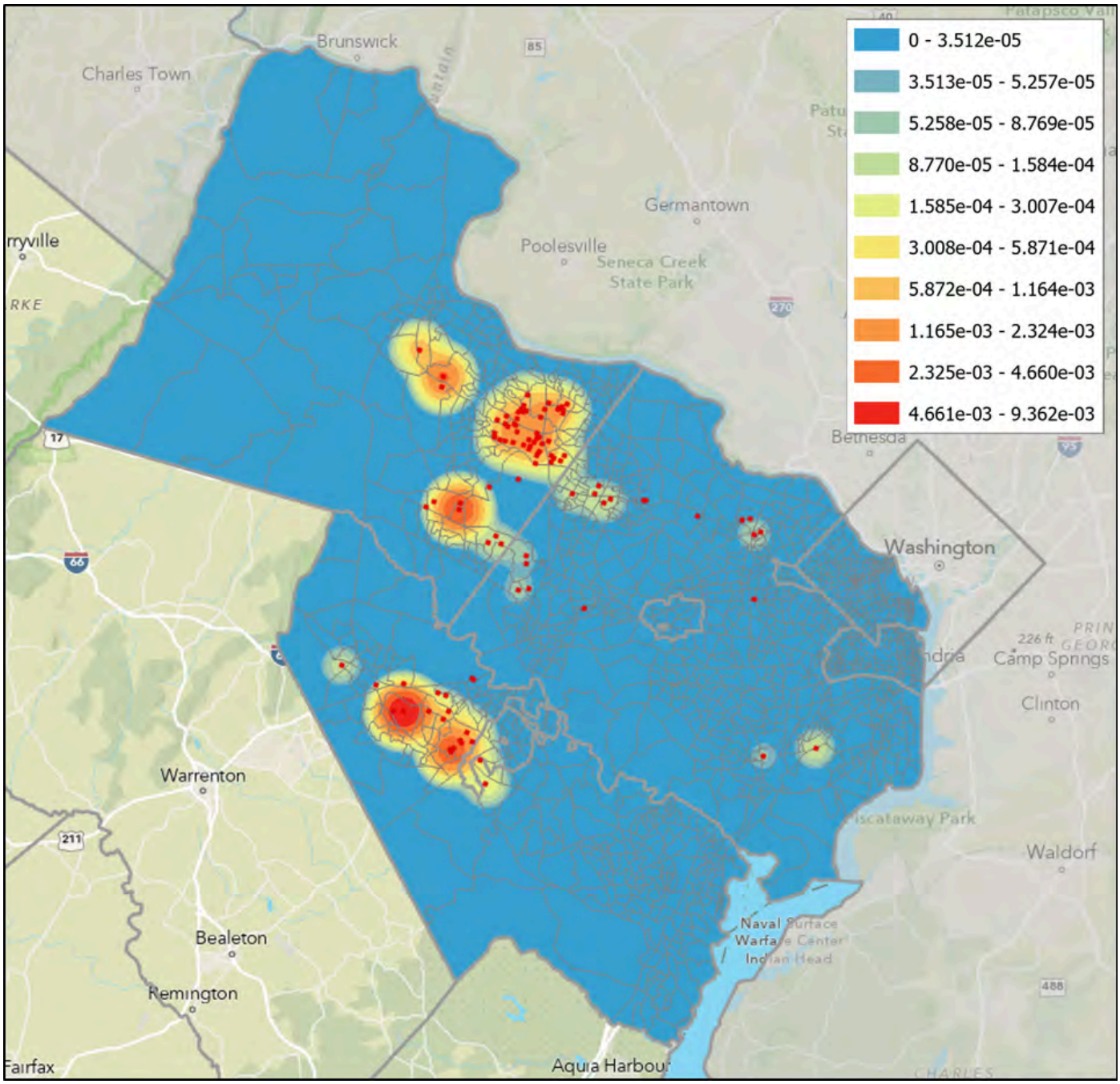
Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.

Figure B-2B. Map of Derived Total Nitrous Oxides (NOx) Emission Concentrations from Northern VA Data Centers (2023), by Census Block Group, tons per year per square mile



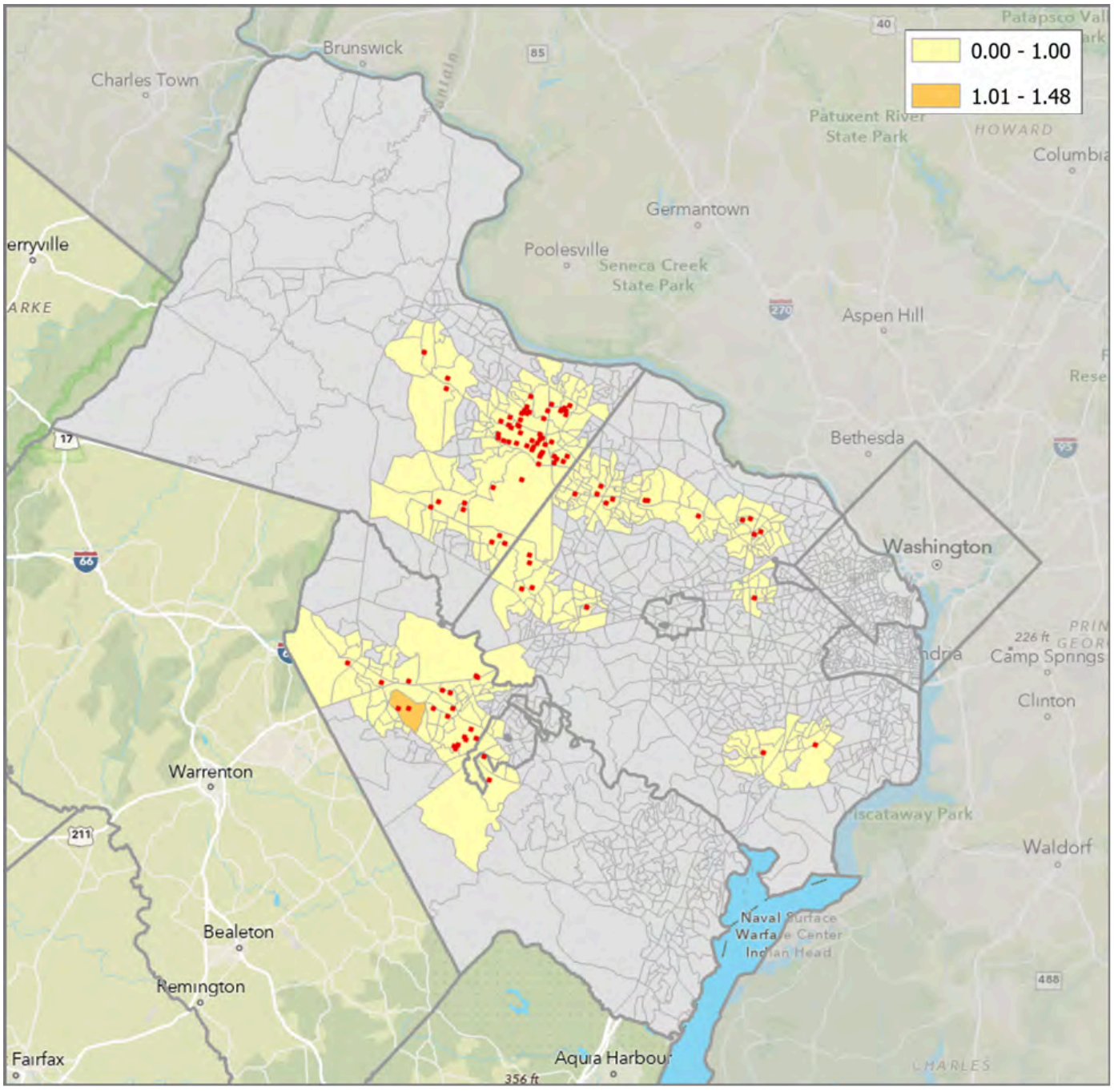
Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.

Figure B-3A. Diffusion Map of Particulate Matter (PM 2.5) Emissions from Northern Virginia Data Centers (2023), tons per year by raster grid cells (330’ x 330’ resolution)



Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.

Figure B-3B. Map of Derived Total Particulate Matter (PM 2.5) Emission Concentrations from Northern VA Data Centers (2023), by Census Block Group, tons per year per sq. mi.



Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.

Table B-1. Descriptive Statistics: Cumulative Current Emissions Exposure from Data Centers (2023) – Census Block Groups within 1 Mile of a Data Center (Tons / Sq. Mi.)

Pollutant (Tons / Sq. Mi.)	N	Minimum	Maximum	Mean	Std. Deviation
Carbon Monoxide (CO)	338	0.000	9.160	0.512	0.111
Nitrous Oxides (NOx)	338	0.001	20.250	1.884	3.550
Particulate Matter (PM 2.5)	338	0.000	1.478	0.063	0.155

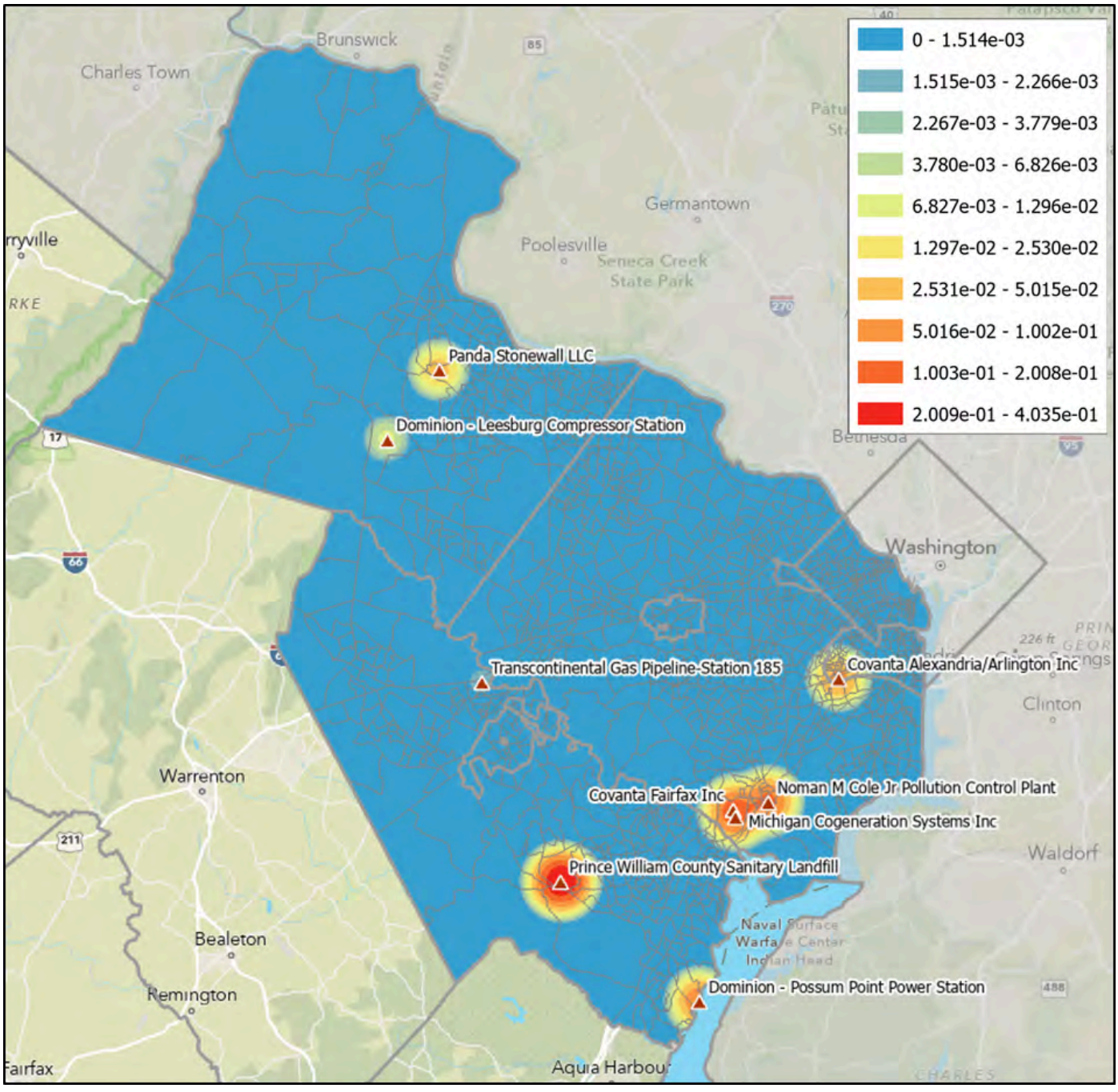
Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.

Table B-2. Correlations: Cumulative Current Emissions Exposure from Data Centers (2023) – Census Block Groups within 1 Mile of a Data Center and Select Demographic Characteristics

Pollutant	Correlation Statistics	Population Density	Non-White Percent	Median HH Income	Higher Ed Percent	Home Owner Percent
CO / sq. mi.	Pearson Corr.	-0.104	0.047	-.114*	-.160**	-0.108
	Sig. (2-tailed)	0.06	0.39	0.041	0.004	0.051
NOx / sq. mi.	Pearson Corr.	-0.059	0.061	-.133*	-.158**	-.156**
	Sig. (2-tailed)	0.287	0.265	0.017	0.004	0.005
PM 2.5 / sq. mi.	Pearson Corr.	-.121*	0.02	-0.008	-0.098	0.022
	Sig. (2-tailed)	0.028	0.719	0.888	0.077	0.692
** Correlation is significant at the 0.01 level (2-tailed).						
* Correlation is significant at the 0.05 level (2-tailed).						

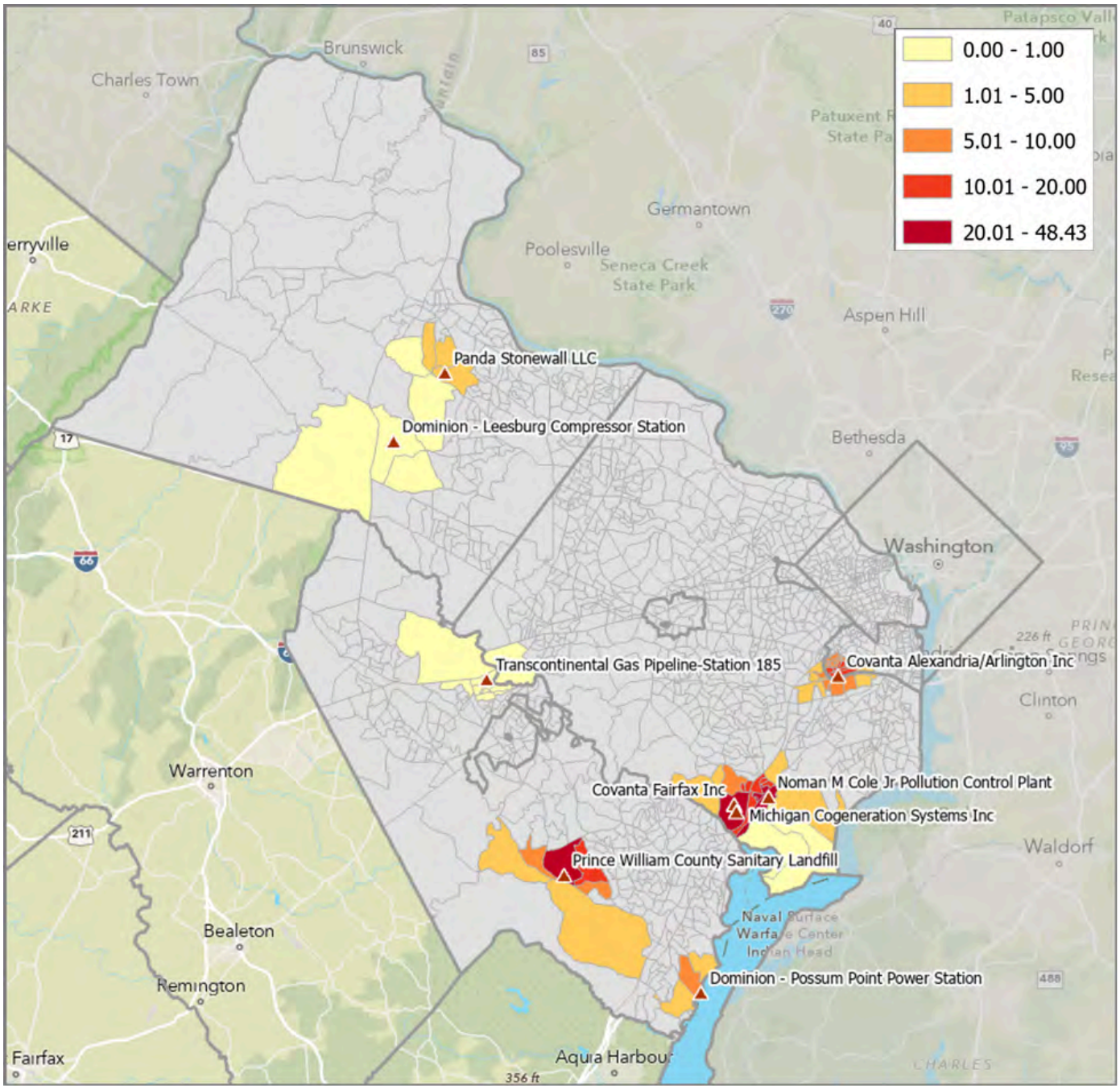
Source: Virginia DEQ data. Analysis by Virginia Commonwealth University research team.

Figure B-4A. Diffusion Map of Carbon Monoxide (CO) Emissions from Select other NOVA Facilities (2022), tons per year by raster grid cells (330' x 330' resolution)



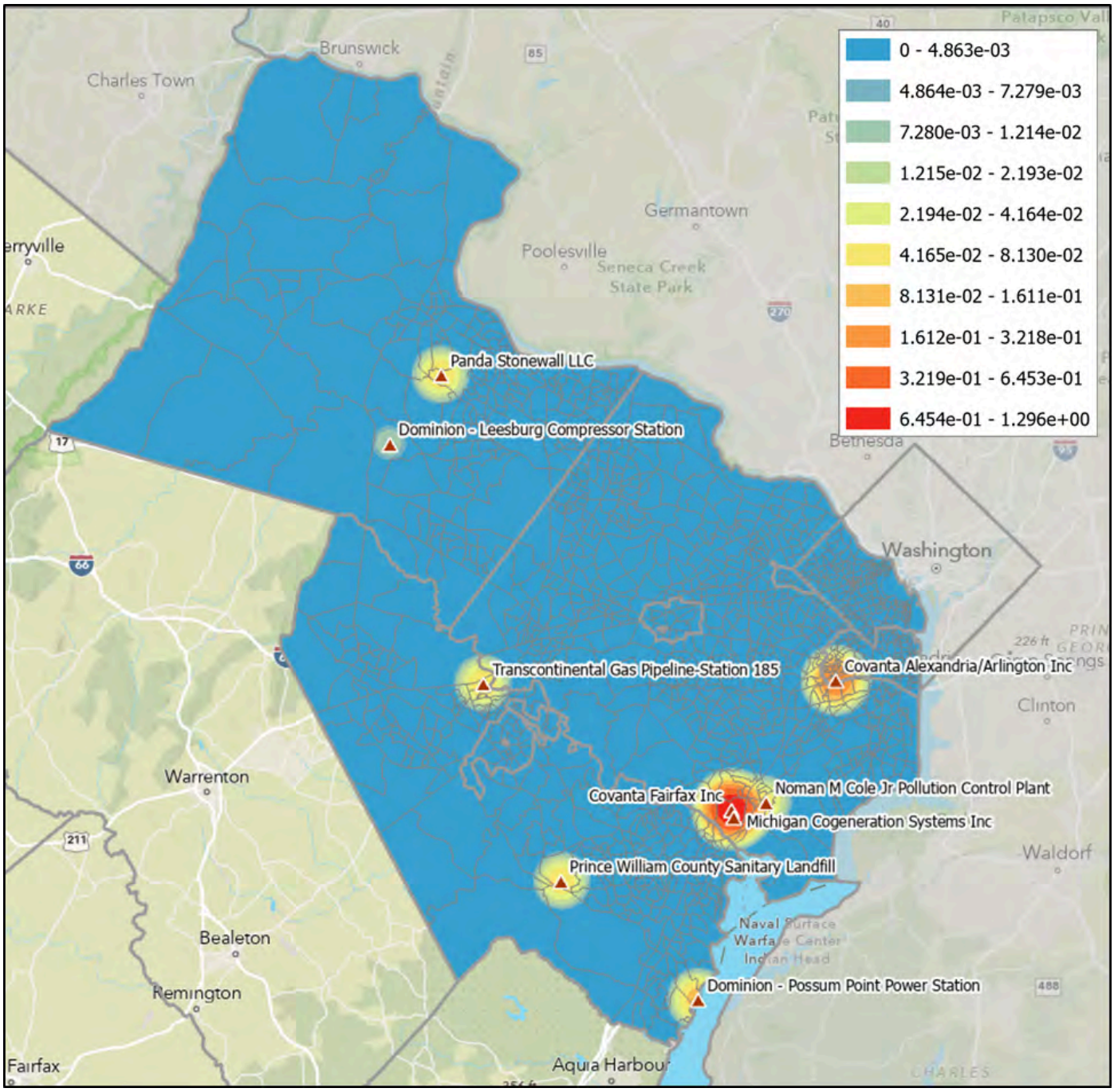
Source: U.S. Environmental Protection Agency. National Emissions Inventory. 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.

Figure B-4.B. Map of Derived Total Carbon Monoxide (CO) Emission Concentrations from Select other NOVA Facilities (2022), by Census Block Group, tons per year per square mile



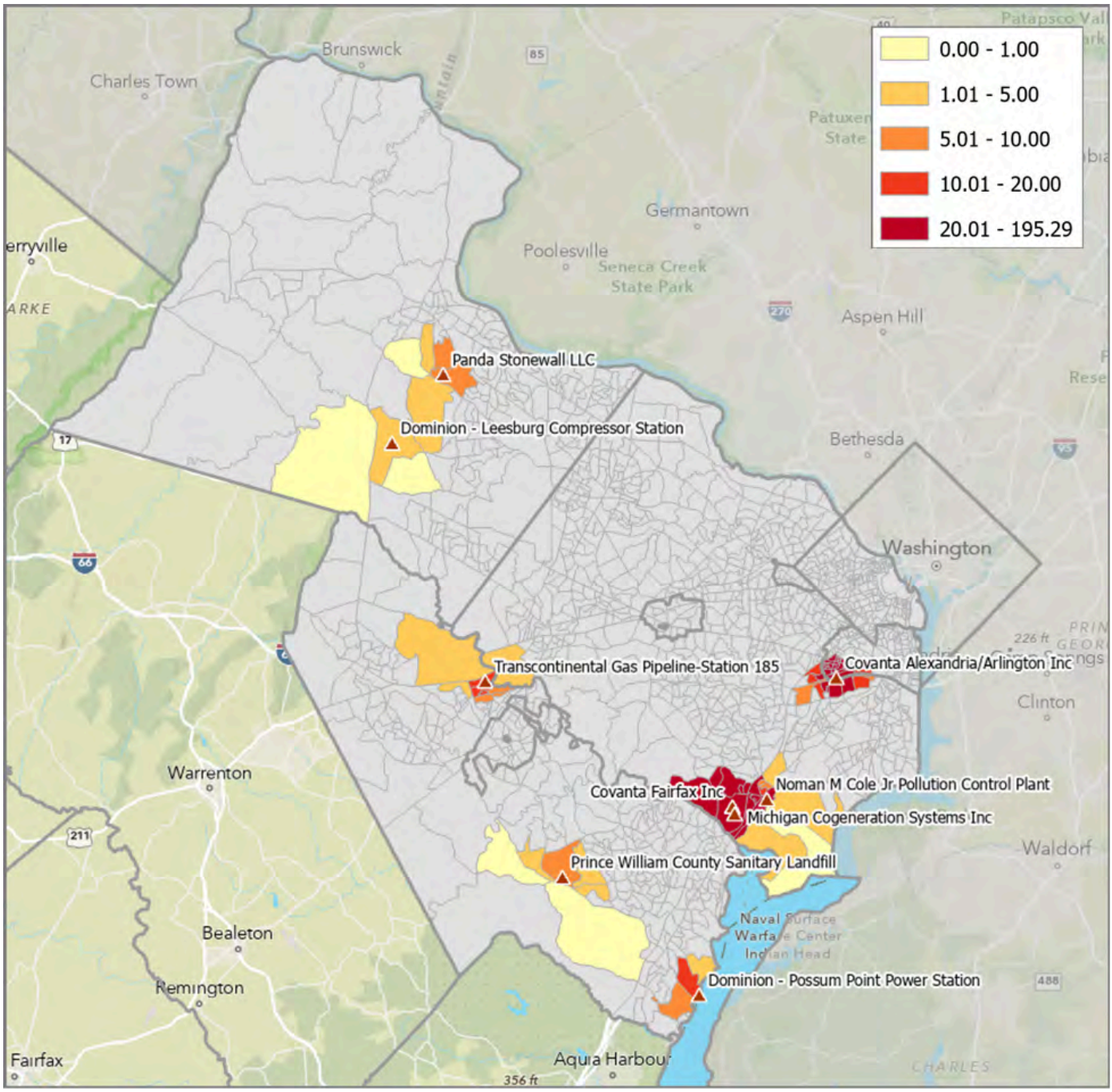
Source: U.S. Environmental Protection Agency. National Emissions Inventory. [2022 v2 Emissions Modeling Platform](). Analysis by Virginia Commonwealth University research team.

Figure B-5A. Diffusion Map of Nitrous Oxides (NOx) Emissions from Select other NOVA Facilities (2022), tons per year by raster grid cells (330' x 330' resolution)



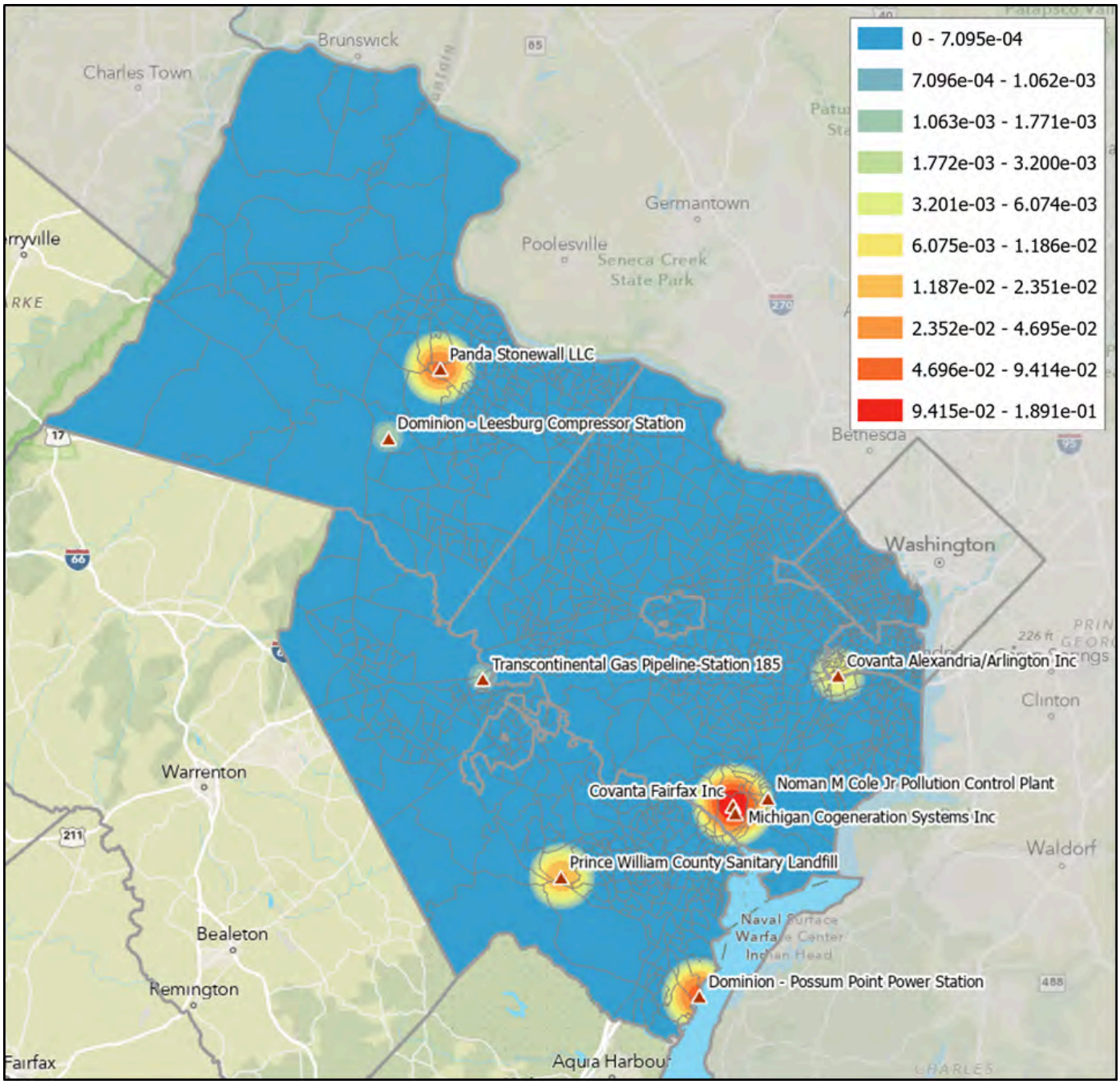
Source: U.S. Environmental Protection Agency. National Emissions Inventory. 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.

Figure B-5.B. Map of Derived Total Nitrous Oxides (NOx) Emission Concentrations from Select other NOVA Facilities (2022), by Census Block Group, tons per year per square mile



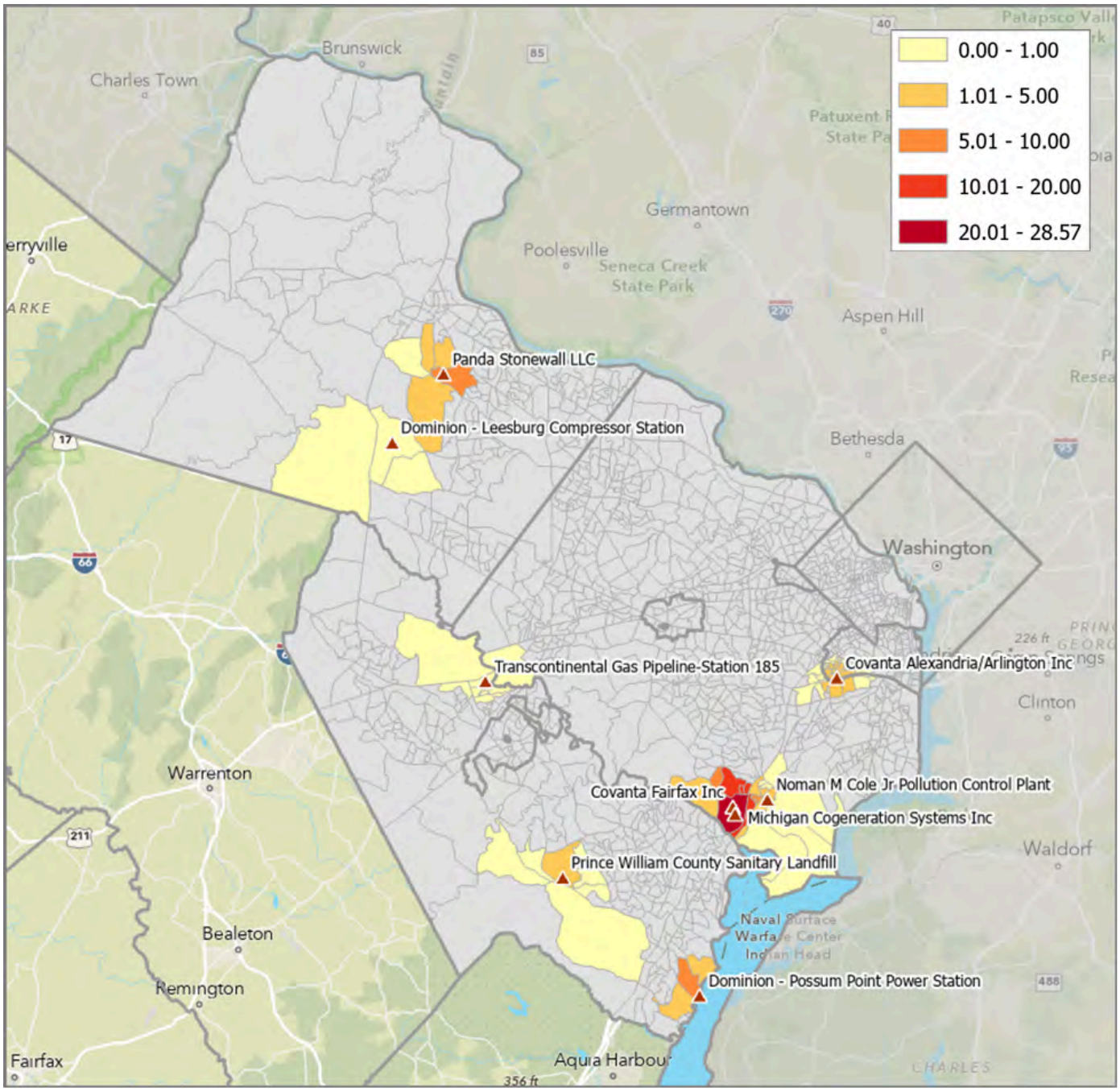
Source: U.S. Environmental Protection Agency. National Emissions Inventory. 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.

Figure B-6A. Diffusion Map of Particulate Matter (PM 2.5) Emissions from Select other NOVA Facilities (2022), tons per year by raster grid cells (330' x 330' resolution)



Source: U.S. Environmental Protection Agency. National Emissions Inventory. 2022 v2 Emissions Modeling Platform. Analysis by Virginia Commonwealth University research team.

Figure B-6.B. Map of Derived Total Particulate Matter (PM 2.5) Emission Concentrations from Select other NOVA Facilities (2022), by Census Block Group, tons / year / square mile



Source: U.S. Environmental Protection Agency. National Emissions Inventory. [2022 v2 Emissions Modeling Platform](). Analysis by Virginia Commonwealth University research team.

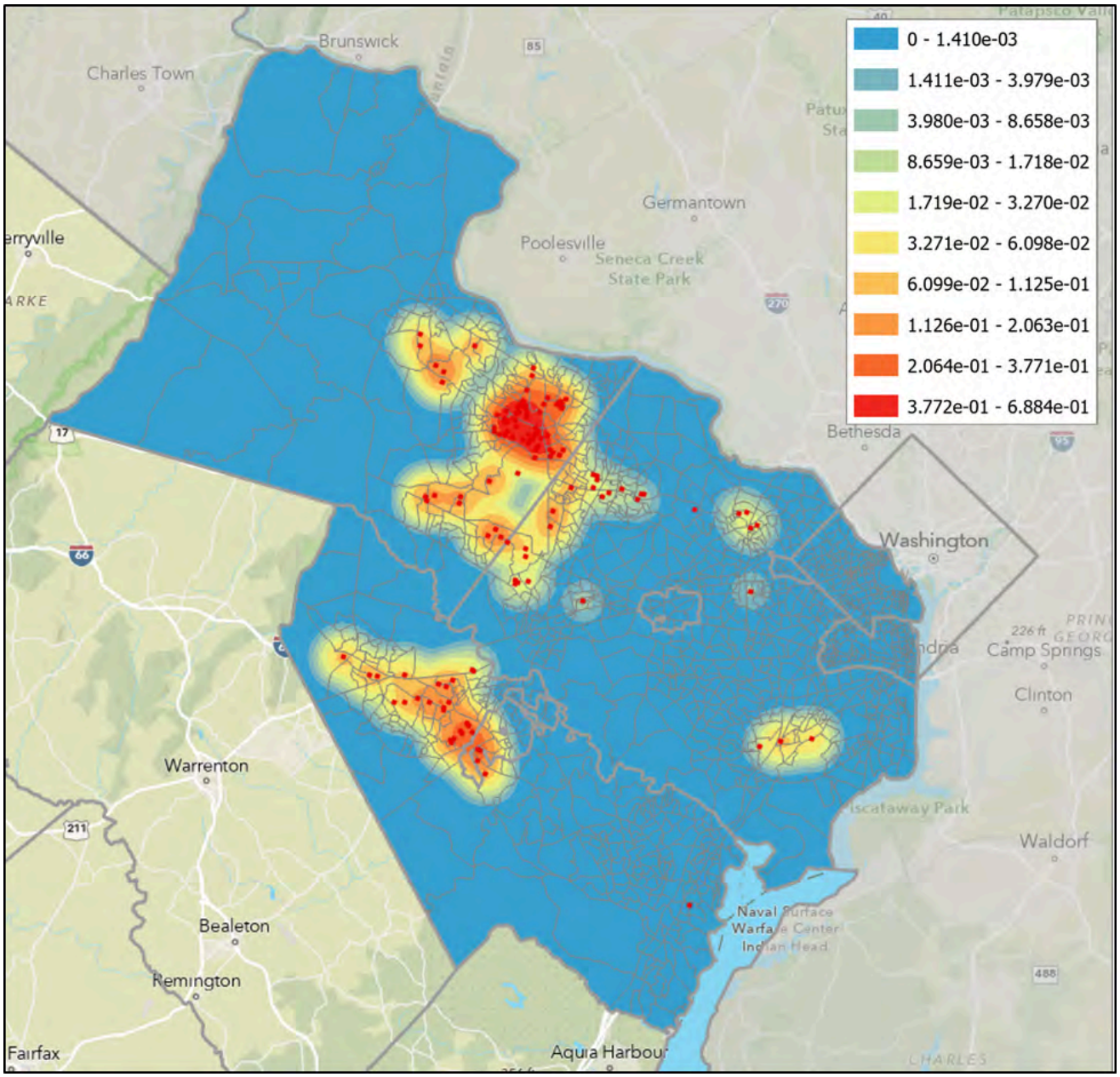
Table B-3. Descriptive Statistics: Current Emissions Exposure (2023) from Select NOVA Facilities – Census Block Groups within One Mile of Facility (Tons per Square Mile)

Pollutant (Tons / Sq. Mi.)	N	Minimum	Maximum	Mean	Std. Deviation
Norman M Cole Jr Pollution Control Plant (Wastewater Treatment Plant), Covanta Fairfax Inc (Municipal Waste Combustor), Michigan Cogeneration Systems Inc (LandfillGas Power Plant)					
Carbon Monoxide (CO)	19	0.842	26.823	13.285	8.993
Nitrous Oxides (NOx)	19	0.504	195.286	44.101	50.204
Particulate Matter (PM 2.5)	19	0.010	28.569	5.999	7.457
Covanta Alexandria / Arlington Inc. (Municipal Waste Combustor)					
Carbon Monoxide (CO)	34	1.123	15.312	7.373	3.578
Nitrous Oxides (NOx)	34	6.022	82.087	39.524	19.182
Particulate Matter (PM 2.5)	34	0.146	1.985	0.956	0.464
Prince William County Sanitary Landfill (Landfill)					
Carbon Monoxide (CO)	6	1.478	48.430	13.770	17.530
Nitrous Oxides (NOx)	6	0.275	8.996	2.558	3.256
Particulate Matter (PM 2.5)	6	0.094	3.067	0.872	1.110
Dominion - Possum Point Power Station (Natural Gas Power Plant)					
Carbon Monoxide (CO)	3	2.923	9.204	5.576	3.252
Nitrous Oxides (NOx)	3	4.002	12.601	7.634	4.452
Particulate Matter (PM 2.5)	3	2.237	7.044	4.267	2.489
Panda Stonewall LLC / Potomac Energy Center (Natural Gas Power Plant)					
Carbon Monoxide (CO)	5	0.371	3.880	1.890	1.527
Nitrous Oxides (NOx)	5	0.823	8.618	4.196	3.395
Particulate Matter (PM 2.5)	5	0.559	5.851	2.846	2.307
Transcontinental Gas Pipeline - Station 185 (Natural Gas Compressor Station)					
Carbon Monoxide (CO)	10	0.037	0.462	0.224	0.152
Nitrous Oxides (NOx)	10	1.250	15.503	7.505	5.104
Particulate Matter (PM 2.5)	10	0.023	0.285	0.138	0.094
Dominion - Leesburg Compressor Station (Natural Gas Compressor Station)					
Carbon Monoxide (CO)	3	0.024	0.768	0.285	0.419
Nitrous Oxides (NOx)	3	0.036	1.134	0.420	0.618
Particulate Matter (PM 2.5)	3	0.005	0.149	0.055	0.081

Source: U.S. EPA, NEI 2022 v2 Emissions Modeling Platform. Analysis by VCU research team.

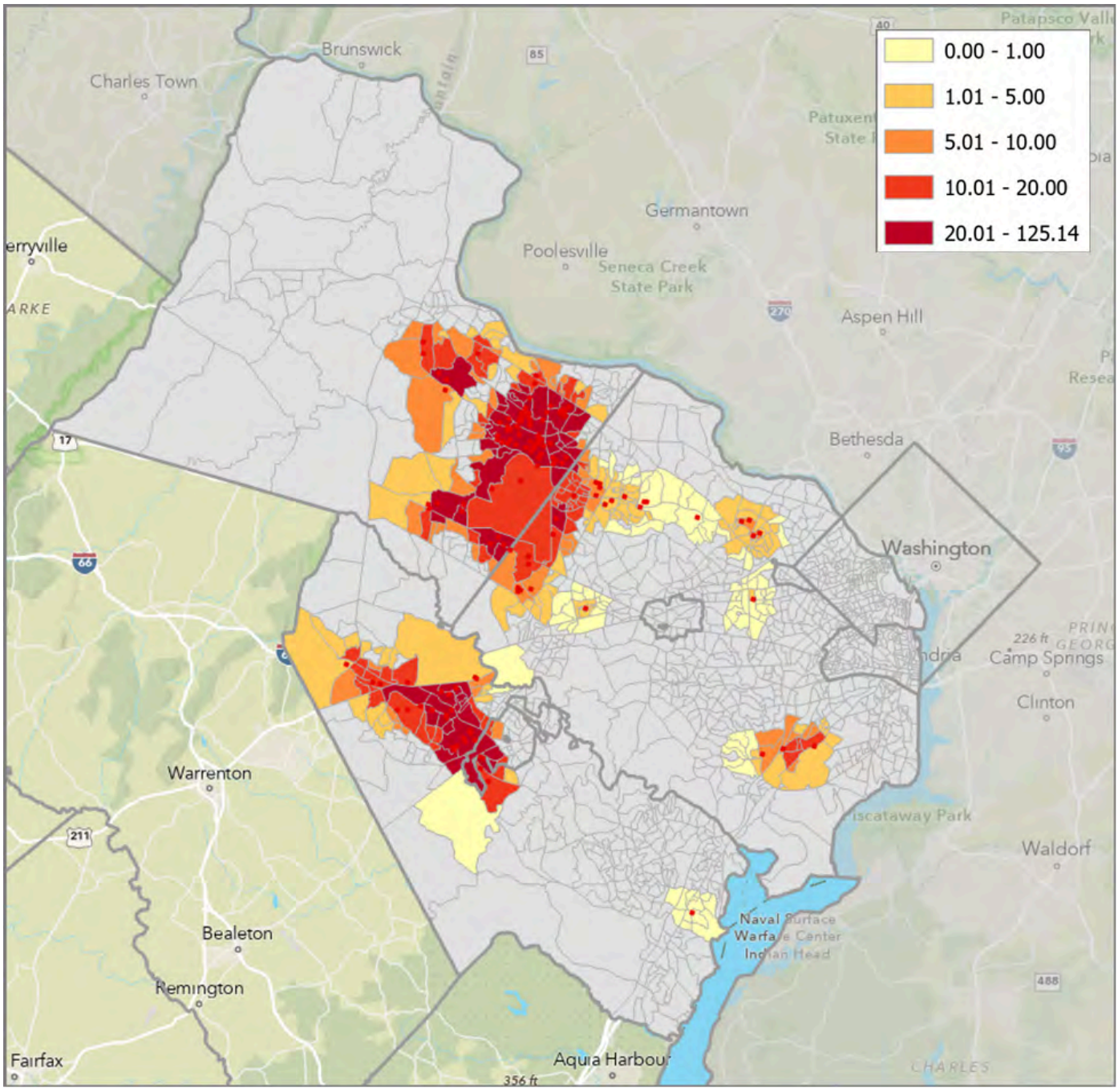
Appendix C. Detailed Results for Analysis of Potential Localized Air Pollution Emissions from Data Centers In Northern Virginia

Figure C-1A. Diffusion Map of Potential Carbon Monoxide (CO) Emissions from NOVA Data Center Permits, tons per year by raster grid cells (330' x 330' resolution)



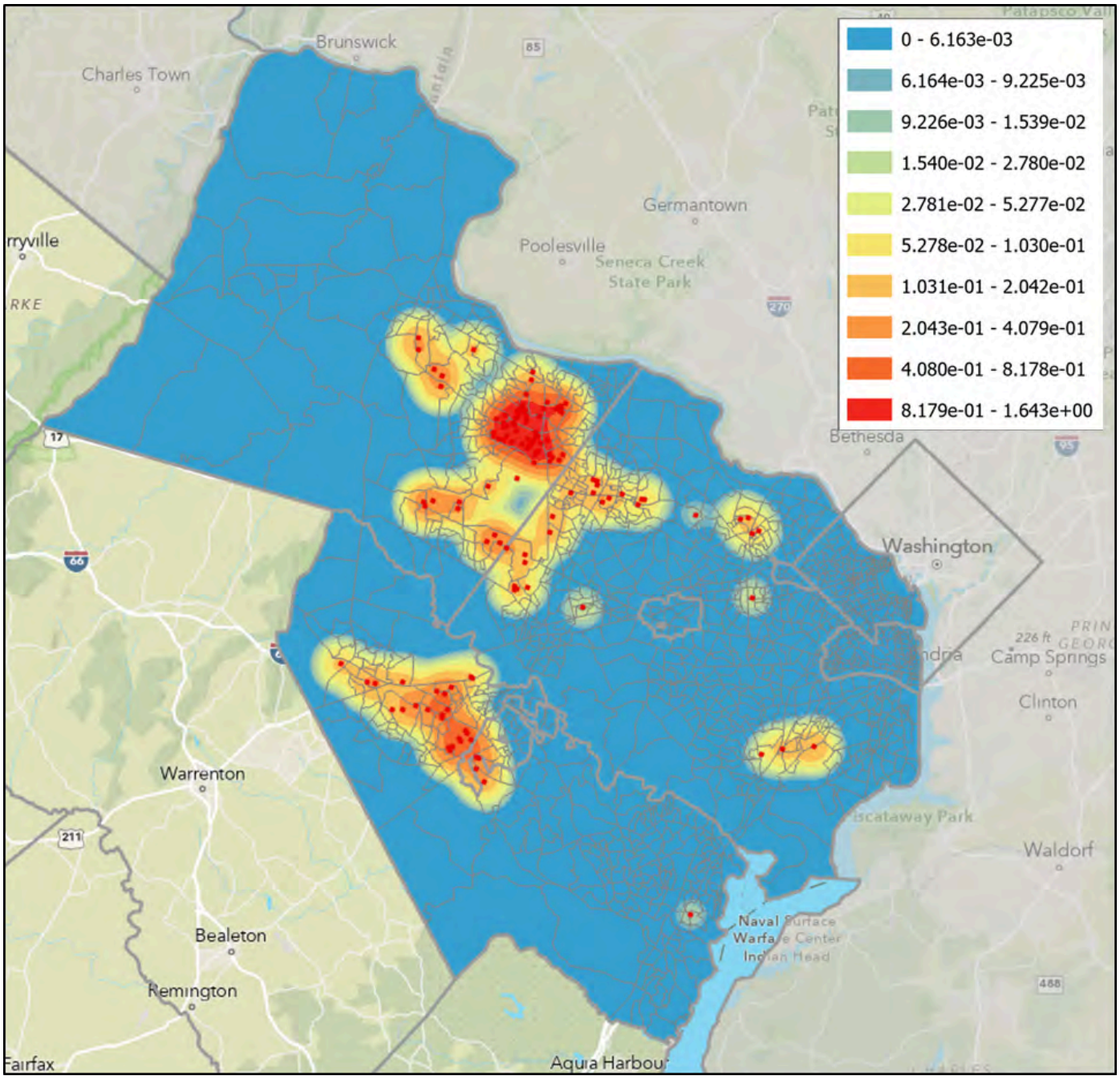
Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Figure C-1.B. Map of Derived Potential Carbon Monoxide (CO) Emission Concentrations from NOVA Data Center Permits, by Census Block Group, tons per year per square mile



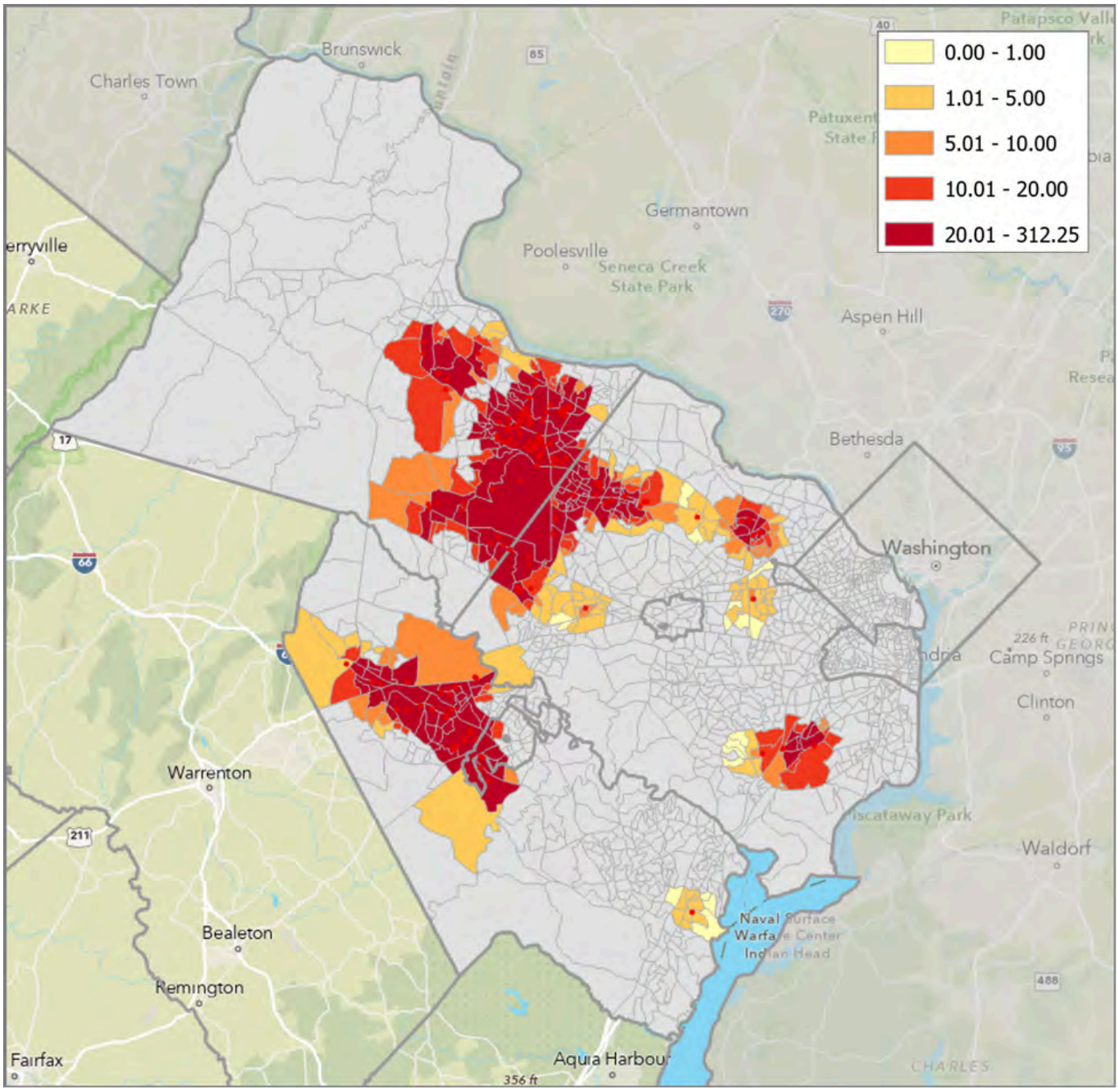
Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Figure C-2A. Diffusion Map of Potential Nitrous Oxides (NOx) Emissions from NOVA Data Center Permits, tons per year by raster grid cells (330’ x 330’ resolution)



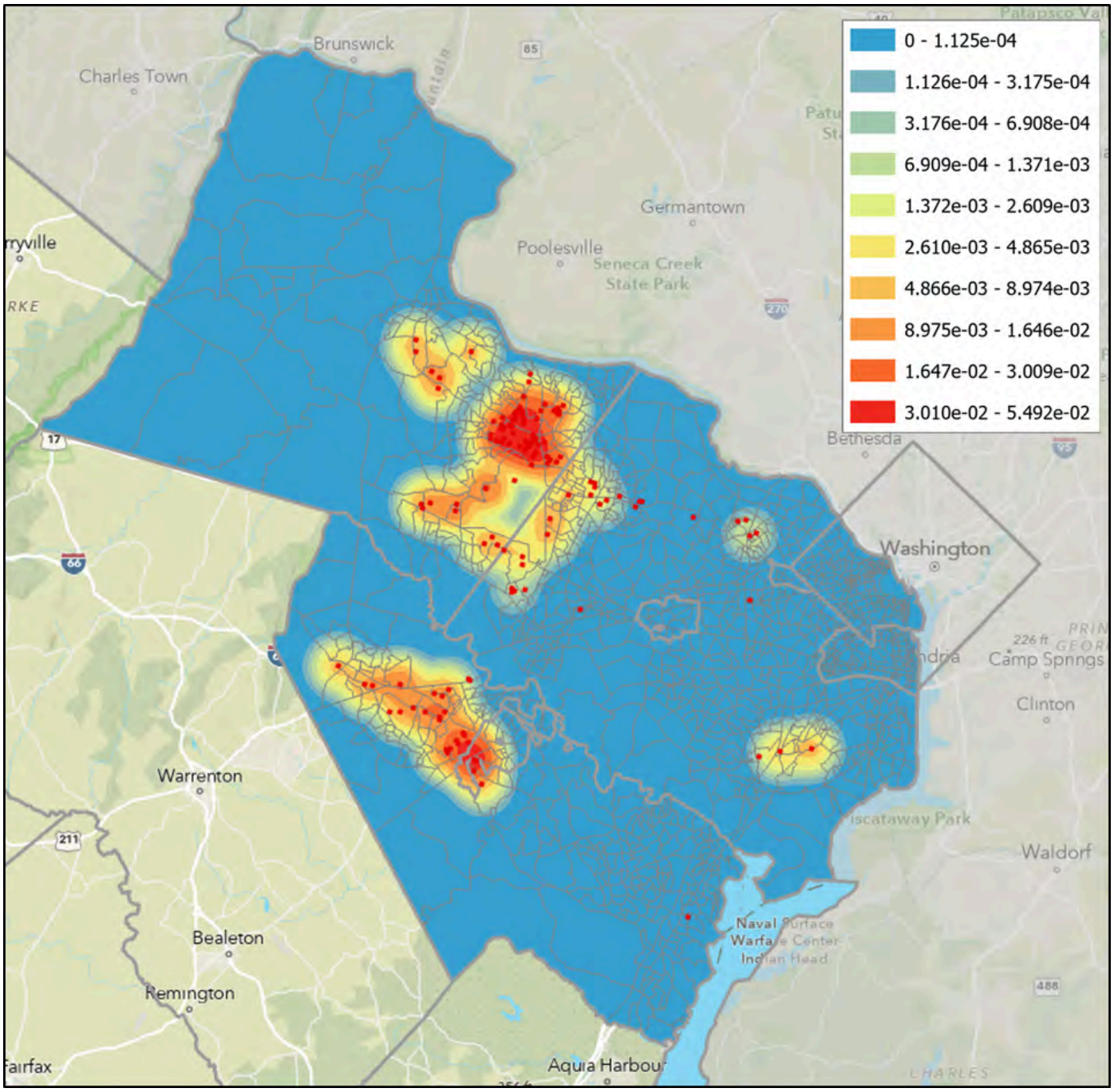
Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Figure C-2.B. Map of Derived Potential Nitrous Oxides (NOx) Emission Concentrations from NOVA Data Center Permits, by Census Block Group, tons per year per square mile



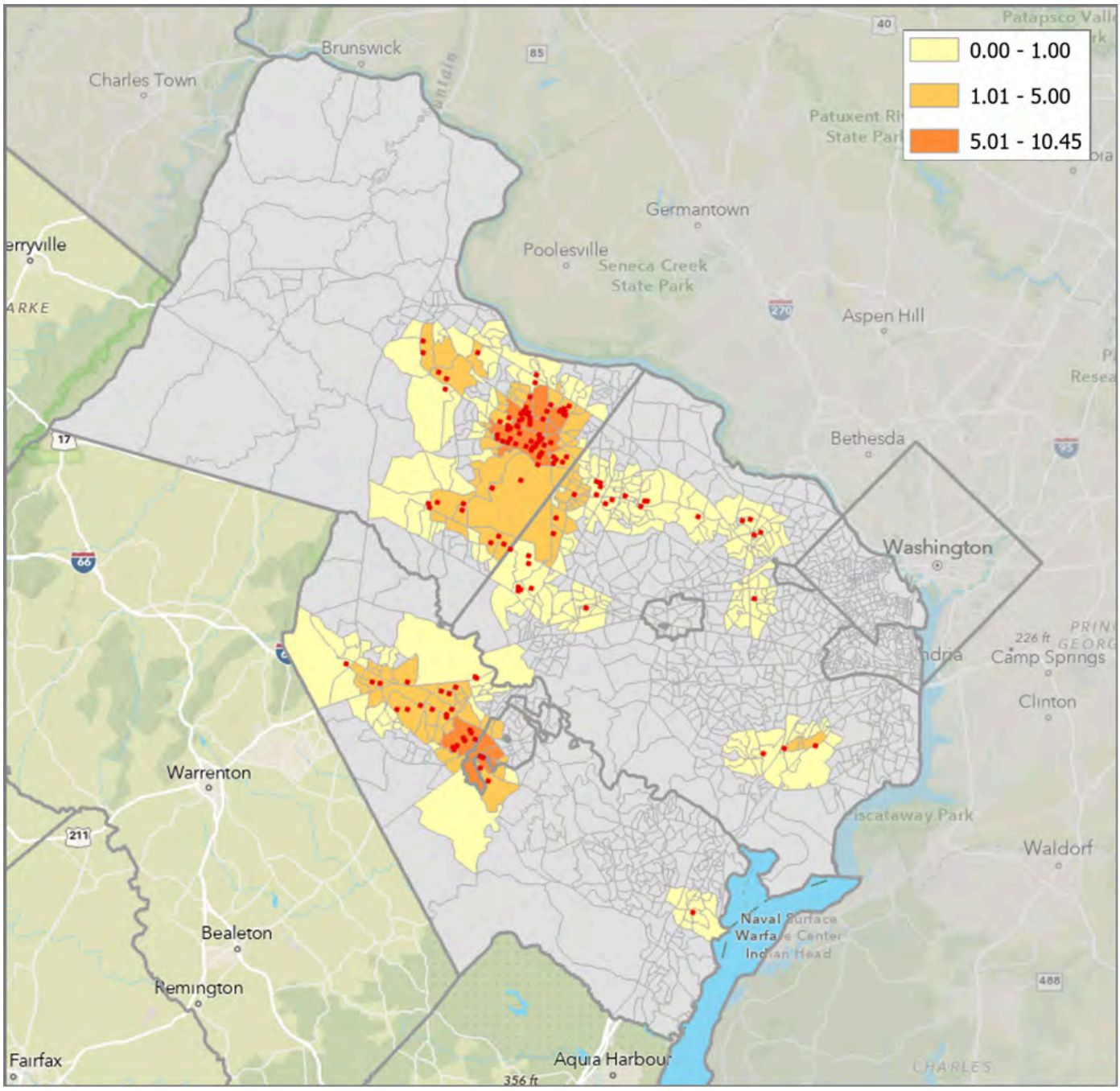
Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Figure C-3A. Diffusion Map of Potential Particulate Matter (PM 2.5) Emissions from NOVA Data Center Permits, tons per year by raster grid cells (330’ x 330’ resolution)



Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Figure C-3.B. Map of Derived Potential Particulate Matter (PM 2.5) Emission Concentrations from NOVA Data Center Permits, by Census Block Group, tons / year / square mile



Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Table C-1. Descriptive Statistics: Cumulative Permitted Emissions Exposure from Data Centers – Census Block Groups within One Mile of a Data Center

Pollutant (Tons / Sq. Mi.)	N	Minimum	Maximum	Mean	Std. Deviation
Carbon Monoxide (CO)	378	0.027	125.140	11.376	17.236
Nitrous Oxides (NOx)	378	0.361	312.248	29.924	42.771
Particulate Matter (PM 2.5)	378	0.000	10.446	0.932	1.487

Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Table C-2. Correlations: Permitted Emissions Exposure from Data Centers (Census Block Groups within One Mile of a Data Center) and Select Demographic Characteristics

Pollutant	Correlation Statistics	Population Density	Non-White Percent	Median HH Income	Higher Ed Percent	Home Owner Percent
CO / sq. mi.	Pearson Corr.	-0.051	0.064	-.117*	-.175**	-.111*
	Sig. (2-tailed)	0.327	0.219	0.027	<.001	0.032
NOx / sq. mi.	Pearson Corr.	-0.018	0.051	-.154**	-.162**	-.160**
	Sig. (2-tailed)	0.724	0.326	0.003	0.002	0.002
PM 2.5 / sq. mi.	Pearson Corr.	-0.074	0.056	-.113*	-.185**	-0.081
	Sig. (2-tailed)	0.154	0.282	0.032	<.001	0.119
** Correlation is significant at the 0.01 level (2-tailed).						
* Correlation is significant at the 0.05 level (2-tailed).						

Source: Virginia DEQ (June, 2025). Issued Air Permits for Data Centers. Analysis by VCU research team.

Health-Informed Computing: Estimating and Addressing the Public Health Impact of Data Centers

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Abstract

The surging demand for artificial intelligence (AI) has led to a rapid expansion of energy-intensive data centers, contributing to criteria air pollutant emissions and raising public health concerns that have received comparatively limited attention in sustainability assessments. This paper introduces a principled methodology to model air pollutant emissions for data centers and estimate the public health impacts. Our findings show that the growing demand for AI and computing technologies is projected to push the total annual public health burden of U.S. data centers up to more than $20 billion in 2028. Although national-level impacts remain modest, data center health costs are unevenly distributed: in the most affected counties, the estimated per-household health burden can reach about seven times the national average. Next, we propose a health-informed computing framework that explicitly incorporates public health impacts into data center resource management across space and time, mitigating public health costs while supporting environmental sustainability. More broadly, we recommend extended energy reporting to include public health impact of data centers and paying attention to all impacted communities.

1 Introduction

Artificial intelligence (AI) has significant potential to address major societal challenges, including air quality, public health, disease prevention and healthcare optimization. At the same time, the rapid growth of generative AI, particularly large language models (LLMs), has sharply increased computational demand and accelerated the expansion of energy-intensive data centers. According to the recent U.S. data center energy report [1], AI workloads are projected to proliferate and, together with other growing computing demands, could raise U.S. data center electricity consumption to 6.7–12.0% of the national total by 2028, up from 4.4% in 2023.

This surge in electricity demand places growing stress on power grids [2] and intensifies environmental impacts through increased carbon emissions [3] and water consumption [4]. While mitigation strategies such as grid-interactive data centers, energy-efficient hardware and software, and carbon- and water-aware computing have been explored [4,5], these efforts have yet to incorporate another critical dimension: Public Health.

The underexamined public health impact of data centers. The reliance on fossil fuel-based electricity and usage of on-site (typically diesel) generators to operate data centers contribute to air quality concerns and public health costs through the emission of criteria air pollutants. These pollutants include fine particulate matter ($PM_{2.5}$), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2).

Exposure to criteria air pollutants, especially $PM_{2.5}$, is causally linked to premature mortality, asthma, cardiovascular disease, and other health effects, with adverse impacts observed even at $PM_{2.5}$ concentrations below national air quality standards ("no-threshold") [6]. Further, criteria air pollutants are not confined to the immediate vicinity of their emission sources; they can travel hundreds of miles through atmospheric dispersion (i.e., cross-state air pollution) [7].

Globally, ambient air pollution caused 4.2 million premature deaths in 2019 and remains one of the leading risk factors for disease burden across all socio-demographic groups [8,9]. While the U.S. has generally better air quality than many other countries, 4 in 10 people in the U.S. still live with unhealthy levels of air pollution, according to the "State of the Air 2024" report published by the American Lung Association [10]. In 2019 (the latest year of data provided by the World Health Organization, or WHO, as of November 2024), an estimate of 93,886 deaths in the U.S. were attributed to ambient air pollution [11].

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Electricity generation, along with transportation and industrial activities, is an important contributor to ambient air pollution with significant public health consequences [12]. For example, a recent study [13] found that 460,000 *excess* deaths were attributed to $PM_{2.5}$ emissions from coal-fired power plants between 1999 and 2020 in the U.S. alone. As emphasized by the U.S. Environmental Protection Agency (EPA), despite decades of progress, "fossil fuel-based power plants remain a leading source of air, water, and land pollution that affects communities nationwide" [12].

Looking forward, the electricity sector is generally expected to become cleaner over time, but the pace, scale, and regional distribution of this transition may remain limited [14]. For example, the U.S. Energy Information Administration's 2026 Annual Energy Outlook projects that coal consumption by the electricity sector in 2050 remains approximately 40% of its 2025 level in the "Alternative Electricity" case, which assumes that EPA's April 2024 power-plant CO_2 rule is not in place [14]. At the global scale, electricity generation has remained heavily dependent on coal and other fossil fuels, underscoring the persistent challenge of fully powering data centers with pollutant-free energy [15]. Moreover, the growing energy demand of data centers is already delaying the decommissioning of coal-fired power plants and driving the expansion of fossil-fuel power plants in some regions [2, 16].

Addressing air-pollution-related health impacts requires coordinated efforts across sectors, along with mitigation strategies tailored to each sector [17]. While health impacts of air pollution from sectors such as transportation have been widely studied [18], the public health impacts of data centers have received comparatively less attention and often remained absent from infrastructure risk assessments and sustainability reports. Without effective mitigation strategies, the health impacts, including hospital admissions, asthma symptoms, and mortality, are likely to grow with rising data center demand.

Estimating and addressing public health impacts. To address the gap in the literature, we introduce a novel methodology to estimate the hidden public health impacts of data centers. Specifically, focusing on the contiguous United States, we use the EPA's COBRA model [17] to estimate pollutant dispersion and resulting health outcomes attributed to data centers associated with their backup generation (Scope 1) and electricity usage (Scope 2). Our estimates show that U.S. data centers could contribute to various health outcomes including approximately 600,000 asthma symptom cases and 1,300 deaths in 2028 under the high-growth scenario, with total public health costs exceeding $20 billion. This corresponds to an increase of 213% relative to the 2023 level, compared with a projected 17% increase in U.S. stationary fuel-combustion-related health costs over the same period. Although national-level impacts remain modest, data center health costs vary substantially across counties: the highest county-level per-household health cost is about seven times the national average and approximately 200 times the lowest county-level value, warranting closer attention.

To help mitigate the growing public health burden, we propose *Health-Informed Computing* (`HICO`), which leverages data center flexibility and explicitly incorporates public health costs into siting and resource management decisions. Using spatial load shifting as a case study, we show that `HICO` can substantially reduce health costs while complementing the broader sustainability goals of existing carbon-aware computing. `HICO` also aligns well with demand-side energy innovations aimed at improving public health [19].

Finally, we provide broader recommendations to address the increasing public health impact of data centers, including extended energy reporting to include public health assessment and paying attention to all impacted communities.

Disclaimer. *The results presented in this paper are not intended to encourage or discourage the construction of data centers, nor should they be used to support or oppose any specific project, which requires more detailed and context-specific evaluation. We do not take a position on decisions related to any specific data centers or the use of AI. Instead, our goal is to provide a quantitative assessment of the potential public health impacts of the data center industry and to develop health-informed computing as a mitigation strategy that can help reduce these impacts while supporting sustainable growth. Throughout this paper, terms such as "health costs," "health impacts," and "health burden" refer to population-level estimates produced using the U.S. EPA's screening model COBRA (Desktop v5.1), rather than observed health outcomes or individually attributable effects.*

2 Methodology of Estimating Public Health Impacts of Data Centers

This section presents our methodology of estimating data centers' contribution to criteria air pollutants and public health impacts throughout its lifecycle across three scopes (Fig. 1). The scoping definition in this paper parallels the well-established greenhouse gas protocol [20].

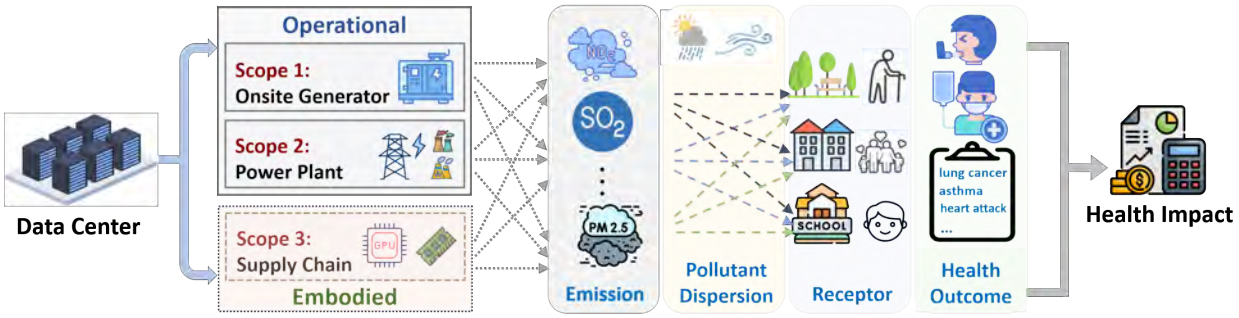


Figure 1: *The overview of data centers' contribution to air pollutants and public health impacts. Scope-1 and scope-2 impacts occur during the operation of data centers ("operational"), whereas scope-3 impacts arise from activities across the supply chain ("embodied").*

2.1 Background on Air Pollutants

Criteria air pollutants, including $PM_{2.5}$, SO_2 and NO_2, are a group of airborne contaminants that are emitted from various sources such as industrial activities and vehicle emissions. The direct emission of $PM_{2.5}$ is called primary $PM_{2.5}$, while precursor pollutants such as SO_2, NO_x, and VOCs, can form secondary $PM_{2.5}$ and/or ozone. These air pollutants can travel a long distance (a.k.a. cross-state air pollution), posing direct and significant risks to public health over large areas, particularly for vulnerable populations including the elderly and individuals with respiratory conditions [7].

Under the Clean Air Act, the U.S. EPA is authorized to regulate the emission levels of criteria air pollutants, reducing concentrations to comply with the National Ambient Air Quality Standards (NAAQS). For example, the NAAQS primary standards set the annual average $PM_{2.5}$ concentration at $9\mu g/m^3$ and the 98-th percentile of 1-hour daily maximum NO_2 concentration at 100 parts per billion by volume, both counted over three years [21]. In addition, state and local governments may set additional regulations on criteria air pollutants to strengthen or reinforce national standards [22].

The U.S. EPA treats $PM_{2.5}$ as a "no-threshold" pollutant, meaning that adverse public health impacts can occur even at concentrations below national or regional air quality standards [6]. Thus, regulatory compliance does not necessarily imply the absence of health risk. For example, the U.S. standard for the annual average limit of $PM_{2.5}$ is still higher than the WHO's recommended level of 5 $\mu g/m^3$ [21,23].

While CO_2 is broadly classified by the U.S. EPA as an air pollutant following the U.S. Supreme Court ruling in 2007 [24], it often does not cause the same immediate health impacts as criteria pollutants. Thus, we use "air pollutants" to solely refer to criteria air pollutants wherever applicable.

2.2 Modeling Tool

We focus on the United States, one of the world's largest data center markets. The U.S. EPA provides COBRA, a convenient tool for assessing public health impacts of air pollutants in contiguous U.S. (simply referred to as the U.S. in this paper) [17]. By taking the amount of emissions at the source as the input, COBRA performs simplified air dispersion modeling (including both primarily emitted $PM_{2.5}$ and secondarily formed $PM_{2.5}$ and ozone) with various concentration-response functions [7], offering a quantitative analysis of county-level public health impacts.[2]

Specifically, COBRA uses a simplified source-receptor (S-R) matrix to model air dispersion, i.e., the movement of emitted pollutants in the atmosphere. It then estimates a range of health outcomes based on epidemiological evidence, including mortality, heart attacks, and asthma symptoms [17]. For example, mortality is estimated using a log-linear concentration-response function for $PM_{2.5}$, with $\beta = 0.011330$ and $\beta = 0.006390$ for the high and low estimates, respectively [7]. Finally, COBRA assigns an economic value to each health outcome and aggregates these values to estimate the overall public health burden associated with a pollutant-emitting activity. Further details of COBRA are provided in the supporting manual [7].

Although COBRA is a screening model and cannot replace more sophisticated air quality models for site-level regulatory decisions, its estimates have been shown to be reasonably consistent with those from

[2]Independent cities considered county-equivalents for census purposes are also referred to as "counties" in COBRA.

advanced models [7], making it well suited for regional public health impact assessment. COBRA has also been widely used in the literature to study the health impacts of various sectors, including transportation and electricity generation [25].

We use COBRA Desktop v5.1 for our analysis. All monetary values are reported in 2023 U.S. dollars, using COBRA's default discount rate of 2% [17]. We report COBRA results in the format of "mid (low, high)," where the three values correspond to the midrange, low, and high estimates, respectively. When presenting a single value or ratio, we use the midrange estimate by default. More details are available in Appendix A.

2.3 Data Centers' Contribution to Air Pollutant Emissions

As illustrated in Fig. 1, data centers contribute to criteria air pollutant emissions through three scopes, which serve as the key inputs to COBRA for estimating their public health impacts.

2.3.1 Scope 1: Onsite Generator

Data centers are mission-critical facilities with high availability requirements and need reliable backup power sources [26, 27]. Due to the limited experience with cleaner backup alternatives at scale [2], many data centers, including newly built facilities, continue to depend on onsite diesel generators for backup power [2, 28]. Nonetheless, diesel generators are known to emit significant amounts of air pollutants during operation [29].

In Northern Virginia, which has the world's largest concentration of data centers, most of the diesel backup generators, including many recently installed units, are classified as Tier 2 [28]. Tier 4 generators use more advanced exhaust aftertreatment and therefore have lower emission rates than Tier 2 units, but they often add cost, complexity, and operational constraints [30]. As of the end of 2024, the total permitted annual emission limits for these on-site generators were approximately 13,000 U.S. short tons of NO_x, 1,400 tons of VOCs, 50 tons of SO_2, and 600 tons of $PM_{2.5}$.

While backup generators typically do not operate for extended periods, regular testing and maintenance are necessary for reliability. In 2023, backup generators at Virginia data centers emitted about 7% of their permitted amounts, primarily for maintenance (often 10 to 20 hours per year) [31]. Similarly, historical emissions at some data centers in Quincy, Washington reached 3%–12% of permitted levels [32]. More recently, the U.S. EPA clarified that data center backup generators may be operated for up to 50 hours per year for non-emergency demand response or reliability-related purposes, provided that specific regulatory conditions are met and the operation complies with applicable air permits [33].

According to a recent Virginia state report [31], during an extended outage, an affected data center could potentially reach its annual emissions limits "within a few days." More broadly, when many generators in a region operate simultaneously during grid stress, they can produce short-term spikes in local air pollutants. For example, in an upper-bound case where data center backup generators in Northern Virginia emit air pollutants at their maximum permitted levels during a prolonged regional grid outage, their NO_x emissions could amount to more than half of the region's annual NO_x emissions from all sources [31].

To account for scope-1 emissions, we consider a reference case in which actual emissions are 10% of permitted levels, informed by both historical reports and potential future demand-response use. If the actual percentage is $x\%$, our estimate scales approximately by $\frac{x}{10}$. We derive an average annual emission rate in tons/MWh from Virginia data centers (representing approximately 20% of U.S. data center electricity use in 2023) [28, 34] and apply it to data center electricity consumption in other states, because scope-1 emissions data for data centers in other states are often less readily available. The effect of this approach on our overall results is expected to be limited because scope-2 health costs are significantly larger in our reference case.

2.3.2 Scope 2: Power Plant

Data centers' scope-2 public health impacts depend on where the power plants supplying their electricity are located. For national-scale analysis, we use the average attribution method unless otherwise stated, which is also widely adopted by technology companies for carbon emission accounting [26]. We focus on location-based accounting without considering market-based offsetting mechanisms, which may be less effective in mitigating health impacts from location-dependent emission sources.

The U.S. electricity grid is divided into 14 regions following the AVoided Emissions and geneRation Tool (AVERT v4.3) provided by the U.S. EPA [35]. We first calculate the total data center electricity consumption

e_{DC} and the overall electricity consumption (including non-data center loads) e_{Total} within each electricity region. We use the state-level data center electricity consumption distribution for 2023 provided by EPRI [34], scale it by the U.S. total data center electricity consumption in 2023 and for the 2028 projection based on data provided by [1], and then distribute state-level electricity consumption to relevant electricity regions following the state-to-region electricity apportionment used by AVERT.

Next, we calculate the percentage $x\% = \frac{e_{DC}}{e_{Total}}$ of the data center electricity consumption with respect to the total electricity consumption for each region. The relationship between the health impact and emission reduction in COBRA is approximately linear. Thus, we apply a reduction by $x\%$ to the baseline emissions of all the power plants within the respective electricity region in COBRA and estimate the corresponding county-level health impacts.

Although co-location with on-site, often temporary and gas-fired, power plants is an emerging option for mitigating grid capacity constraints, it remains limited today. Thus, our average attribution of data center electricity use to regional off-site power plants remains a reasonable approximation for our national-scale analysis. Moreover, depending on the technology, pollutant control, and operational settings, on-site plants may also have emission rates comparable to regional grids, raising potential public health concerns [36].

2.3.3 Scope 3: Supply Chain

Scope-3 air pollutants include embodied supply-chain emissions, such as those associated with manufacturing GPUs and servers. Because these emissions are harder to quantify due to limited public data, we focus on scope-1 and scope-2 health impacts in this paper, which we collectively refer to as "operational" impacts. A detailed assessment of the health impacts associated with a specific U.S. semiconductor manufacturing facility is provided in Appendix A.3.

3 Public Health Impact of U.S. Data Centers

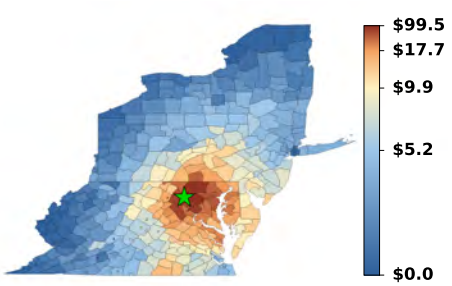
We present our public health impact analysis for U.S. data centers, beginning with the scope-1 impacts of Virginia data centers, followed by the scope-1 and scope-2 impacts of U.S. data centers in 2023 and projections for 2028. We focus on 2023 and 2028, because COBRA provides county-level population, health incidence, valuation, and baseline emissions data for both years [17] and they are also used as the reference years in the recent U.S. data center energy report [1].

Importantly, the 2023 and 2028 baseline emissions used by COBRA are based on the U.S. EPA's Emissions Modeling Platform 2016v1 and account for federal and state regulations as of May 2018 [17]. However, regulatory and emissions changes since then may introduce substantial uncertainty into the underlying emission projections, warranting future re-analysis where applicable. Accordingly, our COBRA-based estimates should not be interpreted as assigning responsibility for any specific individual health outcome, establishing site-specific impacts, or implying that data centers are a dominant contributor to national air-pollution-related health burdens. Rather, they represent a modeled, first-order approximation of how data center-related emissions may contribute to population-level public health impacts, with the goal of informing potential mitigation strategies.

3.1 Scope-1 Health Impact of Virginia Data Centers

The high emission rate from onsite backup generators, mostly powered by diesel fuel, could pose health risks, especially in regions with a concentration of large data centers. To illustrate this point, we consider the data centers' onsite generators in Virginia. Assuming that the actual emissions are 10% of the permitted level (as of December, 2024) as a reference case, our estimates show that the backup generators could contribute to approximately 14,000 asthma symptom cases and 13–19 deaths each year, among other health outcomes, resulting in an annual public health impact of $220–300 million throughout the U.S. In the hypothetical worst-case scenario where data centers' onsite generators in Virginia emit air pollutants at their full annual permitted levels (e.g., during a prolonged regional grid outage), the estimated annual public health cost would be $2.2–3.0 billion.

We show the county-level per-household health cost and the top 10 counties in Figure 2. The results suggest that elevated health impacts can occur not only in host communities, but also in downwind communities, including those far from the data centers, due to long-range pollutant transport. The choropleth map of county-level total health costs is provided in Appendix A.2.

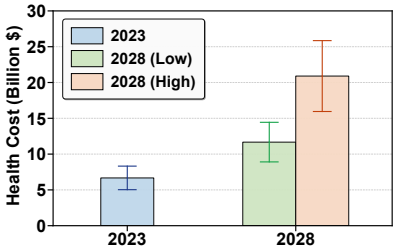


(*a*) *Per-household health cost*

State	County	Per-Household Health Cost ($)
VA	Fairfax City	**99.5** (85.8, 113.1)
VA	Falls Church	**58.3** (46.6, 69.9)
MD	Montgomery	**46.9** (40.9, 53.0)
MD	Frederick	**44.1** (37.6, 50.6)
MD	Carroll	**41.0** (35.0, 46.9)
VA	Manassas City	**37.2** (32.1, 42.3)
VA	Fairfax	**36.4** (31.9, 40.9)
VA	Manassas Park	**35.4** (29.9, 40.8)
VA	Fauquier	**29.8** (25.3, 34.4)
VA	Loudoun	**29.6** (25.9, 33.4)

(*b*) *Top-10 counties*

Figure 2: *County-level scope-1 per-household health costs from data center backup generators in Virginia under the reference case, assuming emissions equal 10% of total permitted emissions as of December 2024.* (*a*) *Choropleth map. Loudoun County, Virginia, which has the largest concentration of data centers, is marked in a green star. The legend shows percentile anchors at the 0th, 50th, 75th, 90th, and 100th percentiles, with colors interpolated between anchors.* (*b*) *Top-10 counties by per-household health cost.*



(*a*) *Total health cost*



(*b*) *Per-household health cost*

State	County	Per-Household Health Cost ($)
WV	Marion	**332.8** (266.6, 399.0)
WV	Mason	**322.6** (254.2, 391.1)
OH	Meigs	**317.5** (237.6, 397.4)
OH	Gallia	**312.9** (234.0, 391.8)
WV	Marshall	**307.2** (236.5, 377.8)
WV	Taylor	**289.8** (234.4, 345.3)
PA	Fayette	**279.4** (220.5, 338.3)
PA	Greene	**267.4** (218.4, 316.4)
WV	Brooke	**258.6** (195.7, 321.6)
WV	Jackson	**245.5** (198.2, 292.7)

(*c*) *Top-10 counties*

Figure 3: *Scope-1 and scope-2 public health costs of U.S. data centers.* (*a*) *Total health costs in 2023 and 2028. "High" and "Low" denote the high- and low-growth scenarios in* [1]*, respectively.* (*b*) *County-level per-household health cost distribution in 2023. The legend shows percentile anchors at the 0th, 50th, 75th, 90th, and 100th percentiles, with colors interpolated between anchors.* (*c*) *Top-10 counties by per-household health cost in 2023.*

3.2 Health Impact of U.S. Data Centers in 2023

We present the total health costs of U.S. data centers in Fig. 3a, with details reported Table 1. In our reference case of scope-1 emissions set at 10% of permitted levels, scope-2 health costs dominate scope-1 costs. This suggests that, although alternative fuels for on-site diesel generators can help mitigate direct health impacts near data centers, greater health benefits may come from powering data centers with less polluting electricity. However, if scope-1 emissions increase and approach permitted levels (e.g., due to extended wide-area grid outages), scope-1 health impacts could become substantially larger, especially for data center host communities.

3.2.1 Uneven Distribution of Data Centers' Public Health Impacts

The public health impacts of data centers depend largely on the locations of both the data centers and the power plants supplying them. As shown in Fig. 3b, health impacts of data centers vary significantly across counties. The highest county-level per-household health cost is about seven times the national average and approximately 200 times the lowest county-level value. This substantial disparity highlights the need to carefully examine local and regional health impacts to support more responsible computing and data center siting.

Importantly, the uneven distribution of per-household health impacts from data centers is strongly correlated with that of the power grid, with a correlation coefficient of 0.901. For example, several counties in West Virginia are among the most affected, reflecting in part the role of coal-fired power plants in West Virginia in supplying electricity to data centers in neighboring Virginia. This highlights the need to address

Table 1: *The public health cost of U.S. data centers in 2023 and projection for 2028. FC: Fuel Combustion*

Year	Electricity (TWh)	Electricity Cost (billion $)	Scope	Mortality	Health Cost (billion $)	Per-Household Health Cost ($)	% of FC Health Cost
2023	176.39	15.11	Scope-1	**32** (26, 37)	**0.51** (0.43, 0.59)	**3.65** (3.08, 4.21)	0.10%
			Scope-2	**401** (294, 508)	**6.16** (4.59, 7.73)	**43.83** (32.69, 54.97)	1.21%
			Total	**433** (320, 546)	**6.67** (5.03, 8.32)	**47.48** (35.77, 59.19)	1.31%
2028 (**Low**)	325.00	27.84	Scope-1	**54** (46, 63)	**0.90** (0.77, 1.03)	**6.11** (5.22, 7.00)	0.15%
			Scope-2	**650** (483, 818)	**10.78** (8.14, 13.41)	**73.29** (55.37, 91.21)	1.82%
			Total	**705** (529, 880)	**11.67** (8.91, 14.44)	**79.40** (60.59, 98.21)	1.97%
2028 (**High**)	580.00	49.68	Scope-1	**97** (82, 112)	**1.61** (1.37, 1.84)	**10.94** (9.35, 12.53)	0.27%
			Scope-2	**1165** (865, 1464)	**19.29** (14.58, 24.01)	**131.23** (99.14, 163.31)	3.26%
			Total	**1262** (947, 1576)	**20.90** (15.95, 25.85)	**142.16** (108.49, 175.84)	3.53%

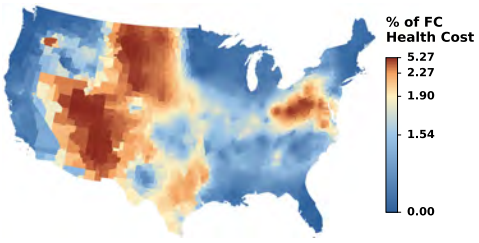
data center health disparities holistically, through both less-polluting power supply and careful data center siting.

The county-level total public health impacts of data centers are shown in Appendix B.1. These results suggest that local population density and proximity to emissions sources, including power generation infrastructure, may partly explain why estimated public health impacts are higher in some counties than in others.

3.2.2 Relative to Fuel Combustion Health Impacts

Stationary-source fuel combustion, including fossil-fuel electricity generation, industrial and commercial fuel use, and residential wood combustion, is an important source of anthropogenic air pollutants [17]. Mobile sources, such as vehicles, are classified separately in COBRA. Because both scope-1 and scope-2 health impacts of data centers arise from stationary-source fuel combustion, we show the *relative* health impact of data centers by considering U.S. fuel combustion as the reference, modeled by COBRA as three broad fuel combustion sectors: electric, industrial, and other [17]. Setting emissions from these fuel-combustion sectors to zero in COBRA yields an estimated U.S. fuel-combustion health impact of $507.79 ($369.45, $646.12) billion in 2023.

The ratio of U.S. data center to fuel combustion health costs is approximately 1.31% in 2023, suggesting a relatively low national burden. As shown in Fig. 3b, however, the regional concentration of data center health costs underscores the need for closer attention to local impacts.



(*a*) *Relative health cost*

State	County	% of FC Health Cost
UT	Millard	**5.27**
UT	Juab	**4.91**
UT	Emery	**4.52**
UT	Sanpete	**4.47**
UT	Sevier	**4.36**
MT	Rosebud	**4.33**
UT	Carbon	**4.24**
AZ	Apache	**4.22**
MT	Custer	**4.15**
MT	Garfield	**3.96**

(*b*) *Top-10 counties*

Figure 4: *County-level U.S. data center health cost relative to fuel combustion health cost in 2023. The legend shows percentile anchors at the 0th, 50th, 75th, 90th, and 100th percentiles, with colors interpolated between anchors. Per-household data center and fuel combustion health cost correlation coefficient: 0.842. "FC" denotes fuel combustion.*

We analyze the county-level ratio of data center health costs to fuel combustion health costs in Fig. 4. The results further indicate a disproportionate distribution of data centers' relative health burden. Moreover, county-level per-household health impacts from data centers are strongly correlated with the fuel combustion health burden, with a correlation coefficient of 0.842. This suggests that data center-related emissions may add to existing public health burdens in some counties already experiencing higher fuel-combustion-related impacts.

While COBRA only provides county-level results, finer-grained analyses, such as at the Census Block level, are an important future direction and can identify opportunities to better target resources toward mitigating the public health impacts of data centers.

3.3 Projection for 2028

As shown in Table 1, the growing demand for data centers is projected to increase their public health impacts, reaching $11.7 billion and $20.9 billion in 2028 under the low- and high-growth scenarios, respectively. These estimates represent 75% and 213% increases relative to the 2023 level, respectively, while U.S. fuel-combustion-related health costs are projected to increase by 17% over the same period.

Under the high-growth scenario, the estimated health outcomes associated with U.S. data center emissions in 2028 include approximately 600,000 asthma symptom cases and 1,300 premature deaths, along with other morbidity outcomes. While this impact remains relatively small compared with the overall national public health burden and the broad stationary fuel-combustion sectors, the projected growth, localized concentration, and uneven geographic distribution of the health costs warrant closer attention.

4 Health-Informed Computing: Addressing Data Centers' Public Health Impact

In this section, we present Health-Informed Computing, a framework that explicitly incorporates public health impacts as a key optimization objective and strategically manages data center workloads to reduce adverse health outcomes while supporting broader sustainability goals.

4.1 Spatiotemporal Heterogeneity of Health Prices

The grid fuel mix varies substantially across space and time [37, 38], depending on generation schedules, transmission constraints, electricity demand, and other factors. Because power plants and fuels differ in their air pollutant emission rates, variation in the grid fuel mix creates spatiotemporal heterogeneity in the externalized scope-2 public health impact of electricity use, which we refer to as the *health price*, measured in dollars per unit of electricity consumed.

Although criteria air pollutants can share common sources with carbon emissions, health price may not be well captured by carbon intensity alone. Carbon emissions have approximately the same climate impact regardless of where they are emitted. By contrast, the same amount of criteria air pollutants can lead to very different health impacts depending on the emitting source, atmospheric conditions, downwind transport, baseline air quality, and the size of exposed populations.

As a result, low-carbon electricity does not necessarily imply a low public health burden, and vice versa. For example, two regions with similar carbon intensities may have different health costs if their generators are located near populations with different exposure risks or if local weather conditions affect pollutant dispersion differently. Conversely, regions with different carbon intensities may produce similar health impacts if their air pollutant emissions, atmospheric conditions and exposed populations are comparable.

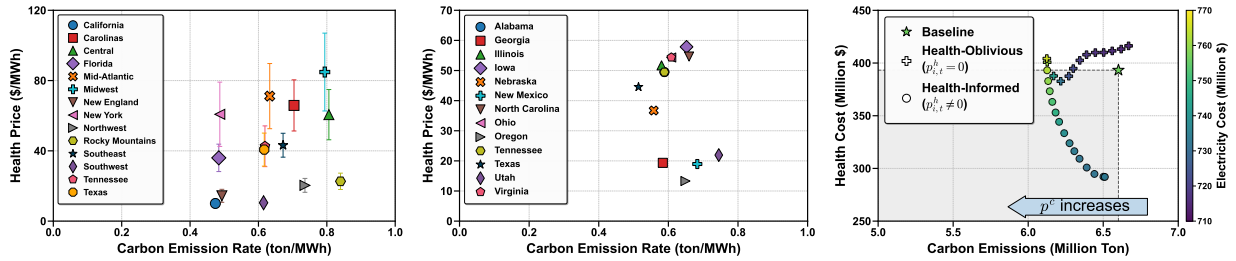
To further illustrate this point, we analyze the marginal health price and marginal carbon emission rate from the U.S. EPA's AVERT model across the 14 grid regions in 2023 [19,35]. We use the U.S. EPA's "uniform EE" scenario for health price [19], which estimates the marginal health impact of a constant load. As shown in Fig. 5a, health price exhibits greater spatial and temporal variability than carbon intensity, with a weak-to-moderate spatial correlation between the two signals (correlation coefficient 0.338). We also analyze 5-minute marginal health price and carbon intensity signals across the U.S. from October 1, 2023, to September 30, 2024, using data from WattTime [37]. The details are provided in Appendix C.1. The results show similar patterns, reaffirming that health prices can differ significantly from carbon intensities.

Our analysis suggests that carbon-aware computing alone may miss important opportunities to mitigate public health impacts, motivating the development of health-informed computing.

4.2 Health-Informed Computing

Computing workloads in data centers often have substantial scheduling flexibility [38]. For example, as supported by EPRI's recent initiative on maximizing data center load flexibility [5], AI training can be shifted across data centers or paused temporarily. When combined with the spatiotemporal heterogeneity of scope-2 health prices, this flexibility creates opportunities to reduce public health impacts by shifting computation toward data centers and/or hours with lower health costs.

To date, data center scheduling flexibility has been used primarily to reduce electricity costs, carbon emissions [38], water consumption [39], environmental inequity [40], and emergency demand response [41].



(*a*) (*b*) (*c*)

Figure 5: *Marginal health impact vs. marginal carbon emission based on the 2023 data. (a) U.S. EPA signals for 14 U.S. independent electricity regions [19, 35]. The error bar indicates the high and low health prices. Carbon and (mid) health correlation coefficient: 0.338. (b) WattTime signals for a large technology company's U.S. data center locations [27,37]. Carbon and health correlation coefficient: -0.351. (c) Results for different GLB settings (p^c varying from 0 to ∞) using a large technology company's 2023 energy usage across its U.S. data center locations, assuming that each data center can consume up to 1.5 times its baseline energy use.*

Table 2: *`HICO` under different settings ($\lambda = 1.5$), with percent changes in parentheses reported relative to the baseline. Three special cases: Electricity Cost Optimal (`E-OPT`, with $p^c = 0$ and $p^h_{i,t} = 0$), Carbon Emission Optimal (`C-OPT`, with $p^e_{i,t} = 0$ and $p^h_{i,t} = 0$), and Health Impact Optimal (`H-OPT`, with $p^e_{i,t} = 0$ and $p^c = 0$).*

Metric	Baseline	E-OPT	C-OPT	H-OPT	Health-Oblivious ($p^h_{i,t}=0$)		Health-Informed ($p^h_{i,t}\neq 0$)		
					p^c =\$50/ton	p^c =\$200/ton	p^c =\$0/ton	p^c =\$50/ton	p^c =\$200/ton
Health (Million \$)	393.23	416.29 (+5.86%)	404.26 (+2.80%)	**289.67 (-26.34%)**	400.81 (+1.93%)	383.32 (-2.52%)	291.94 (-25.76%)	294.21 (-25.18%)	305.99 (-22.18%)
Energy (Million \$)	756.50	**714.99 (-5.49%)**	765.68 (+1.21%)	741.49 (-1.98%)	720.49 (-4.76%)	734.77 (-2.87%)	733.66 (-3.02%)	732.69 (-3.15%)	732.11 (-3.22%)
Carbon (Million Ton)	6.60	6.67 (+1.02%)	**6.12 (-7.23%)**	6.54 (-0.89%)	6.33 (-4.07%)	6.20 (-6.01%)	6.51 (-1.38%)	6.45 (-2.31%)	6.36 (-3.67%)

We propose *Health-Informed Computing* (`HICO`), which builds on existing scheduling systems and incorporates public health impact as an additional metric to prioritize data centers with lower health impacts.

We use geographical load balancing (GLB) as a concrete example. A canonical objective in GLB is carbon-aware computing, which dynamically dispatches workloads to data centers with lower carbon intensities [42]. To further incorporate public health impacts, the GLB objective for each time slot t can be written as:

$$\min_{\mathbf{w}_t \in \mathcal{W}_t} \sum_{i=1}^{N} \left(p^e_{i,t} + p^h_{i,t} + p^c r^c_{i,t}\right) \cdot w_{i,t}, \tag{1}$$

where N is the number of data centers, $p^e_{i,t}$, $p^h_{i,t}$, and $r^c_{i,t}$ denote, respectively, the electricity price, health cost, and carbon emissions per kWh at data center i and time t, p^c denotes the carbon price, $\mathbf{w}_t = (w_{1,t}, \cdots, w_{N,t})$ denotes the energy use induced by the dispatched workloads, and $\mathcal{W}_t$ denotes the feasible set at time t, capturing operational constraints such as latency constraints and workload-specific requirements [43]. Carbon prices commonly fall in the range of \$10 to \$200 per ton, depending on the market and compliance requirements [44].

By adding the health price $p^h_{i,t}$, the GLB algorithm optimizes a more holistic objective that accounts for electricity costs, carbon emissions, and public health impacts. All else being equal, this objective prioritizes data centers with lower health impacts. Importantly, the objective in (1) recovers existing carbon-aware GLB when the health price $p^h_{i,t} = 0$.

At each time slot, the scheduler considers electricity price, carbon cost, and public health price across data centers, subject to practical constraints such as capacity, latency, workload-specific requirements, and data availability. Flexible workloads can then be shifted toward locations and times with a lower combined cost as formulated in (1).

Beyond GLB, `HICO` can help data centers reduce externalized public health costs and better align operational decisions with corporate responsibility and community-impact goals. It also provides a practical mechanism for incorporating public health considerations into data center siting and energy procurement decisions. At the same time, broader deployment of `HICO` requires more accurate, timely, and standardized public health impact data, which remains an important direction for future research.

4.3 Empirical Evaluation

To illustrate the empirical impact of HICO, we evaluate GLB under a standard formulation with workload-conservation and per-site capacity constraints. The evaluation is based on a technology company's U.S. data center locations and uses its published 2023 per-site energy consumption as the baseline workload assignment [27]. Because the U.S. EPA provides health prices only on an annualized basis, we obtain 5-minute health prices and carbon emission rates from WattTime [37]. Note that WattTime also uses a simplified S-R matrix for air dispersion modeling, but unlike COBRA which models a variety of health outcomes, it considers only mortality in its health price estimate. Importantly, because health prices involve uncertainties from air-dispersion modeling and health-outcome estimation, our results should be interpreted as illustrative rather than as an actual health impact assessment of the technology company's public health impacts.

We vary the carbon price parameter $p^c \in [0, \infty]$ to characterize how different scheduling objectives trade off electricity cost, carbon emissions, and public health impacts. The resulting curve is shown in Fig. 5c, with detailed results for representative settings reported in Table 2.

Specifically, Fig. 5c shows that, compared with the health-oblivious case (i.e., $p^h_{i,t} = 0$), HICO can substantially reduce public health impacts while keeping carbon emissions and electricity costs within a moderate range. This highlights that explicitly accounting for health impacts in GLB can uncover scheduling opportunities that are not captured by existing carbon-aware computing alone. Compared with the baseline, HICO reduces the estimated health cost from about \$390 million to below \$300 million, while maintaining a similar level of carbon emissions. Notably, as the carbon price p^c increases, HICO traces a clear tradeoff curve: prioritizing carbon reductions lowers emissions but may increase health and electricity costs.

The results can be further explained by the relationship between health prices and carbon emission rates across the technology company's 13 U.S. data center locations used in our evaluation, as shown in Fig. 5b. The correlation coefficient is approximately -0.351, indicating a weak-to-modest negative association between the two metrics in this setting. Thus, locations with lower carbon emissions do not necessarily have lower public health impacts. Moreover, consistent with the U.S. EPA's nationwide analysis in Fig. 5a, health prices exhibit greater spatial variability than carbon emission rates across the data center locations. This helps explain why HICO can substantially reduce public health impacts while only modestly affecting carbon emissions.

5 Additional Recommendations

We provide the following additional recommendations to complement HICO.

Recommendation 1: Extended Energy Reporting. Despite their immediate public health impacts, criteria air pollutants and their downstream health effects are rarely included in technology companies' sustainability reports. Importantly, these impacts do not necessarily require a separate reporting framework: much of the needed information, including data center location, electricity use, and on-site fuel use, already overlaps with energy reporting. We therefore recommend extending existing energy reporting practices to include criteria air pollutants and associated public health impacts across regions.

Recommendation 2: Attention to All. While data centers' scope-1 health impacts on host communities are increasingly recognized, scope-2 impacts on other affected communities have received less attention. This gap may make it harder to identify and address communities affected by scope-2 emissions. To support more comprehensive sustainability assessment, we recommend that technology companies evaluate the cross-state public health burdens of their operations when deciding where to build data centers and how to source electricity.

Recommendation 3: Improving Data Accuracy for Health Impact Assessment. To estimate data centers' public health impacts with greater accuracy and better inform potential mitigation strategies, we recommend further interdisciplinary research that integrates air-quality dispersion modeling, health economics, epidemiology, and health-informed computing. Such research can better capture cross-state and downwind impacts, improve estimates of population-level morbidity and mortality, and translate these estimates into actionable strategies for siting, energy procurement, workload scheduling, and backup-generation management.

6 Conclusion

In this paper, we model U.S. data centers' air pollutant emissions and estimate their associated public health impacts using COBRA. Our findings suggest that the total annual public health burden of U.S. data centers could exceed $20 billion in 2028 under the high-growth scenario. Importantly, these health costs are not evenly distributed, with certain communities bearing a disproportionate share.

We also propose `HICO`, a novel framework that explicitly incorporates public health impact as a key metric when siting data centers and/or scheduling computing workloads. More broadly, we recommend extended energy reporting to account for the public health impacts of data centers and paying attention to all impacted communities, thereby supporting responsible and sustainable development of future computing infrastructures.

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References

[1] Arman Shehabi, Sarah J. Smith, Alex Hubbard, Alex Newkirk, Nuoa Lei, Md Abu Bakar Siddik, Billie Holecek, Jonathan Koomey, Eric Masanet, and Dale Sartor. 2024 United States data center energy usage report. *Lawrence Berkeley National Laboratory LBNL-2001637*, December 2024.

[2] U.S. Department of Energy. Recommendations on powering artificial intelligence and data center infrastructure, Jul. 2024.

[3] Carole-Jean Wu, Ramya Raghavendra, Udit Gupta, Bilge Acun, Newsha Ardalani, Kiwan Maeng, Gloria Chang, Fiona Aga, Jinshi Huang, Charles Bai, et al. Sustainable AI: Environmental implications, challenges and opportunities. In *Proceedings of Machine Learning and Systems*, volume 4, pages 795–813, 2022.

[4] Pengfei Li, Jianyi Yang, Mohammad A. Islam, and Shaolei Ren. Making AI less "thirsty": Uncovering and addressing the secret water footprint of AI models. *Commun. ACM*, 68(7):54–61, June 2025.

[5] EPRI. DCFlex initiative. `https://msites.epri.com/dcflex`, 2024.

[6] U.S. EPA. Estimating PM2.5- and ozone-attributable health benefits: 2024 update, June 2024. Technical Support Document.

[7] U.S. EPA. User's manual for the co-benefits risk assessment (COBRA) screening model. `https://www.epa.gov/cobra/users-manual-co-benefits-risk-assessment-cobra-screening-model`.

[8] World Health Organization. Ambient (outdoor) air pollution. `https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health`, 2024.

[9] Institute for Health Metrics and Evaluation (IHME). Global burden of disease 2021: Findings from the GBD 2021 study. `https://www.healthdata.org/research-analysis/library/global-burden-disease-2021-findings-gbd-2021-study`, May 2024.

[10] American Lung Association. State of the air. *Report*, 2024.

[11] World Health Organization. Ambient air pollution attributable deaths. `https://www.who.int/data/gho/data/indicators/indicator-details/GHO/ambient-air-pollution-attributable-deaths`, 2024.

[12] U.S. EPA. Human health and environmental impacts of the electric power sector. `https://www.epa.gov/power-sector/human-health-environmental-impacts-electric-power-sector`.

[13] Lucas Henneman, Christine Choirat, Irene Dedoussi, Francesca Dominici, Jessica Roberts, and Corwin Zigler. Mortality risk from united states coal electricity generation. *Science*, 382(6673):941–946, 2023.

[14] U.S. Energy Information Administration. Annual energy outlook 2026. https://www.eia.gov/outlooks/aeo.

[15] Hannah Ritchie and Pablo Rosado. Electricity mix. *Our World in Data*, 2024.

[16] Virginia Electric and Power Company. Integrated resource plan. https://www.dominionenergy.com/-/media/pdfs/global/company/IRP/2024-IRP-w_o-Appendices.pdf, October 2024.

[17] U.S. EPA. Co-benefits risk assessment health impacts screening and mapping tool (COBRA). https://cobra.epa.gov/.

[18] Jean Schmitt, Marianne Hatzopoulou, Amir FN Abdul-Manan, Heather L MacLean, and I Daniel Posen. Health benefits of US light-duty vehicle electrification: Roles of fleet dynamics, clean electricity, and policy timing. *Proceedings of the National Academy of Sciences*, 121(43):e2320858121, 2024.

[19] U.S. EPA. Estimating the health benefits per kilowatt-hour of energy efficiency and renewable energy. https://www.epa.gov/statelocalenergy/estimating-health-benefits-kilowatt-hour-energy-efficiency-and-renewable-energy, 2024.

[20] Greenhouse Gas Protocol. Standards and guidance. https://ghgprotocol.org/.

[21] U.S. EPA. National ambient air quality standards (NAAQS) table. https://www.epa.gov/criteria-air-pollutants/naaqs-table.

[22] California Air Resources Board. Laws and regulations. https://ww2.arb.ca.gov/resources/documents/laws-and-regulations.

[23] World Health Organization. WHO global air quality guidelines. https://www.who.int/publications/i/item/9789240034228.

[24] John P. Stevens and Supreme Court of The United States. U.S. reports: Massachusetts v. EPA, 549 U.S. 497. *The Library of Congress*, 2007.

[25] U.S. EPA. Publications that cite COBRA. https://www.epa.gov/cobra/publications-cite-cobra.

[26] Google. Environmental report. https://sustainability.google/reports/google-2024-environmental-report/, 2024.

[27] Meta. Sustainability report. https://sustainability.atmeta.com/2024-sustainability-report/, 2024.

[28] Virginia Department of Environmental Quality. Issued air permits for data centers. https://www.deq.virginia.gov/permits/air/issued-air-permits-for-data-centers.

[29] U.S. EPA. Controlling air pollution from stationary engines. https://www.epa.gov/stationary-engines.

[30] U.S. EPA. Regulations for Emissions from Heavy Equipment with Compression-Ignition (Diesel) Engines. https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-heavy-equipment-compression.

[31] Virginia Joint Legislative Audit and Review Commission. Report to the Governor and the General Assembly of Virginia: Data centers in Virginia (JLARC report 158), December 2024.

[32] Washington Department of Ecology. Health risks from diesel emissions in the Quincy area. *Air Quality Program Report* (*Publication 20-02-019*), August 2020.

[33] U.S. EPA. Use of backup generators to maintain the reliability of the electric grid. https://www.epa.gov/system/files/documents/2025-05/rice-memo-on-duke-energy-regulatory-interpretation-04_17_25.pdf, May 2025.

[34] EPRI. Powering intelligence: Analyzing artificial intelligence and data center energy consumption. *White Paper on Technology Innovation Report*, 2024. https://www.epri.com/research/products/3002028905.

[35] U.S. EPA. Avoided emissions and generation tool (AVERT). https://www.epa.gov/avert.

[36] Virginia Department of Environmental Quality. Stationary Source Assessment (SSA) Response to Health Impact Claims Related to the Vantage Data Centers VA2 Facility. Report, April 2026. Accessed: 2026-05-07.

[37] WattTime. https://watttime.org/.

[38] Ana Radovanović, Ross Koningstein, Ian Schneider, Bokan Chen, Alexandre Duarte, Binz Roy, Diyue Xiao, Maya Haridasan, Patrick Hung, Nick Care, Saurav Talukdar, Eric Mullen, Kendal Smith, MariEllen Cottman, and Walfredo Cirne. Carbon-aware computing for datacenters. *IEEE Transactions on Power Systems*, 38(2):1270–1280, 2023.

[39] Yanran Wu, Inez Hua, and Yi Ding. Not all water consumption is equal: A water stress weighted metric for sustainable computing. *SIGENERGY Energy Inform. Rev.*, 5(2):84–90, August 2025.

[40] Pengfei Li, Jianyi Yang, Adam Wierman, and Shaolei Ren. Towards environmentally equitable AI via geographical load balancing. In *e-Energy*, 2024.

[41] Niangjun Chen, Xiaoqi Ren, Shaolei Ren, and Adam Wierman. Greening multi-tenant data center demand response. In *IFIP Performance*, 2015.

[42] Praneet Arshi and Joel Miller. Our approach to carbon-aware data centers: Central data center fleet management. https://cloud.google.com/blog/topics/sustainability/googles-approach-to-carbon-aware-data-center, 2025.

[43] Peter Xiang Gao, Andrew R. Curtis, Bernard Wong, and Srinivasan Keshav. It's not easy being green. *SIGCOMM Comput. Commun. Rev.*, 2012.

[44] Nicholas Z. Muller. Measuring the impact of data centers in the United States economy: Monetary damage from air pollution and greenhouse gas emissions. NBER Working Paper 35100, National Bureau of Economic Research, April 2026.

[45] Gianluca Guidi, Francesca Dominici, Nat Steinsultz, Gabriel Dance, Lucas Henneman, Henry Richardson, Edgar Castro, Falco J Bargagli-Stoffi, and Scott Delaney. The environmental burden of the United States' bitcoin mining boom. https://pubmed.ncbi.nlm.nih.gov/39502776/, 2024.

[46] Christopher W. Tessum, Jason D. Hill, and Julian D. Marshall. InMAP: A model for air pollution interventions. *PloS ONE*, 12(4):e0176131, 2017.

[47] Eleanor M. Hennessy, Jacques A. de Chalendar, Sally M. Benson, and Inês ML Azevedo. Distributional health impacts of electricity imports in the United States. *Environmental Research Letters*, 17(6):064011, 2022.

[48] U.S. EIA. Electric power plants, capacity, generation, fuel consumption, sales, prices and customers. https://www.eia.gov/electricity/data.php, 2023.

[49] U.S. Energy Information Administration. Annual energy outlook 2023. https://www.eia.gov/outlooks/aeo.

[50] U.S. National Park Service. Where does air pollution come from? https://www.nps.gov/subjects/air/sources.htm.

[51] U.S. EPA. Clean Air Act vehicle and engine enforcement case resolutions. https://www.epa.gov/enforcement/clean-air-act-vehicle-and-engine-enforcement-case-resolutions.

[52] Piedmont Environmental Council. Data centers, diesel generators and air quality – PEC web map. https://www.pecva.org/uncategorized/data-centers-diesel-generators-and-air-quality-pec-web-map/.

[53] U.S. EPA. Semiconductor industry. https://www.epa.gov/eps-partnership/semiconductor-industry.

[54] Intel. Ocotillo campus. https://www.exploreintel.com/ocotillo, 2024.

[55] Intel. 2024 H1 semi-annual monitoring report (Intel Ocotillo facility). https://www.exploreintel.com/ocotillo, 2024.

[56] Intel. 2023-24 corporate responsibility report, 2024.

[57] Meta Llama. Model information. https://github.com/meta-llama/llama-models/blob/main/models/llama3_1/MODEL_CARD.md.

[58] U.S. Department of Transportation. Estimated U.S. average vehicle emissions rates per vehicle by vehicle type using gasoline and diesel. *National Transportation Statistics Table 4-43*, June 2024.

[59] California DMV. Vehicles registered by county. https://www.dmv.ca.gov/portal/dmv-research-reports/research-development-data-dashboards/vehicles-registered-by-county/.

[60] U.S. EPA. Final rule: Multi-pollutant emissions standards for model years 2027 and later light-duty and medium-duty vehicles. https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-multi-pollutant-emissions-standards-model, April 2024.

[61] Asfandyar Qureshi, Rick Weber, Hari Balakrishnan, John Guttag, and Bruce Maggs. Cutting the electric bill for internet-scale systems. In *Proceedings of the ACM SIGCOMM 2009 Conference on Data Communication*, SIGCOMM '09, page 123–134, New York, NY, USA, 2009. Association for Computing Machinery.

[62] Mohammad A. Islam, Kishwar Ahmed, Hong Xu, Nguyen H. Tran, Gang Quan, and Shaolei Ren. Exploiting spatio-temporal diversity for water saving in geo-distributed data centers. *IEEE Transactions on Cloud Computing*, 6(3):734–746, 2018.

[63] WattTime. Signal: Health damage. https://watttime.org/data-science/data-signals/health-damage/.

[64] Joe Gorka, Noah Rhodes, and Line Roald. ElectricityEmissions.jl: A framework for the comparison of carbon intensity signals. *arXiv 2411.06560*, 2024.

[65] Meta. Introducing Llama 3.1: Our most capable models to date. https://ai.meta.com/blog/meta-llama-3-1/.

Appendix

A Modeling Details

We describe the evaluation methodology used for our empirical analysis. We use the COBRA Desktop v5.1 provided by the U.S. EPA [17] to study the public health impact of U.S. data centers in both 2023 and 2028. While COBRA uses a reduced-complexity air quality dispersion model based on a source-receptor matrix for rapid evaluation, its accuracy has been validated and the same or similar model has been commonly adopted in the literature for large-area air quality and health impact analysis [25,45–47]. We consider county-level air pollutant dispersion throughout the contiguous U.S., which is the area currently supported by COBRA [17]. Note that cities considered county-equivalents for census purposes are also referred to as "counties" in COBRA. Throughout the paper, we use "county" without further specification.

All the monetary values are presented in the 2023 U.S. dollars unless otherwise stated. We set the discount rate as 2% in COBRA as recommended by the EPA based on the U.S. Office of Management and Budget Circular No. A-4 guidance [17]. When presenting a single value or a ratio (e.g., health-to-electricity cost ratio) if applicable, we use the midrange of the low and high estimates provided by COBRA.

COBRA provides data for county-level population, health incidence, valuation, and baseline emissions for 2023 and 2028 [17]. Specifically, the baseline emissions used by COBRA are based on the U.S. EPA's Emissions Modeling Platform 2016v1 and account for federal and state regulations as of May 2018 [17]. Regulatory and emissions changes since then may affect the accuracy of the estimates. Therefore, the modeled health impacts should be interpreted as a first-order approximation, and future re-analysis using updated dispersion models, emissions data, population data, and health economics assumptions would help improve the assessment.

Electricity price. When estimating the electricity cost for data centers in 2023 and 2028, we use the state-level average price for industrial users in [48]. The projected U.S. nominal electricity price for industrial users remains nearly the same from 2023 to 2030 (24.96 $/MMBtu in 2023 vs. 23.04 $/MMBTu in 2030) in the baseline case per the EIA's Energy Outlook 2023 [49]. Thus, our estimated health-to-electricity cost ratio may be even higher if we further adjust inflation.

A.1 Public Health Impact of On-road Vehicles

Mobile sources, including vehicles, marine engines, and generators, collectively are a major contributor to air pollution in the U.S., with automobile (vehicles) being a primary contributor [50, 51]. In the COBRA model, on-road emissions are categorized under the "Highway Vehicles" sector and include both tailpipe exhaust and tire and brake wear. Based on the emission data projected by the U.S. EPA's COBRA modeling tool [17], we show in Fig. 6 that the electric power sector's total public health cost in the contiguous U.S. approaches the scale of on-road vehicle emissions by all the registered vehicles (including tailpipe exhausts and brakes) in 2028.

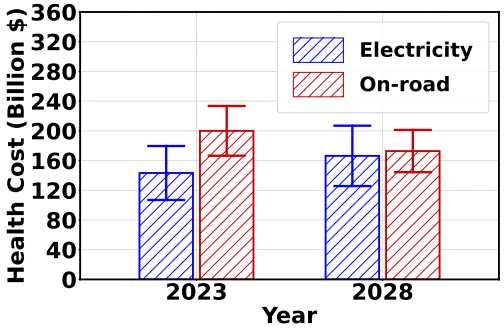


Figure 6: *Public health costs of electricity generation and on-road emissions in the contiguous U.S. in 2023 and 2028 [17]. The error bars represent high and low estimates returned by COBRA using two different exposure-response functions.*

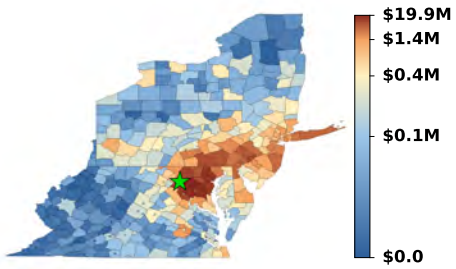
Addressing air-pollution-related health impacts requires coordinated efforts across sectors, and emissions from the electric power sector and on-road vehicles call for different mitigation strategies. Therefore, our comparison between the electric power sector impacts and on-road emissions is intended only to provide a sense of scale. It should not be interpreted as suggesting that one sector is more or less important than another, or that mitigation approaches are directly interchangeable across sectors.

A.2 Public Health Impact of Backup Generators in Virginia

We collect a dataset of the air quality permits: permits issued before January 1, 2023, from [52], and permits issued between January 1, 2023 and December 1, 2024, from [28]. The total permitted site-level annual emission limits are approximately 13,000 tons of NO_x, 1,400 tons of VOCs, 50 tons of SO_2, and 600 tons of

$PM_{2.5}$, all in U.S. short tons. Assuming actual emissions equal 10% of the permitted level as of December 2024 as a reference case, our estimates indicate that backup generators could contribute to approximately 14,000 asthma symptom cases and 13–19 premature deaths each year, among other health impacts. These impacts correspond to an estimated annual public health burden of $220–300 million across the U.S., including $190–260 million in Virginia, West Virginia, Maryland, Pennsylvania, New York, New Jersey, Delaware, and Washington, D.C., based on COBRA modeling under the "Fuel Combustion: Industrial" sector. If the data center diesel generators in Northern Virginia emit air pollutants at the maximum permitted levels during a prolonged regional grid outage, the emission of NO_x could exceed half of the annual total emissions by all sources in the region [31]. In this hypothetical upper-bound scenario, the estimated annual public health cost would be $2.2-3.0 billion.

We show the county-level health cost and the top 10 counties in Figure 7. The results suggest that elevated health impacts can occur not only in host communities, but also in downwind communities, including those far from the data centers, due to long-range pollutant transport. In addition, higher population density can amplify aggregate health costs, even when per-household impacts are relatively lower.



(*a*) *County-level health cost*

State	County	Health Cost (million $)
MD	Montgomery	**19.9** (17.3, 22.4)
VA	Fairfax	**18.9** (16.6, 21.2)
MD	Prince Georges	**8.9** (7.5, 10.4)
MD	Baltimore	**8.3** (7.0, 9.6)
DC	District of Columbia	**7.6** (6.2, 9.0)
MD	Anne Arundel	**6.3** (5.5, 7.2)
MD	Baltimore City	**6.0** (4.8, 7.1)
VA	Loudoun	**5.4** (4.7, 6.1)
VA	Prince William	**5.0** (4.4, 5.7)
MD	Frederick	**4.6** (3.9, 5.2)

(*b*) *Top-10 counties by health cost*

Figure 7: *County-level scope-1 health costs from data center backup generators in Virginia under the reference case, assuming emissions equal 10% of total permitted emissions as of December 2024. (a) Choropleth map. Loudoun County, Virginia, which has the largest concentration of data centers, is marked in a green star. The legend shows percentile anchors at the 0th, 50th, 75th, 90th, and 100th percentiles, with colors interpolated between anchors. (b) Top-10 counties by the total health cost.*

A.3 Public Health Impact of a Semiconductor Facility

Although semiconductor manufacturing facilities are subject to air quality regulations [53], their emissions can still contribute to regional air quality and public-health concerns, depending on location, emissions profile, and exposed populations.

We consider a semiconductor manufacturing facility located in Ocotillo, a neighborhood in Chandler, Arizona [54]. By averaging the rolling 12-month air pollutant emission levels listed in the recent air quality monitoring report (as of October, 2024) [55], we obtain the annual emissions as follows: 150.4 tons of NO_x, 82.7 tons of VOCs, 1.1 tons of SO_2, and 28.9 tons of $PM_{2.5}$. By applying these on-site emissions to COBRA under the "Other Industrial Processes" sector, we obtain a total public health cost of $14-21 million. Additionally, the total annual energy consumption by the facility is 2074.88 million kWh as of Q2, 2024 [54]. Assuming 84.2% of the energy comes from the electricity based on the company's global average [56], we obtain the facility's annual electricity consumption as 1746.63 million kWh. By using the average attribution method, we further obtain an estimated health cost of $12-17 million associated with the electricity consumption. Thus, the total health cost of the facility is $26-39 million. This example is illustrative and is not included in the national data-center public-health estimates reported in our main analysis.

By relocating the facility from Chandler, Arizona, to a planned site in Licking County, Ohio, and assuming the same emission level and electricity consumption in a hypothetical scenario, we can obtain the total health cost of $94-156 million, including $23-36 million attributed to direct on-site emissions and $70-120 million attributed to electricity consumption.

A.4 Energy Consumption for Training a Generative AI Model

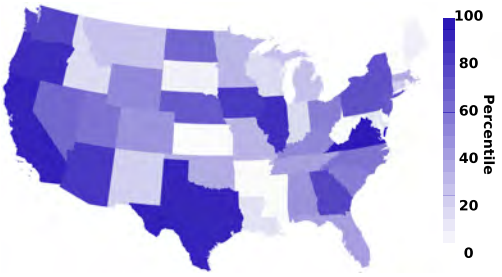
We consider Llama-3.1 as an example generative AI model. According to the model card [57], the training process of Llama-3.1 (including 8B, 70B, and 405B) utilizes a cumulative of 39.3 million GPU hours of computation on H100-80GB hardware, and each GPU has a thermal design power of 700 watts. Considering Meta's 2023 PUE of 1.08 [27] and excluding the non-GPU overhead for servers, we estimate the total training energy consumption as approximately 30 GWh. Our estimation method follows Meta's guideline [57]. It excludes non-GPU server overheads such as CPUs and memory, but actual training electricity use may differ depending on utilization, power management, infrastructure overhead, and accounting boundaries.

A.5 Average Emission for Each LA-NYC Round Trip by Car

We use the 2023 national average emission rate for light-duty vehicles (gasoline) provided by the U.S. Department of Transportation [58]. The emission rate accounts for tailpipe exhaust, tire wear and brake wear. Specifically, the average $PM_{2.5}$ emission rate is 0.008 grams/mile (including 0.004 grams/mile for exhaust, 0.003 grams/mile for brake wear, and 0.001 grams/mile for tire wear), and the average NO_x emission rate is 0.199 grams/mile for exhaust. We see that half of $PM_{2.5}$ for light-duty vehicles comes from brake and tire wear (0.004 gram/miles), which are also produced by other types of vehicles including electric vehicles. The distance for a round-trip between Los Angeles, California, and New York City, New York, is about 5,580 miles. Thus, the average auto emissions for each LA-NYC round trip are estimated as 44.64 grams of $PM_{2.5}$ and 1110.42 grams of NO_x.

A.6 State-wide Electricity Consumption by U.S. Data Centers in 2023

We show in Fig. 8 the state-wide data center electricity consumption in 2023 [34]. It can be seen that Virginia, Texas and California have the highest data center electricity consumption in 2023. The total national electricity consumption reported by EPRI is slightly lower than the values in [1], and we scale it up accordingly in our calculations to ensure consistency.



(***a***) *Electricity consumption map*

State	Electricity Consumption (TWh)	State	Electricity Consumption (TWh)	State	Electricity Consumption (TWh)
VA	33.85	OH	2.36	ID	0.15
TX	21.81	SC	2.02	WI	0.15
CA	9.33	WY	1.86	MD	0.10
IL	7.45	KY	1.62	LA	0.08
OR	6.41	CO	1.51	SD	0.07
AZ	6.25	AL	1.49	ME	0.03
IA	6.19	FL	1.38	NH	0.02
GA	6.18	TN	1.33	RI	0.02
WA	5.17	OK	1.23	KS	< 0.01
PA	4.59	MA	1.06	AR	< 0.01
NY	4.07	MO	0.97	DE	< 0.01
NJ	4.04	MN	0.82	DC	< 0.01
NE	3.96	MT	0.58	MS	< 0.01
ND	3.92	MI	0.53	VT	< 0.01
NV	3.42	NM	0.40	WV	< 0.01
NC	2.67	CT	0.26		
UT	2.56	IN	0.19		

(***b***) *Electricity consumption by state (descending order)*

Figure 8: *State-level electricity consumption of U.S. data centers in 2023 [34].*

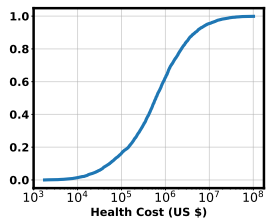
B Additional Results

B.1 County-level Public Health Costs of U.S. Data Centers in 2023

We show in Fig. 9 the county-level total public health cost of U.S. data centers in 2023, which exhibits significant spatial variability. In particular, populated counties located downwind of power plants supplying electricity to data centers tend to experience higher health costs, reflecting the transport of air pollutants across regions. The cumulative distribution function (CDF) in Fig. 9b highlights that while many counties incur relatively low health costs, a small fraction of counties bear substantially higher impacts. Table 9c further identifies the top-10 counties with the highest total health costs, illustrating how local population density and proximity to power generation infrastructure may combine to amplify public health risks in specific counties.



(*a*) *County-level health cost distribution*



(*b*) *CDF*

State	County	Health Cost (million $)
IL	Cook	**101.0** (69.5, 132.4)
PA	Allegheny	**88.7** (77.8, 109.6)
TX	Harris	**81.5** (56.0, 107.0)
PA	Philadelphia	**56.9** (40.2, 73.6)
OH	Hamilton	**53.8** (40.8, 66.8)
MI	Wayne	**53.5** (37.9, 69.1)
TX	Dallas	**50.6** (38.5, 62.6)
NY	Kings	**49.5** (31.0, 68.0)
OH	Cuyahoga	**48.0** (34.7, 61.3)
OH	Franklin	**47.2** (34.8, 59.7)

(*c*) *Top-10 counties*

Figure 9: *The county-level total health cost of U.S. data centers in 2023.* (*a*) *Health cost map using same percentil-anchored color scale;* (*b*) *CDF of county-level health cost;* (*c*) *Top-10 counties by total health cost.*

B.2 Relative to On-road Vehicles

Section 3.2.2 compares the estimated health impacts of data centers with those of stationary fuel-combustion sectors. Here, we provide a cross-sector comparison focused on on-road emissions (Appendix A.1). As before, this comparison is intended only to provide a sense of scale. It should not be interpreted as suggesting that a higher or lower estimated impact in one sector affects the importance of mitigating public health impacts in other sectors. In particular, we consider on-road emissions in California, which has about 35 million registered vehicles and exhibits the highest public health cost from on-road emissions among all U.S. states [17, 59].

In 2023, the estimated total public health cost of U.S. data centers is equivalent to 42% of that from California's on-road emissions. At the national level, the health costs of on-road emissions are estimated to generally decline from 2023 to 2028, reflecting, among other factors, increasingly stringent air-pollutant regulations for vehicles [60]. Based on the low- and high-growth data center demand scenarios considered in [1], the estimated total public health impact of U.S. data centers could reach $11.7 billion and $20.9 billion in 2028, respectively. Under the high-growth scenario, this estimated health burden could approach the scale of California's on-road emissions. This comparison is intended to illustrate that the estimated health externalities associated with U.S. data centers may grow relatively faster under the scenarios considered, rather than to suggest that the data centers and on-road vehicles are directly comparable or that their mitigation strategies are interchangeable.

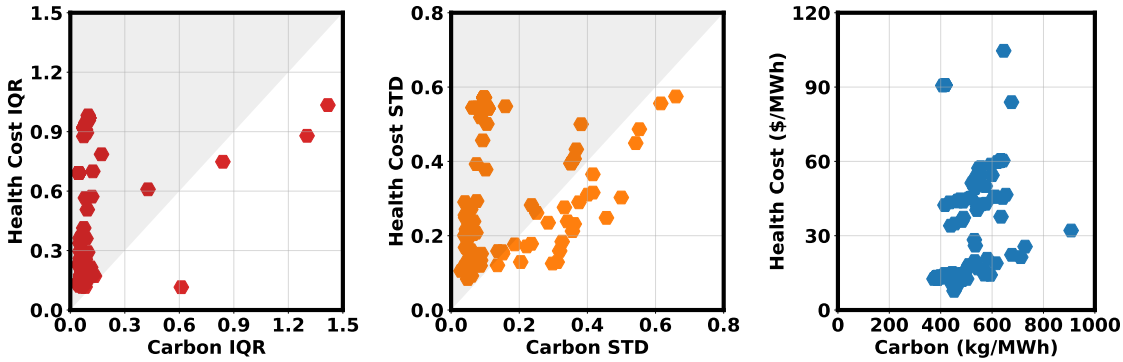
C Health-Informed Computing

Addressing air-pollution-related health impacts requires coordinated efforts across sectors, along with mitigation strategies tailored to each sector [17]. While air pollution health impacts from sectors such as transportation have been widely studied [18], the public health impacts of data centers have received comparatively less attention. Here, we present Health-Informed Computing, a framework that explicitly incorporates public health impacts as a key optimization objective and strategically manages data center workloads to minimize adverse health outcomes while supporting broader sustainability goals.

To mitigate the public health impact of data centers, one straightforward approach is to focus solely on reducing the energy consumption. While reducing energy consumption is beneficial, overlooking the downstream public health impact of *where* and *when* energy is produced does not necessarily lead to minimized health burdens. For example, Table 4 demonstrates a 10x difference in health costs for training the same AI model across different locations. This suggests that health-informed and energy-aware computing, when combined, can offer complementary benefits, leading to better public health outcomes.

C.1 Opportunities for Health-Informed Computing

Data centers, including those operated by major technology companies [26, 27], mostly rely on grid electricity due to the practical challenges of installing on-site low-pollutant and low-carbon energy sources at scale. However, the spatial-temporal variations of scope-2 health prices (Fig. 10) open up new opportunities to reduce the public health impact by exploiting the high scheduling flexibilities of computing workloads (e.g., AI training). For example, as further supported by EPRI's recent initiative on maximizing data cen-



(*a*) *Normalized IQR (110)* (*b*) *Normalized STD (90)* (*c*) *Average*

Figure 10: *Analysis of marginal scope-2 carbon emission rates and public health costs over 114 U.S. regions between October 1, 2023 and September 30, 2024* [37]. (*a*) *In 110 out of the 114 U.S. regions* (96%)*, the normalized IQR of marginal health cost is higher than that of marginal carbon intensity.* (*b*) *In 90 out of the 114 U.S. regions* (79%)*, the normalized standard deviation of marginal health cost is higher than that of marginal carbon intensity.* (*c*) *The Pearson correlation between the per-region yearly average marginal health cost and carbon intensity is 0.292.*

ter flexibility for demand response [5], AI training can be scheduled in more than one data center, while multiple AI models with different sizes are often available to serve AI inference requests, offering flexible resource-performance tradeoffs.

To date, the existing data centers have mostly exploited such scheduling flexibilities for reducing electricity costs [61], carbon emissions [38], water consumption [62], and/or environmental inequity [40]. Nonetheless, the public health impact can differ from these environmental costs or metrics.

Concretely, despite sharing some common sources (e.g., fossil fuels) with carbon emissions, the public health impact resulting from the dispersion of criteria air pollutants is highly dependent on the emission source location and only exhibits a weak correlation with carbon emissions. For example, the same quantity of carbon emissions generally results in the same climate change impacts regardless of the emission source; in contrast, criteria air pollutants have substantially greater public health impacts if emitted in densely populated regions compared to sparsely populated or unpopulated regions, emphasizing the importance of considering spatial variability.

To further confirm this point and highlight the potential of health-informed data center load shifting, we analyze the scope-2 marginal carbon intensity and public health cost for each unit of electricity generation across all the 114 U.S. regions between October 1, 2023, and September 30, 2024, provided by WattTime [37].[3] The time granularity for data collection is 5 minutes.

Here, we focus on marginal health impacts and carbon emissions for two main reasons: first, WattTime provides only real-time marginal health impact estimates [63]; and second, marginal signals are sometimes considered more useful for guiding energy load adjustments [64], which also explain why the EPA reports marginal health benefits per kWh (i.e., marginal health price) to inform energy demand changes [19].

We show in Fig. 10a the region-wise normalized interquartile ranges (IQR divided by the yearly average) for both public health costs and carbon emissions. The normalized IQR measures the spread of the time-varying health and carbon signals. Specifically, in 110 out of the 114 U.S. regions (96%), the normalized IQR of health cost is higher than that of the carbon intensity for each unit of electricity consumption. Moreover, the normalized IQR for carbon emissions is less than 0.2 in most of the regions. This implies that health costs exhibit a greater temporal variation than carbon emissions in 110 out of the 114 U.S. regions. Likewise, in Fig. 10b, the greater temporal variation of health costs is also supported by its greater normalized standard deviation (STD divided by the yearly average) in 90 out of the 114 U.S. regions (79%). Next, we show in Fig. 10c the weak spatial correlation (Pearson correlation coefficient: 0.292) between the yearly average

[3]The health cost signal provided by [37] only considers mortality from $PM_{2.5}$, while COBRA includes a variety of health outcomes including asthma, lung cancer, and mortality from ozone, among others [7].

Location	Pearson Correlation	Normalized IQR			Normalized STD		
		Health	Carbon	$\frac{\text{Health}}{\text{Carbon}}$ Ratio	Health	Carbon	$\frac{\text{Health}}{\text{Carbon}}$ Ratio
Loudoun County, VA	0.427	0.158	0.065	2.409	0.131	0.059	2.222
Central Ohio, OH	0.479	0.160	0.065	2.441	0.137	0.066	2.064
The Dalles, OR	0.326	0.957	0.099	9.614	0.546	0.103	5.296
Douglas County, GA	0.756	0.507	0.093	5.418	0.293	0.075	3.913
Montgomery County, TN	0.760	0.289	0.067	4.320	0.195	0.046	4.236
Papillion, NE	0.736	0.748	0.840	0.891	0.487	0.553	0.881
Storey County, NV	0.584	0.178	0.057	3.132	0.168	0.042	4.004
Ellis County, TX	0.474	0.196	0.082	2.384	0.232	0.361	0.641
Berkeley County, SC	0.416	0.156	0.054	2.911	0.105	0.044	2.405
Council Bluffs, IA	0.361	0.185	0.111	1.671	0.129	0.311	0.415
Henderson, NV	0.584	0.178	0.057	3.132	0.168	0.042	4.004
Jackson County, AL	0.760	0.289	0.067	4.320	0.195	0.046	4.236
Lenoir, NC	0.240	0.176	0.059	2.982	0.129	0.046	2.800
Mayes County, OK	0.617	0.122	0.049	2.495	0.171	0.222	0.772

Table 3: *Correlation analysis of marginal carbon emissions and health impacts for a technology company's U.S. data center locations between October 1, 2023, and September 30, 2024* [37]*. According to the region classification of WattTime* [63]*, the two data centers in Storey County, NV, and Henderson, NV, belong to the same power grid region, and so do those in Jackson County, AL, and Montgomery County, TN.*

health cost and carbon intensity across the 114 regions. Furthermore, the normalized IQR of the health cost spatial distribution is 3.62x that of carbon emission spatial distribution (1.05 vs. 0.29), while the health-to-carbon ratio in terms of the spatial distribution's normalized STD is 3.37 (0.64 vs. 0.19). In other words, the health cost could have a greater spatial spread than the carbon emission.

In addition to analysis for all U.S. regions, we turn to specific regions where a large technology company builds its U.S. data centers. We present the results Table 3, further confirming that carbon intensities and health impacts are not always aligned and that health impacts vary more significantly than carbon intensities in almost all the locations.

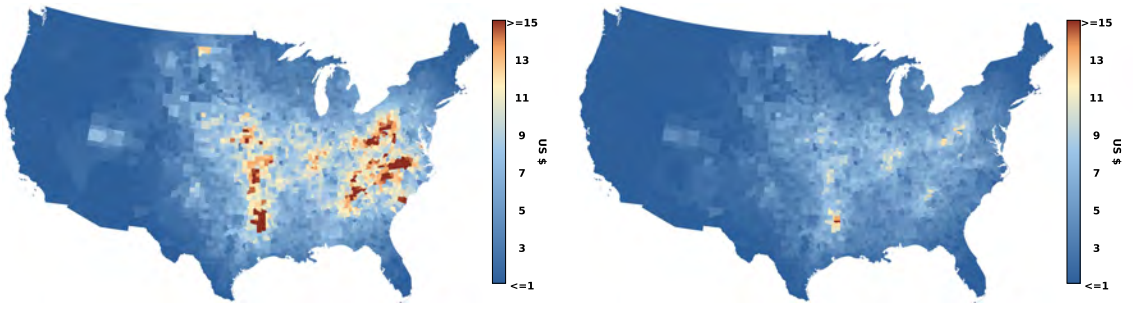
We further analyze the Pearson correlation coefficients between hourly marginal health prices and carbon emission rates throughout 2023 for the U.S. regions that have complete health and carbon data provided by WattTime [37]. Nearly 70% of the regions have a weak or moderate correlation, with a carbon-health correlation coefficient of less than 0.60. This implies that despite having fossil fuels as the common source, health costs and carbon emissions are different and can exhibit trade-offs. Moreover, due to their additional dependence on population distribution and meteorological conditions, health prices often demonstrate more pronounced temporal fluctuations than carbon emissions.

These findings suggest that leveraging spatiotemporal variations in a health-aware manner can reduce the public health costs of data center operations. Moreover, the observed distinctions between health impacts and carbon emissions suggest the need to optimize data center decisions by explicitly accounting for and exploiting the spatiotemporal heterogeneity of health impacts.

C.1.1 Location-Dependent Public Health Impacts of Two Technology Companies

We further highlight locational dependency of public health impacts by considering two major technology companies' U.S. data center locations in 2023, excluding their leased colocation data centers whose locations are proprietary. We name these two companies A and B, respectively. These two companies do not have same data center locations. While company B discloses its per-location electricity usage [27], company A does not. Thus, we uniformly distribute company A's North America electricity consumption over its U.S. data center locations based on its latest sustainability report [26]. We consider location-based emission accounting without taking into account renewable energy credits these two companies apply to offset their grid electricity consumption. Note that our results are intended to illustrate the locational dependence of public health impacts and should not be interpreted as a precise assessment of the actual impacts of these two companies.

We see from Fig. 11 that the two companies have different per-household health cost distributions and most-affected counties. This is partly due to the two companies' different data center locations, and highlights the locational dependency of public health impacts. That is, unlike carbon emissions that have a similar effect regardless of the emission source locations, the public health impact of criteria air pollutants



(***a***) *Per-household health cost (Company A)* (***b***) *Per-household health cost (Company B)*

Figure 11: *The county-level per-household health cost of two U.S. technology companies in 2023. The legend uses a linear value scale from $1 to $15 per household, with values below $1 and above $15 shown at the endpoints.*

heavily depends on the location of the emission source. Thus, technology companies should account for public health impacts when deciding where they build data centers, where they get electricity for their data centers, and where they install renewables in order to best mitigate public health impacts.

Table 4: *The public health cost of training a large AI model in selected U.S. data centers.*

Location	**Electricity Price** (¢/kWh)	**Electricity** (million $)	**Health Cost** (million $)	**% of Electricity Cost**	**Emission** (Metric Ton)		
					PM2.5 (LA-NYC)	**NOx** (LA-NYC)	**SO2**
Huntsville, AL	7.11	2.1	**0.70** (0.54, 0.87)	33%	0.61 (13800)	2.80 (2500)	2.72
Stanton Springs, GA	6.88	2.0	**0.85** (0.65, 1.04)	41%	0.69 (15500)	3.37 (3000)	3.35
DeKalb, IL	8.20	2.4	**1.92** (1.41, 2.42)	79%	1.25 (28100)	7.31 (6600)	7.83
Altoona, IA	6.91	2.1	**2.51** (1.84, 3.17)	122%	1.52 (34000)	11.78 (10600)	14.76
Sarpy, NE	7.63	2.3	**1.54** (1.16, 1.92)	68%	1.13 (25300)	13.5 (12200)	18.51
Los Lunas, NM	5.75	1.7	**0.73** (0.56, 0.90)	43%	0.78 (17500)	8.36 (7500)	9.84
Forest City, NC	7.15	2.1	**1.07** (0.85, 1.30)	50%	0.72 (16200)	5.72 (5200)	3.27
New Albany, OH	7.03	2.1	**1.61** (1.20, 2.03)	77%	1.13 (25200)	5.15 (4600)	4.44
Prineville, OR	7.52	2.2	**0.23** (0.19, 0.28)	10%	0.59 (13300)	4.67 (4200)	2.40
Gallatin, TN	6.23	1.9	**0.32** (0.24, 0.40)	17%	0.41 (9200)	1.21 (1100)	0.93
Fort Worth, TX	6.60	2.0	**0.51** (0.38, 0.65)	26%	0.47 (10500)	3.02 (2700)	3.81
Eagle Mountain, UT	6.99	2.1	**0.24** (0.19, 0.29)	12%	0.60 (13300)	4.82 (4300)	2.52
Henrico, VA	8.92	2.7	**1.61** (1.20, 2.03)	61%	1.13 (25200)	5.15 (4600)	4.44

C.1.2 Location-Dependent Public Health Impact of Generative AI Training

We next examine the estimated health impact of a specific computing task to illustrate how the same workload can result in different public health costs depending on where it is performed. Specifically, because AI training workloads often have substantial spatial flexibility, we consider the training of an LLM and assume electricity consumption comparable to that reported for training Meta's Llama-3.1 [65]. Because scope-2 impacts dominate in our analysis, and because the power allocation and on-site backup generation usage for training Llama-3.1 are not publicly known, we focus on scope-2 health costs associated with electricity consumption.

Importantly, although we use the estimated electricity consumption of Llama-3.1 and a set of U.S. data center locations as an illustrative example, our results should be interpreted as estimates for training a general LLM at a scale comparable to Llama-3.1, rather than as an assessment of the actual health impact of Llama-3.1. The actual health impacts of Llama-3.1 depend on specific factors such as timing, electricity procurement, grid mix, and any on-site generation use, and may differ substantially from our estimates.

We show the results in Table 4. It can be seen that the total health cost varies widely depending on the training data center locations. For example, the total health cost is only $0.23 million in Oregon, whereas the cost will increase dramatically to $2.5 million in Iowa due to various factors, such as the wind direction and the pollutant emission rate for electricity generation [35].

Additionally, depending on the data center location, training an AI model at the scale of Llama-3.1 can be associated with air-pollutant emissions comparable to those from more than 10,000 LA-NYC round trips

by car. This cross-sector comparison is intended only to provide a sense of emissions scale. It should not be interpreted as discouraging either activity or as suggesting that the two activities have the same public health impacts. The health impacts depend strongly on factors such as pollutant mix, emissions location, atmospheric dispersion, and exposed population density. Quantitatively, our estimates suggest that in some locations, the public health externalities of AI model training can be comparable to the associated electricity costs.

Overall, the results highlight that the public health impact of AI model training is highly location-dependent. Combined with the spatial flexibility of model training, they suggest that AI model developers can take into account potential health impacts when choosing data center locations for training where applicable.

C.2 Formulation of Health-Informed Computing

To improve system performance and reliability, technology companies typically operate data centers over a variety of geographically distributed regions and *dynamically* distribute computing workloads through a process known as geographical load balancing (GLB). Here, we leverage the unique spatial load flexibility of geographically distributed data centers to demonstrate the benefits of health-informed computing as a proof of concept.

Specifically, we study health-informed GLB as an example of `HICO` to mitigate the public health impacts of data center operation. We consider a discrete-time model of duration T and measure the workloads in terms of their energy demand. For the sake of examining the impact of spatial flexibility, we assume that the energy loads (i.e., workloads) can be flexibly distributed across a set of N data centers denoted as $\mathcal{N} = \{1, 2, \ldots, N\}$. In each time $t \in \{1, 2, \ldots, T\}$, the total energy demand is M_t, and $w_{i,t}$ represents the load assigned to data center i. We use l_i to represent the default load capacity of data center i, and introduce a slackness parameter $\lambda \geq 1$ to represent the ability of each data center to accept loads in excess of its default capacity. Thus, the greater the value of λ, the more spatial flexibility the operator has. In each time t, we use $p^e_{i,t}$ and $p^h_{i,t}$ to denote the electricity price and health price at data center i, respectively.

The health price $p^h_{i,t}$ depends on the emission source of criteria air pollutants (e.g., power plants' emission rates and their locations), air pollutant dispersion, and estimates of adverse health outcomes and resulting costs attributed to the increased air pollutant concentration in each region [7]. Thus, the health price quantifies the ultimate health burden imposed on affected populations and is measured in terms of economic costs for each unit of electricity consumption. It varies over time due to fluctuations in the grid's generation mix and changing meteorological conditions. Third-party organizations such as WattTime [63] provide real-time estimates of the marginal health price of electricity across 114 power balancing regions in the U.S., while the EPA [19] reports annualized average health prices for electricity in 14 broader regions nationwide.

A canonical objective in GLB is carbon-aware computing, which dynamically dispatches workloads to data centers with lower carbon intensities. To further incorporate public health impacts, the GLB objective for each time slot t can be written as:

$$\min_{\mathbf{w}_t \in \mathcal{W}_t} \sum_{i=1}^{N} \left(p^e_{i,t} + p^h_{i,t} + p^c r^c_{i,t}\right) \cdot w_{i,t}, \tag{2a}$$

$$\text{s.t.} \quad \sum_{i=1}^{N} w_{i,t} = M_t, \tag{2b}$$

$$0 \leq w_{i,t} \leq \lambda \cdot l_i, \quad \forall i \in \mathcal{N}, \tag{2c}$$

where N is the number of data centers, $p^e_{i,t}$, $p^h_{i,t}$, and $r^c_{i,t}$ denote, respectively, the electricity price, health cost, and carbon emissions per kWh at data center i and time t, p^c denotes the carbon price, $\mathbf{w}_t = (w_{1,t}, \cdots, w_{N,t})$ denotes the energy use induced by the dispatched workloads, the constraint (2b) means that all loads must be dispatched to a data center (with no loads dropped), the constraint (2c) encodes the maximum workload capacity of each data center parameterized by the slackness factor $\lambda \geq 1$, and $\mathcal{W}_t$ denotes the feasible set at time t, capturing operational constraints such as latency constraints and workload-specific requirements [43]. Carbon prices commonly fall in the range of $10 to $200 per ton, depending on the market and compliance requirements

Table 5: *HICO under different settings ($\lambda = 1.2$), with percent changes in parentheses reported relative to the baseline. Three special cases: Electricity Cost Optimal (E-OPT, with $p^c = 0$ and $p^h_{i,t} = 0$), Carbon Emission Optimal (C-OPT, with $p^e_{i,t} = 0$ and $p^h_{i,t} = 0$), and Health Impact Optimal (H-OPT, with $p^e_{i,t} = 0$ and $p^c = 0$).*

Metric	Baseline	E-OPT	C-OPT	H-OPT	Health-Oblivious ($p^h_{i,t} = 0$)		Health-Informed ($p^h_{i,t} \neq 0$)		
					p^c =\$50/ton	p^c =\$200/ton	p^c =\$0/ton	p^c =\$50/ton	p^c =\$200/ton
Health (Million \$)	393.23	374.20 (-4.84%)	404.72 (+2.92%)	**345.26 (-12.20%)**	377.01 (-4.13%)	395.28 (+0.52%)	349.29 (-11.17%)	349.10 (-11.22%)	350.34 (-10.91%)
Energy (Million \$)	756.50	**732.06 (-3.23%)**	761.20 (+0.62%)	752.26 (-0.56%)	733.25 (-3.07%)	747.88 (-1.14%)	738.49 (-2.38%)	739.32 (-2.27%)	744.67 (-1.56%)
Carbon (Million Ton)	6.60	6.68 (+1.22%)	**6.37 (-3.54%)**	6.54 (-0.87%)	6.53 (-1.14%)	6.40 (-3.04%)	6.57 (-0.44%)	6.54 (-0.89%)	6.49 (-1.71%)

Table 6: *HICO under different settings ($\lambda = 2.0$), with percent changes in parentheses reported relative to the baseline. Three special cases: Electricity Cost Optimal (E-OPT, with $p^c = 0$ and $p^h_{i,t} = 0$), Carbon Emission Optimal (C-OPT, with $p^e_{i,t} = 0$ and $p^h_{i,t} = 0$), and Health Impact Optimal (H-OPT, with $p^e_{i,t} = 0$ and $p^c = 0$).*

Metric	Baseline	E-OPT	C-OPT	H-OPT	Health-Oblivious ($p^h_{i,t} = 0$)		Health-Informed ($p^h_{i,t} \neq 0$)		
					p^c =\$50/ton	p^c =\$200/ton	p^c =\$0/ton	p^c =\$50/ton	p^c =\$200/ton
Health (Million \$)	393.23	368.10 (-6.39%)	408.92 (+3.99%)	**221.38 (-43.70%)**	380.09 (-3.34%)	374.82 (-4.68%)	223.96 (-43.05%)	227.73 (-42.09%)	261.56 (-33.48%)
Energy (Million \$)	756.50	**702.16 (-7.18%)**	767.59 (+1.47%)	734.29 (-2.94%)	709.77 (-6.18%)	723.42 (-4.37%)	728.19 (-3.74%)	727.07 (-3.89%)	725.11 (-4.15%)
Carbon (Million Ton)	6.60	6.72 (+1.73%)	**5.84 (-11.49%)**	6.61 (+0.19%)	6.06 (-8.13%)	5.95 (-9.91%)	6.55 (-0.71%)	6.43 (-2.60%)	6.16 (-6.71%)

Our formulation can be easily extended to incorporate additional considerations. For example, it can include long-term, per-region health impact constraints, rather than focusing solely on national-level total health costs. For the sake of clarity, we set these extensions aside to focus on the novel metric of health cost for data center resource management.

C.3 Sensitivity Analysis of Capacity Slackness λ

The parameter $\lambda \geq 1$ represents the amount of capacity slackness for accommodating additional workloads: a larger λ provides greater spatial flexibility. We vary λ and report the results for $\lambda = 1.2$ and $\lambda = 2.0$ in Tables 5 and 6, respectively. As λ increases, the additional spatial flexibility leads to larger health benefits. In particular, when $\lambda = 2.0$, the health-oblivious GLB algorithm ($p^h_{i,t} = 0$) reduces carbon emissions by nearly 10%, but lowers health cost by less than 5% relative to the baseline. By contrast, HICO incorporates health into the scheduling objective. Although carbon emissions and health cost cannot in general be minimized at the same time, a suitable choice of p^c allows HICO to substantially reduce health cost while also achieving meaningful reductions in carbon emissions and electricity cost. For example, under $\lambda = 2.0$ and $p^c = \$200/\text{ton}$, HICO reduces carbon emissions by nearly 7% while lowering health cost by more than 30%. More broadly, these results suggest that health-informed scheduling can enable data center operation to jointly improve public health, environmental sustainability, and economic efficiency.

Talk to a rep

How Much Power Does a Hyperscale Data Center Use? In-Depth Analysis



By Josh Mahan

12 min read · Updated Dec 15, 2025 · Data Center Resources

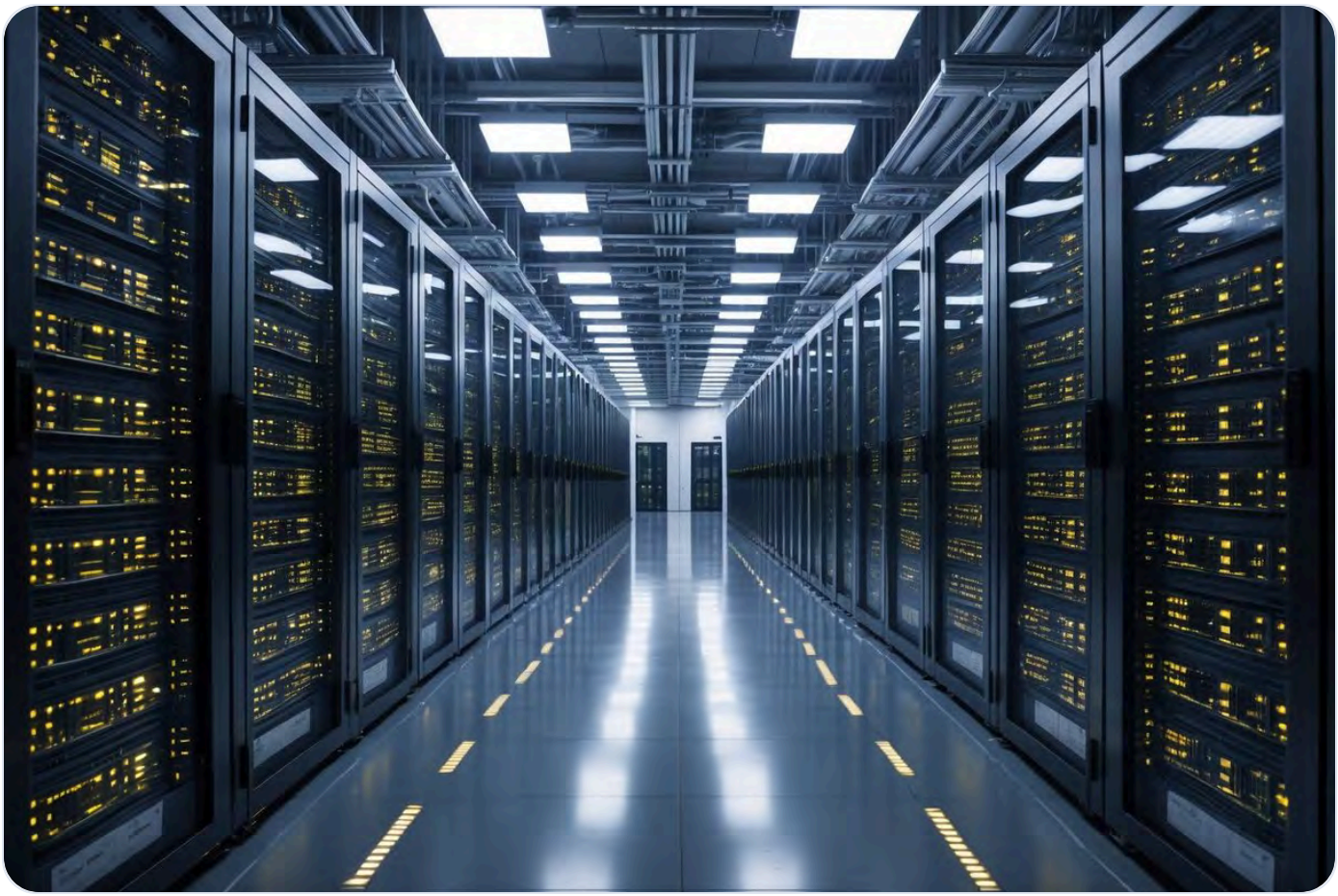


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Hyperscale data centers power the digital world. Every video stream, cloud backup, and AI model depends on the incredible energy these massive facilities pull from the grid.

KEY TAKEAWAYS

- Hyperscale data centers use enormous power, often exceeding 100 megawatts each.
- Rising digital and AI demand keeps pushing energy use higher.
- Efficiency efforts and renewable energy help balance rapid growth with sustainability goals.

A single hyperscale data center can use around 100 megawatts of power—enough to supply electricity to hundreds of thousands of homes, according to Statista. Their constant operation keeps global networks running every second of the day.

As data and AI workloads keep expanding, energy demand rises fast. Analysts think overall data center electricity use could hit 12% of U.S. consumption by 2028, noted in a government report.

Cooling systems, power distribution, and server operations all suck up huge amounts of energy. To ease pressure on the grid, new centers increasingly use renewable energy and more efficient infrastructure.

Defining Hyperscale Data Centers

Hyperscale data centers deliver massive computing capacity for cloud platforms and digital services. These purpose-built facilities support rapid scaling of applications and handle

enormous amounts of data.

They use advanced technologies to manage power, cooling, and network efficiency.

Key Characteristics of Hyperscale Facilities

A **hyperscale data center** stands out for its scale, efficiency, and automation. It usually has at least **5,000 servers** and covers **10,000 square feet or more**, according to IBM.

Some campuses sprawl across millions of square feet, hosting tens of thousands of servers connected by high-speed networks. These sites are engineered for **high density** and **low latency**, with uniform hardware and modular design.

Companies like Amazon, Google, and Microsoft can expand capacity quickly and keep performance steady thanks to this modular approach.

Many hyperscale sites draw **20–40 megawatts (MW)** of power each, though the biggest ones go well over 100 MW. Cooling matters a lot; some facilities using evaporative methods can gulp down up to **5 million gallons of water per day**, as The Detroit News points out.

Energy efficiency, resilience, and scalability drive every design decision.

Differences Between Hyperscale, Enterprise, and Colocation Data Centers

Every **data center type** fills a unique role. Here's a quick look at how they differ:

Type	Typical Use	Scale	Ownership	Customization
Hyperscale	Supports major cloud and internet platforms	5,000+ servers	Owned by hyperscalers (e.g., Amazon, Microsoft, Google)	Highly standardized
Enterprise	Dedicated to a single	Hundreds to thousands of servers	Owned and managed by the enterprise	Fully customized

Type	Typical Use	Scale	Ownership	Customization
	organization's IT operations			
Colocation	Leased space for multiple customers	Variable	Operated by third-party providers	Shared infrastructure, partial flexibility

Unlike enterprise and colocation sites, hyperscale facilities are built for automation and **horizontal scaling**. Operators can add computing power without much fuss.

Hyperscalers often design their own hardware and networking gear to squeeze out every bit of efficiency and cut costs.

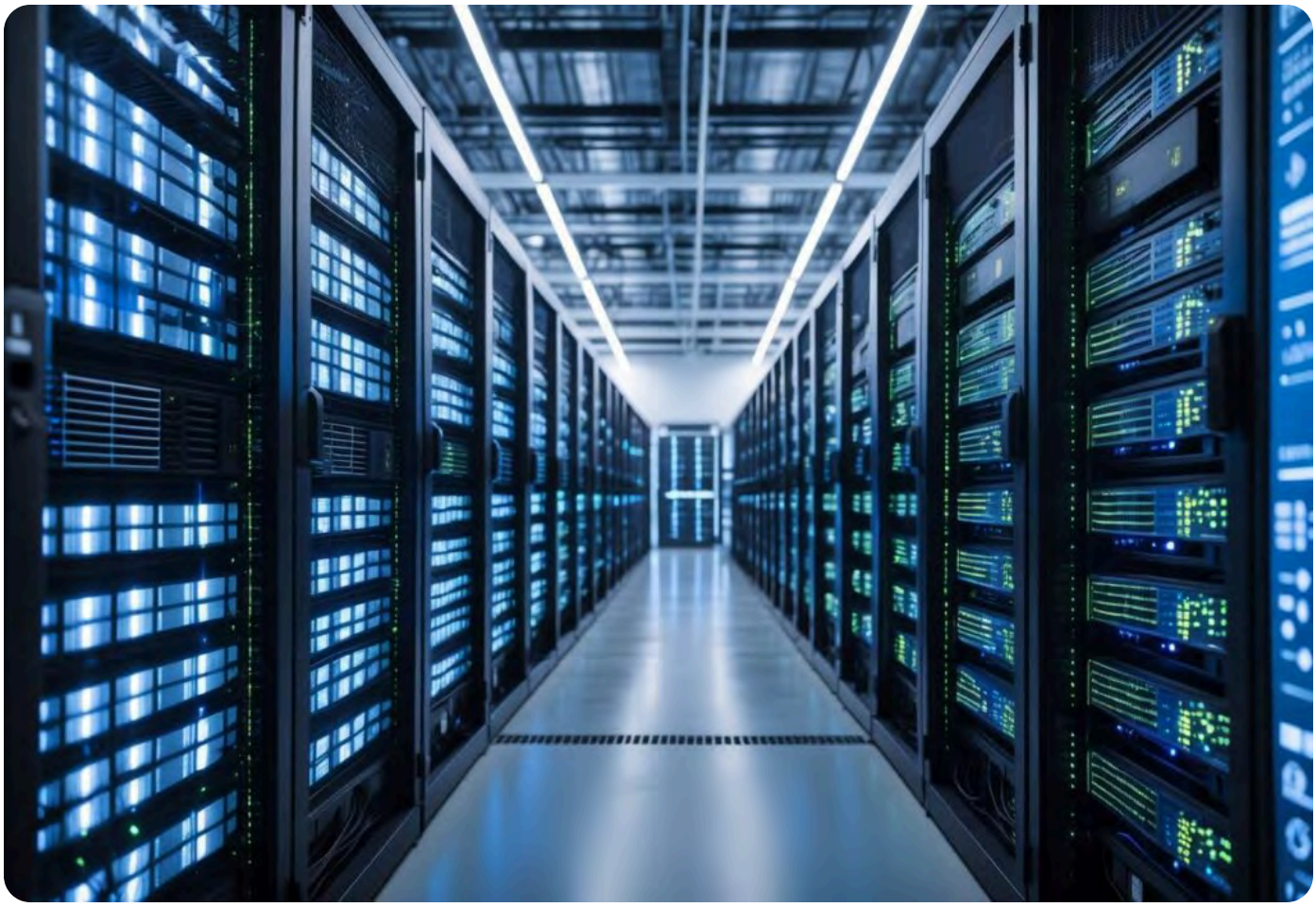
Growth of Hyperscale Data Centers

The number and size of hyperscale data centers have exploded as cloud computing and AI demand more muscle. In 2024, U.S. data centers used about **4% of national electricity**. That figure could **triple by 2030**, says Data Center Frontier.

Analysts expect global hyperscale infrastructure to reach **thousands of sites worldwide** by the late 2020s. New campuses often include on-site renewable energy, battery systems, and smart grid integration.

Projects highlighted by Schneider Electric even help stabilize the grid by managing energy flow in real time.

Typical Power Consumption of Hyperscale Data Centers



Typical Power Consumption of Hyperscale Data Centers

Hyperscale data centers need massive, steady power to run thousands of servers and cooling systems. Electricity use depends on things like total floor area, IT equipment density, and how the place is designed for efficiency.

Facilities built for artificial intelligence workloads burn through even more energy because of heavy-duty computing.

Average Power Requirements by Size and Configuration

A new hyperscale facility usually needs at least **50–100 megawatts (MW)** of power capacity. Statista's data says centers this size can use as much electricity in a year as over 400,000 electric vehicles.

Globally, data center electricity consumption hit about **460 terawatt-hours (TWh)** in 2022 and could double by 2026.

Smaller hyperscale sites, which support fewer racks, might run in the **10–30 MW** range. For comparison, a mid-size enterprise data center draws less than 5 MW.

Most of the demand—sometimes over half—comes right from **electronic IT equipment** like processors and storage. Cooling and power distribution soak up the rest.

Operators fight inefficiency using **modular power supply systems**, liquid cooling, and advanced heat recovery. Many now mix in renewable energy, like solar, wind, or even hydrogen fuel cells.

Comparison to Traditional Data Centers

Traditional data centers just aren't in the same league for size or power use. A regular center might use **1–5 MW** and serve a single company or region.

Hyperscale data centers can need **dozens to hundreds of megawatts** and support global operations.

TechTarget points out that hyperscale operators offset their bigger energy appetite with **energy-efficient computing equipment** and optimized HVAC systems.

Still, electricity use keeps climbing as storage and processing demand grow.

The **Power Usage Effectiveness (PUE)** metric shows the efficiency gap. Traditional centers average around **1.7 PUE**, but hyperscale sites get down to about **1.2**. They waste less on cooling, but total consumption is still way higher because of their size.

Notable Real-World Examples

The biggest hyperscale data clusters operate in **Virginia (U.S.)**, **Beijing**, and **London**. Together, they combine for **over 5 gigawatts** of power capacity, according to Statista.

Amazon, Google, and Microsoft run many of these sites to power global cloud, search, and AI workloads.

Microsoft’s modern campus-level data centers often top **70 MW**. Amazon’s typical U.S. cloud zones get close to **100 MW** each.

Some AI-focused sites, built for training huge language models, have reported single-tenant operations using several **terawatt-hours per year**.

To deal with rising energy use, many companies chase **sustainable cooling**, on-site solar microgrids, and renewable power purchase agreements. It’s a constant balancing act as digital growth and AI adoption keep pushing global data center power demand higher.

Factors Driving Energy Demand in Hyperscale Data Centers



Factors Driving Energy Demand in Hyperscale Data Centers

Artificial intelligence and cloud computing are sending electricity demand in hyperscale data centers through the roof. High-density servers and specialty chips crave more power and

advanced cooling, while the spread of digital services keeps the infrastructure growing.

AI Workloads and High-Density Servers

Artificial intelligence workloads chew through huge numbers of GPUs and specialized accelerators. These systems run at high power density, pulling several kilowatts per rack.

Heavy parallel processing for training and inference generates loads of heat, which operators have to manage with liquid or immersion cooling.

As workloads scale up, hyperscale operators install advanced power distribution units and cooling systems to cut energy loss. AI-focused facilities may need **100 megawatts or more** of capacity—about as much as hundreds of thousands of electric vehicles use in a year, according to Statista.

The Data Center Power Report shows that next-gen sites pair on-site generation with fast-response batteries to handle AI's wild power swings.

Key reasons AI keeps driving up energy use:

- **Increased GPU utilization** for model training
- **Intensive cooling needs** because of dense server racks
- **Grid constraints**, which push adoption of nuclear, battery, or renewables

Cloud Computing Expansion

As more companies move to the cloud, hyperscale campuses keep adding compute and storage. This scaling effort means higher base loads and continuous uptime requirements.

Each data hall runs thousands of servers, all day, every day.

Cloud-driven digital transformation means services like streaming, storage, and analytics just keep expanding. MIT Energy Initiative says this puts pressure on grid infrastructure and speeds up work on low-carbon energy solutions.

Big providers now look for sites near renewable-rich regions to balance cost and reliability.

Common strategies for managing power growth:

Approach	Benefit
Renewable power purchase agreements	Shrinks fossil fuel reliance
Modular infrastructure	Makes scaling and maintenance easier
Advanced cooling systems	Boosts efficiency in hot climates

Cloud use boosts server density and energy draw, so data center infrastructure design has to keep evolving.

Power Grids and Infrastructure Challenges



Power Grids and Infrastructure Challenges

Hyperscale data center power demand is growing so fast that it's straining electricity supply and exposing infrastructure limits. Rising AI workloads and high-density computing have made power availability a major constraint for expansion in many U.S. regions.

Regional Grid Limitations

Power grids in several regions now run close to their limits. Hyperscale facilities often need hundreds of megawatts—sometimes more than 100 MW each.

That's about the same as a small city. In the U.S., data centers already use nearly 4% of national electricity.

By 2030, that number could triple, according to Data Center Frontier.

Places like **Northern Virginia** and **Texas** run into delays getting new grid connections. Grid upgrades can take years, but data centers want power in months.

In **Ireland and parts of the U.S. Midwest**, data centers already use more than 10% of local generation. This strains distribution networks, as Solar Tech Online points out.

Region	Estimated Data Center Power Share	Key Challenge
Northern Virginia	~20% of state grid load	Transmission congestion
Texas	~9–10 GW projected in 2025	ERCOT volatility
Ireland	>22% of national electricity	Limited grid capacity

Backup Power and Reliability Strategies

Operators are building **on-site generation** and **energy storage** to reduce their reliance on fragile regional grids. Natural gas generators, fuel cells, and big battery energy storage systems (BESS) are some of the go-to options.

These technologies help keep things running when the grid can't deliver. Many companies now design "microgrid" setups that combine renewables with backup power.

Hybrid sites in Texas and Arizona, for instance, use solar with lithium-ion batteries to stay online during peak demand. Some firms experiment with small modular nuclear units or geothermal, looking for more stable sources—a trend Orrick's energy guide covers in detail.

Highly reliable on-site backup keeps data flowing and can even help balance the wider grid during outages or congestion.

Cooling Systems and Non-IT Energy Use

Large data centers spend a big chunk of their electricity on things that don't process data directly. Most of it goes to cooling servers, distributing power, and running the building.

Boosting the efficiency of these systems can make a real dent in overall energy use.

Cooling Technology Innovations

Cooling systems keep servers from overheating and make up one of the biggest non-IT power draws. In some hyperscale sites, cooling eats up anywhere from 7% to over 30% of total electricity, depending on how things are set up (Pew Research Center).

Modern data centers mix and match cooling methods:

- **Air cooling** with aisle containment to separate hot and cold air.
- **Liquid cooling** for high-density AI servers—it just works better.
- **Evaporative and adiabatic systems** that use water sparingly for efficient heat exchange.

Some operators let machine learning fine-tune temperatures and fan speeds in real time. That helps avoid wasting power.

Others capture waste heat and send it to nearby buildings or district heating systems. Every method aims to lower the *Power Usage Effectiveness (PUE)* ratio—a key efficiency metric.

Other Major Power Consumers in Data Centers

Non-IT energy use doesn't stop at cooling. Power distribution units, uninterruptible power supplies, and lighting systems also draw a surprising amount of juice.

In some facilities, these can add up to 10–15% of total energy use (Enconnex's analysis).

Facilities also use energy for **fire suppression**, **security equipment**, and building ventilation. Even little things—humidity controls, battery chargers—add up.

Newer centers use efficient transformers, LED lighting, and management software to direct power only where it's needed. Staying on top of maintenance and monitoring in real time helps keep small inefficiencies from growing into big problems.

Sustainability Initiatives and Renewable Energy Integration

Hyperscale data centers burn through a lot of electricity, but operators are pouring resources into sustainable operations to shrink their carbon footprint.

They're chasing cleaner power sources, transparent environmental reporting, and partnerships that push renewable tech forward.

Shift Toward Clean Power Sources

Modern data centers lean on **renewable energy**—solar, wind, hydro, sometimes even nuclear—to cut down on fossil fuels. Many pick locations with abundant renewables or generate their own on-site to hit sustainability targets.

The Environmental and Energy Study Institute says that choosing efficient sites and building renewables into facility design can really lower grid demand.

Companies are also putting money into **energy storage and distribution** to keep things steady during peak times. Cloud providers use battery storage and microgrids to balance local supply and guarantee uptime.

For cooling, some centers take advantage of cold climates or reuse water to keep power needs down. Cleaner energy and smarter site design make the whole operation more resilient and efficient.

Hyperscaler Commitments and Industry Collaborations

Big tech leads the way on sustainability. **Amazon Web Services (AWS)**, for example, plans to run on **100% renewable energy** worldwide by 2025—five years ahead of schedule (TechTarget). Other hyperscalers have made similar promises to hit carbon neutrality or net-zero in the next couple decades.

Collaboration is everywhere. Hyperscalers, utilities, and grid operators are dreaming up new energy procurement models together.

Initiatives like *Bring Your Own Power (BYOP)* help facilities and utilities design flexible energy-sharing strategies, as Data Center Frontier explains.

When companies work together, they set new efficiency standards and get more transparent about **power usage effectiveness (PUE)**. It's not just talk—these partnerships turn sustainability into actual performance gains.

Role of Government and Research Institutions

Government and research outfits play a huge role in nudging data centers toward energy efficiency. The **U.S. Department of Energy (DOE)** funds studies on national energy trends, including work at **Lawrence Berkeley National Laboratory** looking at how **U.S. data centers** use and optimize electricity.

Their research calls out the need for infrastructure that balances performance and sustainability. DOE's assessments, summed up by ScienceDirect, dig into this.

Regulations now push for renewable integration, energy reporting, and incentives for innovation. These policies encourage centers to try advanced cooling, smarter energy management, and modular designs.

The **International Energy Agency (IEA)** tracks how AI and hyperscale growth impact global electricity demand. By encouraging international teamwork, these agencies help the industry grow without blowing past sustainable limits.

From this guide

Questions about How Much Power Does A Hyperscale Data Center Use.

What is the typical power consumption of a large-scale data center on an annual basis? ×

A hyperscale data center usually draws **at least 100 megawatts (MW)**. That's about as much electricity as **400,000 electric vehicles** use in a year (**Statista** →). Annual consumption can push past **870 gigawatt-hours (GWh)**, depending on the workload and cooling needs.

What are the average electricity usage rates per square foot for modern data centers? +

Considering recent trends, how much energy do data centers consume each day? +

How has data center energy usage per hour changed over recent years? +

Can you quantify the energy demands of major data centers on a per hour metric? +

What is the estimated power usage of high-capacity data centers annually? +

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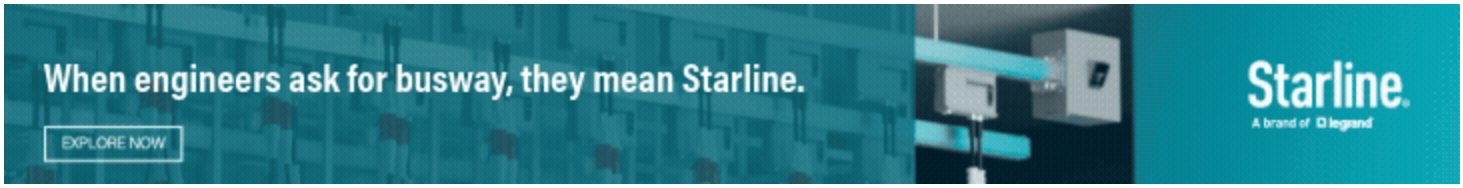
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POWER

The Data Center Power Squeeze: Mapping the Real Limits of AI-Scale Growth

Where will the power come from? As AI workloads explode and U.S. data center power demand races toward 134 GW by 2030, the industry faces a fundamental constraint: the grid can't keep up. This deep dive maps the regions, tools, and hidden power corridors that will define AI growth over the next decade, and where operators must look next to secure their megawatts.

Melissa Farney Dec. 1, 2025 15 min read

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Key Highlights

- AI workloads are significantly more energy-intensive, with data center electricity consumption expected to reach 134 GW by 2030, nearly tripling current levels.
- Mapping tools like national capacity maps, hosting capacity maps, and real-time congestion dashboards are vital for site selection and risk management amid grid constraints.
- Regions such as Pennsylvania, Texas, Atlanta, Ohio, and emerging markets like Phoenix and Las Vegas are identified as strategic hubs due to their power potential, infrastructure, and untapped resources.
- The industry must innovate in energy sourcing, including utilizing underused assets like non-powered dams and retired industrial sites, to meet future demand sustainably.
- Overcoming grid bottlenecks requires collaboration between public and private sectors, policy innovation, and technological advancements to unlock new power sources and expand capacity.



Meta data center in New Albany, Ohio near Columbus.

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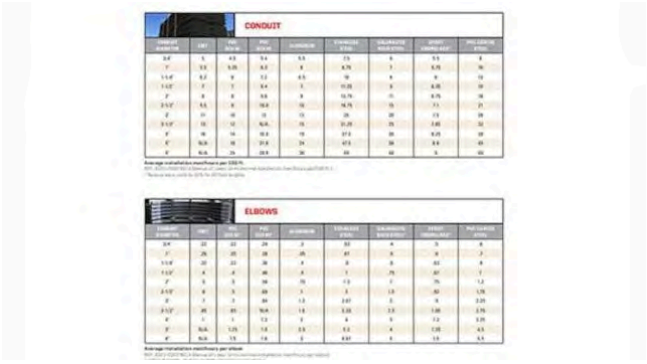
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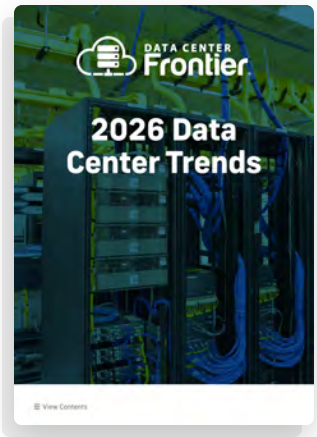
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ORDINANCE NO. 6474

HCP-003-22 2021 ECONOMIC OPPORTUNITIES ANALYSIS

AN ORDINANCE AMENDING THE HILLSBORO COMPREHENSIVE PLAN TEXT AND ADOPTING THE 2021 ECONOMIC OPPORTUNITIES ANALYSIS TO REPLACE THE EXISTING ECONOMIC OPPORTUNITIES ANALYSIS IN THE HILLSBORO COMPREHENSIVE PLAN IN ITS ENTIRETY.

WHEREAS, the Economic Opportunities Analysis (EOA) is a planning document that is incorporated into the Hillsboro Comprehensive Plan (HCP) in its entirety by reference and the existing EOA was adopted by Ordinance No. 6249 on November 21, 2017, and was effective January 2, 2018; and

WHEREAS, changes to land use, growth projections, future commercial and industrial needs, and regulatory requirements have resulted in a need to update the EOA to reflect the latest industrial and employment land supply and projected 20-year need; and

WHEREAS, the Hillsboro Comprehensive Plan (HCP) has adopted policies to encourage the update and refinement of the EOA to support the Economic Development Section and other sections of the HCP including employment-related policies; and

WHEREAS, procedures for processing Comprehensive Plan Minor Text Amendments are set forth in Community Development Code Sections 12.80.164 and 12.70.060, which require a public hearing by the Planning Commission on a City-initiated Comprehensive Plan Minor Text Amendment; and

WHEREAS, on May 11, 2022, the Planning Commission approved Order No. 8370 initiating the EOA adoption process and the EOA-related Comprehensive Plan Amendment; and

WHEREAS, on October 12, 2022, the Planning Commission approved Order No. 8374, recommending that the City Council amend the HCP to incorporate the 2021 EOA and 2021 EOA Technical Appendices, based on the testimony, the evidence in the Record, and the supporting findings; and

WHEREAS, on November 15, 2022, based on the evidence, testimony, and argument in the record, the City Council approved Ordinance No. 6420, amending the HCP, Part III, Chapter 14, Section 23.4 and adopting the 2021 EOA and 2021 EOA Technical Appendices in their entirety; and

WHEREAS, on July 20, 2023 the Oregon Land Use Board of Appeals (LUBA) remanded the City's decision on two issues, compliance with Hillsboro Community Development Code (CDC) Section 12.80.164 (Minor Text Amendment), and the standards in state law for the buildable lands inventory; and

WHEREAS, on May 8, 2024, the Planning Commission reopened the public hearing and continued the item to May 22, 2024; and

WHEREAS, on May 22, 2023, after receiving a staff report and hearing public testimony, the Planning Commission approved a recommendation that the City Council amend to the HCP as shown in Exhibit A to incorporate the 2021 EOA provided in Exhibit B and the 2021 EOA Technical Appendices in Exhibit C, based on the testimony, evidence, and argument in the Record and the supporting findings attached as Exhibit D; and

WHEREAS, the City Council considered the Planning Commission's recommendation at its regular meetings on June 4, 2024 and June 18, 2024, and finds that the proposal is consistent with all applicable standards and criteria.

NOW, THEREFORE, THE CITY OF HILLSBORO ORDAINS AS FOLLOWS:

Section 1. Pursuant to CDC Sections 12.70.060 and 12.80.164, the City Council hereby approves the amendment to the HCP, Part III, Chapter 14, Section 23.4, as described in Exhibit A attached to this Ordinance.

Section 2. The City Council's decision on this matter is based on the findings in Exhibit D, attached to this Ordinance.

Section 3. Based on the testimony, evidence, and argument in the record, the City Council adopts the 2021 EOA as supplemented May 2024, in its entirety, attached as Exhibit B to this Ordinance; and the 2021 EOA Technical Appendices as supplemented May 2024, in its entirety, attached as Exhibit C to this Ordinance.

Section 4. Except as herein amended, HCP Ordinance No. 6249, as amended, shall remain in full force and effect.

Section 5. This ordinance shall become effective 30 days following its passage and approval by the Mayor.

First approval of the Council on this 4th day of June, 2024.

Second approval and adoption by the Council on this 18th day of June, 2024.

Approved by the Mayor this 18th day of June, 2024.

_____
Steve Callaway, Mayor

ATTEST: _____
Amber Ames, City Recorder

EXHIBIT A

HCP-003-22: 2021 ECONOMIC OPPORTUNITIES ANALYSIS
PROPOSED AMENDMENTS

Language proposed to be added shown in ***bold italic*** typeface.
Language proposed to be deleted shown in ~~overstrike~~ typeface.
Explanatory comments not included in amendments
Shown in *[bracketed italic gray highlight]*.

Section 23 Incorporated by Reference

Section 23.4 Economic Opportunities Analysis/Buildable Lands Inventory – Employment. The "City of Hillsboro, Economic Opportunities Analysis (Oregon Statewide Planning Goal 9), ~~February 2017~~***2021***," providing an employment analysis and inventory supporting the goals and policies within the Economic Development Section and other sections of the Comprehensive Plan including employment-related policies, is incorporated into the Comprehensive Plan in its entirety.

EXHIBIT B

HILLSBORO ECONOMIC OPPORTUNITIES ANALYSIS

Prepared for:

City of Hillsboro

December 2021

(As supplemented May 2024 with
Employment Buildable Lands Inventory Data from December 2020)

Hillsboro
OREGON

This **Economic Opportunities Analysis (EOA)** has been prepared for the City of Hillsboro by the economic and development consulting firm E. D. Hovee & Company, LLC in cooperation with the planning firm MIG, Inc.

The Hillsboro 2021 EOA has benefited from the input of local and external stakeholders and from project support in cooperation with the planning and the economic and community development department of the City of Hillsboro.

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GLOSSARY OF TERMS

A listing of key terms used in this EOA report is noted and defined as follows:

- **Buildable Lands Inventory (BLI)** as described in this EOA represents the City of Hillsboro's parcel-by-parcel inventory of the supply of buildable acreage within the City's Urban Growth Boundary (UGB) designated for employment uses amended in March 2024 based on December 2020 data. Potentially developable acreage comprises the sum of undeveloped portions of tax lots not already built, environmentally constrained, and/or allocated for rights-of-way.
- **Covered Employment** refers to employees covered by regular unemployment insurance typically excluding sole proprietor and gig workers. Data is compiled and made available by the Oregon Employment Department (OED) through the *Quarterly Census of Employment and Wages (QCEW)*. Published data is available at the state, county and metropolitan statistical area (MSA) levels. For this EOA, OED has provided customized data runs specific to the City of Hillsboro.
- **Economic Opportunities Analysis (EOA)** is a document required as consistent with Oregon land use planning law (OAR 660-009-0015) to "compare the demand for land for industrial and other employment uses to the existing supply of such land."
- **NAICS** is the North American Industry Classification System used by the U.S. Department of Commerce to categorize all industrial, commercial and institutional employment.
- **OAR 660-009** provides the Oregon Administrative Rules as an official compilation of rules and regulations having the force of law in Oregon as applied to Division 9 Economic Development to implement Goal 9 Economy of the State in compliance with Oregon Revised Statutes [ORS 197.712(2) (a) to (d)].
- **Target Industries** represent industrial and commercial sectors of the economy that are prioritized for business expansion and/or recruitment by state and local jurisdictions as well as regional public-private economic development organizations. Targeted sectors may include business clusters encompassing disparate industrial or commercial sectors important in the local or regional supply chain – whether as vendors or customers.
- **Urban Growth Boundary (UGB)** is a land use planning tool to separate land characterized by urban services and development from farms and forest lands protected from urban development. Hillsboro's UGB encompasses land within the current city limits and areas as yet not annexed but anticipated for future growth – as part of the Metro determined regional UGB for urban portions of the three-county area of Washington, Multnomah and Clackamas Counties.
- **Urban Growth Report (UGR)** is a publication of Metro as required by Oregon law to periodically evaluate the capacity of the Portland region's UGB to accommodate a 20-year forecast of housing needs and employment growth. The most recent regional update is provided by the 2018 UGR.

EOA SUMMARY

This report is intended to provide an updated Economic Opportunities Analysis (EOA) for the City of Hillsboro – addressing conditions of rapid employment growth in recent years including changing conditions prior and subsequent to the 2020 COVID pandemic together with an associated employment land needs analysis. Added detail is provided on the following pages.

EOA *Take-Aways*

Background

- ✓ An EOA articulates community priorities for economic development and addresses statewide land use planning Goal 9 together with Metro Urban Growth Boundary UGB considerations.
- ✓ This 2021 EOA updates a prior pre-pandemic EOA last completed in 2017 and adopted in 2018, also addressing federal and state initiatives for revitalized tech (notably semiconductor) manufacturing.

Employment Trends & Outlook

- ✓ Pre-pandemic, Hillsboro had 81,000+ jobs, up by 30% in 11 years, twice the metro-wide % increase.
- ✓ Manufacturing accounts for 1/3 of all Hillsboro jobs, three times the metro-wide proportion.
- ✓ As tech center of the state and metro region, Hillsboro firms pay well above average wage rates.
- ✓ 20-year forecast is for 36,910 more jobs (with straight line growth) to 87,800 (exponential growth).
- ✓ Recommended is a hybrid scenario for 61,895 added jobs based on detailed review of sector-by-sector job trends together with prioritization for Hillsboro's high-tech target industry clusters.

Community Economic Potential

- ✓ Business and community stakeholder input prior to and through the pandemic augments the data.
- ✓ Forces of disruptive technology and improved live-work connection accelerated thru the pandemic.
- ✓ The next economic cycle will redefine pivotal technologies and alter historic live-work boundaries.
- ✓ Target industry clusters serve to focus economic opportunities for: computers & electronics, software & information technology, advanced manufacturing, bioscience & medical devices

Employment Land Needs (Amended in March 2024 with BLI data from December 2020)

- ✓ Hillsboro has over 6,210 acres of employment land, of which 1,225 acres remain developable.
- ✓ Growth areas outside the current city limits but in the UGB represent 46% of future job potential.
- ✓ By 2040, Hillsboro faces a land need for 2,228-5,329 acres (3,481 acres with a hybrid scenario).
- ✓ Bringing land availability and needs into alignment may require adjustment on multiple fronts.
- ✓ For example, BLI capacity might expand by up to 12% with more redevelopment on low value land.

Implementation Policies

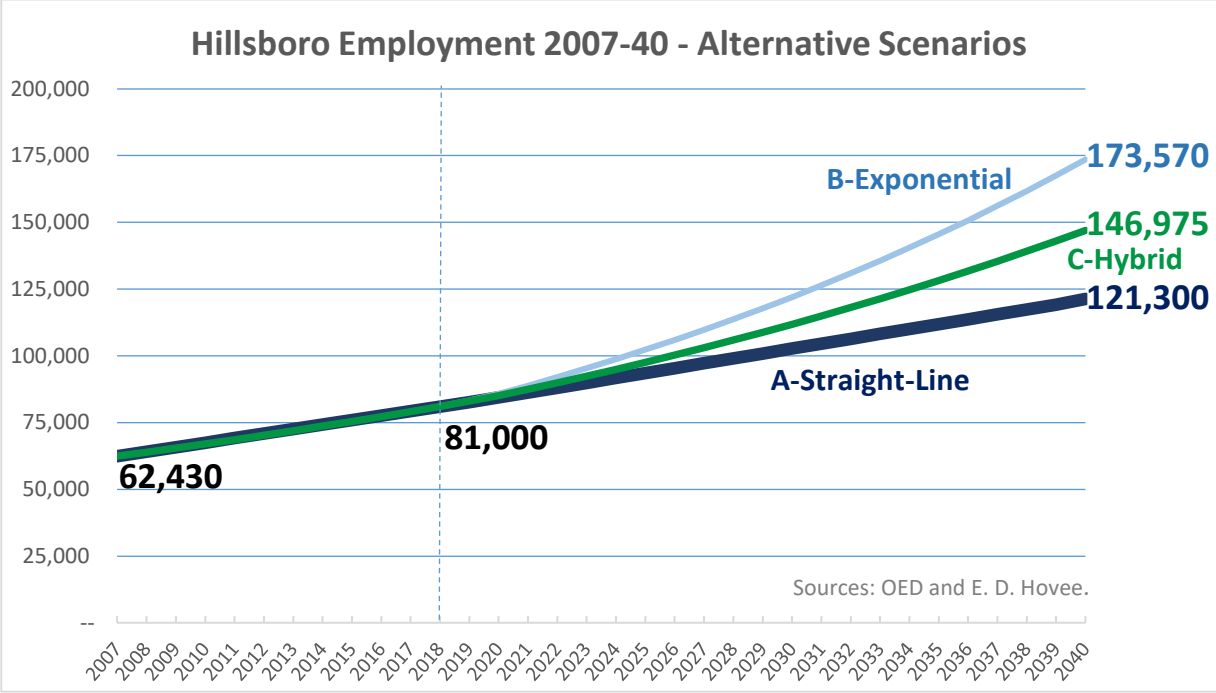
- ✓ Adopt a 20-year jobs and land use forecast similar to Scenario C Hybrid Growth together with implementing measures for supportive annexation and large site employer campuses.
- ✓ Target transportation/utility infrastructure and annexation to meet short-term (5-year) land needs.
- ✓ Adapt target industries to emerging traded sector opportunity and supporting community amenity.
- ✓ Support workforce readiness for employers and opportunities for under-represented businesses.
- ✓ Orient state and local incentives to support land readiness and support traded sector investment.
- ✓ Encourage support for Hillsboro tech as an economic engine benefiting the metro region and state.

Employment Trends & Outlook

As the tech center of the Portland metro region, Hillsboro is a major economic contributor to the metro area and state. Of note is the significance of manufacturing – accounting for nearly one-third of all Hillsboro employment versus just 11% of the sector's job-count metro-wide. This is largely due to the economic performance of Hillsboro's semiconductor industry.

From 2007-18, employment in Hillsboro increased by nearly 30%, double the approximately 15% increase in regional-wide employment (pre-pandemic). Annual payroll of Hillsboro firms in 2018 averaged $87,635 per job, 46% above the average per job wage of $59,900 metro-wide.

Covered employment (for jobs covered by unemployment insurance) has increased from 62,430 jobs located in Hillsboro as of 2007 to nearly 81,000 in 2018 (pre-pandemic).



As detailed by the Section II Employment Trends and Outlook portion of this EOA, three scenarios of potential employment growth to 2040 have been prepared (as illustrated above):

- **Scenario A Straight-Line Growth** results in 121,300 in-city jobs by 2040, with 36,910 net new jobs added over the 20-year forecast period of 2020-40, a 44% increase.
- **Scenario B Exponential Growth** predicated on compound annual growth rates (CAGRs) specific to each employment sector results in a substantially higher forecast of 173,570 jobs by 2040. An estimated 87,800 net new jobs would be added in the two decades from 2020-40 – a virtual doubling of employment over this 20-year forecast horizon.
- **Scenario C Hybrid Growth** results in an estimated 146,975 jobs in Hillsboro by 2040, based on assumption of compounding growth for sectors evidencing this trend and/or

associated with cluster industry targets versus lesser rates of growth for other sectors. With this scenario, 61,895 net new jobs would be added over 20 years from 2020-40.

Since the Great Recession of 2007-09, Hillsboro has outperformed the U.S. and metro region in rates of job growth. And during the pandemic and economic downturn unfolding in 2020, Hillsboro's semiconductor and manufacturing industries have lost fewer jobs than experienced across other sectors of the Portland metro economy.

With about 21,400 employees as of early 2021, Intel is the largest private employer in Hillsboro and the state of Oregon. Hillsboro's 18 largest firms employ 35,200 – with 12 of the 18 firms directly connected to semiconductor, high tech research/support and bio-tech sectors. These top employers provide an economic foundation of good paying/high wage jobs, supporting the economic vitality of the metro area and state as well as for the immediate Hillsboro community.

After the recession of the 2007-09, Hillsboro's job counts recovered more quickly and exceeded pre-recession levels more fully than was the case for the entire U.S. and Portland metro region. Stronger employment performance was apparent across manufacturing sectors – most notably for computer/electronics products – together with information services. And during the most recent pandemic-related downturn of 2020, Hillsboro was less adversely affected than the rest of the region, due to lesser reliance on hospitality and retail coupled with resilience of its industrial sectors.

To summarize, Hillsboro's current and prospective employment mix appears to offer benefits both of economic resilience and long-term growth potential:

- Hillsboro's business and industry mix demonstrates a path toward economic **recovery and resilience** beyond what has been achievable across the rest of the metro region.
- The community's **nurturing of technology** industries aligns well with the best opportunities for economic growth regionally and nationally – in recent years, through the 2020 economic downturn and post-pandemic.

These demonstrated advantages position the community to be an even more significant source of job stability and renewed growth for the PDX metro region and state of Oregon in the technology-driven economy of the years just ahead. These opportunities are best realized with land use planning for added tech-led industrial investment and are supportive of the EOA recommendation for selection of a **Scenario C Hybrid Growth** approach.

Community Economic Potential

Discussion of Community Economic Potential draws from the quantitative data analysis combined with qualitative research consistent with ORS 660-009 guidance. Background research has included focus group and interview discussions with business and community stakeholders. Initial conversations were conducted in early 2020 – just prior to the pandemic. A second round of interviews was conducted in late summer 2020 as firms were in the midst of adaptation to rapidly changing regulatory and market conditions.

This sequential research approach has proven useful to better identify economic opportunities that remain as before vis-à-vis those that clearly point in new directions. Two themes have emerged from **pre-pandemic** conversations with local and regional stakeholders:

- **Disruptive technology** – exemplified by emerging opportunities as for autonomous vehicles with less parking need, artificial intelligence (AI), internet of things (IoT), 5G telecommunications, exponential growth of data needs, and decarbonization.
- **Live-work connection** – as tech workforce has become more mobile. Employees don't want to get stuck in a location or sector with few options for re-employment. As millennials age, there is a shift in live-work preferences, less toward center cities and more to full-service communities meeting a greater array of family and job interests.

For stakeholders contacted over the summer of 2020, the **post-pandemic** world of work and business has become a different place than in early 2020. However, underlying forces of change already at work globally and locally remain in place. Existing trends for Hillsboro of disruptive technology and live-work connection have not changed markedly, but rather have **accelerated.**

An assessment of Hillsboro's competitive position has been conducted from the perspective of strengths, weaknesses, opportunities and threats (or SWOT) with key results as follows.

Summary Hillsboro Economic Strengths, Weaknesses, Opportunities & Threats

Strengths	Weaknesses
• Oregon's high-tech driver	• Overdependence on one anchor semiconductor firm
• Low-cost west coast metro setting	• Consumer services not fully meeting local needs
• Attraction to tech labor force	• Lack of nationally recognized research university
• Good internal circulation + Hillsboro airport & MAX	• Regional congestion affecting freight & workforce
• Increased diversity of area housing & health services	• Availability and affordability of workforce housing
• Major portion of regional land inventory for jobs	• Land inventory inadequate for forecast job growth
• Record of public-private partnership	• Uncertain tax & regulatory environment

Opportunities	Threats
• R&D with applied technology manufacturing	• Risk of losing the anchor competitive edge
• Business diversification	• Workforce displacement
• Job/housing balance	• Less than full-service community
• Transport innovation	• Transport gridlock
• Market-driven 50-year urbanization	• Non-market regulation

A clear message from business and community leaders is that this next economic cycle will be about more than economic recovery or a simple return to the business and economic development practices of the last decade. In addition to accelerating trends of disruptive technology and live-work connection, the next decade may well serve to redefine the technologies viewed as most pivotal globally and to alter current live-work boundaries – further changing traditional distinctions between employment and residential land uses.

Like many communities, Hillsboro also has identified target industry clusters for which it is either competitive now or can reasonably aspire to realize increased economic opportunity in the years ahead. Key industries of the of the City's economic development program are for:

- Computers and electronics (consistent with federal-approved *Chips and Science Act of 2022*)
- Software and information technology
- Advanced manufacturing
- Bioscience and medical devices

Historically defined in terms of readily measurable industry (NAICS) categories, target sector listings now often intentionally reach across traditional industry classifications. This approach recognizes the reality of the marketplace – especially where there are opportunities for a particular industry to be supported by local vendors or customers within a related business or industry segment.

As in the past, Hillsboro may modify its industry clusters to reflect and serve new or **emerging industry** opportunities in the years ahead. This would recognize the potential to step in alongside and encourage sectors that currently may be weakly represented in Hillsboro but with growing competitive presence. Priority consideration for business targeting might be provided to those emerging sectors (or specific businesses) offering potential for strong employment, tax revenue, and/or supplemental business leveraging (or "pull-through") benefits.

Emerging Economic Development Opportunities

This EOA is intended to support business opportunities as being identified by the City's economic development department. Examples include:

- Increased computer chip design & manufacturing capacity (supporting U.S. and state initiatives)
- Automotive & aerospace applications
- Energy storage
- Data centers
- Artificial intelligence research & deployment
- Supply chain onshoring & management
- On-shoring national defense manufacturing
- Tangible hardware
- Bio-tech expansion
- Climate technology
- Digital security

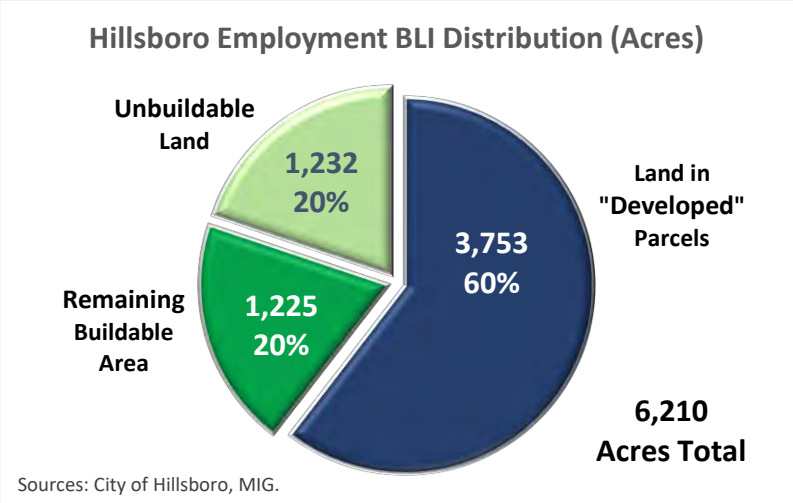
Consistent with Scenario C for hybrid development, an adaptive industry cluster approach addresses both national and regionally-driven opportunities. This strategy reflects recent federal policy and strategic industry initiatives – as for increased domestic semiconductor investment. As industry needs change in ways not always readily foreseen, the City of Hillsboro also expects to increasingly focus on assuring variable land parcel availability.

From an EOA land perspective, it is increasingly necessary to highlight the need or impact of having or not having a highly variable range of land parcels available and ready-to-build. Of particular importance, achieving community economic potential requires maintaining large lots to the extent possible to attract and retain campus-oriented manufacturing and support uses.

These more qualitative and forward-looking portions of a Community Economic Potential review set the stage for resumed quantitative and qualitative analysis of associated employment land needs over 5-, 20- and 50-year planning horizons.

Employment Land Needs

As shown by the graph to the right and detailed in this EOA report, Hillsboro's employment buildable lands inventory (BLI) as of 2020 totaled an estimated 6,210 acres. Of this, 3,753 acres (60%) are **already developed** – with 2,457 acres (40%) as not yet developed. Of the undeveloped acreage, the amended BLI model indicates that approximately 1,232 acres (20% of the total inventory) are identified as **unbuildable** portions of vacant and partially vacant sites due to constraints and future infrastructure set-asides.



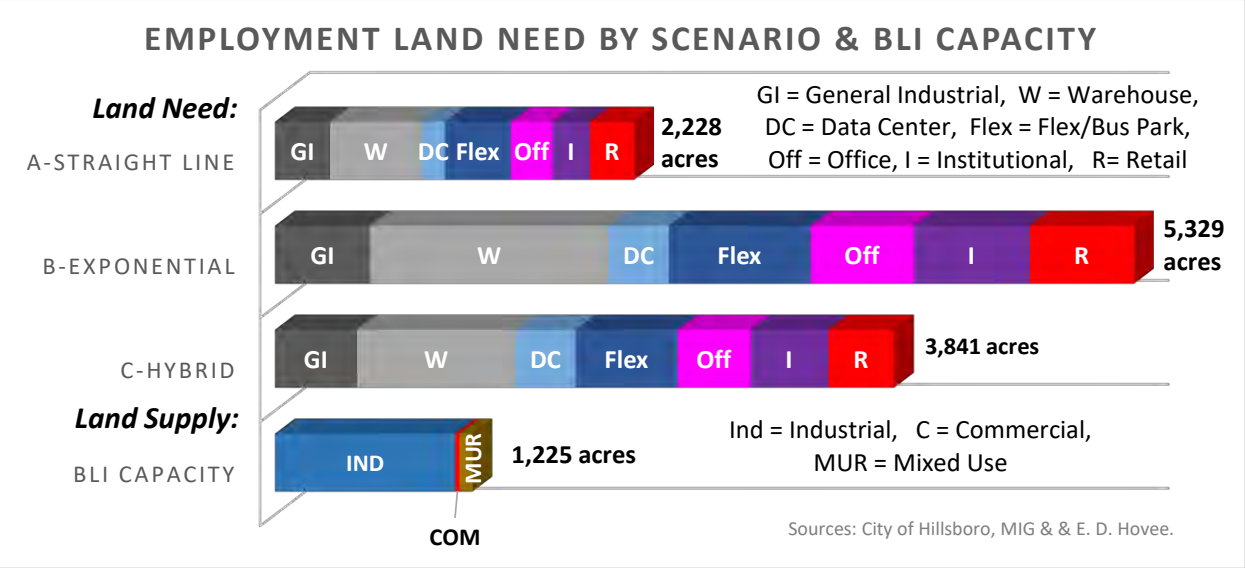
The remaining 1,225 acres (approximately 20% of the total inventory) comprise Hillsboro's currently **remaining buildable area** for employment use. Adequacy of this net buildable employment land inventory to meet projected needs over short- and long-term planning horizons is a major focus of this EOA. The 1,225 net buildable acres result of this refined BLI methodology is 132 acres (10%) less than the 1,357 acres indicated by the previously prepared land inventory as noted with the 2021 EOA. However, "strike-price" analysis (as detailed by Appendix E) of low value already developed parcels indicates that potentially up to 143 acres could be shifted from the category of "developed" to "remaining buildable" area for redevelopment – a nearly 12% increase in remaining buildable (i.e., net employment) acreage. Given the numerous variables that determine whether an individual site will redevelop, including property owner willingness, the availability of other suitable sites, and macroeconomic factors, the 143 acres of potentially redevelopable land was not included in the clearly identified 1,225 acres of remaining buildable area for employment use.

Properties **in the City** comprise 83% of gross acres – both developed and vacant but only 54% of Hillsboro's land for job growth. In effect, realization of Hillsboro's employment opportunity will depend on development of net buildable lands both within and outside current city limits but all in Hillsboro's current UGB – including sites not yet annexed as with the Jackson East area.

In addition to consideration of overall land availability versus needs, an important component of a Goal 9 EOA is to evaluate the adequacy of parcel size distribution. Parcels of 50+ acres comprise only 18% of Hillsboro's current vacant inventory though current trends indicate greater demand for large lots ahead. Employment land needs likely will be further affected in ways not yet fully foreseen by post-pandemic conditions – as for mixed-use development, site utilization, remote work trends, industrial automation including robotization, and e-commerce.

Key components of employment need – for each of three job growth scenarios – can be compared with the primary categories of BLI capacity – industrial, commercial and mixed-use designated lands. Components of land demand are noted across the spectrum of seven distinct building use and three generalized land use types. The chart on the next page depicts a

significant land supply shortfall across all three employment growth scenarios considered. This supply gap affects Hillsboro's future capacity to attract continued investment especially from major employers requiring campus sites. This capacity is further impaired as large parcels are primarily in growth areas outside of Hillsboro's current city limits.



As is further detailed by the Section IV Employment Land Needs portion of this EOA, summary observations from these comparisons are three-fold:

- Forecast land demand over 20 years is 1.8 times existing BLI land supply with Scenario A, more than four times greater with Scenario B and three times greater with Scenario C.
- With the limited supply of BLI capacity comprised primarily of industrially designated land, not only is supply inadequate for potential industrial use but there may be pressure – including potential to realize higher land values – with conversion of some industrial land to commercial development as well as added redevelopment incentive.
- The commercial development that does occur on non-industrial lands is more likely to occur with MUR than COM designated sites.

50-Year Employment Framework

While largely focused on 5- and 20-year forecast scenarios, this EOA also addresses the longer-term horizon of the next 50 years. This is significant for Hillsboro from two perspectives:

- Assuring that there will be adequate economic opportunity not just for the current generation but for the next – by planning now for future urban land reserves
- Being better prepared if employment growth and land needs prove to be greater than expected and planned for within a 20-year Comprehensive Plan time frame

Features and implications of these three forecast scenarios differ more when extrapolated beyond a 20-year to 50-year horizon – as summarized by the chart on the following page.

20-/50-Year EOA Outlook & Implications by Employment Growth Scenario

Feature	A – Straight-Line	B – Exponential	C - Hybrid
20-Year			
2040:20 Jobs	1.44:1	2.02:1	1.73:1
Technology Shift	AI/EV deployment, strong IoT & cloud computing growth, data center needs beyond local BLI capacity	Greatest role in technology testing & manufacture, data center pull-thru; 2nd possible major tech anchor	Captures semiconductor-driven demand across multiple industry sectors and re-shoring priority
Employment Mix	Led by health care/bio-tech & advanced manufacturing	Led by healthcare & distribution, manufacturing & support services	Diversifies to clusters w/ competitive advantage – bio-tech & support sectors
Land Supply	1,225 acres	1,225 acres	1,225 acres
Employment Land Need	2,228 acre need Scenario w/least land need	5,329 acre need Scenario w/most land need	3,841 acre need Focused on target clusters
Gap Strategies	• Reduce jobs forecast • Increased job density • Increased at-home work • Added land supply (Or combined strategies)	Consider same strategies as with Scenario A (Depends more on UGB expansion & economic incentives for site redevelopment)	Similar strategies focused to improve efficiency of land utilization (with monitoring & land triggering tools to capture high value opportunities)
50-Year			
2070:20 Jobs	2:1	6:1	4:1
Technology Shift	Dramatically altered transport & artificial intelligence (AI) including robotization with potential workforce displacement	Hillsboro positioned as a globally-recognized applied tech leader with venture capital & research university infrastructure	Challenge of determining whether & how to broaden or more narrowly define Hillsboro's best industry & service cluster options
Employment Mix	Continued strong manufacturing mix (as major strategic priority)	Greater orientation to service sector (with more urban-scale development)	Continued focus on tech-related industry clustering & support businesses
Land Supply	1,225 acres	1,225 acres	1,225 acres
Land Need	~ 3,200 acre need (if same industry mix as 2040 is maintained)	~15,000 acre need (if same industry mix & density as 2040 is maintained)	~8,700 acre need (focused on target industry & support service clusters)
	(assuming similar industry mix and land demand factors from 2040-70 as from 2020-40)		
Gap Strategies	Similar to a 20-year Scenario B option but over more time (with substantial site redevelopment & opportunity to phase in changes over a 50-year time horizon)	Likely not feasible without substantial UGB expansion (coupled with use prioritization, land use & job/work-at-home intensification)	Requires less UGB expansion than Scenario B (potentially with more targeting of higher density industrial and mixed-use live-work options)

Sources: E. D. Hovee. Preliminary and subject to refinement including with future EOA updates.

Qualitatively, technological change may well have the most profound effects across Hillsboro's economic landscape – in 20 years and yet more so over 50 years. How Hillsboro and the metro region address the gap between land need and supply will affect the question of whether Hillsboro asserts an even stronger position on the U.S. and global stage – or just holds its own.

This EOA clearly indicates that Hillsboro's current inventory of employment lands (including potential growth areas) will not come close to accommodating a continuation of strong local employment growth over the next 20 years. There is a **pronounced shortfall of employment land** with even with a base case Scenario A forecast. The shortfall intensifies with Scenario B or C outcomes and is especially severe for capacity to serve major large campus employers.

Bringing Hillsboro's land availability and needs into alignment may require **substantial adjustments on multiple fronts** – likely involving revisions to forecast outcomes, BLI adjustments and/or supportive state/regional land use policy.

Potential options for consideration include any or some combination of actions to:

- Reduce the EOA employment forecast to match current BLI capacity
- Focus EOA forecast reductions on the most land extensive sectors
- Adjust employment to land need conversion factors toward a more urban profile
- Increase the planned BLI supply, especially for growth areas around Hillsboro
- Pursue Metro region and statewide recognition of Hillsboro's strategic significance to long-term competitiveness and high wage jobs integral to long-term economic vitality

Advantages and disadvantages of these options are further described with the Section V Implementation Policies portion of this EOA report.

Implementation Policies

Hillsboro implementation policies and measures are closely linked to ***2018 Hillsboro Comprehensive Plan*** goals for competitive advantage, facilities/utilities/services, land supply, equity and livability. The more recently adopted Hillsboro ***2035 Community Plan*** focuses on five vision-based initiatives – all related to economic development:

- **Initiative 1:** Promote Hillsboro's business-friendly culture and proactive workforce development initiatives.
- **Initiative 2:** Encourage and support the growth of emerging industries, small business, and the spirit of entrepreneurship.
- **Initiative 3:** Expand shopping, entertainment, and dining destinations.
- **Initiative 4**: Continue efforts to develop a vibrant, mixed-use downtown as a unique attraction.
- **Initiative 5:** Implement efforts to ease congestion in and around Hillsboro.

Recommended EOA implementation policies and measures are outlined by the following chart.

Summary of Recommended EOA Implementation Policies & Measures

EOA Topic	Implementation Measures
Employment Land Use	✓ As a minimum measure, adopt a 20-year jobs and land use forecast similar to Scenario C Hybrid Growth ✓ Annex and serve added employment land as needed to meet at least the 5-Year Scenario A Straight-Line short-term supply requirement ✓ Utilize the Scenario B forecast as an initial means to begin determination of longer-term needs for added industrial reserves and land capacity ✓ Provide more opportunity to accommodate both exclusive industrial zones and mixed-use development ✓ Provide opportunity for large acreage, major employer campuses of up to 600+ acres consistent with national trends but not readily available regionally in Oregon ✓ Orient state and local incentive measures to support increased employment land utilization and redevelopment together with attraction and retention of target industries
Transportation & Utility Infrastructure	✓ Target added local transport and utility infrastructure in conjunction with annexation to meet short-term employment land supply forecasts ✓ Provide explicit policy support for a regional transportation system that effectively supports the movement of raw materials, manufactured goods and workforce to and through Hillsboro's employment areas ✓ Increase policy emphasis on north-south access and reduction of work-force commutes (to maximize Hillsboro's work-force commute-shed accessibility) ✓ Provide explicit policy support to further strengthen Hillsboro's competitive advantage as a Pacific Northwest data hub for low latency, data intensive firms offering high "pull-through" potential
Target & Supporting Industry Clusters	✓ Periodically modify and update Hillsboro's current target industry listing to reflect and serve new or emerging traded sector industry opportunities in the years ahead ✓ Retain existing businesses including those at risk of displacement from pandemic and/or economic downturn ✓ Add policy language to expand business opportunities for minority- and women-owned businesses ✓ Add a policy priority for community amenities that support traded sector business investment, talent recruitment/retention and high wage job potential
Workforce Readiness	✓ Include retraining emphasis for employees displaced in times of economic disruption and transition ✓ Add policy language to expand employment opportunities for under-represented members of the community including racial/ethnic minority groups, women and veterans ✓ Coordinate with Washington County to evaluate the most effective Workforce Board arrangements in support of community workforce needs ✓ Support efforts to create new workforce development programs meeting the needs of target and emerging industries ✓ Pursue designation as a Center of Innovation Excellence and Regional Technology Hub to support Hillsboro's leadership role in research and development with expanded benefits and opportunities to the community

Summary of Recommended EOA Implementation Policies & Measures

EOA Topic	Implementation Measures
Economic Development Incentives	✓ Provide a more prominent position for incentive mechanisms as integral to supporting or facilitating achievement of economic goals and policies ✓ More specifically include incentives as a means to leverage increased density with uses that currently are associated with relatively low job per acre counts ✓ Advance incentives focused on land readiness together with land aggregation as needed for industrial expansion and recruitment
Partnership Opportunities	✓ Include urban renewal as a potential economic development funding tool within designated renewal districts ✓ Add policy language to more explicitly encourage Metro and state-wide support for Hillsboro tech-focused economic development as an economic engine of significance and benefit regionally and statewide

Implementation policies and measures are made consistent with the EOA recommendation for adoption of an economic strategy supportive of Scenario C Hybrid Growth. Recommendations also are consistent with adoption of the *CHIPS and Science Act of 2022* and with parallel August 2022 findings and recommendations of the Oregon Semiconductor Competitiveness Task Force.

Recommended policies and measures also are aimed to reinforce adopted City-wide planning priorities and identify new initiatives as appropriate near-term with continued pandemic and associated economic recovery – as well as better assuring longer term economic resilience and community vitality going forward over 20-year and longer-term 50-year time horizons.

I. HILLSBORO EOA INTRODUCTION

This report provides an updated Economic Opportunities Analysis (EOA) for the City of Hillsboro. This EOA addresses conditions of rapid employment growth in recent years including changing conditions prior and immediately subsequent to the 2020 COVID pandemic, together with an associated land needs analysis.

EOA BACKGROUND & PURPOSES

As with other cities throughout Oregon, an EOA is intended to serve two related purposes:

- Clearly articulate community priorities for economic development over a 20+ year planning horizon – for jobs, employment land needs, business and associated infrastructure development
- Address requirements of Oregon Land Use Planning (Goal 9) and Metro regional determinations of Urban Growth Boundaries (UGBs), as reviewed every six years

Prior to this updated analysis, an earlier EOA report was completed in 2017 and then adopted by the City of Hillsboro and subsequently acknowledged by the state in 2018. Work on this updated EOA was initiated in 2019, then revised to reflect COVID-related experience and post-pandemic emerging trends. The updated EOA provides both pre- and post-pandemic information as well as more detailed specification and updating of recommended implementation measures – ranging from local initiatives to recommendations for added employment land in Hillsboro as an *economic engine* for the city, Metro region and state.[1]

COMMUNITY ECONOMIC DEVELOPMENT OBJECTIVES

In addition to the EOA, there are two primary documents that serve to frame community economic development objectives for the City of Hillsboro – the 2018 *Hillsboro Comprehensive Plan* and the *Hillsboro 2035 Community Plan*.

Hillsboro Comprehensive Plan

Chapter 11 of the *Hillsboro Comprehensive Plan* addresses **Building Economy & Infrastructure** with the goal statement stating that:

> Hillsboro's world class economy, advanced technical training, and innovative, business-friendly culture attract investments and support businesses of all sizes. The city boasts a diverse and sustainable employment base, with jobs accessible to all community residents. State of the art infrastructure systems including communications, roads, transit, and water supply are in place and continually updated to accommodate the city's growth and evolution. Hillsboro is a vibrant, regional destination for arts, recreation, cuisine, and entertainment.

The Comprehensive Plan addresses five goals, each of which is supported by more specific and detailed policy and implementation measures – with the goal statements reading as follows:

- **Goal 1 – Competitive Advantage:** Diversify and expand the economy to give Hillsboro, the region, and the state a competitive advantage.
- **Goal 2 – Facilities, Utilities & Services:** Catalyze economic development through high-quality public facilities, utilities and services.
- **Goal 3 – Land Supply:** Manage land supply to meet short and long-term economic development needs of Hillsboro, the region, and the state.
- **Goal 4 – Equity:** Promote economic development opportunities for individuals and small and emerging businesses to ensure equitable access to resources.
- **Goal 5 – Livability:** Develop and sustain a vibrant City to support economic development.

Hillsboro 2035 Community Plan

Building on the success of the original award-winning *Hillsboro 2020 Vision and Action Plan*, in 2020 the City completed an updated *Hillsboro 2035 Community Plan* as representing "a shared vision for a sustainable future."[2] **Economy and Infrastructure** comprises the first of five focus areas for 2035 accompanied by a goal statement representing continued high aspiration:

> Hillsboro's world-class economy, advanced technical training, and innovative, business-friendly culture attracts investment and supports businesses of all sizes. State of the art infrastructure systems including communications, roads, transit, and water supply are in place and continually updated to accommodate the city's growth and evolution. Hillsboro is a vibrant, regional destination for arts, recreation, cuisine, and entertainment.

Five supportive initiatives and actions are detailed as part of the updated Community Plan:

- **Initiative 1:** Promote Hillsboro's business-friendly culture and proactive workforce development initiatives.
- **Initiative 2:** Encourage and support the growth of emerging industries, small business, and the spirit of entrepreneurship.
- **Initiative 3:** Expand shopping, entertainment, and dining destinations.
- **Initiative 4**: Continue efforts to develop a vibrant, mixed-use downtown as a unique attraction.
- **Initiative 5:** Implement efforts to ease congestion in and around Hillsboro.

This updated EOA aims to both reinforce adopted City-wide planning priorities and to identify potential new initiatives as appropriate to facilitate economic recovery and resilience for Hillsboro and the metro region going forward.

EOA Approach & Report Organization

This EOA has been prepared to address planning requirements of Oregon's Division 9 LCDC Economic Development guidance, with particular attention to:

- OAR 660-009-0015 for economic opportunities analysis
- OAR 660-009-0020 for industrial and other employment development policies
- OAR 660-009-0025 designation of lands for industrial and other employment use

EOA Approach

While a primary focus of the analysis is on determination of 20-year employment land needs, the EOA analysis also addresses the short-term land supply deficiencies associated with 25% of the long-term need. Also considered is a longer 50-year planning horizon. Added attention is given to land needs not met within the current urban growth boundary (UGB) as within the purview of Metro for potential boundary expansion.

Work on this EOA update was initiated in the last half of 2019 just prior to the pandemic and associated economic downturn of 2020. EOA completion was then suspended through the early stages of the pandemic with EOA preparation resumed in the autumn of 2020. Much of the economic data has been maintained as of the time of the initial work, due to specialized data runs but representative of trends over the most recent economic cycle.

Qualitative data regarding community economic potential is updated to reflect pre- and post-pandemic conditions. A buildable lands inventory (BLI) based on data from December 2020 was prepared together with analysis of industrial land demand through the pandemic and recession.

Report Organization

The remainder of this report is organized to cover the following topics:

- **Employment trends and outlook** – focused on Hillsboro in the context of regional to national experience prior to the COVID-19 pandemic and with recovery to date
- **Community economic potential** – incorporating stakeholder interview input together with analysis of Hillsboro's changing competitive position and target industry clusters
- **Employment land needs** – reflecting an updated employment buildable lands inventory as compared with employment-driven land need and associated site size requirements over the next 20 years and as might be realized over a longer-term 50-year plan horizon
- **Implementation policies** – addressing key drivers of economic recovery and resilience together with recommended implementation policies and related measures

This EOA report is organized to cover highlights of the full analysis. Standing behind the analysis is supporting research provided as a separate and more detailed Technical Appendices document with references as appropriate in this report. This EOA also references statewide and federal initiatives affecting economic opportunities taken over the summer of 2022.

II. EMPLOYMENT TRENDS & OUTLOOK

In cooperation with the Oregon Employment Department (OED), it has been possible to assemble a consistent employment dataset in recent years for the City of Hillsboro in comparison to trends experienced for the 7-county Portland metro region. Topics covered are:

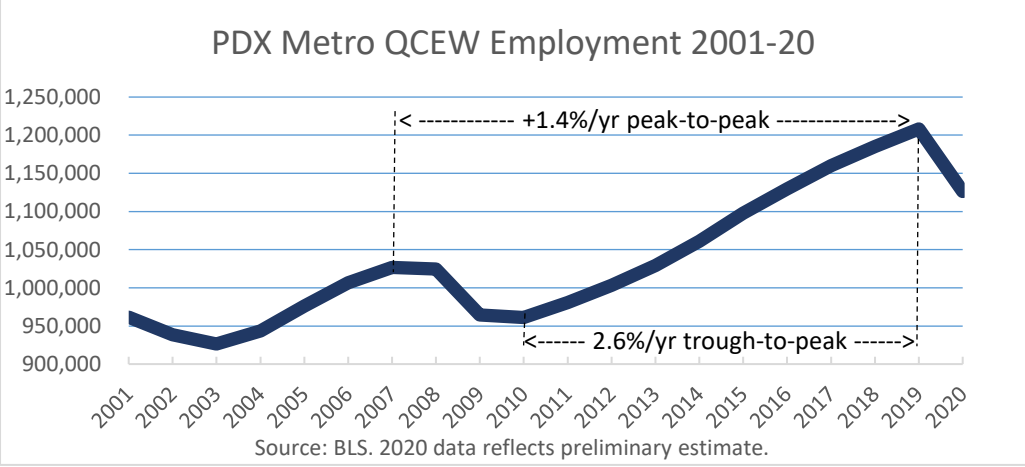
- **Metro Region Employment Trends** – focused on experience of the last economic cycle
- **Hillsboro Employment Trends** – for top employers and by employment sector
- **Shift-Share Analysis** – as a means to assess comparative advantage with the metro area
- **Employment Forecast Scenarios** – for straight-line, exponential or hybrid job growth

Trend data evaluated for the City of Hillsboro and the 7-county Portland-Vancouver-Hillsboro metropolitan statistical area (MSA) for 2007 and 2018 was compiled from the **Quarterly Census of Employment and Wages (QCEW)** by the Oregon Employment Department (OED). This data is for jobs covered by unemployment insurance, excluding some workers as with sole proprietors.

This dataset reflects experience from a peak employment year in advance of the Great Recession of 2007-09, followed by subsequent change through 2018 in advance of the COVID-19 pandemic and associated economic downturn of 2020. More detailed technical documentation for this employment analysis is provided by Appendix A to this EOA report.

METRO REGION EMPLOYMENT TRENDS

Evaluation of employment trends begins with a review of employment change for the full 7-county Portland-Vancouver-Hillsboro MSA. As depicted by the following graph, as of 2019 there were an estimated 1.2 million QCEW covered workers employed region-wide, followed by an approximate 7% decline averaged across the full year of 2020.



Since the Great Recession, metro wide employment increased by 25-26% from the 2010 low point of 961,000 persons employed, equating to an annual average compound annual growth

rate of (CAGR) of 2.6% per year through 2019. When considered from the last employment peak of 1.03 million in 2007 to the more recent annual 2019 peak of 1.21 million, employment region-wide has experienced a net increase approaching 18%, equating to a job growth rate approaching 1.4% per year.

A *peak-to-peak* analysis offers the logical benefit of calculating job growth over the time period of what appears to be approaching a full economic cycle. In effect, the ups and downs are averaged out over this business cycle. Consequently, the years 2007 and 2019 could serve as primary employment benchmarks for this updated EOA analysis – for Hillsboro as well as for sustained economic vitality of the greater metro region.

In this case, due to availability of customized OED data runs specific to Hillsboro prepared as of late 2019 for full-year data then available through 2018, a similar 2007-18 average growth rate also in the range of 1.3-1.4% per year has been applied for this analysis. This is also consistent with a somewhat greater fall-off of employment in 2020 than occurred in the prior trough years of 2008-10.

HILLSBORO EMPLOYMENT TRENDS

This analysis now shifts to consideration of employment trends specific to Hillsboro. Topics reviewed include consideration of Hillsboro's top employers, employment trends, employment by sector and manufacturing focus. As of a 2018 benchmark year, Hillsboro firms accounted for 88,980 jobs.

Hillsboro's Top Employers

While detailed data reflects experience of the local and regional economy pre-pandemic, it is useful to begin with a review of more recent job counts associated with Hillsboro's major employers as of the first quarter of 2021. As indicated by the listing on the following page, 18 Hillsboro firms account for an estimated 35,180 jobs as of early 2021. These firms range in size from 400 to over 21,000 employees.

Unlike the rest of the region for which employment had yet to recover to pre-pandemic levels (as of mid-2021), these 18 firms have experienced a net increase of over 2,000 jobs in a little over a year from October 2019 to the first quarter of 2021, an increase of 6%. Seven of the 18 companies account for this employment gain, with the other 11 remaining stable or with minor reductions in job counts.

Twelve of the 18 firms are directly connected to semiconductor, high tech research/support and bio-tech sectors. The other six include firms in apparel and food manufacture, health care and financial services.

Accounting for about 40% of Hillsboro employment, these top employers provide an economic foundation of good paying/high wage jobs, supporting the economic vitality of the metro area and state as well as for the immediate Hillsboro community.

Hillsboro Top Employers (2021 Q1)

Employer	Business Product/Services	Employment
Intel	Designs & manufactures semiconductor integrated circuits	21,394
Kaiser Permanente	Hospital, medical offices, call center	2,405
Nike Inc.	Administrative offices	1,850
Wells Fargo	Customer service center	1,800
Qorvo	Supplies high performance modules & components for the communications industry	1,085
First Tech Credit Union	Regional headquarters, financial services, customer service center	744
Genentech	Bio-tech firm that develops, manufactures & commercializes medicines	606
Tokyo Electron America	Semiconductor production equipment	600
Standard Insurance	Customer service center	550
ASML	Supplies high performance modules & components for the communications industry	527
Oregon National Primate Research Center	One of seven national NIH centers with basic research emphasis on primate colonies	520
Applied Materials	Semiconductor chips, flat panel displays, flexible electronics & energy efficient glass	500
Jireh Semiconductor	Manufactures semiconductor devices	480
Oracle America	Produces computer electronics & support systems	453
Salesforce.com	Customer relations software	446
Acumed	Orthopedic implant manufacturers; bond fracture fixation & fusion solutions	415
Reser's Fine Foods	Food processing company making a variety of sides, salads & deserts	405
Cinder Staffing	Tech staffing services	400
	Total - 18 Firms	**35,180**

Source: City of Hillsboro Economic Development.[3]

As has been noted by the City of Hillsboro website, Oregon has the fourth-highest concentration of computer and electronics companies in the U.S. Intel tops this list but there is also a clear network of supporting tech infrastructure and with pivotal supply chain linkages. This extends beyond the list of top employers to include a range of other tech-related firms – including communications, software, information technology and data centers together with advanced manufacturing, bioscience and medical device companies.

Taken together, this tech cluster has given Hillsboro and Oregon global recognition as *The Silicon Forest.*

Employment Trend (2007-18)

This EOA now turns to a broader review of employment activities across all economic sectors, extending over the period of the last U.S. and regional economic cycle prior to the COVID pandemic. As noted, the EOA analysis relies on data of the Oregon Employment Department (OED) compiled for QCEW employees covered by unemployment insurance.

As of 2018, Hillsboro had a covered count of approximately 88,980 employees. Hillsboro has accounted for an estimated 6.8% of the region's employment. By comparison, with a population of 101,920 as of 2018, Hillsboro represented 4.1% of the metro area's population of nearly 2.5 million. This illustrates the extent to which the city serves as a regional job magnet.

For the 2007-18 benchmark period, employment in Hillsboro increased by nearly 30%, almost double the just over 15% increase in regional-wide employment. Annual payroll of Hillsboro firms averages $87,635 per job, 46% above the average per job wage of $59,900 region-wide.

In effect, these overview statistics indicate that Hillsboro makes disproportionately high contributions to the region's economic vitality, evidenced by:

- Accounting for 1.66 times the share of the region's job versus population base.
- Experiencing a rate of employment growth over the prior 11 years double that of the rest of the region.
- Serving as home to firms that pay 46% above the average wage across the metro region.

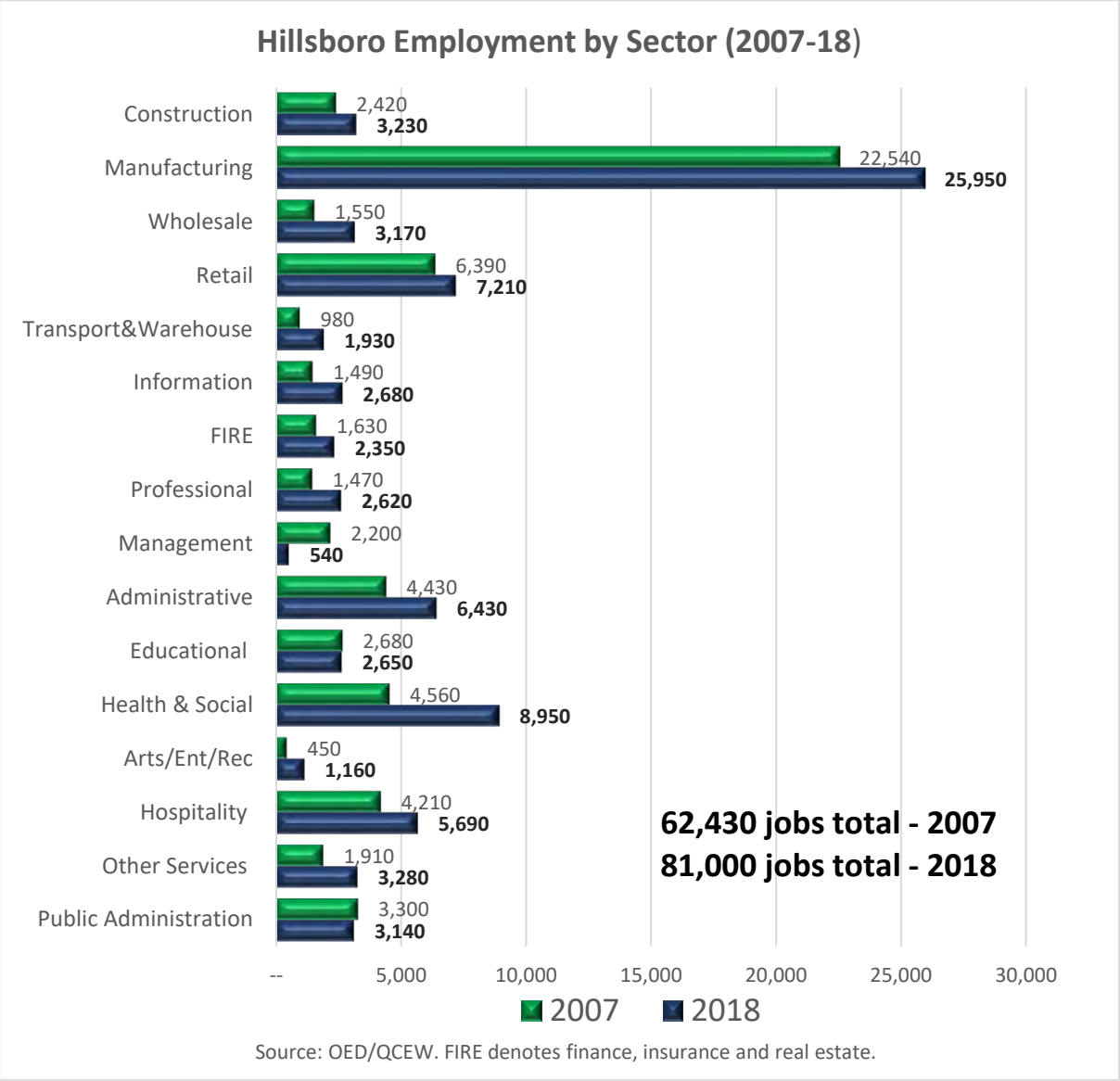
Employment by Sector

What stands out is the dominant role played by manufacturing in Hillsboro's economy. With 29,950 jobs, manufacturing accounted for 32% of all employment in Hillsboro as of 2018. By comparison, manufacturing has represented only 11% of the job count metro-wide.

From 2017-18, manufacturing jobs locally increased by 3,400 (+15%) as compared with manufacturing job growth of only 1% for the full 7-county metro region. Excluding Hillsboro, the rest of the metro area experienced a net loss of 1,800 manufacturing jobs pre-pandemic.

Most other sectors of the Hillsboro's economy also have experienced increasing employment since the pre-recession peak of 2007. Health care and social assistance experienced an increase of 4,390 jobs – outpacing the gains even of manufacturing employment in absolute numbers. Significant employment growth – of more than 1,000 net new jobs each – also was experienced in the sectors of wholesale trade, information, professional services, administrative services, accommodation and food services, and other private services.

In percentage terms, the biggest gains are noted for arts, entertainment and recreation – up by over 150%. One sector – management of companies and enterprises – is noted as having experienced a net reduction of nearly 1,660 jobs. Other sectors experiencing minor job losses of about 200 or less apiece are ag/mining/utilities, educational services, and public administration.



Source: OED/QCEW. FIRE denotes finance, insurance and real estate.

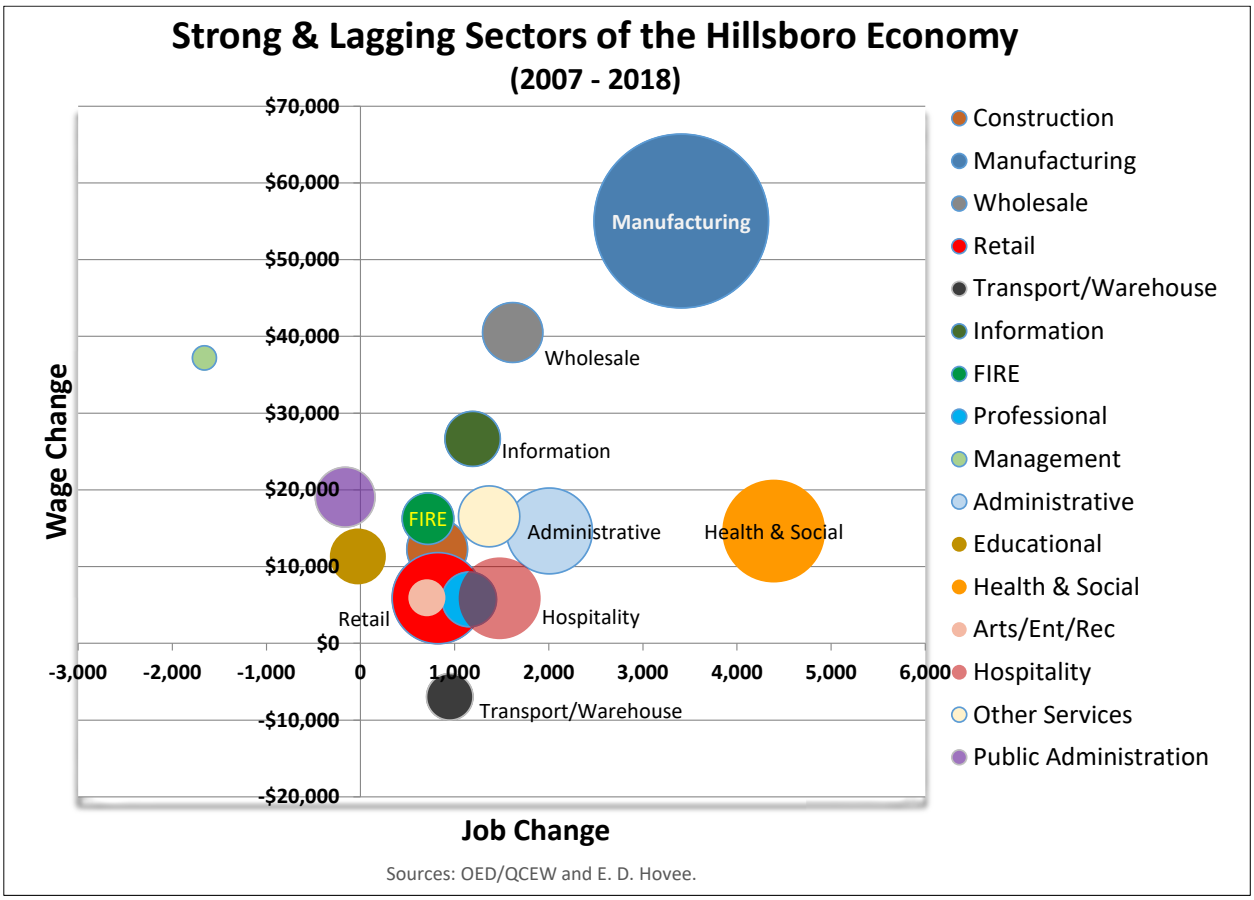
The number of firms increased across every category – except manufacturing which appears to have experienced some industry consolidation despite strong job growth. Average wage levels increased by nearly $26,000 per worker (or 42%) across all Hillsboro employment sectors. This compares with a $15,600 average wage gain (+35%) across the full 7-county metro region.

The most significant wage growth occurred with Hillsboro's manufacturing sector, up by over $55,000 (from a per worker average of $97,000 in 2007 to $152,000 in 2018). Other strong wage gains of $35,000+ are noted for wholesale trade and management of companies. The only sector for which average wage decline is noted is with transportation and warehousing.

Strong & Lagging Sectors

Much of this analysis of sectoral economic performance can be visually brought together as represented by the graphic shown below. For each of 16 major employment sectors, information is provided for:

- **Job change** – shown on the *X-axis* of the graph to depict the numerical change in sectoral employment from 2007-18.
- **Wage change** – showing on the *Y-axis* the change in average annual wage per employee.
- **Relative scale of employment** – illustrated by the *size of the circles* representing number of employees as shown for each of the 16 sectors portrayed.



Where space on the graphic permits, key sectors are labelled for ease of reference. As illustrated, a number of Hillsboro sectors are clustered in the lower left portion of the chart – for sectors of varied sizes but with similar levels of limited job and wage gain. These are sectors that experienced relatively low growth in employment and wage levels from 2007-18.

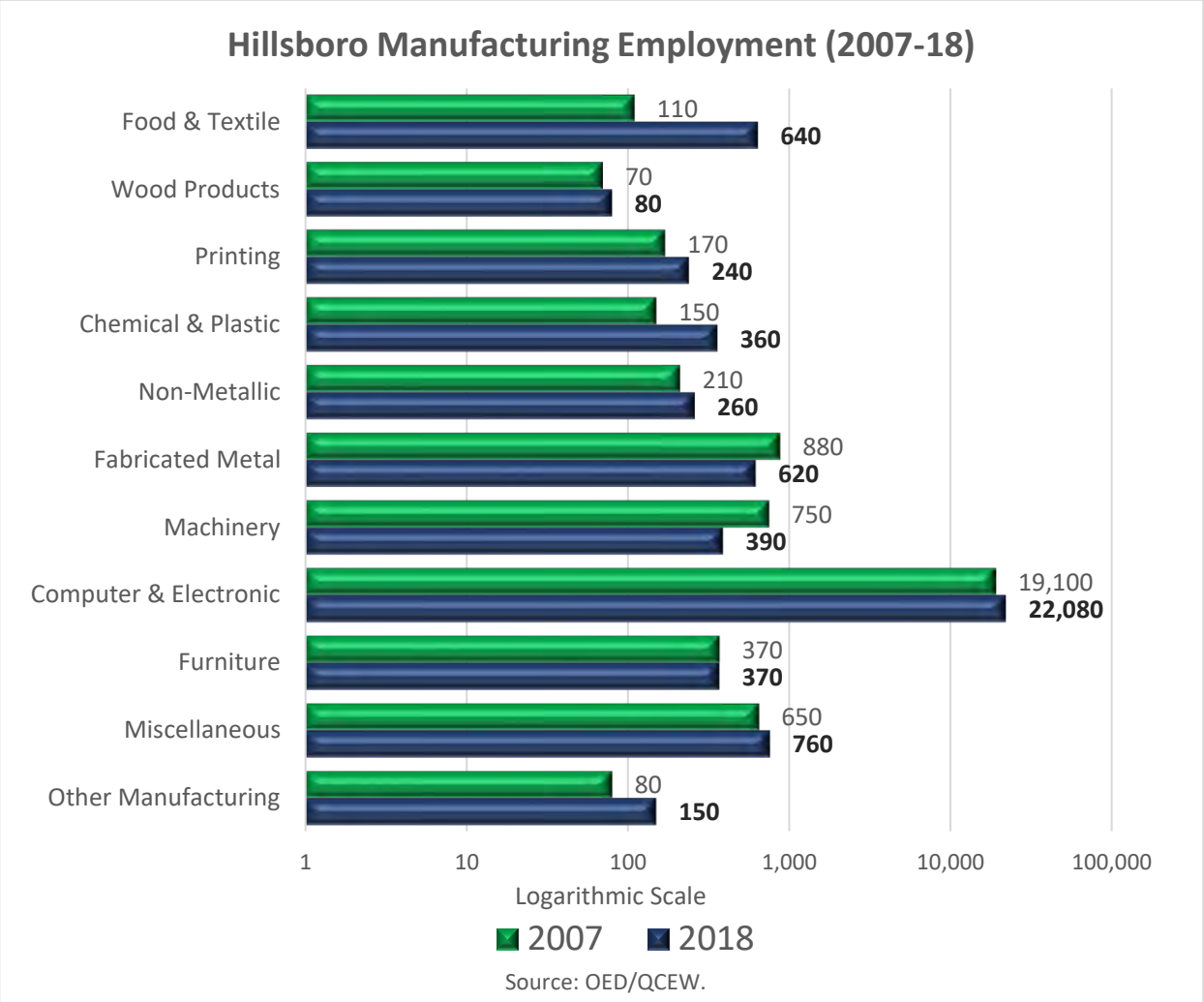
The standout performer in terms of wage gain and current employment size is manufacturing. Health and social care is noted as the #1 performer in terms of job growth from 2007-18.

While relatively smaller in size, wholesale trade and information are each noted for strong wage growth – although transportation/warehousing is indicated for a decline in average wage levels. Public administration and educational services appear to have been in relative no-growth modes locally while management of companies is the only sector for which significant loss of employment is noted (due in large part to a business NAICS reclassification).

Manufacturing Focus

Due to its outsize importance in Hillsboro, a more detailed look at the manufacturing sector is warranted for this EOA. Based on aggregation of data by OED (to avoid disclosure of proprietary data), information as to the number of firms, employment and payroll information is provided for 11 subsectors of manufacturing activity in Hillsboro.

As was done with consideration of all employment, a graph depicting the sectors with manufacturing employment is provided below – including illustration of employment in 2007 and 2018. Note that the scale of X-axis employment with this chart is **logarithmic,** due to the outsize role of computer and electronic manufacturing.



With 22,080 employees as of 2018, a combined computer and electronics sector is accounting for 85% of the manufacturing jobs in Hillsboro – far out-pacing all other manufacturing categories.

From 2007-18, computer and electronic equipment accounted for 2,980 added jobs – 88% of the manufacturing increase of 3,410 jobs. While much smaller in scale, it is noted that job gains were experienced by seven other sectors – led by food and textile manufacturing with a net gain of 525 employees.

Employment growth also was experienced in chemical/plastic, printing, non-metallic, wood products, miscellaneous and a handful of other manufacturing sectors. Some of these sectors appear to have clear inter-industry relationships – especially as vendors – to the dominant computer/electronic cluster. The only employment losses noted were with machinery and fabricated metals – down by 360 and 260 employees, respectively.

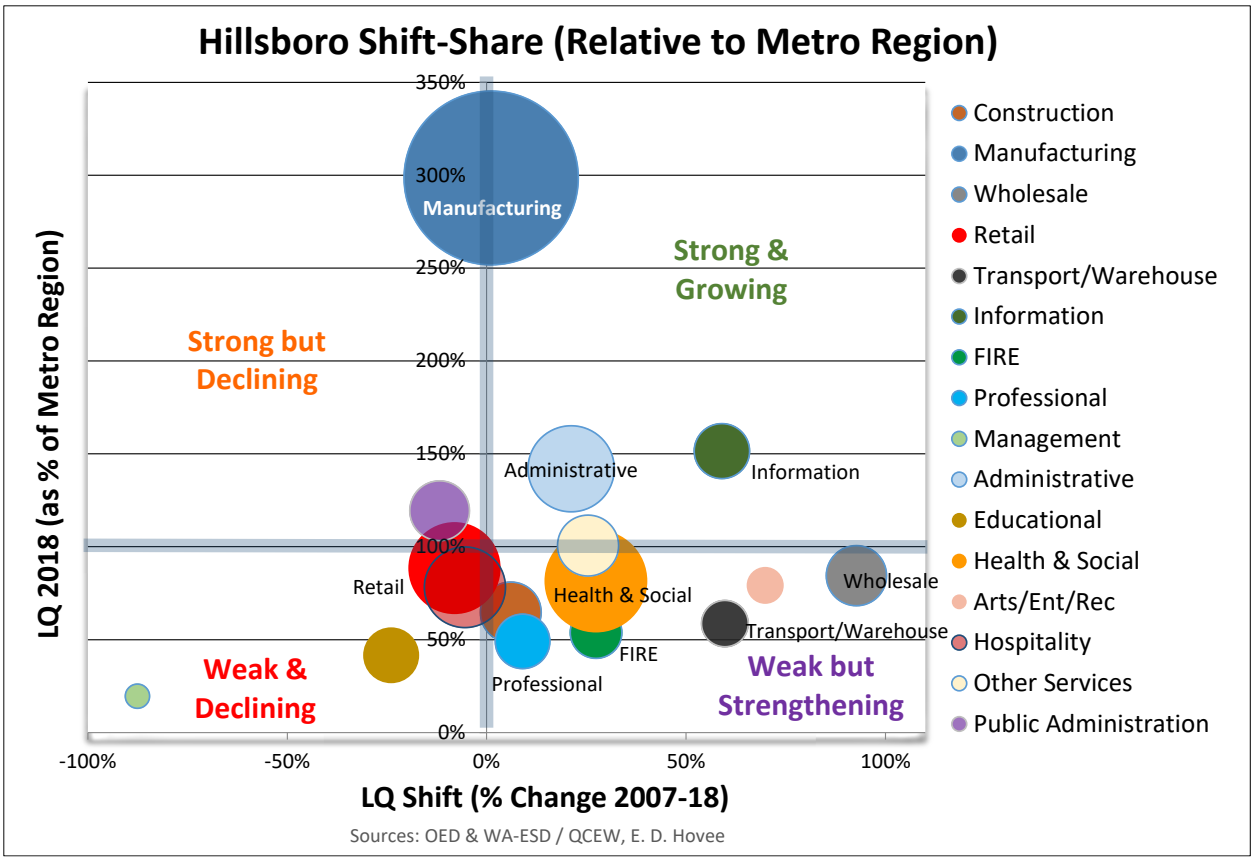
Overall, Hillsboro manufacturing wages averaging $151,700 per worker were 86% above the average manufacturing wage of $81,700 as of 2018 for the Portland MSA. While due in large part to the dominance of computer/electronics manufacturing, it is also the case that Hillsboro wages are above MSA-wide industry-specific averages for printing, chemical, non-metallic, furniture and miscellaneous manufacturing.

SHIFT-SHARE ANALYSIS

As an added step, it is useful to consider the current and changing competitive relationship between key clusters of economic activity in Hillsboro relative to the metro region. One way of presenting this information is by way of what is termed as **shift-share** analysis. With the graphic on the next page, the following information is illustrated for each of 16 major employment sectors:

- **Location Quotient (LQ)** – illustrated on the *Y-axis* of the graph to depict the concentration of a sector in Hillsboro vis-à-vis the metro region. (An LQ above 100% indicates above average local job concentration).
- **LQ Shift (2007-18)** – shown on the *X-axis* as the % change in sectoral LQ from 2007-18.
- **Relative size of employment (2018)** – as depicted by the *size of the circles* shown for each sector.

In terms of total employment, Hillsboro's most prominent sector is manufacturing at nearly 26,000 jobs – equating to 32% of total employment city-wide. Manufacturing has nearly three times the job count of health and social services (with nearly 9,000 jobs) as the city's second largest source of employment. The other major standouts – in terms of job count – are the sectors of retail, administrative and hospitality services which each account for between 5,700-7,200 jobs per sector.



These sectors may be further distinguished by their current and changing LQ as follows:

- **Strong and growing** – for sectors with above average and increasing industry concentration relative to the metro region (including manufacturing, information, administrative and other service sectors).
- **Strong but declining** – for sectors with above average but declining Hillsboro industry concentration (currently noted only for public administration).
- **Weak & declining** – describing sectors that have below average and declining industry concentration (including retail, management, educational and hospitality services).
- **Weak but strengthening** – for sectors with below average but improving industrial concentration (including construction, wholesale trade, transport/warehousing, FIRE (or financial/insurance/real estate), professional, health/social, and arts/entertainment/recreation services).

By far and away, manufacturing is the employment sector with the highest local concentration, comprising 32% of employment in Hillsboro versus 11% metro-wide – for an LQ that is nearly 300% of (or three times) the region-wide manufacturing representation. However, Hillsboro appears to have plateaued out with its manufacturing LQ – increasing by only about 1% from 2007-18. Strong gains in computer/electronic products have been offset by slow or declining performance in some other manufacturing sectors (as further considered below).

Looking beyond manufacturing, the other high performer in the **strong and growing** quadrant of the shift-share chart is information (with an LQ of over 150% and positive 11-year shift of nearly 60%). Also noted is the healthy performance of administrative services (with LQ of over 140% and LQ shift of +20%). Other services (largely personal services) lie at 101% of the regional share but with a noticeable positive 25% shift in regional share over the last decade.

As the only **strong but declining** sector, public administration (as a portion of governmental activity) has an LQ that is about 120% of the regional average (as of 2018), but with a 12% negative LQ shift since 2011.

Of the four **weak and declining** sectors, three are clearly linked to local consumer or population-driven services – retail, educational, and hospitality (covering both dining and lodging). Hillsboro residents and businesses clearly exhibit some tendency to obtain a large share of these services outside of the immediate community. The fourth weak and declining sector involves management of companies and enterprises – with an LQ of 20% (lowest of all employment sectors). Despite Hillsboro's strong manufacturing base, these functions appear to have gravitated pre-pandemic more toward Portland's central business district,

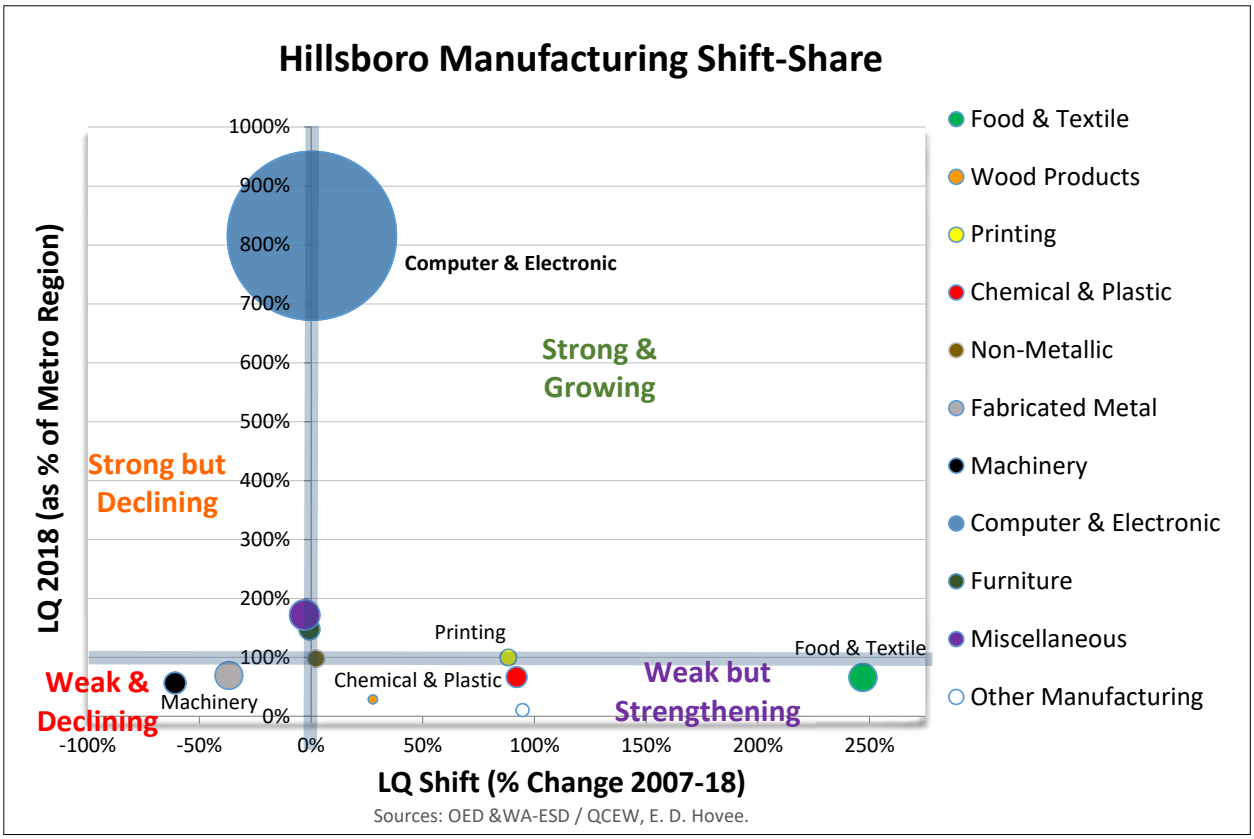
Seven of 16 employment sectors fall into the **weak but strengthening** quadrant of the shift-share chart. Three of these sectors have experienced a strong positive LQ shift of 60% or better since 2007 – wholesale trade, transportation/warehouse and arts/entertainment/recreation. Two of these sectors are bolstered by proximity to Hillsboro's manufacturing center while growth in arts-related activity reflects a maturing, more diverse and more affluent community. The other four sectors – construction, finance/insurance/real estate (FIRE), professional and health/social services – are also seeing some positive LQ change but not to the same extent (in percentage terms).

In terms of the **number of jobs**, employment in health and social service activities represents the single largest job gainer of Hillsboro's 16 employment sectors over the last decade. However, health care employment has also increased rapidly across the full metro region – leaving Hillsboro with a 25%+ positive LQ gain (but still 28% below the region-wide average job share as of 2018).

More on Manufacturing

As illustrated by the following graph, it is also possible to portray shift-share findings associated with Hillsboro's manufacturing sectors. As clearly depicted by the graph on the next page, manufacturing in Hillsboro is dominated by computer and electronic related products.

Other manufacturing sectors are not as readily discerned, by comparison. This is due to the much lesser employment counts together with less dominant location quotients (relative to the rest of the 7-county metro region).



However, there are important distinctions to be made between the four quadrants of the chart:

- **Strong and growing** sectors have been limited (barely) to computers/electronics and printing. Computer/electronic manufacturing has an LQ of over 800%, meaning that this industry has more than 8 times the representation in Hillsboro than throughout the rest of the metro region. However, the industry has experienced essentially zero shift (neither negative nor positive) since 2007. This means that the pace of job growth (in percentage terms) for Hillsboro is being matched by other firms region-wide – albeit from a much smaller base of historic employment activity.

  Printing has an LQ of 100% meaning that Hillsboro has neither more nor less of this industry's employment concentration than the rest of the metro region. However, there has been a positive shift of 88% since 2007 as a weak but strengthening sector, meaning that this industry has come from a limited local presence to play a more significant role for Hillsboro in recent years.
- **Strong but declining** activity is noted for furniture making and miscellaneous manufacturing. To date, the regional share declines are relatively modest vis-à-vis similar firms region-wide.
- **Weak and declining** sectors include fabricated metals and machinery – both of which have lost employment in Hillsboro since the economy peaked pre-recession in 2007.
- **Weak but strengthening** performance is noted for five manufacturing sectors – including food/textile, wood products, chemical/plastic, non-metallic, and other

manufacturing. These are all relatively small sectors – ranging in size from wood products with less than 80 employees to food/textile manufacturing at a combined total about 640. The biggest positive shift relative to the rest of the region is noted for food/textile manufacturing with a Hillsboro LQ increasing by 250%. Another strong positive shift is noted for Hillsboro's chemical, plastic (and rubber) industry – up by over 90% relative to the rest of the metro area since 2007.

Shift-Share Implications

To summarize, four overview observations are suggested by this shift-share evaluation:

- The economy of Hillsboro functions quite differently from the rest of the region – less affected by metro-wide growth factors and more by **competitiveness** of the city's key computer and related electronic products within much broader domestic and international markets.
- While there are early signs of **economic diversification** with complementary producer functions taking hold in Hillsboro, it remains unclear as to whether and how these will emerge to also exhibit substantial comparative advantage relative to the rest of the metro region in the years ahead.
- The production side of the local economy has tended to fare better and more competitively than the **consumer economy** which has lagged behind – with the noted exception of a potential break-through arts/entertainment/recreation sector. Whether and in what fashion consumer-driven retail, hospitality and service functions emerge as the community further matures likely depends on marketplace competitiveness together with pandemic resilience as well as public planning and policy response.
- Looking ahead, Hillsboro's economic potential likely remains more tethered to **global technology and market influences** together with local supply initiatives than is the case for much of the rest of the Portland metro region. Continued success with the path taken to date is by no means assured. Taking advantage of this distinct opportunity will nonetheless depend on cooperative regional initiatives, recognizing Hillsboro's role as a competitive and dynamic economic engine for growth, both regionally and statewide.

These implications (and caveats) are important as this report now transitions to consider future economic opportunity – in the context of anticipated continuing employment growth.

EMPLOYMENT FORECAST SCENARIOS

With many communities, there may be multiple scenarios of future economic pathways and outcomes to consider. The challenge lies in adequately understanding the regional economic environment in which the community is working, then pulling the right mix of public policy and private investment levers that will come closest to achieving desired outcomes.

In Hillsboro's case, potentially viable scenarios appear to be shaped more by forces external than internal to the metro region or state of Oregon. Consequently, potential forecast

alternatives for Hillsboro are driven by extrapolation of documented local trends, then checking these as appropriate against regional forecasts for a sense of forecast reasonableness.

Boundaries of the External Drivers?

To begin, it is useful to reflect on the experience of the Great Recession of 2007-09 and ensuing recovery as a potential backdrop for future expectations. Consistent with key drivers of the Hillsboro economy, this discussion considers recent trends and forecast implications – going from the macro to micro level across four metrics:

- Starting with total employment
- Proceeding to manufacturing employment
- Then with more exclusive focus on computer/electronics as a proven job driver
- And add information as an emerging driver of Hillsboro job growth going forward

The chart to the right depicts the extent to which the U.S. and Portland metro economies had recovered post-2007 (at the peak of last economic cycle) to 2018 (just prior to the most recent downturn). As indicated by the chart, the Portland MSA recovered to exceed U.S. recovery and pre-recession levels across all four metrics considered. As late as 2018, job counts nationally had yet to exceed pre-recession levels for manufacturing including computer/electronics and the information sector.

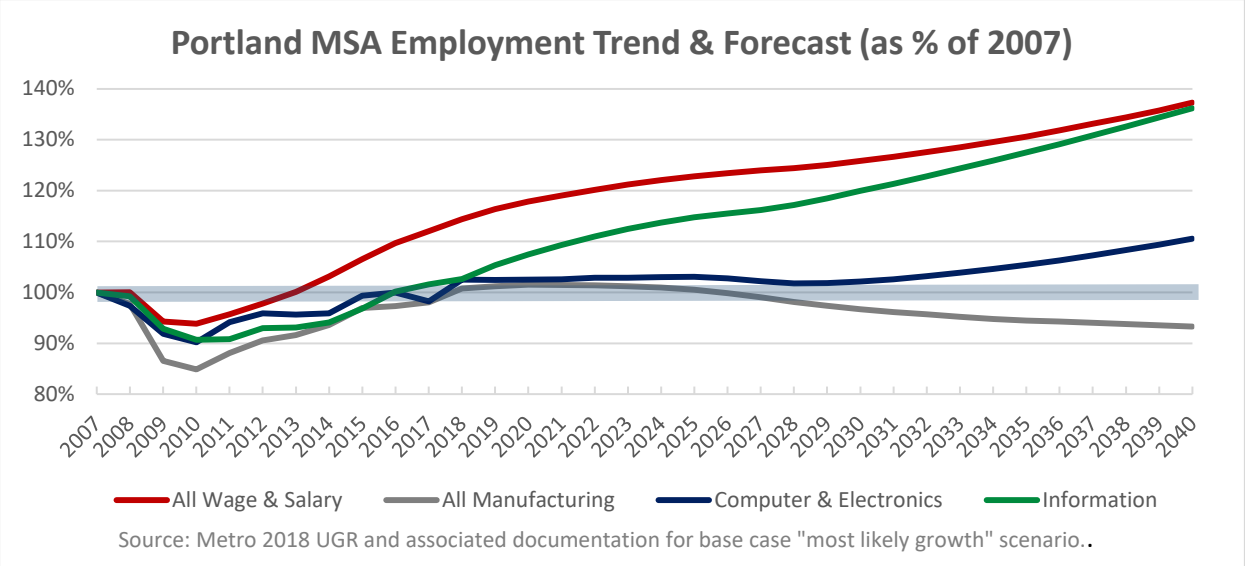
2018 Covered Employment As % of 2007

Employment Metric	City of Hillsboro	Portland MSA	United States
All Employment	130%	115%	108%
All Manufacturing	115%	101%	92%
Computer & Electronics	116%	102%	83%
Information	180%	101%	93%

Sources: Data is from BLS/QCEW.

Also noted is that while Portland metro employment in manufacturing, computer/electronics, and information by 2018 had exceeded pre-recession conditions, these traded sectors have lagged behind the bounce-back experienced for all jobs region-wide. Conversely for Hillsboro, these targeted traded sectors have experienced much stronger job growth than regionally.

A key question for this EOA is whether and how Hillsboro can continue to depend on its lead sectors if these sectors continue to experience subpar job growth region- and nation-wide. For added perspective on this question, it is also worthwhile to consider how Metro has forecast job growth across these four metrics. Metro's 2018 Urban Growth Report (UGR) covers a forecast time period from 2018-38 but the chart on the following page utilizes added Metro projections to 2040 with 2020-40 as the anticipated timeframe for Hillsboro's 20-year EOA.



Source: Metro 2018 UGR and associated documentation for base case "most likely growth" scenario..

With this *most likely* regional employment scenario, Metro has forecast that total non-agricultural jobs for the 7-county region could reach to 137% of 2007 levels by 2040. Job counts across all manufacturing activities have been forecast to reach slightly above pre-recession levels through about 2026, then drop back down to only 93% of the 2007 peak by 2040.

Within manufacturing, computer/electronics fares somewhat better, back above the pre-recession peak by about 2018-19 and increasing to 111% of the 2007 level by 2040. However, the region-wide job growth for this sector that has proven pivotal to Hillsboro is expected to be much less robust than for other sectors of the metro region's economy.

Metro's long-term outlook for the information sector has been considerably more bullish. This sector dipped below the rest of the MSA economy through to about 2018 but is projected by Metro to move toward a more rapid growth trajectory in the years ahead – with internet related applications even as the traditional publishing side of the information industry slows or fades.

Hillsboro Forecast Scenarios Defined

Recognizing that Hillsboro's economy has been driven in large part by computer/electronics traded sector activity which is dependent largely on market forces external to the Portland MSA, two initial scenarios considered with this EOA have been to project the sector-by-sector growth rates of the recent 2007-18 economic cycle forward over the 2020-40 EOA time frame.

A third hybrid scenario was then added to better reflect Hillsboro's competitive advantage and priority given to clearly defined target industry sectors. These alternative forecast scenarios have then been compared with job growth projected for the region as a first test to assess reasonableness of Hillsboro forecast scenarios.

The three sectoral forecast scenarios considered with this EOA are described as follows:

- **Scenario A – Straight-Line (Linear) Growth** forecasts employment change assuming that the recent employment trend is extrapolated forward in straight-line or linear fashion – with the same number of jobs per year added through 2040 as occurred (on average) from 2007-18. This equates to over 1,830 jobs added (on average) in Hillsboro each year to 2040. If calculated at a compound annual growth rate (CAGR), the CAGR rate averages about 1.8% per year from 2020-40.
- **Scenario B – Exponential (Non-Linear) Growth** forecasts employment change assuming that growth occurs at a compound average growth rate (CAGR), with the compounding factor meaning that the number of jobs added in one year is greater than the jobs added the previous year. From 2007-18, Hillsboro's employment increased at a CAGR averaging about 2.4% per year.

  Going forward, the rate of employment increase is forecast to increase by 3.6% per year from 2020-40 (or 3.5% per year from 2018-40). A higher overall job growth rate in the years ahead occurs as the effect of already large and rapidly growing industry sectors outweighs the effects of smaller and/or slow growth/declining sectors.
- **Scenario C – Hybrid Growth** was added as a third in-between forecast scenario based on review of Scenarios A/B and consideration of Hillsboro target industry and associated sectors (or industry clusters).[4] The net effect of these applications is for an overall employment growth rate (CAGR) averaging 2.8% per year from 2020-40 (or a CAGR of 2.7% from 2018-40).

  Sectors of construction, manufacturing, transportation/warehousing, information, real estate and professional services are forecast for growth at continued exponential CAGRs as experienced over the last economic cycle. Finance/insurance, health care/social assistance, accommodation and food services, and other services are expected to experience results at a mid-point between the CAGR and linear extrapolation models.

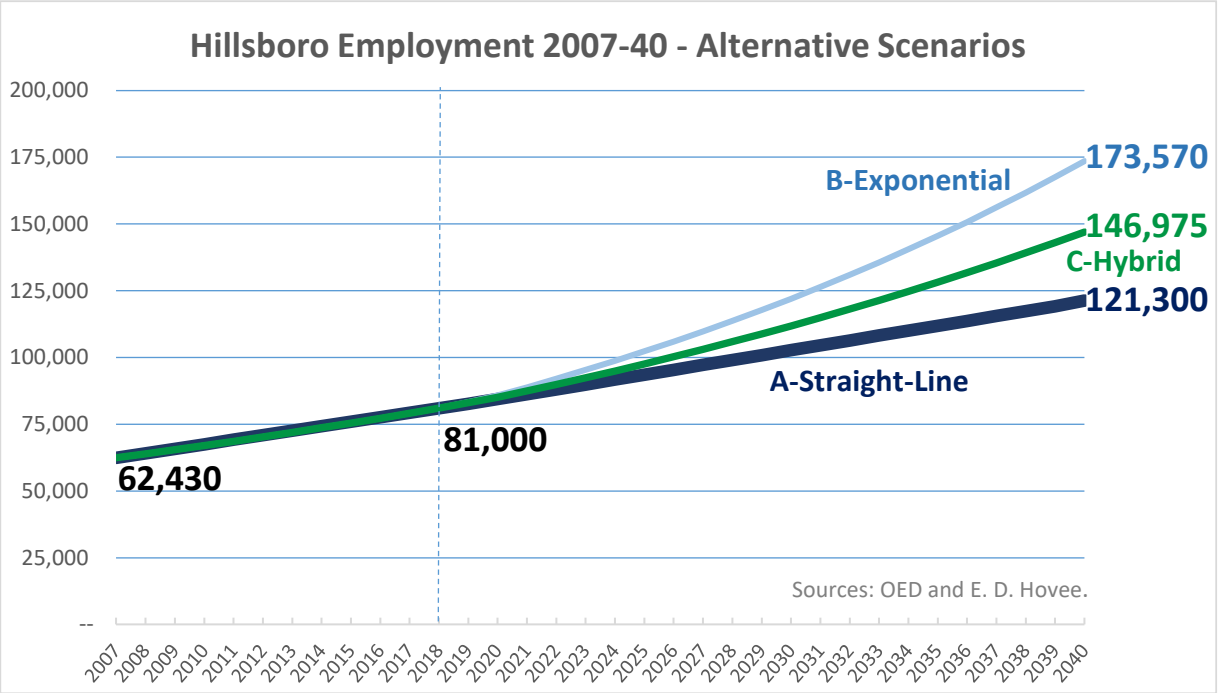
  Wholesale, retail, administrative and arts/entertainment/recreation sectors are forecast for linearly trended growth consistent with historically observed rates calculated on a straight-line basis. And employment sectors related to management, educational services and public administration which experienced net job loss in recent years are forecast to experience no further job loss going forward.

All three scenarios are reported in terms of QCEW covered employment – but also adjusted to provide for a meaningful *apples-to-apples* comparison with the Metro UGR prepared regional non-agricultural employment forecast.

The 2020 pandemic, economic downturn and subsequent recovery may well alter longer-term job growth patterns going forward. However, in spite of uncertainty as to changing trajectories, these forecast scenarios assume an eventual return to trends as experienced with the last economic cycle. For Hillsboro, the most significant question is whether job growth resumes at an even year-to-year growth increment or accelerates as with the effects of compounding interest in an investment portfolio.

Forecast Scenario Outcomes

As illustrated by the following graph, Hillsboro QCEW employment has increased from 62,430 jobs in 2007 to 81,000 in 2018 – with the smoothed (average year) trajectory shown rather than more than more detailed year-to-year variations.



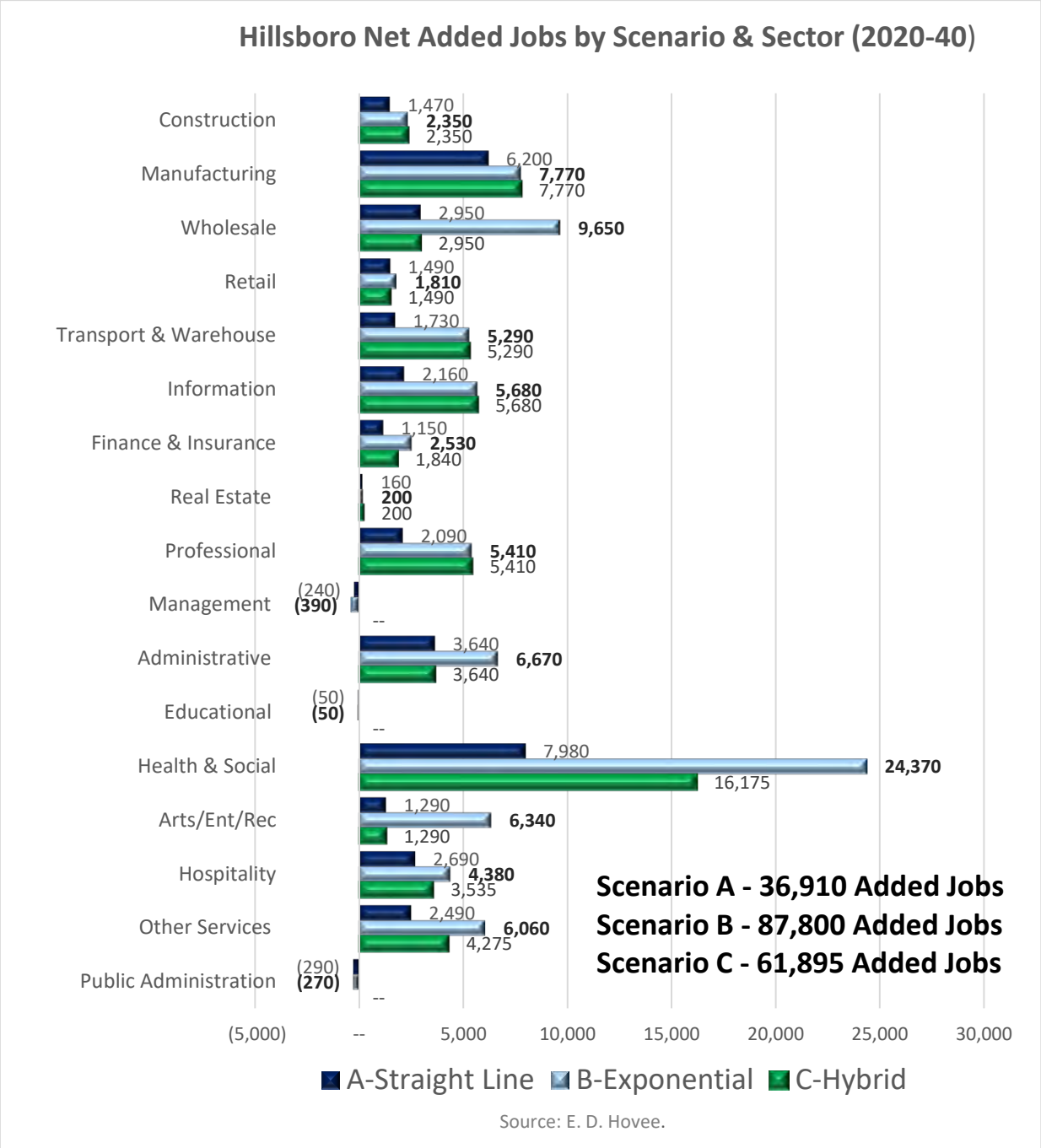
Results of the three alternative forecast scenarios considered are summarized as follows:

- **Scenario A Straight-Line Growth** results in 121,300 in-city jobs by 2040, with 36,910 net new jobs added over the 20-year forecast period of 2020-40, a 44% increase.
- **Scenario B Exponential Growth** predicated on compound annual growth rates (CAGRs) applied across all employment sectors results in a substantially higher forecast of 173,570 jobs by 2040. An estimated 87,800 net new jobs would be added in the two decades from 2020-40 – a virtual doubling of employment over this 20-year forecast horizon.
- **Scenario C Hybrid Growth** results in an estimated 146,975 jobs in Hillsboro by 2040, based on assumption of compounding growth for sectors evidencing this trend and/or associated with cluster industry targets versus lesser rates of growth for other sectors. With this scenario, 61,895 net new jobs would be added over 20 years from 2020-40.

As noted, job growth is not expected to increase on a smooth path as illustrated for these three scenarios. Rather, year to year variations can be expected in response to economic cycles or external events as the COVID-19 pandemic demonstrated in 2020. In effect, net job losses as experienced in 2020 also will need to be made up within subsequent years to achieve the scenario projections indicated.

Alternative Forecasts Outcomes By Scenario & Employment Sector

The mix of employment by job sector may vary, in some cases considerably, depending on the growth scenario and specific sector considered – as depicted by the following graph.



Outcomes for each of the three scenarios considered with this EOA are summarized as follows.

Scenario A Straight-Line Growth. With the lowest growth overall of the three scenarios, health care and social assistance would add an estimated 7,980 jobs over 20 years (the most of any sector) – followed by manufacturing at 6,200 added jobs. Job growth is more modest for other sectors with small potential reductions noted for sectors of management, educational services and public administration (assuming the continuation of recent trends).

Considered in terms of region-wide employment, Hillsboro would increase from just under 7% of the region's employment currently to about 8.5% in 2040. Manufacturing would increase from 20-21% to just under 28% of the sector's MSA count, information from 10-11% to 15%, and health care/social assistance from 5-6% to nearly 8% of that sector's regional job count.

Scenario B Exponential Job Growth. As with Scenario A, health care and social services would add the most jobs, followed by wholesale trade and manufacturing. From 2007-18, Hillsboro health care employment nearly doubled. Assuming continued growth at a 6.3% CAGR, health care and social assistance alone could add 24,370 jobs over 20 years – with a total count nearly 34,500 jobs and even exceeding manufacturing's total job count by 2040.[5]

Wholesale trade has experienced 6.7% per year job growth since 2007 and at this continued rate could see a net gain of as many as 9,650 jobs in the next 20 years. The related sector of transportation/warehousing could add another 5,290 jobs – reflecting the creation of a second regional distribution hub on the westside to support continued area-wide manufacturing and health care growth.

Manufacturing would add an estimated 7,770 jobs – for about 25% more new jobs than with Scenario A.[6] Strong growth is likely predicated on availability of large campus sites for major employers. Job growth in the range of 5-7,000 jobs per sector might also be experienced for the transportation/warehousing, information, professional services, administrative, arts/education/recreation, and other services sectors.

With Scenario B, Hillsboro would increase from about 7% currently to 12% of metro-wide *most likely* employment by 2040. Within 20 years, Hillsboro could account for 30% of the arts/entertainment/recreation, 29% of the manufacturing, 25% of the information, 22% of the wholesale trade, 16% of the transportation/warehousing, and 15% of the health care/social assistance jobs metro-wide.

Scenario C Hybrid Job Growth. This hybrid or targeted job growth scenario would be led by health care with an added 16,175 jobs followed by manufacturing at an added 7,770 jobs. Strong job growth (in the range of 5-6,000 added jobs each) would be experienced by the information, professional services and transportation/warehouse sectors.

With Scenario C, Hillsboro would increase from about 7% (as of 2018) to more than 10% of metro-wide employment by 2040. Hillsboro would account for similar shares of the region's employment in manufacturing, information, and transportation/warehouse sectors as with Scenario B. Hillsboro would increase from 5-6% to about 11-12% of the region's employment in health care and social services.

Comparison With National & Regional Expectations

As an added step in the employment outlook and planning process, it is useful to set Hillsboro's prospective jobs scenarios in the context of nation-wide employment trends and forecasts – as well as in conjunction with the metro-wide experience of the COVID pandemic, associated recession and subsequent recovery. What follows represents a synopsis of more detailed review and analysis provided by Appendix A to this EOA.

National Employment Trend & Forecast. The employment forecast associated with Metro's current 2018 Urban Growth Report (UGR) is driven by national assumptions and resulting employment forecasting conducted by IHS Global Insight – all of which predate the events of 2020. Based on pre-pandemic trends, IHS previously forecast that manufacturing together with associated sectors of wholesale trade and transportation/warehousing would continue to decline as a share of U.S. employment through 2040.

These expectations all run counter to Hillsboro's employment experience and now to clear signs of a resurgence in industrial activity through the pandemic and with increased emphasis on industrial re-shoring to the U.S. Also forecast by IHS is little change in information as a share of all U.S. employment, though this sector now appears to have increasing potential for Hillsboro.

IHS also has forecast that health and social services together with administrative and also arts/entertainment/recreation services will represent growing shares of U.S. employment. This is a trend that appears to be reflected in Hillsboro's experience and future growth projections.

Overall, Hillsboro appears well positioned to support and reinforce the most recent national shift back to strengthened industrial activity including freight-intensive transportation and distribution functions while at the same time capturing other national growth sectors, for example, with health-related services including bio-tech applications. In addition, with changing national priorities, there appear to be emerging opportunities for clean-tech industries addressing climate change (as with energy storage, transportation electrification, and manufacturing of energy generation equipment).

Metro-Wide 2020-21 Employment Experience. Observations noted with the national perspective are reinforced by review of metro region experience through the 2020 pandemic and recession together with ensuing partial recovery up through year-end 2021. While the nation. state and metro area all experienced similar proportionate job loss early in the pandemic, the subsequent bounce-back nationally has been stronger than for the state or metro area. Hillsboro-specific data for 2020 indicates that employment dropped by only 2.8% in versus a 6.8% drop metro-wide from 2019-20.

As of December 2021, the metro region had 3.3% fewer jobs than in February 2020 versus U.S. under-performance of 2.1%. On average up through year-end 2021, Portland metro **cumulative job loss** has averaged 1.7% points above the nation-wide average job loss. This equates to net metro-wide loss of about 21,200 jobs more than would be the case if the bounce-back experience parallel that of the nation.

Regardless, Hillsboro has consistently maintained one of the lowest unemployment rates in the region, for example at 2.5% (as of May 2022). Much of this can be attributed to the complimentary key industries Hillsboro chooses to foster and grow; computer and electronics (semiconductor), information technology, advanced manufacturing, and bioscience/medical devices. Hillsboro supports these existing industries and has aimed to continually improve the business climate at the local, regional, and state levels to help business succeed.

Hillsboro has a smaller share of employment in sectors that were **most affected** by business and employment restrictions during the pandemic – notably hospitality and retail. These sectors represent continued vulnerability ahead to the extent that pandemic-related conditions prove resurgent over time. Professional services represent the only commercial sector for employment that rebounded to pre-pandemic levels starting March 2021 with subsequent added new hires to year-end 2021 – followed by retail and finance/insurance/real estate (FIRE) sectors also returning to more employment than experienced pre-pandemic.

Industrial uses held up **considerably better** through 2020 to year-end 2021. Pre-recession, industrial sectors have accounted for 29% of PDX metro and 46% of Hillsboro employment. Industrial uses accounted for 14% of all metro area jobs lost in April 2020, but returned to exceed pre-pandemic job counts by the autumn of 2021. By comparison, commercial uses have accounted for all of the remaining metro-wide job loss as of year-end 2021.

Transportation/warehousing activities proved to be a **star performer** through the pandemic and recession – with more job growth than any other commercial or industrial sector. This sector benefits from the renewed attention to supply chain management across multiple industries and coupled with the *Amazon effect* of dramatically increased shipments to residences including newly created home offices.

With the exception of construction (since rebounded), other industrial sectors maintained relatively stable employment through the pandemic with minimal net job loss. Metro area **manufacturing** employment (as of May 2022) has exceeded pre-pandemic levels – especially with regard to employment in computer and electronic manufacturing (including semiconductors). In 2020, Hillsboro represented 25% of the region's manufacturing employment and over 50% of the region's high-tech manufacturing. Food and advanced manufacturing employment have remained steady with some job growth. Companies like Beaverton Foods, Meta Fab and FiberSensys reportedly have expanded their facilities and operations.

The semiconductor industry expansion presents Hillsboro and Oregon with an extraordinary opportunity to intentionally create the kind of jobs and investment the state needs to emerge from the pandemic with a stronger, more deliberately equitable economy. Globally, **semiconductor demand has soared** beyond expectations due to strong performance for everything from cloud storage to mobile devices to notebook computers due to work from home options. There is also the anticipation of accelerating growth related to new technologies, as for artificial intelligence (AI), machine learning and the internet of things (IoT) – compounded by backlogged demand. This paired with national attention and funding to restore

domestic semiconductor innovation and manufacturing, and the industry's preference to have manufacturers and suppliers located near each other focuses Hillsboro and Washington County to encourage more of these investment opportunities.

To summarize, Hillsboro's current and prospective employment mix including recent pandemic experience appears to offer benefits of economic resilience and long-term growth potential:

- Hillsboro's business and industry mix demonstrates a path toward economic **recovery and resilience** beyond what has been achievable across the rest of the metro region.
- The community's nurturing of technology industries **aligns well** with the best opportunities for economic growth regionally and nationally – in recent years, through the 2020 economic downturn and post-pandemic.
- The growth and resilience of these industries have led to a **more stable and predictable tax base** ensuring a more consistent level of service for community members.
- The additional growth of manufacturing jobs also presents opportunity for area residents and workers with a variety of backgrounds, educational levels and socio-economic diversity to access **higher wage careers.**

Bottom line, these demonstrated advantages position Hillsboro to be an even more significant source of job stability and renewed growth for the PDX metro region and state of Oregon post-pandemic. This sets the stage for sharing in the longer-term transition to a more resilient and sustainable global as well as domestic U.S. economy.

Tech & Semiconductor Initiatives

Added impetus for renewed focus on tech and the semiconductor industry stems from recent global and national issues ranging from supply chain disruption to national defense and security. Expanded and more technologically focused semiconductor domestic research and production has become a national and statewide priority highlighted by federal and Oregon-specific initiatives culminating over the summer of 2022:



- Federal action has resulted in the CHIPS and Science Act of 2022, now signed into law.
- Oregon's response is evidenced by the work of the Oregon Semiconductor Competitiveness Task Force, with recommendations released as of August 17, 2022, focused on the opportunity for a *world class* innovation center organized around topics as illustrated by the above graphic.

Key elements of these initiatives are further detailed on the next two pages. **This EOA is aimed to align with both the federal CHIPS initiative and statewide task force recommendations.**

Federal & State Tech Manufacturing Initiatives

Hillsboro's updated EOA coincides with key federal and state initiatives, notably:

- The federal *CHIPS and Science Act of 2022* as approved by Congress and signed into law by the President on August 9, 2022.
- The *Initial Report and Subcommittee Findings* of the Oregon Semiconductor Competitiveness Task Force released as of August 17, 2022.

Taken separately and when viewed together, these initiatives are consistent with the robust strategy of the Hillsboro EOA for continued rapid tech industry investment and job growth – anchored by on-going semiconductor R&D innovation, manufacturing and expansion – with this region continuing as the #1semiconductor industry cluster in the U.S.

CHIPS and Science Act

Renewed investment in domestic semiconductor manufacturing is viewed as pivotal to American competitiveness and national security. A major rationale provided with the CHIPS and Science Act legislation is recognition that only 12% of chips globally are currently manufactured domestically, down from 37% in the 1990s.

As stated by a White House issued *Fact Sheet* of August 9, a major objective of the CHIPS legislation is to encourage the re-shoring of American manufacturing, "bringing good-paying manufacturing jobs back home."

The *Fact Sheet* further elaborates that this legislation is intended to "strengthen American manufacturing, supply chains, and national security, and invest in research and development, science and technology, and the workforce of the future to keep the United States the leader in the industries of tomorrow, including nanotechnology, clean energy, quantum computing, and artificial intelligence."

More specifically, the CHIPS and Science Act provides $52.7 billion in funding for American semiconductor research, development, manufacturing, workforce development. Included is $39 billion in manufacturing incentives, $13.2 billion in research and development and workforce development, and $500 million for international information, communications technology security and semiconductor supply chain activities.

Also provided is a 25% investment tax credit for capital expenses for manufacturing of semiconductors and related equipment. The bill requires recipients to "demonstrate significant worker and community investments, including opportunities for small businesses and disadvantaged communities, ensuring semiconductor incentives support equitable growth and development."

The Act further authorizes $10 billion for regional innovation and technology hubs across the U.S. as "regional partnerships to develop technology, innovation and manufacturing sectors. And the Act will provide science, technology, engineering and mathematics (STEM) workforce development critical to skills needed for emerging industries and technologies of the future.

$2 billion is reserved for the formation of a National Semiconductor Technology Center (NSTC). A proposal for an Advanced Lithography Center to be located in Oregon and funded under the NSTC is under development. If successful, regional location of an advanced lithography focused NSTC hub would draw billions of federal investments to Oregon and serve to significantly increase the level of industry interest and investment regionally and statewide.

Oregon Semiconductor Competitiveness Task Force

Recognizing that the "global semiconductor industry is investing billions to fill a worldwide chip shortage," a statewide Semiconductor Task Force was convened to frame a strategy to **"secure this once**-in-a-**generation opportunity for all Oregonians."**

Co-chaired by Senator Ron Wyden, Governor Kate Brown and Portland General Electric CEO Maria Pope, the task force comprised industry, educator and elected official representation with participation from the City of Hillsboro.

Intel's Gordon Moore Park at Ronler Acres Research Campus in Hillsboro is one of the global centers of semiconductor research and development, Impressively, Intel's Gordon Moore Research Campus is responsible for the creation of 1,000 patents a year – a level of R&D and innovation that exceeds the patent output of more than 21 U.S. states. So immense is the semiconductor patent activity that Oregon ranks 5th in the nation in patents per capita.

The impact of that technological leadership and impact is evident across the state. Semiconductors represent nearly half of Oregon exports. And it is widely recognized that export-sector businesses bring-in wealth that circulates through benefiting communities and expands state and local budgets.

As depicted by the graphic at the introduction to this discussion, the work of the Task Force was organized around five subcommittees – addressing industrial land, incentives, university-industry partnerships, talent and workforce and environmental regulations. Much of this work is also addressed with implementation measures for economic development and opportunity as outlined in the last chapter of this EOA report.

Principal findings and recommendations of the Task Force are summarized as follows:

- R&D Strength: Semiconductor research and development is Oregon's unique competitive advantage. Oregon's strategy to secure chip investment should focus on solidifying a world-class innovation ecosystem around chip research and production.
- Talent: Premier access to talent and a robust, private sector-led innovation ecosystem separates Oregon from others. To preserve this advantage, Oregon needs to invest across the talent continuum, from entry-level positions to PhDs.
- Land: To attract semiconductor manufacturers, the state needs more buildable industrial land. Oregon's land use system and infrastructure investment programs require *urgent* legislative attention and investment to address this need. Of pivotal importance for this EOA, the Task Force concluded that "there are no development ready sites of the size needed to attract a major semiconductor investment, or to support larger size suppliers." With the Metro region cited as key to semiconductor growth, specifically recommended are two sites of 500+ acres, four sites of 50-100 acres and at least eight sites of 15-35 acres (for key suppliers to the semiconductor cluster).
- Incentives: Oregon needs to become more competitive on incentives. Other states offer incentive packages that are both larger and more specifically tailored to the semiconductor industry.
- Regulation: When it comes to governmental oversight, from permitting facilities to environmental regulations, the subcommittee reviewed "best practices" from competing states and identified the importance of forming stronger partnerships with manufacturers and streamlining the permitting process.

Toward a Preferred Scenario

Based on the EOA analysis provided and coupled with state and national priorities, a question arises: *Is there enough information on which to base selection of an empirically supported preferred job growth scenario for Hillsboro?* In a time of rapid if not profound economic change, it remains uncertain as to whether conditions will return to the now dated period of the *new normal* experienced with recovery from the Great Recession of 2007-09. *Or is the structure of the economy now morphing to some form of a post-pandemic new-new normal not yet fully understood?*

For tech-forward communities like Hillsboro, there is the risk of undershooting economic opportunities by over-reliance on data trends no longer as relevant to guiding future expectations. The pace of tech development has stepped up appreciably in the last few years. Semiconductor demand has exploded with **chip shortages** affecting numerous critical sectors of the U.S. economy including automobiles, mobile devices, data storage, and computers as well as defense related national security interests.

$2 billion was reserved for the formation of a *National Semiconductor Technology Center*. If successful, regional location of an advanced lithography focused NSTC hub would draw billions of federal investments to Oregon and serve to significantly increase the level of industry interest and investment statewide.

A resulting question is: *by basing future projections primarily on past experience no longer as relevant, could Hillsboro and the region find itself woefully underestimating the tech growth curve?*

Supply chain shifts lead firms to further expand and new entities to enter the region. Existing firms serving these sectors will expand as they outgrow current facilities. Nearly 44% of the semiconductor workforce holds only high school or two- year post-secondary degrees. Intel alone has hired 1,900 workers a recent year, many of whom need no more than a high school degree to earn well above average paychecks.

Under-Estimating the Tech Growth Curve?

A couple of national consultant groups have recently released a study on just the semiconductor industry indicating that current market trends and potential federal policy and programs could drive the creation of between 57,000 and 115,000 new direct permanent jobs associated with this industry.

If we take the average of that (86,000) and we apply that Oregon currently has approximately 15% of the national share of this workforce, that would mean Oregon (and largely Hillsboro) could be seeing around 14,620 new employees in this industry alone.

Now, not all of them will be coming to Hillsboro and that is basing it off of some rough methodology, but it also is nearly double what we are showing for all manufacturing.

We are also likely to see opportunities for similar expansion in other manufacturing areas receiving similar focus and momentum in biotech, information technology, and an emerging climate tech sector, all of which for which we are likely to be competitive for (if we have the basics covered)

- Dan Dias, Director Hillsboro Economic & Community Development, September 2021

The three 20-year employment growth scenarios evaluated with this EOA indicate a **possible range** of 36,910 - 87,800 added jobs (as covered by unemployment insurance) over the 20-year period of 2020-40. If adjustments are made for non-covered workers as was with Hillsboro's 2017 EOA, the range of the current forecast would be from 44,650 - 106,870 added jobs:

- The lower **Scenario A** straight-line forecast associated with this current analysis comes closest to the results of the prior 2017 EOA alternative forecast – albeit with a somewhat modified methodology.
- The higher **Scenario B** exponential sectoral growth approach yields a result that well exceeds what was presented by earlier EOA alternatives – but better reflects the exponential growth curve of key industries in Hillsboro in recent years as well as national economic restructuring currently underway.
- The mid-range and hybrid **Scenario C** approach best reflects Hillsboro's target industry and business clustering approach as reinforced by economic development activity up to and through the pandemic. This scenario emphasizes building on existing strengths consistent with national economic strategies for industrial re-shoring, offering catalytic benefits for the Portland metro region and state. **Recommended with this EOA update is adoption of a Scenario C approach for hybrid growth.**

Forecast Scenario Implications & Decision-Making

Five key implications of the three forecast scenarios are noted with this employment analysis:

- **Widely differing results in employment outcomes are possible** with the scenarios considered – for example, with Scenario B resulting in more than twice the 20-year job growth associated with Scenario A.
- In addition to input from those knowledgeable about Hillsboro's key employment sectors, an important **check on "reasonableness" is with comparison to the Metro UGR forecast** – including a regional high growth jobs scenario (although Metro's high growth projection is only 6% more than the *most likely* scenario identified by the 2018 UGR). Hillsboro's experience likely will continue to be more robust for industrial employment and for related diversification as the local economy further matures in the years ahead.
- **Employment sectors for which declining employment has been observed and extrapolated forward may warrant added attention** – especially as to either the lower reasonable bounds for continued employment decline or regarding the potential for sector turnaround in the years ahead.
- Any employment outcomes substantially more aggressive than Scenario A will benefit from **continued articulation of targeted industry marketing and implementation strategies** – especially for sectors that can be demonstrated as mutually reinforcing.
- **NAICS-defined employment sector potentials may then need to be overlaid with Hillsboro's groupings of targeted industry clusters** – defined as including advanced electronics manufacturing, specialized machinery and equipment, clean tech manufacturing, biotechnology and pharmaceuticals, and software.

These implications receive added consideration and discussion in subsequent sections of this EOA pertaining to community economic potential, employment land needs, and implementation policies.

Forecast Approach

OAR 660-009-0015 for EOAs stipulates that forecast demand is to be based on what could "reasonably be expected to locate or expand in the planning area based on information about national, state, regional, county or local trends." While the OAR does not require the use of a specific methodology, the application of a compound annual growth rate (CAGR) reflects typical practice for EOA employment and land needs analyses – as well as for Metro's Urban Growth Report (UGR). With this EOA forecast, the approach is to apply an approach most consistent with local job trend data. Details of the forecast approach utilized including statistical testing of sector-by-sector trends is provided with Appendix A to this EOA. What follows is a summary of the approach as applied.

Straight Line versus Exponential Job Growth. In communities experiencing relatively slow job growth, there may be relatively little difference in extrapolation of straight-line or annually compounded growth (where each year's growth is built on the higher base number as calculated for the previous year). Hillsboro presents a different situation as growth rates have been relatively rapid across a number of employment sectors in recent years. In this situation, there can be a substantial difference in future growth potentials depending on whether the job trend is extrapolated forward based on a straight line or exponential (CAGR) methodology.

Sector-by-Sector Approach. A second consideration is that, in Hillsboro, widely varied job growth rates have been experienced in recent years depending on the sector being considered. Not all sectors have experienced rapid or accelerated job growth. Some have experienced job change at relatively low (or negative) growth rates. Consequently, as in other similarly affected communities, forecasts of future employment are often made sector-by-sector, with results then summed across all sectors to achieve an overall employment forecast result.

Consistency of Job Trend. Job change also does not always occur on a consistent basis from year-to-year. In these cases, it may not be readily apparent whether growth over a multi-year period reflects more of a linear or exponential growth pattern. This situation is exacerbated by the experience of the COVID pandemic with sudden and severe employment loss followed by varying degrees of subsequent partial to full job recovery. Some sectors have recovered more fully than others. When coupled with emergent workforce shortages, this suggests potential for longer term job displacement, especially in lower paid employment sectors. Also of significance may be local, state or national policy considerations.

Sector Toggle Application. The forecast methodology applied with this EOA reflects the empirically demonstrated experience of Hillsboro employment sectors consistent with the data available. A toggle approach is taken to the forecast, applying a linear, exponential, or mid-course (mid-point) forecast to each sector – depending on experience as recorded sector-by-sector including evaluation of regional capture rates as detailed by Appendix A to this report.

Sector-By-Sector Review

Due to varied industry sector experience, it is useful to review findings and recommendations of this analysis on a more detailed *sector-by-sector* basis. Quantitative outputs of this analysis are of particular importance as inputs to the Section IV analysis of Employment Land Needs.

The chart on the following page summarizes prospects looking forward for each employment sector in terms of both quantitative and qualitative considerations that together have been aggregated to form the EOA recommendation for **Scenario C Hybrid Growth**. As points of reference, the columns of the chart provide the following information for each sector:

- **The sector's % share of total employment in Hillsboro** – as of 2018 a baseline indicator of the sector's significance to community-wide job activity
- **A relative ranking of the sector's job growth over the last economic cycle** – categorized as follows:
  - ✓ *Above* – indicated for sectors which have experienced job increases in excess of the 2.4% compound annual growth rate (CAGR) for jobs across all sectors from 2007-18
  - ✓ *Below* – for sectors with positive job growth but below the overall employment 2.4% Hillsboro-specific CAGR
  - ✓ *Negative* – for sectors which experienced net job loss in Hillsboro from 2007-18
- **Indication of the exponential or linear forecast growth rate methodology** – as applied via a sector-specific *toggle approach,* categorized as follows:
  - ✓ *Exp* – applied to sectors for which exponential CAGR growth is demonstrated (also denoted as Toggle 3 including more detailed discussion as provided by Appendix A to this EOA)
  - ✓ *Mid* – for sectors showing inconclusive evidence of CAGR or linear growth, therefore forecast as the mid-point of the exponential and linear forecast outputs (Toggle 2)
  - ✓ *Linear* – for sectors for which a straight-line forecast is demonstrated with linear extrapolation applied over the EOA forecast period (Toggle 1)
  - ✓ *None* – for sectors that experienced net employment loss from 2007-18 and for which no further net loss (or gain) in job is projected through 2040 or beyond (Toggle 0)
- **Added comments** – noting other factors taken into consideration with determination of the forecast toggle selection applied to each sector. Depending on the sector, this may include consideration of temporary or longer-term structural shifts as might occur based on initial 2020 job data associated with the COVID-19 pandemic and/or with related factors as with effects of demographic shifts, e-commerce, technological change and workforce availability including policy initiatives at local, regional and/or national levels.

More detailed sector-by-sector analysis is provided by Appendix A to this EOA. This summary review also draws from the information compiled with the Chapter III discussion of Community Economic Potential.

Hillsboro Sector by Sector Employment Review & Forecast Summary

Employment Sector	2018 Job %	Growth Trend	Forecast Type	Comments
Construction	4.0%	Above	Exp	High year-to-year job variability but experienced 21% job gain in 2020 pandemic due in large part to Intel expansion
Manufacturing	32.0%	Below	Exp	City has 20% of metro manufacturing jobs vs 4% of regional population – with tech-focused semiconductor anchor and minimal 0.5% sector job contraction in 2020 pandemic year
Wholesale Trade	3.9%	Above	Linear	Hillsboro's jobs count in this sector doubled over the last economic cycle, continued into the 2020 pandemic year
Retail Trade	8.9%	Below	Linear	Modest job growth of just over 1%/year thru last economic cycle with internet erosion and further 5% job loss in 2020
Transport & Warehouse	2.4%	Above	Exp	Employment doubled at accelerating pace over last economic cycle, then 33% further job increase from 2019-20
Information	3.3%	Above	Exp	Building on job gains in recent years, software & information is a key industry priority for Hillsboro tech diversification
Finance & Insurance	2.0%	Above	Mid	Growth has occurred at twice the % increase for all in-city jobs, supporting overall Hillsboro economic diversification
Real Estate	0.9%	Below	Exp	A relatively small sector but with growth experienced at an accelerating pace over the last economic cycle
Professional	3.2%	Above	Exp	Employment increased by about 80% over the last economic cycle, a sector pivotal to continued tech-driven expansion
Management	0.7%	Negative	None	Job loss shown as negative due to sector reclassification of a large employer, assumed is no further job loss going forward
Administrative	7.9%	Above	Linear	Strong job gains noted from 2007-18 but substantial job loss in 2020 suggests possible sector downshift underway
Educational	3.3%	Negative	None	Job loss noted over the last economic cycle and continuing since; assumed is no further employment loss going forward
Health & Social	11.1%	Above	Mid	As the #1 source of job growth thru the last economic cycle, forecast assumes easing pace with Hillsboro increasing from less than 6% to 11-12% of sector jobs metro-wide by 2040
Arts/Ent/Rec	1.4%	Above	Linear	Large % gains in employment in recent years but offset by significant job loss subsequently in 2020 pandemic year
Hospitality	7.0%	Above	Mid	Just above average job gains through the last economic cycle, then offset as a sector with most net job loss in 2020
Other Services	4.1%	Above	Mid	With above average % job gains from 2007-18, large job losses in 2020 suggest potential structural downshift ahead
Public Administration	3.9%	Negative	None	Job loss noted over the last economic cycle and continuing since; assumed is no further job loss going forward
ALL SECTORS COMBINED	**100% of 81,000 jobs**	**2.4%/yr avg CAGR 2007-18**	**Exp (overall)**	**Hillsboro accounted for approximately 4% of metro-wide population and 7% of regional employment in 2018. With Scenario C Hybrid Growth, the city could represent an estimated 10% of regional employment by 2040.**

Employment Forecast Recap

This EOA employment forecast process reflects a customized methodology based on experience and anticipated flexibility of response to as yet uncertain post-pandemic economic prospects.

Methodology. Key features of the approach taken with this EOA update are that it is:

- **Experience based** – drawing from experience of the last economic cycle together with short- and long-term employment-related implications of the COVID pandemic
- **Scenario driven** – distinguishing between outcomes potentially associated with straight-line (linear) versus exponential (CAGR) job growth
- **Sector-by-sector focused** – as individualized sector determinations of linear, exponential or mid-case growth summing to a recommended hybrid growth scenario
- **Qualitative as well as quantitative** – reflecting community priorities together with federal and state initiatives as for substantially increased semiconductor manufacturing

Prior Experience. Two key points of reference are of note with this EOA update:

- **Comparison with prior 2017 EOA** – which after consideration of three alternatives recommended a growth projection an added 40,326 jobs over 20 years – above the current Scenario A 20-year projection of an added 36.910 jobs in the updated 20-year time frame and below the 61,895 added jobs associated the preferred Scenario C for hybrid growth. The prior 2017 EOA was predicated on a 2010-15 observed job CAGR of 3.3% but with the 2015-35 projection trimmed to a 2.0% CAGR. The recommended Scenario C approach with this EOA reflects a higher 2.7% CAGR from 2018-40 – lower than observed experience with the prior EOA but above the 2017 projection.
- **Comparison with recent job growth** – as a more pertinent point of reference for this update. Over the last economic cycle of 2007-18, Hillsboro's employment increased at an observed 2.4% CAGR. When projected forward on a sector-by-sector basis, sectors with high historically experienced CAGRs (as with health care, transportation and wholesale trade) become ever larger proportions of the total over 20 years. This increases the overall CAGR going forward to 2.7%, above what was experienced in the last economic cycle. This is the case even with tempered prospects as for health care.

Flexible Response for an Uncertain Future. As recommended, Scenario C provides:

- **Consistency –** with EOA analyses statewide together with observed trends locally
- **Priority –** emphasizing added opportunity for the community's targeted traded sectors
- **Flexibility –** for future EOA updates as post-pandemic changes become more apparent
- **Opportunity –** for metro/state-wide benefit to harness economic engines of the future

Looking beyond job numbers, this EOA now shifts to review of community economic potential – addressing qualitative considerations of industry, business and community stakeholders.

III. COMMUNITY ECONOMIC POTENTIAL

Discussion of community economic potential draws from the quantitative analysis of economic trends and forecasts combined with qualitative research including focus group and interview discussion with business and community stakeholders. Also covered is a review of pertinent regional to global trends research. This EOA chapter represents a summary of a more detailed discussion as provided by EOA Technical Appendix B.

Key elements of this community economic development potential assessment address:

- **Qualifying Economic Development Potential –** complementing the quantitative assessment with qualitative judgements informed by stakeholder input
- **Factors Affecting Community Economic Development Potential** – addressing Goal 9 requirements and setting the stage for a next step competitive position analysis
- **Competitive Position** – articulating strengths, weaknesses, opportunities and threats (SWOT) affecting Hillsboro's economic potential currently and prospectively
- **Target Industry Clusters –** assessing what has already been outlined for Hillsboro as similar to and distinct from the Portland metro region and state of Oregon

As initially conceived, the purpose of this assessment of community economic potential has been to serve as a *bridge* between the quantitative review of economic trends with associated land use needs and subsequent implementation policies. This work was initiated prior to and then was interrupted by the March-April 2020 recognition of the profound health and economic effects of the then emergent global COVID-19 pandemic.

An initial draft of this analysis was completed in mid-March 2020. Consequently, the approach taken with an updated assessment has been to retain much of the material of the initial analysis – subsequently supplemented by new and potentially altered directions reflecting changing perspectives resulting from the pandemic, economic downturn and subsequent recovery.

When in the middle of sweeping change, it is difficult to reliably assess both short- and long-term prospects for the global economy, let alone implications for any particular jurisdiction. A pivotal question for this EOA is: *Will the economy re-stabilize to pre-COVID conditions, or is this new-new normal to be fundamentally different from what has occurred over recent business cycles, especially as most recently experienced since the Great Recession of 2007-09?*

This assessment takes an approach that looks to the past as one potential guide to the future while also considering the character and extent of potential transformative changes that may now be underway. The decision of a viable path to pursue involves a risk-reward assessment. The analysis and recommendations resulting from this assessment suggest a risk mitigation strategy that might involve elements of both approaches – working to keep the best of the past while being an early adapter of the post-pandemic changes most likely to endure.

QUALIFYING ECONOMIC DEVELOPMENT POTENTIAL

Identifying and characterizing economic development potential to this point has been, in large part, driven by the numbers. Addressing the statewide land use planning Goal 9 Economic Development requires quantification of potential employment change and associated land requirements.

However, understanding and preparing for the future is about more than numerical modeling alone. Qualitative assessment is also important – especially when it comes to setting policies to implement the plan in a way that also will fit with broader community objectives.

For this 2021 EOA, a stakeholder outreach process was conducted in two phases. An initial round of interviews was conducted in early 2020 (pre-pandemic). A second round of phone interviews was conducted over the summer of 2020, as initial steps toward economic recovery were getting underway.

In addition to the topics noted with the first round, the second round also involved asking participants to comment on two key items – the near-term pace and timing for pandemic-related economic recovery together with implications for sustained economic recovery and resiliency longer-term over the next 5-20 years.

What follows is a composite synopsis of what was gathered from initial stakeholder conversations conducted pre-pandemic followed by more recent perspectives including added contacts made over the summer of 2020 as early steps toward national and local economic recovery were beginning to take hold. More detailed discussion of the interview process and results is provided by Appendix B to this EOA.

Pre-Pandemic Global to Local Trends

Two major themes emerged from pre-pandemic conversations with business and public decision makers:

- **Disruptive technology** – exemplified by emerging opportunities for autonomous vehicles with less parking need, artificial intelligence (AI), internet of things (IoT), 5G telecommunications, exponential growth of data needs, and decarbonization.
- **Live-work connection** – as tech workforce needs to be mobile, often work remotely, and reduce the length of the commute trip. Workers don't want to get stuck in a metro or community location with few options for re-employment if their current job goes away. As millennials age, there also is now a shift in live-work preferences, less toward center cities and more to full-service communities meeting a greater array of family as well as job interests.

Pre- and now post-pandemic, Hillsboro has been described as well positioned to capitalize on these trends over the next 20 years.

Working Through & Beyond the Pandemic

For virtually all stakeholders contacted through the summer of 2020, the world of work and business has clearly become a different place than it was pre-pandemic. However, many of the fundamental forces of change already at work globally and locally still appear to remain in place. Existing trends for Hillsboro of **disruptive technology** and **live-work connection** have not necessarily changed, but rather have dramatically accelerated.

Industrial & Commercial Land Needs

Recognizing that a primary purpose of this EOA update is to define short- and long-term needs for industrial and commercial land, an important question is: *What employment land needs are most important to address?*

Again, two overall observations emerged from stakeholder discussions:

- **First, priority should be placed on assuring that *shovel-ready* land required to accommodate new employment will be there as demand warrants.** Hillsboro has a strong track record of serving major employers requiring large sites – making possible development that otherwise would not likely have occurred in the metro region. In the wake of the pandemic, there is growing recognition that employment land use needs may change in ways not previously expected – ranging from more work-at-home to office reconfiguration and retail downsizing to more large-site demand for industrial manufacturing and distribution functions led by major corporate investment.

  Suggested is a need to be more flexible with land use planning and regulation than in the past. Greater flexibility may include consideration of mid-course adjustments as the character and extent of these emerging land demand changes become more apparent.
- **Second, there is growing recognition of the need to accommodate both exclusive industrial zones and mixed-use development**. Business requirements and priorities vary depending on the specific characteristics of different industrial and commercial uses. With potential reduced commercial space demand, horizontal rather than vertical mixed-use may become a more pronounced market opportunity, at least near-term.

Other Public & Private Initiatives

A final topic of discussion has been on identifying other public and private initiatives that should be considered with this EOA. These are initiatives that extend beyond but support the City's land use policies. Priorities suggested by stakeholders interviewed center on workforce training, smart transport investment, long-term utility investment and targeted economic development incentives.

FACTORS AFFECTING ECONOMIC DEVELOPMENT POTENTIAL

An element of the EOA process involves consideration of location or market factors affecting where a particular type of industrial or other employment use may locate. As defined by ORS

660-009-0005, these locational factors "include but are not limited to, proximity to raw materials, supplies, labor, services, markets, or educational institutions; access to transportation and freight facilities such as rail, marine ports and airports, multimodal freight or transshipment facilities, and major transportation routes; and workforce factors (e.g., skill level, education, age distribution)."

Separately outlined by OAR 660-009-0015 (4) are potential advantages and disadvantages to be considered with the assessment of community economic development potential as topics that "may include but are not limited to" the following:

(a) Location, size and buying power of markets
(b) Availability of transportation facilities for access and freight mobility
(c) Public facilities and public services
(d) Labor market factors
(e) Access to suppliers and utilities
(f) Necessary support services
(g) Limits on development due to federal and state environmental protection laws
(h) Educational and technical training programs

Due to the overlap of the locational and market factors stipulated by OAR Definitions (0005) and Economic Opportunities Analysis (0015), these factors are considered together and also organized around topics that have emerged as most germane to Hillsboro's current and prospective community economic potential.

With this EOA, 11 factors are identified as pivotal both now and going forward for economic development in Hillsboro. As further detailed by EOA Appendix B, these are factors related to:

- **Globalization/Localization** – with e-commerce suggesting less localization while a transition back from global to local may significantly affect manufacturing decisions by re-shoring closer to a U.S. home base
- **Technology** – as a continued if not accelerating source of innovation affecting virtually every aspect of business, consumer and residential choice
- **Workforce** – with key industry issues related to availability of workers and to workforce skills and training
- **Vendor & Customer Networks** – with growing opportunity for Hillsboro and metro area businesses to draw from a widening network of other local businesses for key business-to-business relationships where the market is large enough to support key local vendors
- **Incomes & Buying Power –** for added local consumer buying power driven by Hillsboro wage levels that average 46% more than the average wage across the entire metro area
- **Transportation** – important in a more congested metro area for reliable freight transport, reasonable workforce commute, and retail/consumer business accessibility

- **Utility Infrastructure** – notably electric power, redundant fiber, and wastewater treatment – the availability, quality and cost of which has been a significant location consideration and attraction for major Hillsboro area employers
- **Civic Infrastructure** – including critical community infrastructure as for City services, K-12 schools, health care, parks/open spaces, and cultural amenities
- **Environmental Conservation** – with protection of wetlands, other critical areas and open spaces serving as an economic amenity, drawing business facilities that value a campus setting
- **Housing** – with job-housing balance of growing significance amid a more geographically limited commute-shed and with need for greater diversity of affordable housing product including expanded live-work opportunity
- **Quality of Life** – which for Oregon residents is rooted in access to active and passive outdoor recreation including mountains, ocean areas and, more recently, to regional attractions ranging from internationally recognized wineries to locally sourced foods

HILLSBORO'S COMPETITIVE POSITION

This assessment of competitive position has drawn from both the quantitative and qualitative assessments which have been conducted for this updated EOA. The chart below provides a summary listing of **strengths, weaknesses, opportunities and threat**s (or SWOT). More detailed discussion of each SWOT component is provided by Appendix B to this EOA.

Summary Hillsboro Economic Strengths, Weaknesses, Opportunities & Threats

Strengths	Weaknesses
• Oregon's high-tech driver	• Overdependence on one anchor semiconductor firm
• Low-cost west coast metro setting	• Consumer services not fully meeting local needs
• Attraction to tech labor force	• Lack of nationally recognized research university
• Good internal circulation + Hillsboro airport & MAX	• Regional congestion affecting freight & workforce
• Increased diversity of area housing & health services	• Availability and affordability of workforce housing
• Major portion of regional land inventory for jobs	• Land inventory inadequate for forecast job growth
• Record of public-private partnership	• Uncertain tax & regulatory environment

Opportunities	Threats
• R&D with applied technology manufacturing	• Risk of losing the anchor competitive edge
• Business diversification	• Workforce displacement
• Job/housing balance	• Less than full-service community
• Transport innovation	• Transport gridlock
• Market-driven 50-year urbanization	• Non-market regulation

Source: E. D. Hovee based on stakeholder interviews and quantitative assessments.

A major objective of this EOA is to build on existing strengths and emerging opportunities while addressing and, where possible, mitigating critical weaknesses and threats. As observed by one stakeholder, "We have the second most manufacturing economy in the U.S. and Hillsboro is the

most important traded sector in Oregon." These existing conditions represent building blocks for renewed economic prosperity not only locally but regionally and state-wide.

The aftermath of the 2007-09 Great Recession was focused on the transition to what was then termed as a *new normal.* With COVID and the economic contraction of 2020, the focus now shifts perhaps even more dramatically to what might be considered as a *new-new normal.*

Historical economic data presents often useful guideposts of where the economy has been, but not necessarily of where it is now headed. Qualitative evidence from stakeholders provides critical insights as to the transition now underway but not yet with a fully clear picture of where Hillsboro will be five years from now, let alone over the next 20 or 50 years.

However, a clear message from business and community leaders is that this next economic cycle will be about more than economic recovery or a simple return to the business and economic development practices of the last decade. In addition to accelerating trends of disruptive technology and live-work connection, this next decade may well serve to redefine the technologies viewed as most pivotal and to alter current live-work boundaries. Both transitions can be expected to further alter traditional distinctions between employment and residential land uses.

TARGET INDUSTRY CLUSTERS

Like many communities, Hillsboro has identified target industry clusters for which it is either competitive now or has reason for aspiring to increased economic opportunity in the years ahead. Key industry priorities of the City's economic development program currently have been identified for:

- Computers and electronics
- Software and information technology
- Advanced manufacturing
- Bioscience and medical devises

The inset to the right highlights examples of identified emerging industry opportunities. The listing is intended to be illustrative and not to preclude other as yet unforeseen but future potential prospects not yet on the horizon.

Historically defined in terms of readily measurable industry (NAICS) categories, target sector listings now often intentionally reach across traditional industry categories.

Emerging Economic Development Opportunities

This EOA is intended to support business opportunities as being identified by the City's economic development department. Examples include:

- Increased computer chip manufacturing capacity (supporting U.S. and state initiatives)
- Automotive & aerospace applications
- Energy storage
- Data centers
- Artificial intelligence (AI) research & deployment
- Supply chain onshoring & management
- On-shoring national defense manufacturing
- Tangible hardware
- Bio-tech expansion
- Climate technology
- Digital security

This approach recognizes the reality of the marketplace – especially where there are opportunities for a particular industry to be supported by local vendors or customers within a related industry segment.

As in the past, Hillsboro may modify its industry clusters to reflect and serve new or **emerging industry** opportunities in the years ahead. This would recognize the potential to step in alongside and encourage sectors that currently relatively may be weakly represented in Hillsboro but with growing competitive presence.

Priority consideration for business targeting might be provided to those emerging sectors (or specific businesses) offering potential for strong employment, tax revenue, and/or supplemental business leveraging (or "pull-through") benefits.[7] Consistent with a hybrid development scenario, an adaptive industry cluster approach can be positioned to address both national and regionally-driven opportunities.

This target industry strategy also reflects **recent federal policy and strategic industry initiatives.** The congressionally approved CHIPS and Science Act provides both the incentive and impetus for increased U.S. semiconductor manufacturing. This policy initiative is reinforced for Oregon and the metro region with 2022 findings and recommendations of the Oregon Semiconductor Competitiveness Task Force – with emphasis on the need for more buildable industrial land. As these or other policy or industry driven initiatives emerge in ways not previously anticipated, the City of Hillsboro also expects to increasingly focus on securing the capacity to better assure variable land parcel availability.

As discussed with both Chapters II and III of this EOA, significant market and policy shifts have materialized in response to unanticipated **external shocks** domestically and globally. These changes have occurred not only in response to the COVID-19 pandemic health and economic conditions, but also as a result of widespread supply chain disruptions.

From a land use perspective, it is increasingly necessary to highlight the need or impact of having or not having a **variable range of land parcels** available and ready-to-build. Of pivotal importance, the realization of Hillsboro's community economic potential requires maintaining large lots to the extent possible as needed to attract and retain major employer manufacturing and support functions.

Even with a continuing if not accelerated shift to increased automation, parcels suitable to serve large campus needs of major employers may serve not only as a means to increase direct employment but also to enhance the value of output and contribution to other employment generating functions locally, regionally and statewide. This points to a need to encourage adaptive build-out of facility needs, including recycling of older or obsolete facilities to meet **state-of-the-art industrial and technology practices.**

These more qualitative and forward-looking portions of this Community Economic Potential discussion set the stage for resumed quantitative analysis with Chapter IV Employment Land Needs which now follows.

IV. EMPLOYMENT LAND NEEDS

The determination of needs for commercial and industrial employment lands draws on results of the employment forecast scenarios coupled with the more qualitative perspectives describing community economic potential. In effect, this portion of the EOA analysis compares land supply with projected employment driven demand to assess site availability over 5- and 20-year planning horizons with alternate employment scenarios considered. Also included is summary consideration of potential longer-term, 50-year employment land needs.

The land needs analysis is intended to identify and characterize the demand and supply for industrial and commercial sites. Also described are the types of sites needed to accommodate targeted growth industries and existing employers that could potentially expand – together with opportunities for spin-off employers and entities that provide support for existing business and industry clusters.

The analysis aims to further identify specific site sizes, special site requirements or other characteristics affecting the needed land supply. In addition, the analysis includes a brief review and comparison to Metro's regional buildable lands inventory associated with the *2018 Urban Growth Report.* Key elements of this land needs assessment include discussion of:

- **Hillsboro's Employment Buildable Lands Inventory (BLI)** – based on data from December 2020.
- **Employment-Driven Land Need** – for each of three employment scenarios
- **Reconciliation of Land Need & Capacity** – addressing shortfalls with each jobs scenario
- **Site Size Requirements** – with large sites of pivotal importance for Hillsboro industries
- **50-year Outlook** – extrapolating the three job scenarios forward from 20 to 50 years
- **EOA implications & Options** – for bringing land capacity into alignment with demand

HILLSBORO'S EMPLOYMENT BLI

The City of Hillsboro has coordinated with Metro to evaluate the city's supply of buildable lands available for employment uses. The City utilized Metro's Buildable Land Inventory (BLI) methodology to revise portions of the 2018 Draft Urban Growth Report (UGR) pertaining to Hillsboro's Urban Growth Boundary (and future growth areas).

Hillsboro serves as a major source of employment – especially higher wage jobs – in Washington County. For example, as of 2018 QCEW employment data indicates that Hillsboro accounted for 27% of all jobs in Washington County, well above its 17% share of population county-wide.[8]

A supply-focused BLI was initially prepared by the City of Hillsboro in late 2019. The amended BLI also reflects a similar data benchmark date of December 2020. This approximates a similar 2020 starting point for the 20-year 2020-40 EOA employment forecast period.

The 2021 EOA was adopted in 2022 and was appealed to the Land Use Board of Appeals (LUBA) by 1000 Friends of Oregon (Friends) and Metro. While Friends and Metro raised several assignments of error relating to employment growth forecasting and the Comprehensive Plan status, most of these arguments were denied by LUBA. However, LUBA agreed with Friends that the 2019 buildable lands inventory (BLI) for employment land that was included in the 2021 EOA did not apply the correct analysis for determining the redevelopment potential of "developed lands." LUBA thus remanded the decision to the City to address that issue.

Consequently, this 2021 EOA has been amended to incorporate an employment BLI based on December 2020 data as prepared by the planning firm MIG in compliance with the terms of the LUBA remand. The results of the amended BLI are summarized in this chapter with further detail as provided by MIG included as Appendix E.

Amended BLI Methodology & Mapping

As with the initial 2019 BLI, the amended BLI based on data from December 2020 utilizes:

- GIS analysis based on Washington County **tax parcel data** (limited to the City of Hillsboro and associated future growth areas).
- Focus on parcels for which some form of **employment use** is permitted, differentiated between COM commercial, IND Industrial, and MUR mixed use residential and commercially zoned properties (with employment capacity varied to reflect allocations differentiated by mixed use zoning designation).
- Both the initial and amended BLI inventories reflect land use conditions as of 2019-20 consistent with the baseline year for forecasting of employment growth over the ensuing 2020-40 time period. As noted, the revised BLI reflects employment land inventory conditions as of December 2020.

Refined BLI Methodology. The MIG prepared BLI (included in full as Appendix E) is summarized as part of a five-step process:

- **Step 1: Land classification.** This step identifies the land in the City that is available for employment uses.
- **Step 2: Constraints to Development.** This step identifies constraints such as natural resources, steep slopes, and utility easements that limit development.
- **Step 3: Development Status.** This step assigns a "Development Status" of vacant, partially vacant, or developed to tax lots in the inventory.
- **Step 4: Net Buildable Area.** This step removes land for future rights-of-way and other land needs to provide a net number of buildable acres for each City zoning designation.
- **Step 5: Redevelopment.** This analysis includes an assessment of potentially redevelopable sites in the City and adjacent growth areas.

Land Classification. Parcels in the inventory are categorized based on their Comprehensive Plan designations, zoning designations, property ownership, and other characteristics. Employment

classifications include designation of lands with Comprehensive Plan designation as industrial, commercial and as a portion of mixed use land. Residential as well as publicly owned and other uses not consistent with employment activity are excluded from the employment BLI.

Constraints to Development. Employment land that is constrained from development is excluded from net buildable acreage based on constraints including:

- Steep slopes
- Water bodies
- FEMA floodway
- FEMA 100 Year floodplain
- Significant wetlands
- Significant forest resources
- Significant natural resources overlay (SNRO)
- BPA easements
- Airport runway protection area

Unconstrained or buildable areas of are defined as unconstrained vacant and partially vacant sites minus constrained acreage.

Development Status. Each parcel in the study area including employment designated properties in the City and the unincorporated urban growth boundary is categorized as vacant, partially vacant, or developed (further screened for redevelopment potential). Parcels partially vacant have existing development but with some portion of the site identified as potentially available for future development subject to minimum site or use requirements for development suitability (as specific to industrial, commercial and mixed use zones).

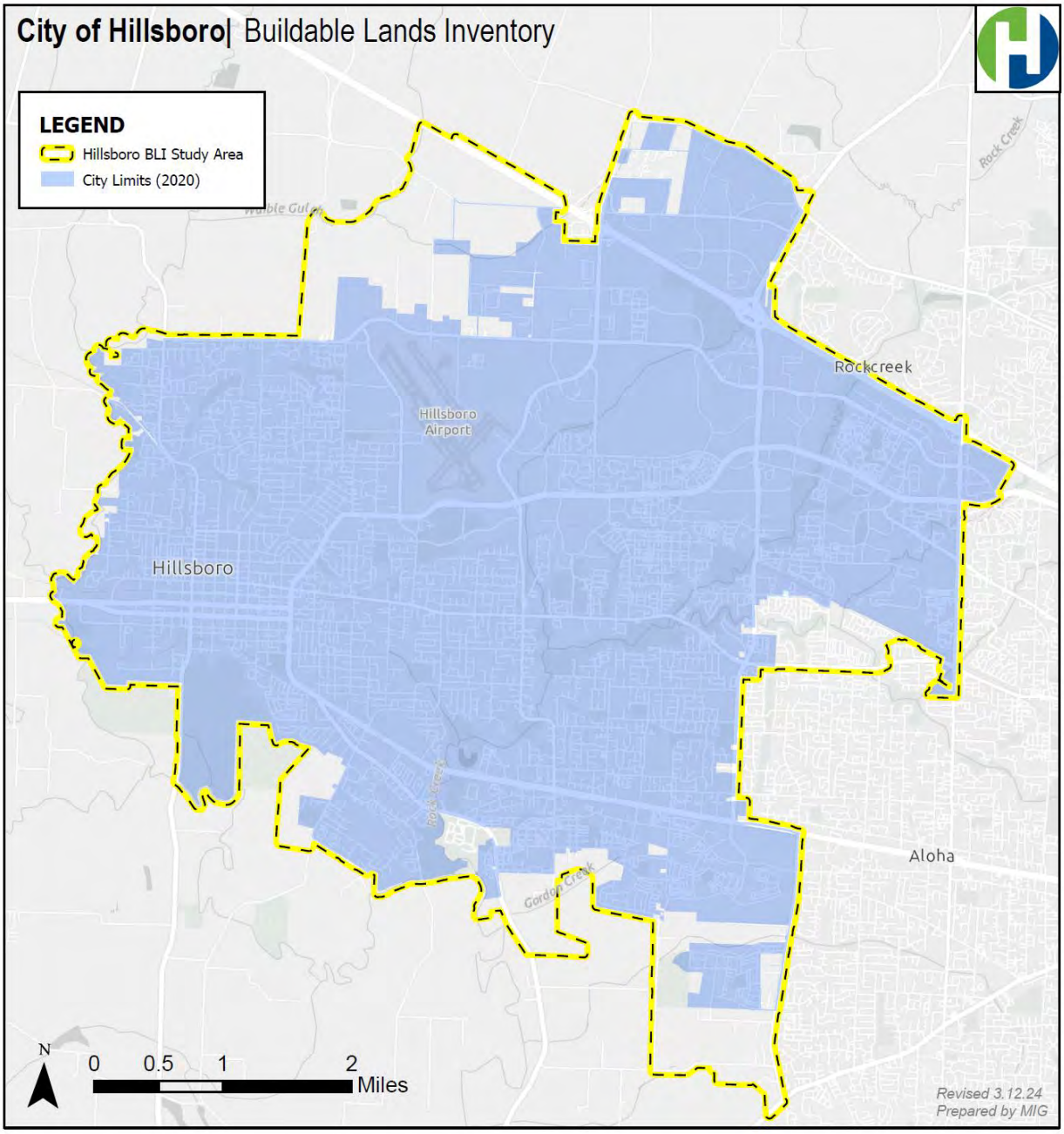
Converting Gross Acreage to Net Employment Area. Land for roads, infrastructure, open space and other needs constitutes reductions of two primary types to calculate net developable acreage for each parcel:

- An overall 25% reduction applied to commercial, industrial and mixed use zones; and
- Proportions of land area in mixed use zones expected to occur as employment uses (with varied deductions applied as specific to each of 16 applicable mixed use zones)

Employment BLI Mapping. Provided on the following four pages are maps illustrating geographies across which the revised employment BLI has been conducted – together with associated employment land categorizations.

The first map identifies boundaries of the Hillsboro city limits as of 2020. A second map depicts comprehensive plan designations for the city and unincorporated UGB. The third map shows portions of Hillsboro's employment land categorized as fully developed, partially vacant, or fully vacant. The fourth map depicts parcels with redevelopment potential using a strike price test.

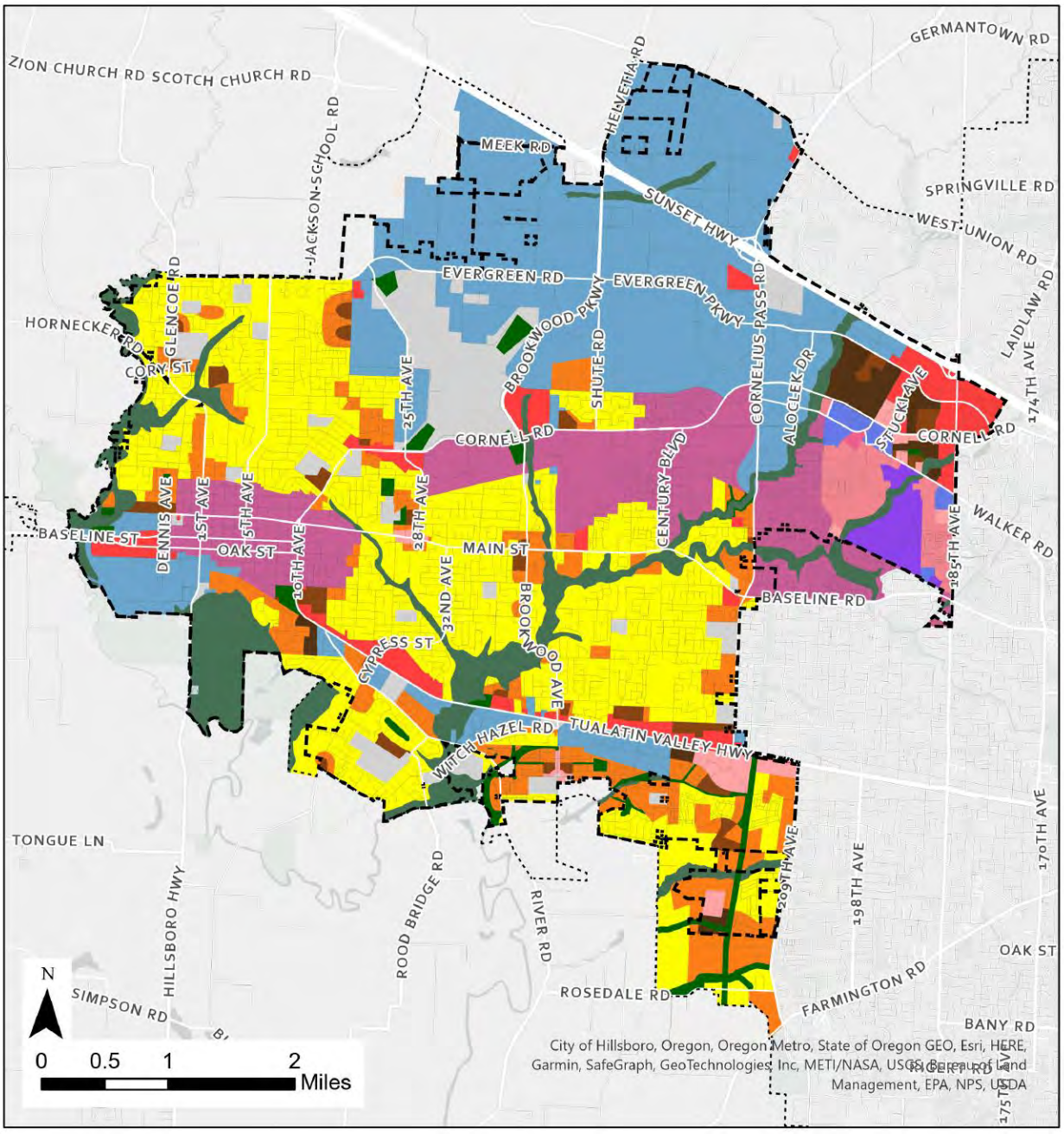
Hillsboro Buildable Lands Inventory Study Area



The study area for this 2021 EOA is illustrated by the above noted map. This comprises the City limits of Hillsboro as of 2020 (shown in blue) together with adjacent areas within the Urban Growth Boundary (UGB) surrounding the City of Hillsboro (with yellow dashed line).

Comprehensive Plan designations are depicted by the map on the following page. Most of the industrially designated land is situated on the north side of Hillsboro while commercial and mixed use designations are more widely dispersed city-wide.

City of Hillsboro Comprehensive Plan Designations



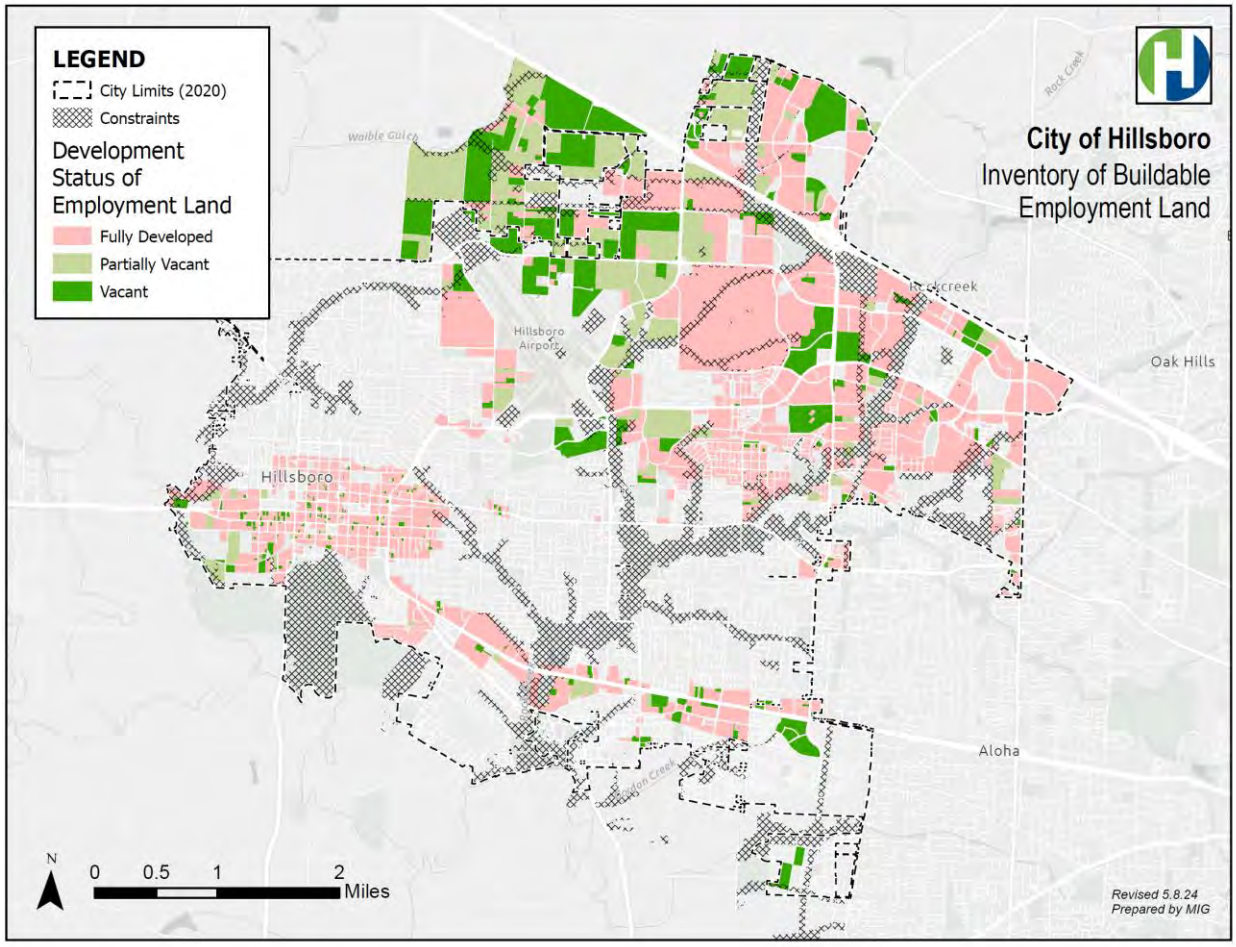
LEGEND

- Hillsboro City Limits
- 2022 Urban Growth Boundary

Comprehensive Plan Designations

- RL: Residential Low Density
- RM: Residential Medium Density
- RH: Residential High Density
- RMR: Residential Mid-Rise Density
- C: Commercial
- SCPA: Station Community Planning Area
- MU: Mixed-Use
- MU-UR: Mixed-Use - Urban Residential
- MU-UC: Mixed-Use - Urban Commercial
- MU-UE: Mixed-Use - Urban Employment
- MU-I: Mixed-Use - Institutional
- ANX: Recent Annexation
- OS: Open Space
- FP: Floodplain
- PF: Public Facility
- IN: Industrial

Development Status

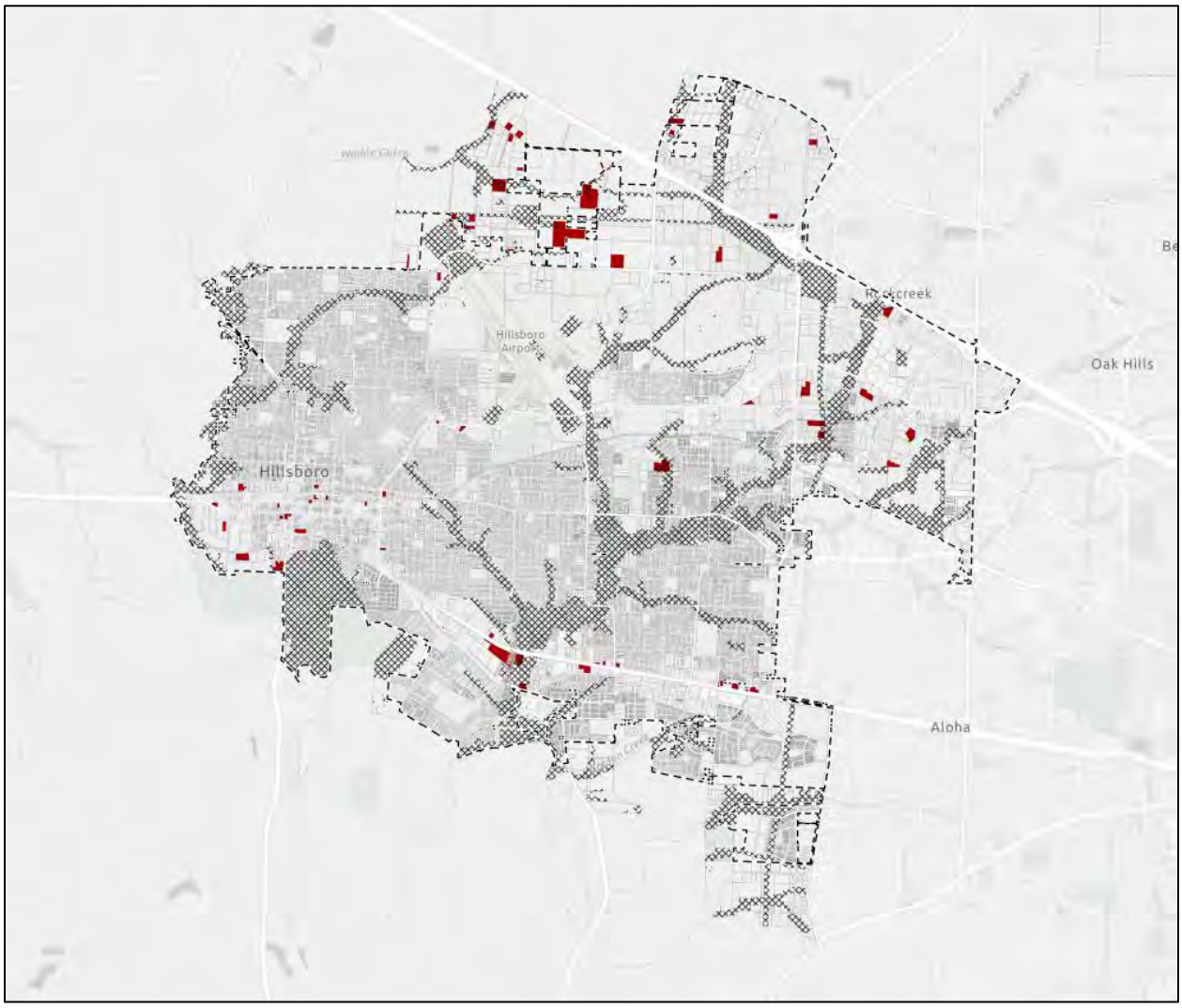


This third map (above) visually illustrates locations of employment designated land identified as fully developed, partially vacant, or fully vacant. Fully developed areas include the Beaverton-Hillsdale Highway corridor, downtown Hillsboro, and industrial/tech with major commercial centers situated in the northeast quadrant of the city. Partially vacant and fully vacant employment sites can be found throughout Hillsboro but are most concentrated in the northwest area including both in-city and unincorporated UGB areas.

As detailed by Appendix E, this employment BLI further evaluates the redevelopment potential of employment parcels categorized as "Developed." This test is an estimate that has been used, for example, with Metro's 2018 Urban Growth Report – involving application of a "strike price" representing a per square foot value of land at which a developer can afford to purchase property and theoretically redevelop profitably.

As depicted by the fourth map (on the following page), an estimated 143 acres of land currently classified as developed have land values low enough to be potentially economically viable for redevelopment. Roughly 85% of this potentially redevelopable land is zoned for industrial use.

Parcels with Redevelopment Potential through Strike Price Test



If redevelopment of these 143 acres were to occur, it would increase Hillsboro's clearly identified buildable lands of 1,225 acres (or net employment land) by up to about 12%. Given the numerous variables that determine whether an individual site will redevelop, including property owner willingness, the availability of other suitable sites, and macroeconomic factors, the 143 acres of potentially redevelopable land was evaluated separately from the remaining buildable area for employment use.

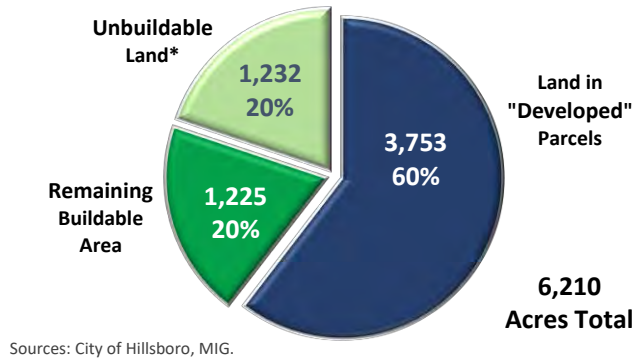
Quantitative data regarding employment BLI outputs is focused on the total inventory and net employment land, categorized by comprehensive plan and zone designation, current and potential development status, city and future growth area, and parcel size considerations. This is followed by comparison of land demand (pursuant to each of three forecast scenarios) with land supply over 5- and 20-year time horizons. A longer-term 50-year outlook is also provided together with resulting EOA implications including options for bringing land capacity into better alignment with demand.

Employment BLI Outputs

As depicted by the graph to the right, Hillsboro's employment buildable lands inventory (BLI) comprises a total of an estimated 6,210 acres. Of this, 3,753 acres (60%) are **already developed** – leaving 2,457 acres (40%) as not yet developed.

Of the undeveloped acreage, the amended BLI model indicates that 1,232 acres (20% of the inventory) represent unbuildable portions of vacant and partially vacant sites due to constraints and infrastructure set-asides.

The remaining 1,225 acres comprise Hillsboro's currently remaining buildable area for employment use. Adequacy of this net buildable employment land inventory to meet projected needs over short- and long-term planning horizons is a major focus of this EOA.



Sources: City of Hillsboro, MIG.

*Unbuildable Land includes land on parcels designated "Vacant" and "Partially Vacant" but with constraints or existing development together with assumptions for future infrastructure set-asides. If further redevelopment of low value lands consistent with strike price analysis were to occur, up to 143 acres could be reclassified from developed status to remaining buildable land identified as net employment) acreage.

Properties in the City comprise 83% of gross acres but only 54% of Hillsboro's net buildable employment land. Growth areas outside the city limits represents up to 46% of Hillsboro's added employment land potential. In effect, realization of Hillsboro's employment opportunity will depend on development of net buildable lands both within and outside current city limits but within Hillsboro's UGB.

As detailed by the chart to the right:

- An estimated 1,118 acres (or 91%) of Hillsboro's employment BLI represents land that has an **industrial (IND)** land designation.
- Just over 27acres (or 2% of the BLI) comprises **commercial (COM)** zoned land with potential for added employment.
- Close to 80 acres (6-7%) also offers commercial employment potential with **mixed-use (MUR) commercial and residential** zoning.

Employment BLI by Zoned Land Use

Employment Land Use	Net Emp Acres	% of Total
Industrial (IND)	1,117.9	91.3%
Commercial (COM)	27.4	2.2%
Mixed Use Commercial & Residential (MUR)	79.2	6.5%
Total Net Employment Lands (Acres)	**1,224.6**	**100.0%**

Source: City of Hillsboro, MIG and E.D. Hovee.

The 1,225 net buildable acres of this refined BLI methodology is 132 acres (or 10%) less than the 1,357 acres indicated by the previous 2019 prepared BLI inventory. This difference could be made up if the 143 acres identified by the strike price analysis proved feasible to redevelop. This may occur in cases where lands classified as already developed are of low enough value to incent redevelopment. While considered potentially feasible, redevelopment is not assured.

Industrial, commercial and mixed-use employment opportunities can occur via 29 distinct zoning designations in the City of Hillsboro. This includes 8 industrial (IND), two commercial (COM) and 19 mixed-use commercial/residential (MUR) zones (detailed by Appendix E).

The planned Jackson East industrial area represents by far the single largest potential employment zone in terms of accommodating job growth – with just over 561 net employment acres accounting for 46% of Hillsboro's acreage for future employment-related development. In terms of acreage potential, the next largest zone is Industrial Park (I-P) – with 264 acres accounting for 22% of net buildable employment land in Hillsboro and its identified growth areas. The area designated for Industrial Sanctuary (I-S) use comprises another 107 acres or 9% of net buildable acreage for future employment development.

In August 2022, Hillsboro City Council adopted Industrial Comprehensive Plan and Community Development Code amendments for the Jackson East Area. Adopted, codes allow for economic development as property owners determine how and when to voluntarily annex into the City of Hillsboro. Tools considered to encourage employment growth in this area include amending the nearby North Hillsboro Industrial Renewal Area, master planning and delivering infrastructure, and expanding the Enterprise Zone to include this larger future development area.

While commercial uses are intended to be accommodated primarily on commercial and mixed-use zoned lands, there is opportunity for some additional complementary and ancillary commercial development with virtually all of the industrial zoning designations. Office is outright permitted in a majority of the city's industrial zones, with limited and/or conditional approval required in some zones, and not permitted in one industrial zone.

Greater limitations are indicated for retail, service, and institutional uses on industrial lands – with the greatest restrictions on residential use (as least compatible with large site industrial activity). Also noted is that, to a relatively limited extent, some (generally smaller scale) industrial uses are allowed on a limited or conditional use basis in some non-industrial zones.

BLI Comparison with Metro UGR

Metro's *2018 Urban Growth Report* identified 2,150-2,530 net buildable acres of **commercial** (including mixed-use) employment land and 8,600 net buildable acres of industrial land inside the region's UGB. With just under 107 net buildable acres of commercial and mixed-use employment land, Hillsboro accounts for about 4-5% of the region's commercial inventory.

By comparison, this amended Hillsboro reported inventory of 1,225 acres of net **industrial** employment land represents an estimated 14% of the region's inventory of net buildable

acreage. On a combined basis, Hillsboro would account for about 12% of the Metro UGB's commercial and industrial employment land inventory.

EMPLOYMENT DRIVEN LAND DEMAND

As described in the prior chapter of this EOA report, three employment scenarios have been identified and quantified – with substantially different potential forecast outcomes:

- **Scenario A Straight-Line Growth**
  (forecast for a net addition of 36,910 Hillsboro jobs from 2020-40)
- **Scenario B Exponential Growth**
  (with net addition of as many as 87,800 net new jobs from 2020-40)
- **Scenario C Hybrid Growth**
  (focused on target industry sectors with 61,895 net new jobs from 2020-40)

For purposes of this EOA, forecast scenario results may be categorized in three separate ways: by NAICS or overall employment sector (as noted in the prior chapter), by building type (as the main focus of this EOA for purposes of allocating employment to buildings and land), and by overall Comprehensive Plan designation.

Categorization of Employment by Building Type

A useful means of categorizing employment is by the type(s) of buildings that a particular employment sector typically inhabits. This categorization system was first applied with Metro's 2009 UGR as a means of translating employment growth to building and associated land needs. This methodology also was applied with the most recent 2017 Hillsboro EOA.

For purposes of this updated EOA, seven employment-related building types are identified – covering office, institutional, flex/business park, general industrial, warehouse, data center and retail uses. NAICS specific employment is allocated to each of these building types using an allocation matrix that cross-references building type by employment sector. Percentage allocations of each employment sector to building types are based on prior research as initially conducted for the 2009 Metro UGR and as reflected (with Hillsboro-specific refinements) with the 2017 Hillsboro EOA (as further detailed by Appendix C to this EOA).

By building typology, office buildings are expected to account for the largest share of forecast employment growth – 31% of job growth with Scenario A and 33% in Scenarios B and C. Retail/storefront space accounts for 18-20% of anticipated job growth, general industrial for 12-16%, warehouse space for 9%, flex/business park (BP) space for 10-11%, and institutional for another 11-15% (depending on the scenario).

The next steps in this demand or needs analysis require the translation of employment growth into associated employment land need. The analysis begins with discussion of the conversion factors utilized, followed by presentation of resulting land need outputs for each of the three employment forecast scenarios considered.

Conversion Factors

Translating employment growth to land demand involves three sets of conversion factors:

- Conversion of **employment need to building space requirement** – by applying typical ratios of building square footage per employee as applicable to each building typology.
- Conversion of **building space need to associated land demand** – by applying a floor area ratio (FAR) factor specific to each building typology.
- Application of a **market vacancy factor** – recognizing space turnover at normalized occupancy typical for each building type.

Applying these three factors in sequence makes it possible to estimate employment densities (as jobs per acre) for each of the seven building types considered. For industrial uses, resulting employment densities range from an estimated three employees per acre with data center uses to about 17 jobs per acre for general industrial. With commercial uses, densities range from 18 jobs per acre for institutional to nearly 45 jobs per acre with office uses. These conversion factors are applied consistently across all three employment forecast scenarios.

Ratios applied are those previously used with Hillsboro's 2017 EOA. These factors also are generally consistent with conversion factors first utilized with Metro's 2009 UGR (including sub-regional variations), but with some modifications apparent with the city's 2017 EOA – including addition of market vacancy factors.

Employment-Driven Land Needs by Scenario

Net industrial land acreage needs associated with the three employment scenarios are estimated as follows:

- With the straight-line growth forecast of **Scenario A**, close to 2,230 net acres of employment land would be required from 2020-40. This is 12% less than the 2,530 net developable acreage need over a 20-year time frame as estimated with the prior 2017 EOA.
- With a more robust compound growth rate applied based on experience of the current economic cycle as estimated with **Scenario B**, the employment land need more than doubles to a net total of nearly 5,330 acres over the same 2020-40 time horizon.
- With the hybrid or targeted growth projection of **Scenario C**, land demand over a 20-year planning horizon is estimated at a net total of just over 3,840 acres.

With any of these three scenarios, the largest single source of land need would be for warehouse-related uses – at 26-28% of total net land demand (depending on the scenario). This is followed by flex/business park need at 16-18%, and general industrial demand at 11-15%.

Data center acreage demand is estimated at 6-10% of the total employment land need. Major generators of commercial related demand are institutional building needs at 10-13% of net land need, with office and retail each at about 11-12%.

Employment-Driven Land Needs by Job Sector

When reviewed by NAICS employment sector, the largest sources of land demand are noted as:

- Manufacturing with **Scenario A** – at 21% of the net developable acreage need. Other major sources of land demand would be health care and social assistance (16%), wholesale trade (15%), information (11%), and transportation/warehousing (10%).
- A changed relative ordering of employment land needs with **Scenario B** – with wholesale trade and health care/social assistance each accounting for as much as 20% of total land need. Information and transportation/warehousing would each account for 12% of land need with manufacturing at 11%.
- A further re-shuffling resulting in more sectoral balance for priority sectors with **Scenario C** – as transportation/warehousing, information and health care/social assistance each account for between 15-18% of total 20-year land need. Manufacturing would represent 15% of total net developable acreage required – a figure about mid-way between the Scenario A and B proportions.

RECONCILIATION OF LAND NEED & CAPACITY

The next step of this EOA needs analysis is to compare forecast employment land need with the BLI-identified supply of net buildable sites. This analysis starts by comparing demand and supply in aggregate, followed by a closer look at the composition of major employment generators.

Employment Land Need vs Capacity Overview

With this analysis, employment land needs are evaluated in terms of both a 20-year plan horizon and also over a 5-year short-term period – for each of three forecast scenarios. As shown by the following chart, employment land capacity appears inadequate to meet anticipated employer needs over both 20-year and 5-year time horizons.

Net Hillsboro Employment Acreage Need by Scenario (2020-40)

Demand/Supply Factor	Net Acres by Scenario & Time Horizon			Comments
	A-Straight Line	B-Exponential	C-Hybrid	
20-Year Plan Horizon (Long-Term):				
Employment BLI Capacity	1,224.6	1,224.6	1,224.6	In-city & future growth area
less Employment Land Need	(2,228.2)	(5,329.2)	(3,841.2)	Preliminary, subject to revision
equals Net Surplus/(Deficit)	(1,003.6)	(4,104.6)	(2,616.6)	
5-Year (Short-Term):				
Employment BLI Capacity	663.1	663.1	663.1	In-city lands only
less Employment Land Need	(557.0)	(1,332.3)	(960.3)	Assumed @ 1/4 long-term need
equals Net Surplus/(Deficit)	106.1	(669.2)	(297.2)	
% of 5-Yr Demand Accommodated	119%	50%	69%	

Sources: MIG, E. D. Hovee. See Appendix C for added detail.

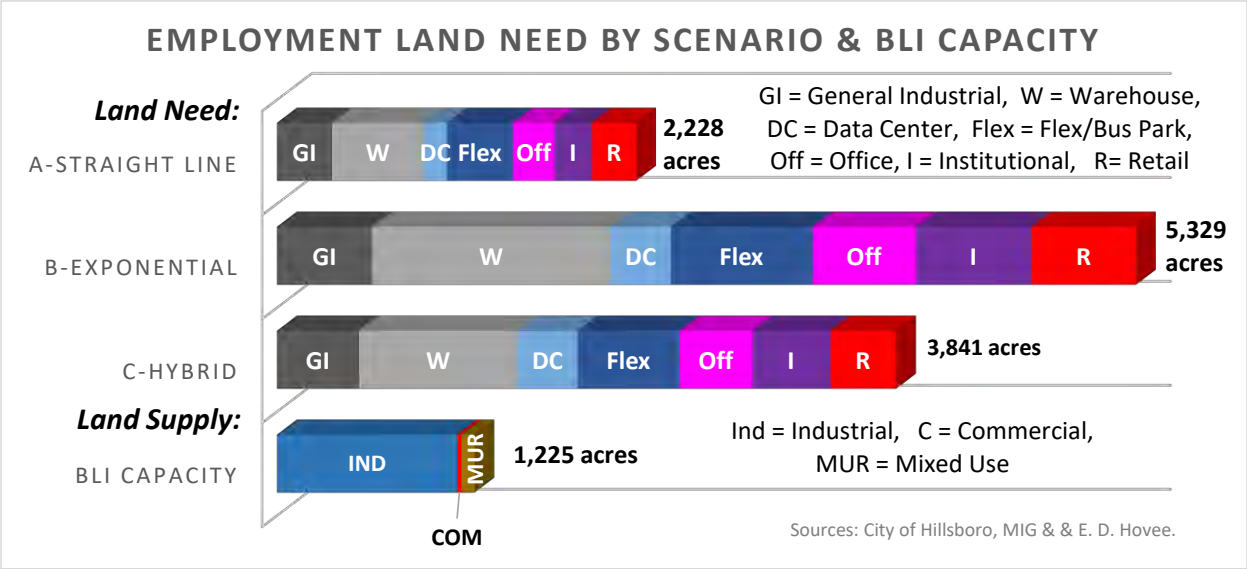
Land shortfalls with the more conservative Scenario A are greatly exacerbated with the more aggressive growth potential associated with Scenario B, albeit better balanced with Scenario C. The long-term 20-year plan horizon assumes the availability of in-city lands plus lands currently outside the City but within Hillsboro's already identified urban reserve areas.

For the 5-year short term assessment, only the lands currently within the Hillsboro city limits are assumed to be ready and available for development with full urban services. Areas not yet annexed would have little to no short-term employment potential assuming that urban services (e.g., water and sewer) are not extended beyond the City's incorporated boundaries within this near-term time span.

Short-term, in-city lands could accommodate essentially all of 5-year demand, assuming the lower growth of a Scenario A forecast scenario. However, substantial deficits occur over a 20-year forecasted horizon. Even greater deficits are indicated over both 5- and 20-year forecast periods – with either of the high growth Scenario B and hybrid Scenario C projections. In effect, securing more land becomes pivotal as a key step toward realization of Hillsboro's full employment potential – also for added higher wage regional job opportunity.

Components of Employment Land Need & Capacity

With the following graphic, employment-driven **land need** associated with each of the job growth scenarios is illustrated across the spectrum of seven building types. By comparison, **land supply** is shown for the three land use types of industrial, commercial and mixed-use lands.



Key observations from these comparisons are three-fold:

- Forecast land demand over 20 years is 1.8 times existing BLI land supply with Scenario A, more than four times greater with Scenario B and three times greater with Scenario C.
- With the limited BLI capacity comprised primarily of industrially designated land, not only is land supply inadequate for potential industrial use but there may be

redevelopment pressure – including potential to realize higher land values – for conversion of some industrial land to commercial and/or mixed-use development.[9]

- The commercial development that does occur on non-industrial lands is more likely to occur with MUR than COM designated sites due to greater MUR land capacity.

Going forward, land need can be expected to be further affected in ways not yet fully foreseen as for horizontal and vertical mixed-use development, remote work trends, e-commerce and new technologies including artificial intelligence (AI). This EOA assumes land needs similar to patterns of the last economic cycle but recognizes that future forecast methodologies will adapt to new patterns of employment development as emerging trends become more evident.

Comparing Forecast Need with Observed Absorption

Forecasts of employment and resulting land need scenarios can be compared with actual land absorption experience recently in North Hillsboro. The City's Economic and Community Development department has compiled data for industrial area development occurring since 2014 – in effect covering a 5-6 year time period through August 2021.

Over this time period, industrial development has occurred on 48 parcels totaling approximately 595 acres. This equates to average annual absorption of 100+ acres per year – not counting development outside the North Hillsboro area (including on commercial and mixed-use designated lands).

By comparison, annualized land needs associated with the three EOA forecast scenarios are estimated at forecast need of 111 acres per year with Scenario A, 266 acres annually with Scenario B and 192 acres per year with Scenario C. This indicates clear support for more than Scenario A straight-line growth as a base expectation going forward, with opportunity for added absorption if Hillsboro continues active pursuit of major tech-related employer commitments.

Site Size

An important component of this Goal 9 EOA report is to evaluate the adequacy of parcel size distribution. This is to address the question: *How well does the mix of small, medium and large parcels match current and anticipated need?*

Parcel Distribution by Site Size (Acres)

Size Class In Acres	All Parcels		Vacant+Partially Developed	
	# of Parcels	Acres	Total Acres	Net Buildable
> 50	9	1,014	442	261
20-50	33	1,020	753	401
10-20	57	802	401	175
5-10	159	1,092	376	156
2-5	337	1,103	345	156
1-2	280	399	78	45
0.5-1	280	210	27	16
0.25-0.5	472	162	16	9
< 0.25	5,868	408	17	7
Total	**7,495**	**6,210**	**2,456**	**1,225**

Sources: City of Hillsboro, MIG & E. D. Hovee.

As illustrated by the chart on the preceding page, this evaluation has been approached from the standpoint of comparing parcel sizes for the full existing inventory of all employment designated lands with parcel sizes of the current vacant and redevelopable employment land inventory. Detailed parcel size classifications are the same as were provided by the 2017 EOA.

Key observations from this review include the following:

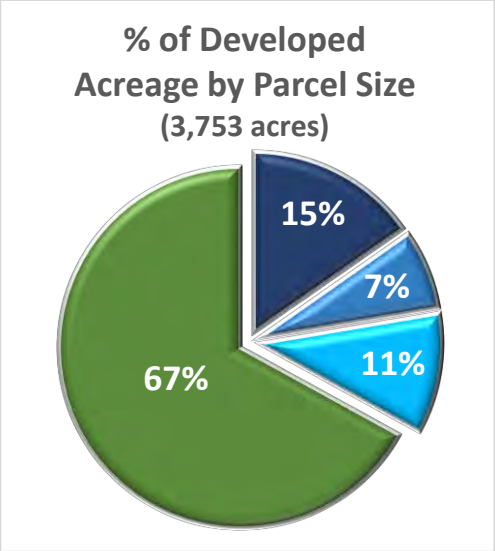
- Hillsboro's amended BLI indicates that out of a total employment designated land base of 6,210 acres, 3,753 acres (60%) are already developed with 1,232 acres (20%) identified as unbuildable for a net remaining inventory of 1,225 acres (or just 20% of the Hillsboro's land area designated for employment use).
- Out of more than 6,210 acres of gross employment designated land area, more than 2,456 acres (or 40% of the total) consist of tax parcels that are fully or partially vacant with potential for some amounts of added employment development (before environmental, infrastructure and other set-asides are taken into consideration.
- Not shown by the chart on the previous page but indicated by the detailed inventory database (provided with Appendix E) is that an estimated 128 parcels are noted as partially vacant. Taken together, these partially vacant properties account for an estimated 1,203 acres. Of this amount, 398 acres are viewed as potentially developable with 805 acres unbuildable. Overall average parcel size is about 9.4 acres for these parcels that are developed but with potentially vacant area.
- A total of 361 vacant land parcels comprise 1,253 acres for an average parcel size of just 3.5 acres. Approximately 826 acres are estimated as net buildable with 427 acres classified as unbuildable. In effect, while Hillsboro's vacant inventory is comprised of relatively small parcels, a higher proportion of this vacant lot inventory is assumed to be ultimately developable than with remaining vacant portions of partially vacant sites.
- Because industrial (IND) designated lands account for over 90% of the vacant inventory (with COM and MUR parcels the remainder), detailed breakouts by zoning class are not provided for each acreage size class. However, it is noted that IND lands identified as suitable for future employment use average about eight acres per remaining land parcels for which full or partial development potential is noted as compared with only 1.2-1.6 acres per lot for the average commercial and mixed uses sites, respectively.
- Of final note is that properties situated in the North Hillsboro area – both in and outside the city limits – are associated with above average size lots for vacant and partially vacant properties. Jackson East properties average about 11 acres per vacant and partially vacant tax lot with development potential. This is also the case for properties designated for industrial sanctuary (I-S) use. The average lot size for industrial park (I-P) designated property is about 7 acres per parcel with development potential.

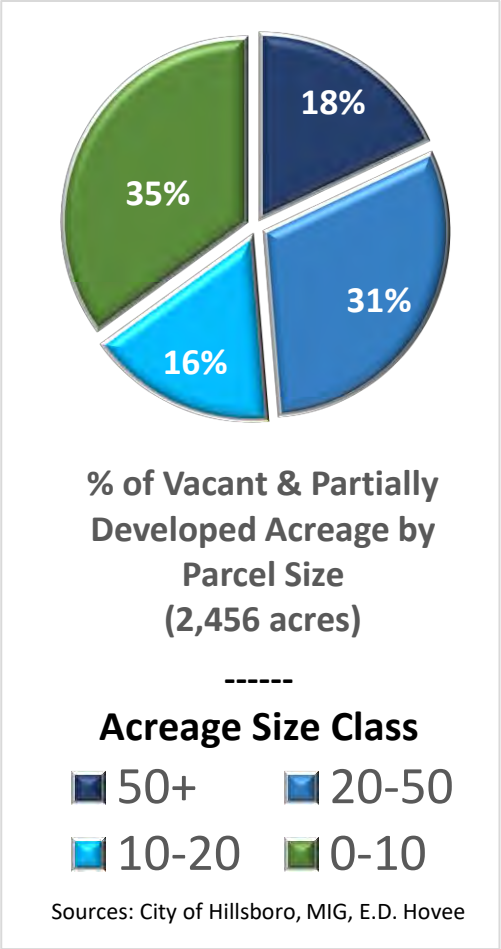
A more detailed review of the distribution of parcel sizing for developed versus vacant and partially vacant employment sites is provided by the graphs and accompanying analysis on the following page.

The **top graph** depicts the distribution of parcel sizes for developed acreage with the **second graph** showing the distribution of vacant and partially vacant acreage. Potential mismatches occur across all portions of the parcel size spectrum:

- Parcels of 50+ acres comprise only 15% of Hillsboro's already developed acreage as compared with a somewhat higher 18% share for as yet vacant and partially vacant employment lands. The large parcel share is greater at 21% if only net buildable total acreage of 1,225 acres is considered.
- Parcels of 10-20 and 20-50 acres combined account for only 18% of already developed lands. These mid-sized parcels represent a more substantial 47% of the vacant and partially vacant inventory. To the extent that industrial needs in excess of 50 acres exceed the existing inventory, part of this shortfall might be addressed by the relatively larger inventory of 10-50 acre parcels – especially in cases where adjoining properties are land banked or otherwise aggregated to achieve more 50+ acre site options. While 10-50 acre parcels may be relatively more abundant, they likely also come up short as the total acreage need with all job scenarios well exceeds the total inventory available.
- At the opposite end of the size scale, 67% of already developed properties involve sites of 10 acres or less. However, these smaller sites account for only 35% of the potential future inventory. This suggests challenges going forward with accommodating smaller scale, often free-standing small business uses as for retail, service, and entrepreneurial activities.

A better balance of parcel sizes may help Hillsboro's competitiveness for large scale industrial users as well as smaller scale businesses. However, to the extent that gross acreage demand is expected to exceed total supply, re-balancing the existing inventory will only go part-way, not addressing the prospective overall shortage of employment land over the next 20 years.





With about one-third (33%) of Hillsboro's net buildable employment land comprised of partially vacant land, it may also prove challenging to release sites being held for future expansion whether in the near term or potentially extending even beyond a 20-year forecast period.

50-YEAR OUTLOOK

While focused on 5- and 20-year forecast scenarios, this EOA also addresses the longer-term horizon of the next 50 years. This is significant for Hillsboro from two perspectives:

- Assuring that there will be adequate economic opportunity not just for the current generation but for the next – by planning now for future reserves
- Also the opportunity to be better prepared if job growth and land needs prove to be greater than expected and planned for within a 20-year Comprehensive Plan time frame

50-Year Employment Framework

The features of three forecast scenarios differ more substantially when extrapolated beyond 20-years to a 50-year time horizon. These implications are compared in summary fashion by the chart on the following page. Primary considerations addressed with this comparison are:

- Ratio of jobs in the forecast period (20 or 50 years) to 2020 base year employment
- Key technology shifts of significance to Hillsboro employers
- Land supply (assumed for initial discussion to be essentially the same in all scenarios)
- Land need (with 20-year as previously estimated and 50-year as rough approximations)
- Gap strategies (or how shortages in land supply might most reasonably be addressed)

Summary Comparison

From a **quantitative** perspective, observations from this review are summarized as follows:

- With the **Scenario A Straight-Line** forecast, employment in Hillsboro could be 44% greater by 2040 than in 2020. Extending this scenario forward to 50 years, employment in Hillsboro by 2070 would be double that of 2020.
- With a **Scenario B Exponential** job growth forecast, employment in Hillsboro could double by 2040. If this compounded growth rate of 3.6% per year is extrapolated out to 50 years, Hillsboro job base in 2070 could be as much as six times more than in 2020.
- With a **Scenario C Hybrid** and targeted job growth projection, Hillsboro employment could be 73% greater by 2040 than at the start of the forecast period. By 2070, employment would be nearly four times current conditions.

From a **qualitative perspective,** technological change may facilitate the most profound effects across Hillsboro's economic landscape – in 20 years and yet more so over 50 years. How Hillsboro and the metro area address the gap between land need and supply will affect whether Hillsboro asserts a stronger position on the U.S. and global stage – or just holds its own.

20-/50-Year EOA Outlook & Implications by Employment Growth Scenario

Feature	A – Straight-Line	B – Exponential	C – Hybrid
20-Year			
2040:20 Jobs	1.44:1	2.02:1	1.73:1
Technology Shift	AI/EV deployment, strong IoT & cloud computing growth, data center needs beyond local BLI capacity	Greatest role in technology testing & manufacture, data center pull-thru; 2nd possible major tech anchor	Captures semiconductor-driven demand across multiple industry sectors and re-shoring priority
Employment Mix	Led by health care/bio-tech & manufacturing	Led by healthcare & distribution, manufacturing & support services	Diversifies to clusters w/ competitive advantage – bio-tech & support sectors
Land Supply	1,225 acres	1,225 acres	1,225 acres
Employment Land Need	2,228 acre need Scenario w/least land need	5,329 acre need Scenario w/most land need	3,841 acre need Focused on target clusters
Gap Strategies	• Reduce jobs forecast • Increased job density • Increased at-home work • Added land supply (Or combined strategies)	Consider same strategies as with Scenario A (Depends more on UGB expansion & economic incentives for site redevelopment)	Similar strategies focused to improve efficiency of land utilization (with monitoring & land triggering tools to capture high value opportunities)
50-Year			
2070:20 Jobs	2:1	6:1	4:1
Technology Shift	Dramatically altered transport & artificial intelligence (AI) including robotization with potential workforce displacement	Hillsboro positioned as a globally-recognized applied tech leader with venture capital & research university infrastructure	Challenge of determining whether & how to broaden or more narrowly define Hillsboro's best industry & service cluster options
Employment Mix	Continued strong manufacturing mix (as major strategic priority)	Greater orientation to service sector (with more urban-scale development)	Continued focus on tech-related industry clustering & support businesses
Land Supply	1,225 acres	1,225 acres	1,225 acres
Land Need	~ 3,200 acre need (if same industry mix as 2040 is maintained)	~15,000 acre need (if same industry mix & density as 2040 is maintained)	~8,700 acre need (focused on target industry & support service clusters)
	(assuming similar industry mix and land demand factors from 2040-70 as from 2020-40)		
Gap Strategies	Similar to a 20-year Scenario B option but over more time (with substantial site redevelopment & opportunity to phase in changes over a 50-year time horizon)	Likely not feasible without substantial UGB expansion (coupled with use prioritization, land use & job/work-at-home intensification)	Requires less UGB expansion than Scenario B (potentially with more targeting of higher density industrial and mixed-use live-work options)

Sources: E. D. Hovee. Preliminary and subject to refinement including with future EOA updates.

EOA IMPLICATIONS & OPTIONS

The juxtaposition of future employment growth with anticipated land capacity provides the quantitative underpinnings for Hillsboro's updated Economic Opportunities Analysis. Two overall implications for the community's economic future are of most significance.

First and foremost, this EOA clearly indicates that Hillsboro's current inventory of employment lands (including potential growth areas) will not come close to accommodating a continuation of strong local employment growth over the next 20 years. There is a **pronounced shortfall of employment land** with even with a base case Scenario A forecast. The shortfall further intensifies with Scenario B or C outcomes.

Second, bringing Hillsboro's land availability and needs into alignment may require **substantial adjustments on multiple fronts** – likely involving revisions to forecast outcomes, BLI adjustments and/or supportive state and regional land use policy.

Potential mitigation options for consideration to address the gap between employment land demand and supply include any or some combination of the following:

- **Reduce the EOA employment forecast to match current BLI capacity.** If this is to be the primary option, it is clear that the high growth Scenario B forecast would need to be discarded. Even the more conservative Scenario A jobs forecast would need to be reduced by about 45% – assuming a pro-rata cut across all economic sectors.
- **Focus EOA forecast reductions on the most land extensive sectors.** This likely would mean that the most significant cuts would be made to allocations for lower employment density data center, warehouse and flex/business park uses.
- **Adjust employment to land need conversion factors with a more urban profile.** One option could be to increase building space utilization (with fewer square feet per employee) and/or floor area ratios (FARs) for more intensive land utilization in the past. This might be done by targeting higher density uses – both generally and within each primary employment sector or industry cluster. Also possible would be to eliminate the market vacancy factor which is not explicitly included in some EOA analyses.
- **Increase the planned BLI supply, especially for growth areas around Hillsboro.** While the prime focus might be on increasing gross employment acreage, options might also be considered for addressing environmental constraint and ROW patterns to minimize reductions from gross to net acreage amounts. Of added potential importance might be consideration of actions to encourage more rapid conversion of land being held for future expansion – as shown feasible without impairing corporate user strategic options.
- **Pursue Metro region and statewide recognition of Hillsboro's strategic significance to long-term competitiveness and high wage jobs as integral to long-term economic vitality.** With respect to high technology clusters (especially semiconductors), reduced competitiveness of a Hillsboro location likely will not be readily or fully offset at other locations regionally or statewide. Any loss to Hillsboro can reasonably be expected to be only partially offset elsewhere in Oregon – with resulting statewide economic impact.

V. IMPLEMENTATION POLICIES

The final chapter of this Hillsboro EOA update draws from the quantitative and qualitative analyses of Chapters I-IV to outline a strategic direction for policies that can serve to implement community economic development objectives for the City of Hillsboro. As stipulated by OAR 660-009-0020, these policies are to provide a statement of community development objectives, commitment to provide a competitive short-term supply of land for industrial and other employment uses, and a commitment to provide adequate sites and facilities.

This Chapter V discussion begins with a brief review of Hillsboro's economic development-related objectives and policies. This is followed by discussion of key drivers of economic change, recommended implementation policies and measures with anticipated updating of Comprehensive Plan goals and policies. An expanded version of this Chapter V discussion is provided by EOA Appendix D.

CURRENT FRAMEWORK FOR HILLSBORO ECONOMIC DEVELOPMENT

The current status of City policy related to economic development appears to be covered primarily from three documents – the 2017 EOA, the most recent adopted *Hillsboro Comprehensive Plan* (dated November 21, 2017 and effective as of January 2, 2018), and the 2020-prepared *Hillsboro 2035 Community Plan.*

2017 EOA

The 2017 EOA does not include a direct statement of community economic development objectives as stipulated by *OAR 660-009-0020* but does contain a series of recommendations organized around three topics – capacity, business environment and recruitment/retention. The 2017 EOA also provided a "summary list of implementation measures to encourage effective utilization of the City's employment capacity."

2018 Hillsboro Comprehensive Plan

Chapter 11 of the *Hillsboro Comprehensive Plan* addresses "Building Economy & Infrastructure" including five goals, each of which is supported by more specific and detailed policy measures. The adopted five goals read as follows:

- **Goal 1 – Competitive Advantage:** Diversify and expand the economy to give Hillsboro, the region, and the state a competitive advantage.
- **Goal 2 – Facilities, Utilities & Services:** Catalyze economic development through high-quality public facilities, utilities and services.
- **Goal 3 – Land Supply:** Manage land supply to meet short and long-term economic development needs of Hillsboro, the region, and the state.
- **Goal 4 – Equity:** Promote economic development opportunities for individuals and small and emerging businesses to ensure equitable access to resources.

- **Goal 5 – Livability:** Develop and sustain a vibrant City to support economic development.

Hillsboro 2035 Community Plan

Building on the success of the original award-winning *Hillsboro 2020 Vision and Action Plan*, in 2020 the City completed an updated *Hillsboro 2035 Community Plan* as representing "a shared vision for a sustainable future."

As noted in the introduction to this EOA, **Economy and Infrastructure** comprises the first of five 2035 focus areas for 2035 accompanied by a goal statement representing continued high aspirations:

> Hillsboro's world-class economy, advanced technical training, and innovative, business-friendly culture attracts investment and supports businesses of all sizes. State of the art infrastructure systems including communications, roads, transit, and water supply are in place and continually updated to accommodate the city's growth and evolution. Hillsboro is a vibrant, regional destination for arts, recreation, cuisine, and entertainment.

Five supportive initiatives and actions are further detailed as part of the updated Community Plan:

- **Initiative 1:** Promote Hillsboro's business-friendly culture and proactive workforce development initiatives.
- **Initiative 2:** Encourage and support the growth of emerging industries, small business, and the spirit of entrepreneurship.
- **Initiative 3:** Expand shopping, entertainment, and dining destinations.
- **Initiative 4**: Continue efforts to develop a vibrant, mixed-use downtown as a unique attraction.
- **Initiative 5:** Implement efforts to ease congestion in and around Hillsboro.

This 2021 EOA aims to both reinforce adopted City-wide planning priorities and identify new initiatives as appropriate to facilitate economic recovery and resilience for Hillsboro and the metro region going forward.

KEY DRIVERS OF ECONOMIC DEVELOPMENT CHANGE

This EOA update reflects key drivers of economic development changes globally that have emerged since the 2017 EOA:

- **The COVID pandemic and economic downturn** which have accelerated temporary and likely lasting changes to work and shop from home at the expense of *brick-and-mortar* commercial office and retail space – but also creating demand for upsized housing and new innovative live-work options
- **Resurgence of industrial space demand** due to e-commerce distribution, accelerated technological change, added data center requirements, and re-shoring of traditional manufacturing
- **Changing competitive advantage of tech leadership** particularly with respect to semiconductors, to the potential disadvantage of American firms including Intel as Oregon's largest private employer if not addressed both regionally and nationally
- **Federal and state government commitment to a reinvigorated domestic tech and semiconductor industry** exemplified by congressional approval of the *CHIPS and Science Act of 2022* coupled with parallel August 2022 findings and recommendations of the Oregon Semiconductor Competitiveness Task Force.

Hillsboro has great **opportunity** to capitalize on these emerging trends – increasingly as Oregon's *economic engine* – as a key source of new wealth generated by traded sector businesses. However, securing and building on the community's comparative and competitive advantages likely depends, in large part, on further reinforcing Hillsboro's core semiconductor technology manufacturing prowess. This will require larger *shovel-ready* campus sites suitable for major corporate investment than are now available as part of the Hillsboro's buildable lands inventory.

There is also new **downside risk**, dependent on the changing fortunes and continued industry leadership of the community's major employer. And on local and regional capacity to better leverage the next waves of tech-forward investment. These considerations serve as a backdrop to implementation policies outlined with this EOA update.

EOA RECOMMENDED IMPLEMENTATION POLICIES & MEASURES

Implementation policies are organized to cover topics stipulated by OAR 660-009-0020 to reflect key issues and objectives. Topics covered are employment land use, transportation and utility infrastructure, target and supporting industry clusters, economic development incentives, workforce readiness, and partnership opportunity.

A full summary listing of recommended implementation policies and measures is provided by the chart on the following two pages. This is followed by more detailed discussion of implementation features for each of the six noted EOA topics.

Summary of Recommended EOA Implementation Policies & Measures

EOA Topic	Implementation Measures
Employment Land Use	✓ As a minimum measure, adopt a 20-year jobs and land use forecast similar to Scenario C Hybrid Growth ✓ Annex and serve added employment land as needed to meet at least the 5-Year Scenario A Straight-Line short-term supply requirement ✓ Utilize the Scenario B forecast as an initial means to begin determination of longer-term needs for added industrial reserves and land capacity ✓ Provide more opportunity to accommodate both exclusive industrial zones and mixed-use development ✓ Provide opportunity for large acreage, major employer campuses of up to 600+ acres consistent with national trends but not readily available regionally in Oregon ✓ Orient state and local incentive measures to support increased employment land utilization and redevelopment together with attraction and retention of target industries
Transportation & Utility Infrastructure	✓ Target added local transport and utility infrastructure in conjunction with annexation to meet short-term employment land supply forecasts ✓ Provide explicit policy support for a regional transportation system that effectively supports the movement of raw materials, manufactured goods and workforce to and through Hillsboro's employment areas ✓ Increase policy emphasis on north-south access and reduction of work-force commutes (to maximize Hillsboro's work-force commute-shed accessibility) ✓ Provide explicit policy support to further strengthen Hillsboro's competitive advantage as a Pacific Northwest data hub for low latency, data intensive firms offering high "pull-through" potential
Target & Supporting Industry Clusters	✓ Periodically modify and update Hillsboro's current target industry listing to reflect and serve new or emerging traded sector industry opportunities in the years ahead ✓ Retain existing businesses including those at risk of displacement from pandemic and/or economic downturn ✓ Add policy language to expand business opportunities for minority- and women-owned businesses ✓ Add a policy priority for community amenities that support traded sector business investment, talent recruitment/retention and high wage job potential
Workforce Readiness	✓ Include retraining emphasis for employees displaced in times of economic disruption and transition ✓ Add policy language to expand employment opportunities for under-represented members of the community including racial/ethnic minority groups, women and veterans ✓ Coordinate with Washington County to evaluate the most effective Workforce Board arrangements in support of community workforce needs ✓ Support efforts to create new workforce development programs meeting the needs of target and emerging industries ✓ Pursue designation as a Center of Innovation Excellence and Regional Technology Hub to support Hillsboro's leadership role in research and development with expanded benefits and opportunities to the community

Summary of Recommended EOA Implementation Policies & Measures

EOA Topic	Implementation Measures
Economic Development Incentives	✓ Provide a more prominent position for incentive mechanisms as integral to supporting or facilitating achievement of economic goals and policies ✓ More specifically include incentives as a means to leverage increased density with uses that currently are associated with relatively low job per acre counts ✓ Advance incentives focused on land readiness together with land aggregation as needed for industrial expansion and recruitment
Partnership Opportunities	✓ Include urban renewal as a potential economic development funding tool within designated renewal districts ✓ Add policy language to more explicitly encourage Metro and state-wide support for Hillsboro tech-focused economic development as an economic engine of significance and benefit regionally and statewide

Employment Land Use

Following the articulation of community economic development objectives, the first policies identified by OAR 660-009 are to provide an adequate employment land inventory with priority emphasis on short term supply defined as "suitable land that is ready for construction within one year of an application."

Hybrid Scenario Recommended for Starters. Based on national and regional recovery experience from the pandemic and related economic downturn, the Scenario C Hybrid Growth forecast option is viewed as providing the best opportunity for short- as well as long-term economic resilience. In addition to playing to Hillsboro's demonstrated competitive advantages, this scenario enhances regional and state-wide competitiveness for high wage employment growth.

The scenario takes into account:

- Continued concentration in semiconductor/chip and electronics manufacturing addressing global supply chain issues with emphasis on domestic re-shoring and national defense considerations together with on-going research and commercialization as with artificial intelligence and electronic vehicles.
- Further expansion of bio-tech which pairs well with the west coast data center hub that Hillsboro has become along with future investments by firms such as Rosch/Genentech.

This strategic focus supports a broader industry cluster with support construction readiness, manufacturing, increasing wholesale and distribution functions, information and professional services. Further detail as to prospective industry opportunities is provided by Section III discussion of Community Economic Potential.

Options for Achieving Scenario C Land Needs. Attention also is needed to assure adequacy of total land supply as determined to be "adequate to accommodate industrial and

other employment uses for a 20-year planning period." Cities are to provide at least 25% of the total land supply within their UGB as short-term supply – albeit with exceptions noted for jurisdictions unable to meet this target.[10]

With both the prior 2017 and the current 2021 EOAs, the clear indication is that Hillsboro does not have adequate employment land capacity to accommodate either short-term (5-year) or long-term (20-year) employment growth. Several options have been outlined with this EOA – together with identification of associated advantages and disadvantages – as **potential means to better reconcile employment land demand and supply:**

- **Reduce the EOA employment forecast to match current BLI capacity** – essentially discarding Scenarios B/C and reducing the Scenario A jobs forecast by about 45%. This option may avoid the need to expand Hillsboro's UGB and future annexations of land for industrial development – but at the expense of foregoing significant high-wage job potential for Hillsboro, the metro region and state in the years ahead.
- **Focus EOA forecast reductions on the most land extensive sectors** – likely resulting in reduced allocations for lower job density uses as for data centers, warehouse and some flex/business park uses. This option may reduce but not necessarily eliminate the impetus for added land outside of Hillsboro's current city boundaries even from higher density major potential employers. Lack of property inventory for some land-extensive supply-chain uses may also dampen the appeal of Hillsboro for major tech employers.
- **Adjust employment to land need conversion factors toward a more urban profile** – emphasizing increased building FAR and job densities together with site redevelopment. This option is associated with advantages and disadvantages similar to those with focused on discouraging land extensive sectors (as noted above). Also possible would be to eliminate the market vacancy factor which is not explicitly included in some EOA analyses.
- **Increase the planned BLI supply, especially for growth areas around Hillsboro** – most notably with further annexation and urban service provision but also via mitigation measures to increase net to gross acreage use ratios – as a significant portion of the vacant and partially vacant employment land inventory is categorized as undevelopable due, in part, to wetland and other environmental constraints. This approach to increasing in-city land supply might be accomplished, for example, with off-site mitigation but would depend on significant and regional planning and regulatory review and approvals.
- **Pursue Metro region and statewide recognition of Hillsboro's strategic significance** – for long-term competitiveness and high wage jobs as integral to long-term economic vitality, both metro and state-wide. Of the options considered, this is perhaps the most pivotal to ensuring the continued competitiveness of Hillsboro as Oregon's center of high-tech investment but depends on broad recognition of current and prospective benefits for sustained community and economic vitality regionally and statewide.

As a result of the pandemic and changing work patterns, yet another option might be considered – allocating more of employment growth (on an FTE equivalent basis) away from work and more to home sites. There are two potential downsides with this option: a) no sustained post-pandemic experience as yet to reliably ascertain the extent of a permanent shift to work from home (primarily affecting office workers); and b) uncertainty as to whether and how much space needs in traditional single use employment settings may change per on-site employee (either decreasing or possibly increasing as from robotization and improved supply change management), especially for manufacturing and warehouse/distribution functions.

Implementation Measures. The following measures are recommended for consideration:

- **As a minimum measure, adopt a 20-year jobs and land use forecast similar to Scenario C Hybrid Growth.** This scenario best serves Hillsboro existing and prospective competitive advantages for sectors targeted to clustered business growth opportunities.
- **Annex and serve added employment land as needed to meet at least the 5-year Scenario A Straight-Line short-term supply requirement.** While it is possible that a slow or delayed economic recovery may dampen demand near-term, this is less likely for industrial than commercial use. Having the full complement of *shovel-ready* site supply in place also better positions Hillsboro and the region from the mutual and reinforcing perspectives of economic recovery and resilience.
- **Utilize the Scenario B forecast as an initial means to begin determination of longer-term needs for added industrial reserves and land capacity.** This will help set the stage for 20-50 year UGB expansions – adjusted as needed to reflect actual experience with economic recovery and sustained economic vitality going forward.
- **Provide more opportunity to accommodate both exclusive industrial zones and mixed-use development.** For large industrial users, it can be important to provide a clear separation or buffer from residential development and other non-industrial uses that would pose an unreasonable risk to public health or safety. For smaller scale uses as with creative and support service firms together with potential reduction in commercial space demand, horizontal rather than vertical mixed-use may become the more pronounced market opportunity for closely linked live-work-recreate communities – so long as total employment capacity is maintained at or above current forecast levels. Also noted is that much of the demand for office as a component of commercial demand can be met with industrially zoned sites.
- **Provide opportunity for large acreage, major employer campuses of up to 600+ acres consistent with national trends but not readily available regionally in Oregon.** This is of pivotal importance nationally for semi-conductor and related tech employers, exemplified by Intel's 2021 announced plans for two new fabrication plants in Chandler, Arizona on an approximately 700-acres "mega-factory" site, and by subsequent announcement for a nearly 1,000-acres multi-phase development in Ohio.
- **Orient state and local incentive measures to support increased employment land utilization and redevelopment together with attraction and retention of target industries.** This should include accounting for the potential of some albeit as yet

uncertain permanent shift to work at home, especially for office workers – as well as for potential reduction in commercial *brick-and-mortar* commercial space needs, at least near-term. Also involved may be short- and long-term incentives for increased efficiency of employment land use including reduction of at-grade parking footprints when shown to be feasible.

While retention of Hillsboro's leading tech manufacturing edge is not guaranteed, success will be dependent on a more expansive land base than is currently available. Initial suggestions as to how these implementation measures might be incorporated into Comprehensive Plan goals and economic development policies are summarized with the concluding section to this EOA Chapter and further detailed with Technical Appendix D.

Transportation & Utility Infrastructure

Transportation and utility infrastructure is critical to assuring development readiness for industrial and other employment sites. DLCD Division 9 guidance calls for "policies, through public facilities planning and transportation system planning, to provide necessary public facilities and transportation facilities for the planning area."

Transportation and utility Infrastructure of importance to Hillsboro-based business is provided both by public and private entities. Compared to other locales regionally and nationally, Hillsboro is better positioned competitively with respect to utility than transportation infrastructure – though that may be changing in the wake of the COVID pandemic and potential temporary or longer-term shift to more work from home.

Key implementation measure recommendations for consideration would be to:

- **Target added local transport and utility infrastructure in conjunction with annexation to meet short-term employment land supply forecasts.** Ideally, infrastructure should be provided in a phased manner ahead of or coterminous with prospective development, creating ready-to-build sites.
- **Provide explicit policy support for a regional transportation system that effectively supports the movement of raw materials, manufactured goods and workforce to and through Hillsboro's employment areas.** This is a topic of growing significance not only regionally but more extensively due to supply chain and associated workforce issues impeding sustained economic recovery both nationally and globally.
- **Increase policy emphasis on north-south access and reduction of work-force commutes (to maximize Hillsboro work-force commute-shed accessibility).** Increasing regional congestion makes it more challenging for Hillsboro to draw substantial workforce from across the metro area; more of the local workforce is shifting to residence locations in Hillsboro or in communities to the north and south (as further documented with Appendix A to this EOA).
- **Provide explicit policy support to further strengthen Hillsboro's competitive advantage as a Pacific Northwest data hub for low latency, data intensive firms**

offering high "pull-through" potential. Building on Hillsboro's existing position as a major west coast data hub, greater value add can be created by using data center investments to leverage higher employment uses increasingly reliant on data hub proximity especially with transition to data intensive research and applications as for AI, autonomous and EV vehicles.

Target & Supporting Industry Clusters

DLCD Division 9 guidance indicates that: "Plans may include policies to maintain existing categories or levels of industrial and other employment uses including maintaining downtowns or central business districts." Unlike many jurisdictions across the state, Hillsboro's Comprehensive Plan clearly emphasizes the importance of traded-sector and associated target industry retention, expansion and recruitment.

Continued prioritization of traded sector investment is warranted as a primary means for local economic prosperity and wealth creation. However, the pandemic has disproportionately and adversely affected local service businesses important to support the community's traded sector industry clusters. This suggests a bifurcated policy approach going forward – both for traded sector industry and for supporting industry clusters.

Recommended with this EOA are four implementation policies – two focused on Hillsboro's traded sectors and two related to supporting business activities and non-traded sectors:

- **Periodically modify and update Hillsboro's current target industry listing to reflect and serve new or emerging traded sector industry opportunities in the years ahead.** This will yield greater opportunity and flexibility to respond to changing market conditions together with local needs and opportunities beyond what is currently most readily foreseen. Along with Hillsboro, Metro and state economic development organizations are showing increased flexibility in adjusting target industry and business clustering priorities as the need arises – a practice that Hillsboro can also apply based on state/regional priorities balanced by Hillsboro's own distinctive competitive attributes.
- **Retain existing businesses including those at risk of displacement from pandemic and/or economic downturn.** The goal is for a more resilient service sector economy, especially for retail, lodging and dining businesses that were disproportionately disadvantaged with the pandemic-related economic downturn.
- **Add policy language to expand business opportunities for minority- and women-owned businesses.** This can occur with programs that encourage small business investment and longer-term improvement of supplier linkages with tech employers.
- **Add a policy priority for community amenities that support traded sector business investment, talent recruitment/retention and high wage job potential.** This is of special importance for attracting and retaining younger workforce to Hillsboro as more of a full-service live-work-recreate community.

Workforce Readiness

While not explicitly called out by DLCD Division 9 administrative rules, workforce readiness is clearly indicated as an economic development resource to be addressed in conjunction with plan policies that may "emphasize the expansion of and increased productivity from existing industries and firms as a means to facilitate local economic development."

Workforce availability and skills (or readiness) is an issue of growing concern as documented by stakeholders with a range of local industries. Key issues include continuing retirement of the large *baby boomer* generation, workforce disruption by the pandemic (particularly as relates to child-care), lack of a nationally recognized metro area research university, and needed skills training for entry-level manufacturing workers.

Frequent mention with stakeholder interviews is made of the importance of partnering with existing area institutions as with PCC, OHSU, PSU, OSU and Pacific University for apprenticeship and technical training – also internships. In addition to these higher education resources, the City of Hillsboro works with a range of local as well as state-level resource providers.

Due to pandemic related business curtailments coupled with other economic fallout, the workers most adversely affected have been those in lower wage sectors including retail, hospitality and dining. These sectors also often have higher proportions of women and minorities – as employees and/or small business owners.

Suggested implementation measures are to:

- **Include retraining emphasis for employees displaced in times of economic disruption and transition.** Getting workers up to speed with rapidly changing work force skills will persist as a higher priority with continued economic recovery and to maintain Hillsboro's long term competitive position for tech-adaptive existing and new employers.
- **Add policy language to expand employment opportunities for under-represented members of the community including racial/ethnic minority groups, women and veterans.** Attention to under-represented populations better addresses not only individual and community vitality objectives but also positions Hillsboro for greater diversity of talent going forward.
- **Coordinate with Washington County to evaluate the most effective Workforce Board arrangements in support of community workforce needs.** This could include partnership initiatives often utilizing existing resources as with the Hillsboro Advanced Manufacturing Work Group.
- **Support efforts to create new workforce development programs meeting the needs of target and emerging industries.** This suggests placing greater priority on reducing the time lag between industry-identified needs and workforce training delivery.
- **Pursue designation as a Center of Innovation Excellence and Regional Technology Hub to support Hillsboro's leadership role in research and development with expanded**

benefits to the community. Hillsboro provides a unique opportunity to advance a key strategic objective of Oregon's *10-Year Innovation Plan* completed in 2021 to "support centers of innovation excellence that leverage Oregon's existing traded sector strengths and emerging market opportunities."

Economic Development Incentives

DLCD Division 9 guidance addresses plan policies that "include additional approaches" in support of economic development that cover but are not limited to such mechanisms as tax incentives and disincentives, preferential tax assessments, and property acquisition techniques. Also strongly encouraged are brownfield redevelopment strategies.

With an active in-house economic development department, the City of Hillsboro offers a variety of state and local incentive programs aimed to reduce a firm's cost of doing business. Some of the most prominent are noted as including enterprise zones, a strategic investment program, loan/guarantees/bonding program, vertical housing development zone, strategic reserve fund, business expansion program, opportunity zones, storefront improvement grants, and tenant improvement programs.[11]

Bottom-line, targeted economic development incentives are recognized as having played an important role in attracting industrial investment to Hillsboro. Some industry and economic development stakeholders suggest that incentives be more narrowly targeted in the years ahead – to businesses that can demonstrate some combination of strong employment, tax revenue, and/or supplemental business leveraging benefits.

Suggested with this EOA is added policy language regarding implementation measures to:

- **Provide a more prominent position for incentive mechanisms as integral to supporting or facilitating achievement of economic goals and policies.** This can occur with active utilization of federal, state and regional programs together with publicized Hillsboro-specific economic development incentives.
- **More specifically include incentives as a means to leverage increased density with uses that currently are associated with relatively low job per acre counts.** Assumed is a long-term shift to more urbanized densities, transition from drive-alone commuting, potential for reduced at-grade parking footprint, and impetus for recycling of obsolete or redundant facilities – especially as current or prospective feasibility is demonstrated.
- **Advance incentives focused on land readiness together with land aggregation as needed for industrial expansion and recruitment.** A particular focus is on assuring capacity to serve expansion and attraction of major high-wage employers requiring large acreage sites.

Partnership Opportunities

This final topic is aimed to cover public-private partnerships and intergovernmental frameworks as objectives to be addressed in local jurisdiction EOAs. Public-private and intergovernmental

partnerships have long been part of Hillsboro's civic and economic development DNA. The best opportunities going forward are to maintain and build on the partnerships already in place, adapted to new challenges that have emerged with the pandemic and attendant economic dislocation -- extending beyond to longer term recovery and resilience.

As implementation measures, two specific policy recommendations are noted to:

- **Include urban renewal as a potential economic development funding tool within designated renewal districts.** As has been demonstrated region-wide, broader application can extend use of this well-tested public/private investment tool beyond urban placemaking to also assist projects offering job-creating high wage employment.
- **Add policy language to more explicitly encourage Metro and state-wide support for Hillsboro tech-focused economic development as an economic engine of significance and benefit regionally and statewide.** Cited last but not least, obtaining support for tech-led Hillsboro investment may represent an increasingly pivotal commitment to raising the bar for economic vitality locally, regionally, and state-wide.

  Hillsboro's economic significance regionally and statewide might be further documented as with economic impact analysis. Analysis of direct and indirect effects could serve to demonstrate the interconnectedness of the metro and state economy and the roles that Hillsboro's leading edge tech industries play – not only for key traded sector industries but also with respect to region-wide housing location, transportation planning and related infrastructure investments.

  More recently, the impetus for statewide support for expanded semiconductor manufacturing is highlighted by recommendations of the Oregon Semiconductor Competitiveness Task Force in conjunction with federally authorized *CHIPS and Science Act of 2022.*

UPDATING COMPREHENSIVE PLAN GOALS & POLICIES

The approach taken with this 2021 Economic Opportunities Analysis EOA is to assure that updated economic development goals and objectives are integrated into the framework of the existing Comprehensive Plan rather than as a separate stand-alone objectives/policies statement. Also assumed is an approach that may well involve refinement of the existing Comprehensive Plan goal/policy framework, rather than a wholesale re-work.

Appendix D to this EOA provides more detail as to how recommended implementation measures might be integrated into a refined, economically centered set of Comprehensive Plan goals and policies together with vision-based Community Plan priority initiatives. Specific revisions to text language are not provided at this time but are appropriate for consideration as next steps with EOA adoption.

END NOTES

[1] Data and related information for this EOA has been obtained from sources generally deemed to be reliable. However, accuracy cannot be guaranteed and information may be subject to change without notice.

[2] Unlike the Comprehensive Plan, the Community Plan represents a vision document not adopted by ordinance.

[3] Information for top employers in Hillsboro is provided as of August 2021 from the web site: https://www.hillsboro-oregon.gov/our-city/departments/economic-development/key-industries

[4] The Scenario C hybrid was prepared in consultation with Hillsboro Economic and Community Development.

[5] With this continued rate of exponential growth, health care and social services could account for 20% of Hillsboro employment by 2040 – up from 11% as of 2018 and exceeding the 7-county Metro forecast of an approximate 14% share of regional employment and a U.S. (nation-wide) 18% forecast share by 2040.

[6] The manufacturing job gains associated with Scenario B are potentially even greater if individual manufacturing subsectors were to be accelerated independently, then aggregated.

[7] An example of a data center economic impact analysis is provided by an April 2018 report by Oxford Economics titled *Google Data Centers: Economic Impact and Community Benefit.* Conducted for six Google data centers including a data center in Oregon, the analysis included consideration of local community spillover effects as with attraction of other economic activity as an agglomeration effect. Per web site link: https://www.oxfordeconomics.com/recent-releases/d8d830e4-6327-460e-95a5-c695a32916d9

[8] Per OED data, the QCEW average wage for all Hillsboro employers was $87,635 in 2018, a figure that is 25% above the average wage for all covered employment in Washington County.

[9] Part of the documentation of Metro's 2018 UGR involved a comparison of industrial and commercial land pricing across 72 geographically distinct zones across the Metro region. In 70 of 72 zones, commercial land prices exceed industrial land prices. Per *MetroScope Generation 4 Model Parameters,* published July 9, 2018.

Tigard is cited an example of a jurisdiction that is allowing vertical mixed-use in industrial zones.

[10] Exceptions to a 25%+ land inventory provision as short-term supply are noted by OAR 660-009-0025 as:

> (3) Short-Term Supply of Land. Plans for cities and counties within a Metropolitan Planning Organization or cities and counties that adopt policies relating to the short-term supply of land must designate suitable land to respond to economic development opportunities as they arise. Cities and counties may maintain the short-term supply of land according to the strategies adopted pursuant to OAR 660-009-0020(2).
>
> (a) Except as provided for in subsections (b) and (c), cities and counties subject to this section must provide at least 25 percent of the total land supply within the urban growth boundary designated for industrial and other employment uses as short-term supply.
>
> (b) Affected cities and counties that are unable to achieve the target in subsection (a) above may set an alternative target based on their economic opportunities analysis.
>
> (c) A planning area with 10 percent or more of the total land supply enrolled in Oregon's industrial site certification program pursuant to ORS 284.565 satisfied the requirements of this section.

[11] More information on these and other incentive programs for qualified business investment in Hillsboro may be found at the web site: https://www.hillsboro-oregon.gov/our-city/departments/economic-development/choose-hillsboro/taxes-incentives.

EXHIBIT C

HILLSBORO ECONOMIC OPPORTUNITIES ANALYSIS: Technical Appendices

Prepared for:

City of Hillsboro

May 2022

(As supplemented May 2024
with Buildable Lands Inventory Data from December 2020)

Hillsboro
OREGON

This **Technical Appendices** document contains detailed research together with supporting data and analysis for the Economic Opportunities Analysis (EOA) prepared for the City of Hillsboro by the economic and development consulting firm E. D. Hovee & Company, LLC in cooperation with the planning firm MIG, Inc.

Appendices provided cover employment trends and outlook, community economic potential, employment land needs, and implementation policies. For more information about this report, please contact:

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APPENDIX A.
EMPLOYMENT TRENDS & OUTLOOK

This appendix provides background data and research utilized with the Chapter II EOA discussion of employment trends and outlook. Topics covered by this appendix include background and approach, employment trends and forecast scenarios, U.S. employment trends and forecast, economic resilience with pandemic recovery, work commute considerations and a detailed employment sector review .

BACKGROUND & APPROACH

In cooperation with the Oregon Employment Department (OED) for analysis conducted at the outset of this EOA in 2019 and subsequently augmented by OED, it has been possible to assemble consistent employment data over several years for the City of Hillsboro in comparison to trends experienced for the 7-county Portland metro region. This appendix reviews the trend data evaluated together with Metro's regional forecast and resulting EOA implications.

Employment Definitions

Employment can be defined in a variety of ways, depending on the purpose of the data and methodology for data compilation. Consequently, it is useful to briefly describe key components of the data sources utilized – including limitations and adjustments made for this 2021 EOA update. Some of the factors noted may affect EOA results and so are important to address in the event questions arise with EOA review. Of particular importance are the following notes:

- Primarily reliance for trend data evaluated both for the City of Hillsboro and the 7-county Portland-Vancouver-Hillsboro metropolitan statistical area (MSA) is placed on **Quarterly Census of Employment and Wages (QCEW)** data as compiled by the Oregon Employment Department (OED). This dataset is for jobs covered by unemployment insurance and so excludes some workers such as sole proprietors – most notably in the real estate sector. However, QCEW data is also consistent with monthly and annual results reported for the MSA by the U. S. Bureau of Labor Statistics (BLS). At the time data was initially compiled in 2019, annual BLS data was readily available for specified years over the 2001-18 period.
- OED economist Christian Kaylor compiled data for the City of Hillsboro for 2007, 2010, 2017 and 2018. For reasons described below, this analysis **focuses on the 2007 and 2018 datasets – both for Hillsboro and the Portland metro region.**
- In compiling data specific to Hillsboro, OED has taken steps to assure that **confidentiality provisions** were not violated. This has necessitated a need to combine some employment categories. For direct *apples-to-apples comparisons*, the same combinations are reported for Hillsboro and the metro area (whenever possible).

- As the Portland MSA straddles two states, employment data is **compiled separately** for the five counties of the Oregon side (Washington, Multnomah, Clackamas, Yamhill and Columbia) and from the two counties of the Washington side (Clark and Skamania). E. D. Hovee has combined these employment estimates, by sector, into a single 7-county dataset. Combined totals provided with this aggregation process match BLS employment estimates for the full 7-county metro region.
- OED/QCEW data is reported for the five Oregon counties of the MSA in two ways: a) with a composite total for all governmental employment; and b) with a narrower definition of NAICS 92 as being limited **to public administration** jobs only. The single biggest difference between the two methods is found in the allocation of education employees. As of 2018, 44% of all governmental workers were employed in education with another 7-8% in health care and social assistance. Smaller proportions are allocated to construction, transportation/warehousing, administrative, arts/entertainment/ recreation and other service sectors.
- OED compiled Hillsboro data with this narrower **NAICS 92 definition limited to Public Administration** and with other governmental employees allocated to their actual employment sector. The two MSA counties of Washington state – Clark and Skamania – use the Governmental Sector figures only, so governmental employees are allocated to other sectors using the ratios applicable for the five counties of the Oregon side of the region. Metro also uses a governmental sector total only (albeit with a yet different dataset) – so similar adjustments have been made as a means to compare Hillsboro with metro-wide forecast results.
- For its regional forecasting process, Metro has relied on **non-agricultural wage and salary employment** information rather than QCEW datasets. This dataset is tracked by BLS and excludes some government workers, private households, proprietors and non-profit employees – based on both a monthly household and business establishment survey. There are some resulting differences in historical employment estimates. For example, as of 2010, the Metro non-ag estimate of 7-county age and salary jobs was 979,140. This is 1.8% above the 961,710 covered jobs number indicated with QCEW data. Adjustments for these differences are made in this EOA with the comparison of updated Hillsboro forecast results with those of the prior 2017 Hillsboro EOA.
- Since the time of initial December 2021 EOA report preparation, OED has provided **updated datasets** for Hillsboro covering the 2003-20 period (albeit with 2021 employment data not yet available). This data was provided to address DLCD questions regarding linear versus exponential employment change as described with the Employment Sector Review portion of this Appendix A. For purposes of employment forecasting, this EOA continues to rely on 2007-18 data as a primary source for the most recent economic cycle based on data as initially provided by OED in 2019. Future EOA updates may be of value as additional post-pandemic jobs data becomes available.

With this background methodological information in hand, this review now proceeds to consider key components of the employment analysis and findings for Hillsboro, the metro region and this EOA report.

Forecast Approach

As a starting point for analysis, employment trends were reviewed for the period 2007-18, starting with the onset of the Great Recession of 2007-09, with subsequent recovery through 2018, just ahead of local and regional job growth slowing in 2019, then followed by the onset of the COVID-19 pandemic and economic downturn in 2020.

As of 2018, Hillsboro had a covered employment count of approximately 88,980 jobs. Hillsboro accounts for 6.8% of the region's QCEW employment. By comparison, with a population of 101,920 as of 2018, Hillsboro represents for 4.1% of the metro area's population of nearly 2.5 million. From 2007-18, employment in Hillsboro increased by nearly 30%, almost double the approximately 15% increase in regional-wide employment.

Recognizing that Hillsboro's economy has been driven in large part by computer/electronics traded sector activity which is dependent on market forces external to the Portland MSA, the initial scenarios considered with this EOA have been to forecast the sector-by-sector growth rates of the current economic cycle forward over the EOA time frame of 2020-40. Then compare this growth with what has been projected for the region as a first test to assess reasonableness of any Hillsboro forecast scenario.

Two scenarios for application of this extrapolation approach were initially prepared – involving a comparison of straight-line with annually compounded growth rates. Both are reported in QCEW covered employment terms, then also adjusted to provide for a meaningful *apples-to-applies* comparison with the Metro-prepared regional non-agricultural employment forecast. Subsequent to review of these initial scenarios, a third hybrid scenario was then prepared.

These two initial scenarios formulated as potentially plausible outcomes for future employment growth are focused on the 20- year 2020-2040 time frame. The forecast scenarios represent two contrasting perspectives on the extrapolation of past trends as a basis for future job growth. The two initial contrasting forecast approaches considered are specified as follows:

- **Scenario A Straight-Line Growth** – assumes that employment for each of up to 18 NAICS-based sectors will continue to increase (or decline) by the same average number of jobs gained or lost per year from 2007-18. The total 20-year job change equals the sum of the individual sectoral changes.
- **Scenario B Exponential Growth –** is based on the same 2007-18 experience but calculates growth in terms of a compound annual growth rate (CAGR) with each year's new job increment greater than the last as the job base keeps getting larger over time.

As an added note, because 2018 was the last year for which detailed Hillsboro-specific QCEW data was initially compiled, an estimate was made of potential 2020 conditions as a starting point for the 20-year comparison. This forecast methodology and application was conducted in advance of the 2020 pandemic and recession. Consequently, the resulting 20-year projections assume the eventual recapture of jobs lost in 2020 *in addition* to the net gains anticipated over the 2020-40 time horizon.

EMPLOYMENT TRENDS & FORECAST SCENARIOS

The tables on the following pages provide results of this sector-by-sector analysis – separately for two scenarios initially considered. For each sector, historical data is provided for Hillsboro QCEW employment as of 2007 and 2018. The next column indicates the average annual change per year from 2007-18. The next two columns in each table provide 2020 and 2040 forecast employment estimates, with the last column indicating the numerical change from 2020-40.

The primary difference between the two approaches and resulting data table is with the change per year column. Scenario A calculates the annual change as the **average numerical change** in jobs each year from 2000-18 – a figure which is applied to each of the succeeding forecast years. In contrast, Scenario B shows the average **compound annual growth rate (CAGR)** experienced, a figure then multiplied by the employment in each prior year to arrive at each of the succeeding years forecast employment. Results of these two initial contrasting scenario approaches are provided as follows – then by consideration of a third hybrid scenario.

Scenario A – Straight-Line Growth

As noted, this first employment scenario provides a sector-by-sector **straight-line** extrapolation of annual growth experienced from 2017-18 forward to 2040. As detailed by the following chart, this scenario results in a 44% net increase of Hillsboro's employment from 2020-40, equating to a 1.8% CAGR over this 20-year period.

Scenario A– Hillsboro Straight-Line Sectoral Growth Jobs Scenario (to 2040)

NAICS	Employment Sector	2007 QCEW	2018 QCEW	Chg/Year (2007-18)	2020 Forecast	2040 Forecast	Change 2020-40
23	Construction	2,420	3,230	74	3,380	4,850	1,470
31-33	Manufacturing (see components)	22,540	25,950	310	26,570	32,770	6,200
42	Wholesale trade	1,550	3,170	147	3,460	6,410	2,950
44-45	Retail trade	6,390	7,210	75	7,360	8,850	1,490
48-49	Transportation & Warehousing	980	1,930	86	2,100	3,830	1,730
51	Information	1,490	2,680	108	2,900	5,060	2,160
52	Finance & Insurance	1,010	1,640	57	1,750	2,900	1,150
53	Real Estate	620	710	8	730	890	160
54	Professional Services	1,470	2,620	105	2,830	4,920	2,090
55	Management	2,200	540	(151)	240	--	(240)
56	Administrative	4,430	6,430	182	6,790	10,430	3,640
61	Educational Services	2,680	2,650	(3)	2,640	2,590	(50)
62	Health Care & Social Assistance	4,560	8,950	399	9,750	17,730	7,980
71	Arts, Entertainment & Recreation	450	1,160	65	1,290	2,580	1,290
72	Accommodation & Food Services	4,210	5,690	135	5,960	8,650	2,690
81	Other Services (Private)	1,910	3,280	125	3,530	6,020	2,490
92	Public Administration	3,300	3,140	(15)	3,110	2,820	(290)
	All Other	220	20	(18)	--	--	--
Total		**62,430**	**81,000**	**1,688**	**84,390**	**121,300**	**36,910**

Source: OED & WA-ESD / QCEW and E. D. Hovee. The forecast scenario reflects QCEW methodology.

With this scenario, employment increases by 36,910 jobs over 20 years, from a projected 84,390 jobs in 2020 to 121,300 jobs by 2040. This equates to over 1,830 jobs added (on average) in Hillsboro each year from 2018-40.

In terms of numerical increase, with this straight-line methodology health care and social assistance would increase the most, by an estimated 7,980 jobs over 20 years – followed by manufacturing at 6,200 added jobs.

Considered in terms of region-wide employment, Hillsboro would increase from just under 7% of the region's employment currently to about 8.5% in 2040. Manufacturing would increase from 20-21% to just under 28% of the sector's MSA count, information from 10-11% to 15%, and health care/social assistance from 5-6% to nearly 8% of that sector's regional job count.

Scenario B – Exponential Growth

Scenario B also is predicated on extrapolation of growth trends as experienced from 2007-18, but extrapolated forward at **compound annual growth rate (CAGR)** rather than straight-line average annual growth rates (AAGR). As detailed by the following chart, with Scenario B, employment in Hillsboro conceivably could more than double over the next 20 years if sector-specific compound annual growth rates of the 2007-18 period were to persist to 2040.

Scenario B – Hillsboro Exponential Growth Jobs Scenario (to 2040)

NAICS	Employment Sector	2007 QCEW	2018 QCEW	CAGR (2007-18)	2020 Forecast	2040 Forecast	Change 2020-40
23	Construction	2,420	3,230	2.7%	3,400	5,750	2,350
31-33	Manufacturing (see components)	22,540	25,950	1.3%	26,620	34,390	7,770
42	Wholesale trade	1,550	3,170	6.7%	3,610	13,260	9,650
44-45	Retail trade	6,390	7,210	1.1%	7,370	9,180	1,810
48-49	Transportation & Warehousing	980	1,930	6.4%	2,180	7,470	5,290
51	Information	1,490	2,680	5.5%	2,980	8,660	5,680
52	Finance & Insurance	1,010	1,640	4.5%	1,790	4,320	2,530
53	Real Estate	620	710	1.2%	730	930	200
54	Professional Services	1,470	2,620	5.4%	2,910	8,320	5,410
55	Management	2,200	540	-12.0%	420	30	(390)
56	Administrative	4,430	6,430	3.4%	6,880	13,550	6,670
61	Educational Services	2,680	2,650	-0.1%	2,640	2,590	(50)
62	Health Care & Social Assistance	4,560	8,950	6.3%	10,120	34,490	24,370
71	Arts, Entertainment & Recreation	450	1,160	9.0%	1,380	7,720	6,340
72	Accommodation & Food Services	4,210	5,690	2.8%	6,010	10,390	4,380
81	Other Services (Private)	1,910	3,280	5.0%	3,620	9,680	6,060
92	Public Administration	3,300	3,140	-0.5%	3,110	2,840	(270)
	All Other	220	20	-19.6%	10	--	(10)
Total		**62,430**	**81,000**	**2.4%**	**85,780**	**173,570**	**87,790**

Source: OED & WA-ESD / QCEW and E. D. Hovee. The forecast scenario reflects QCEW methodology. Due to its relative insignificance, the all other category is deleted to arrive at a 2020-40 change figure of 87,800.

From 2007-18, Hillsboro's employment increased at a CAGR of about 2.4% per year. Going forward, the rate of employment increase is forecast to increase by 3.5% per year from 2018-40 (or 3.6% annually if calculated from 2020-40). A higher overall job growth rate in the years ahead occurs as the effect of already large rapidly growing industry sectors outweighs the lesser effects of smaller and/or slow growth/declining sectors.

With continued growth averaging 6.3% per year, health care and social assistance alone could add 24,370 jobs over 20 years – with a total count of nearly 35,500 jobs and even exceeding manufacturing's total job count by 2040. Wholesale trade has been experiencing 6.7% per year job growth since 2007. Extrapolated to 2040, this sector could see a net gain of as many as 9,650 jobs over 20 years.

Manufacturing would add an estimated 7,770 jobs – for about 25% more new jobs than with Scenario A. The manufacturing job gains would be even greater if individual manufacturing subsectors were to be accelerated independently, then aggregated. Substantial job growth in the range of 5-7,000 jobs per sector could be experienced for the transportation/warehousing, information, professional services, administrative, arts/education/recreation, and other services sectors.

With Scenario B, Hillsboro would increase from about 7% currently to 12% of metro-wide *most likely* employment by 2040. Within 20 years, Hillsboro could account for 30% of the arts/entertainment/recreation, 29% of the manufacturing, 25% of the information, 22% of the wholesale trade, 16% of the transportation/warehousing, and 15% of the health care/social assistance jobs metro-wide.

Scenario C – Hybrid Growth

After review of Scenarios A and B and in consultation with City of Hillsboro Planning and Community Development Departments, a third in-between forecast scenario was added, predicated on consideration of Hillsboro target industry and associated sectors (or industry clusters). The net effect of these applications is for an overall employment growth rate (CAGR) averaging 2.7% per year from 2018-40 (or 2.8% annually from 2020-40).

Recognizing the changing and as-yet uncertain economic trajectory nationally and regionally going forward, Scenario C involves a sector-by-sector analysis as a basis for determining whether and to what extent to apply Scenario A or B outcomes to the Scenario C hybrid model. This is consistent with the detailed and customized approach taken with this EOA that incorporates qualitative as well as quantitative considerations as potentially consequential for forecast outcomes.

Quantitative factors primarily reflect extrapolation of observed employment trends with further sector-by-sector differentiation between straight-line and exponential growth. Qualitative considerations are as detailed with Appendix B Community Economic Potential discussion including stakeholder perspectives and policy priorities, for example, as represented by Hillsboro's adopted target industry priorities.

This Scenario C Hybrid Growth model occurs via a 4-phase scenario selector or sector *toggle* approach described as follows:

0 – is applied to sectors for which employment decline was experienced from 2007-18. Rather than forecasting continued job loss, these sectors are assumed to experience no net change **(None)** in employment going forward to 2040.

1 – is applied to sectors for which Scenario A straight-line **(Linear)** results are assumed as most applicable to the Scenario C hybrid, comprised of sectors not part of Hillsboro cluster industry targets.

2 – is applied to sectors that are likely to be strongly influenced by exponential growth, though not expected to fully experience continued exponential growth going forward. These sectors are assigned mid-point **(Mid)** results by averaging outputs of Scenarios A and B.

3- is applied to sectors that are most expected to experience continued **exponential (Exp)** growth going forward, particularly target industry sectors.

The outputs of this hybrid scenario are as detailed by the chart below.

Scenario C **–** Hillsboro Hybrid Jobs Scenario (to 2040)

NAICS	Employment Sector	Job Add (2007-18)	Job Add (2020-40)			Scenario Selector
			Scenario A	Scenario B	Scenario C	
23	Construction	810	1,470	2,350	2,350	3
31-33	Manufacturing	3,410	6,200	7,770	7,770	3
42	Wholesale Trade	1,620	2,950	9,650	2,950	1
44-45	Retail Trade	820	1,490	1,810	1,490	1
48-49	Transportation & Warehousing	950	1,730	5,290	5,290	3
51	Information	1,190	2,160	5,680	5,680	3
52	Finance & Insurance	630	1,150	2,530	1,840	2
53	Real Estate	90	160	200	200	3
54	Professional Services	1,150	2,090	5,410	5,410	3
55	Management	(1,660)	(240)	(390)	--	0
56	Administrative	2,000	3,640	6,670	3,640	1
61	Educational Services	(30)	(50)	(50)	--	0
62	Health Care & Social Assistance	4,390	7,980	24,370	16,175	2
71	Arts, Entertainment & Recreation	710	1,290	6,340	1,290	1
72	Accommodation & Food Services	1,480	2,690	4,380	3,535	2
81	Other Services	1,370	2,490	6,060	4,275	2
92	Public Administration	(160)	(290)	(270)	--	0
Total	**Total Above Sectors**	**18,770**	**36,910**	**87,800**	**61,895**	

Sources: Derived from Scenarios A and B based on Scenario C hybrid selector tool (as described above). Due to negligible job counts, the all-other (residual) sector is excluded from this overview comparison. Scenario C results have been reviewed with supplemental EOA employment data analysis as of May 2022.

By way of summary, with this hybrid scenario:

- Sectors of construction, manufacturing, transportation/warehousing, information, real estate and professional services are forecast for growth at continued **exponential (exp)** or historically observed CAGRs as experienced over the last economic cycle.
- Finance/insurance, health care/social assistance, accommodation and food services, and other services are assumed to experience results at a **mid-point** between the CAGR and straight-line extrapolation models.
- Wholesale, retail, administrative and arts/entertainment/recreation sectors are forecast experience **linear** (straight line) growth consistent with historically observed rates calculated on a straight-line basis.
- And employment sectors related to management, educational services and public administration which experienced net job loss in recent years are forecast to experience **no further job loss (none)** going forward.

Detailed sector-by-sector review of these Scenario C Hybrid Growth determinations is provided as the last portion of this Appendix A document.

As with Scenario A, this hybrid or targeted job growth scenario would be led by health care with an added 16,175 jobs over 20 years, followed by manufacturing at an added 7,770 jobs. Strong job growth (in the range of 5-6,000 added jobs each) would be experienced by the information, professional services and transportation/warehouse sectors.

These existing and potentially important traded sector activities provide economic multiplier benefits above what can be expected from local consumer-oriented service functions. This is because of added income flowing into Hillsboro and the metro region from customers nation-wide and globally.

With Scenario C, Hillsboro would increase from about 7% to more than 10% of metro-wide employment by 2040. Hillsboro would account for similar shares of the region's employment for sectors including manufacturing, information, and transportation/warehouse sectors as with Scenario B. Hillsboro would increase from 5-6% to about 11-12% of the region's employment in health care and social services.

Comparison to 2017 EOA

Hillsboro's most recent 2017 EOA provided three alternative employment forecasts scenarios covering a 20-year time period (from 2015-35):

- A **safe harbor projection** (based on an OED county-level regional forecast) – of an added 28,906 Hillsboro jobs over 20 years.
- A Metro-based **Transportation Area Zone** (TAZ) forecast – of 34,281 added jobs.
- An **alternative forecast** based on Hillsboro's then most-recent 5-year growth pattern (from 2010-15) – of 40,326 jobs over 20 years (at an average 2.0% growth rate).

As indicated by this summary, the safe harbor methodology resulted in an employment projection that was well below that of other methodologies considered in 2017. The then recommended and adopted 2017 approach of an alternative forecast was 40% above the employment projection associated with the safe harbor forecast approach.

The 2017 EOA concluded that: "while either of the three forecast scenarios is supported by the best available information and methodologies as required by OAR 660-024-0040(1), the employment land forecast is based on the alternative employment forecast scenario" of an added 40,326 jobs in 20 years.

By comparison, the two initial 20-year forecast scenarios as evaluated in this updated 2021 EOA indicate a possible range of 36,910-87,800 net added covered jobs over the 20-year time period of 2020-40. If adjustments are made for non-covered workers as was done with the 2017 EOA, the range of this current 2021 EOA forecast update could be from 44,650-106,870 added jobs over a new 20-year (2020-40) time horizon.[1]

The lower Scenario A straight-line forecast associated with this updated 2021 EOA comes closest to the results of the prior 2017 EOA alternative forecast – albeit with a modified methodology. The higher Scenario B compound sectoral growth approach yields a result that potentially is well in excess of what was presented by any of the 2017 EOA alternatives then considered. The Scenario C hybrid option (selected as a preferred or recommended EOA scenario) is associated with employment outputs between those of Scenarios A and B.

With the current 2021 update process, an updated safe harbor projection initially was not prepared. This was because prior results (from the 2017 EOA) came in below other alternatives considered, not adequately reflecting Hillsboro's historically observed increasing market share of employment.

Also noted is that when the updated forecast scenarios (A and B) were initially prepared in 2019, a similarly updated TAZ zone forecast from Metro was not expected to be available in the time frame anticipated for what was then anticipated to be a 2020 EOA update (subsequently delayed due to the COVID pandemic).

SAFE HARBOR EMPLOYMENT PROJECTION

In review of the 2021 EOA analysis, staff representatives of the state Department of Land Conservation and Development (DLCD) requested preparation of an updated safe harbor projection for comparison with Scenarios A-C of this 2021 EOA. This appendix provides a safe harbor update consistent with the methodology of the prior 2017 EOA report.

Safe Harbor Background

As background, it is useful to review state guidance regarding safe harbor provisions for employment-based land use needs analysis. OAR 660-024-0040 states that an employment safe harbor methodology "may be applied," predicated on assuming that the current number of jobs in the urban area will grow at a rate equal to either the county or regional job growth rate. The OAR does not require a safe harbor projection but rather identifies this as an option to be considered at local discretion.

As noted, the safe harbor projection prepared with the prior 2017 Hillsboro EOA resulted in an employment forecast that was well below that of other methodologies considered in 2017. A similar result is noted with this 2021 EOA update.

As documented by employment data compiled for this EOA update, Hillsboro is accounting for an increasing share of county- and region-wide employment. Consequently, application of a safe harbor methodology can be expected to result in an employment forecast that is below that of other scenarios considered. In effect, the safe harbor option understates Hillsboro's actual recent historical employment experience and its continued opportunity over a 20-year planning horizon.

Safe Harbor Projection

An updated 20-year Safe Harbor forecast is provided by the chart on the following page. As noted, the approach with this update is similar to what was provided by Johnson Economics with the 2017 EOA – applying a compound annual growth rate (CAGR) as has been utilized with the current EOA exponential growth and hybrid growth scenarios.

In 2017, the OED region on which the Safe Harbor projection was made was for Washington and Multnomah Counties. With more recent OED updates, the region now also includes Clackamas County as the full tri-county area.

The time period covered by this safe harbor projection is 2020-2040, extrapolated from OED tri-county projections (and associated CAGRs) for the shorter 10-year period of 2020-30. Baseline 2020 employment estimates represent QCEW job numbers as recently provided by OED.

Hillsboro Safe Harbor Employment Projection (2020-40)

NAICS	Employment Sector	Employment			Change	CAGR
		2020	2030	2040	2020-40	
23	Construction	3,081	3,455	3,875	794	1.2%
31-33	Manufacturing	26,288	29,020	32,035	5,747	1.0%
42	Wholesale Trade	3,854	4,305	4,810	956	1.1%
44-45	Retail Trade	6,796	7,525	8,330	1,534	1.0%
48-49	Transport & Warehouse	3,040	3,580	4,220	1,180	1.7%
51	Information	2,354	2,780	3,280	926	1.7%
52	FIRE	3,239	3,505	3,800	561	0.8%
54	Professional	2,786	3,350	4,030	1,244	1.9%
55	Management	501	605	730	229	1.9%
56	Administrative	5,781	6,870	8,165	2,384	1.7%
61	Educational Services	2,454	2,805	3,205	751	1.3%
62	Health & Social	8,099	9,745	11,725	3,626	1.9%
71	Arts/Ent/Rec	771	1,320	2,255	1,484	5.5%
72	Hospitality	4,554	6,990	10,720	6,166	4.4%
81	Other Services	3,097	3,805	4,675	1,578	2.1%
92	Public Administration	3,243	3,565	3,920	677	1.0%
11,21,22	Other (agric, mining, utilities)	354	385	415	61	0.8%
	Total QCEW Employment	**80,292**	**93,610**	**110,190**	**29,898**	**1.6%**

Sources: Oregon Employment Department (OED) and E. D. Hovee. Estimates are for QCEW covered employment.

The earlier 2017 EOA analysis led to a 1.5% overall average annual growth rate (CAGR) applied to Hillsboro. for a 20-year forecast job increase of 28,906 (from 2015-35). As detailed by the chart above, the updated Safe Harbor projection results in a preliminary 20-year forecast of 29,898 added jobs (from 2020-40) at a now somewhat higher OED-derived growth rate of 1.6% per year.

This updated safe harbor projection comes in 19% below the current EOA straight-line (Scenario A) forecast of an added 36,910 jobs (although calculated differently). It is further below the additions of 87,800 and 61,895 jobs calculated over 20 years with the Scenario B exponential growth and Scenario C hybrid scenarios, respectively.

Also noted is that the safe harbor projection is predicated on a 2020 starting point which reflects an actual 2,331 employment reduction from 2019-20 due to the 2020 pandemic-related recession. No assumption is made for job recovery other than as part of the 2030 and 2040 projections of incremental job increase. By comparison, the current EOA scenarios assume recovery to normalized conditions plus forecast growth post-2020 consistent with the methodologies applied for Scenarios A-C.

U.S. EMPLOYMENT TREND & FORECAST

This discussion of employment trends includes an overview of U.S trends and forecasting – as context within which Metro's regional employment forecast (with the 2018 UGR) has been set.[2]

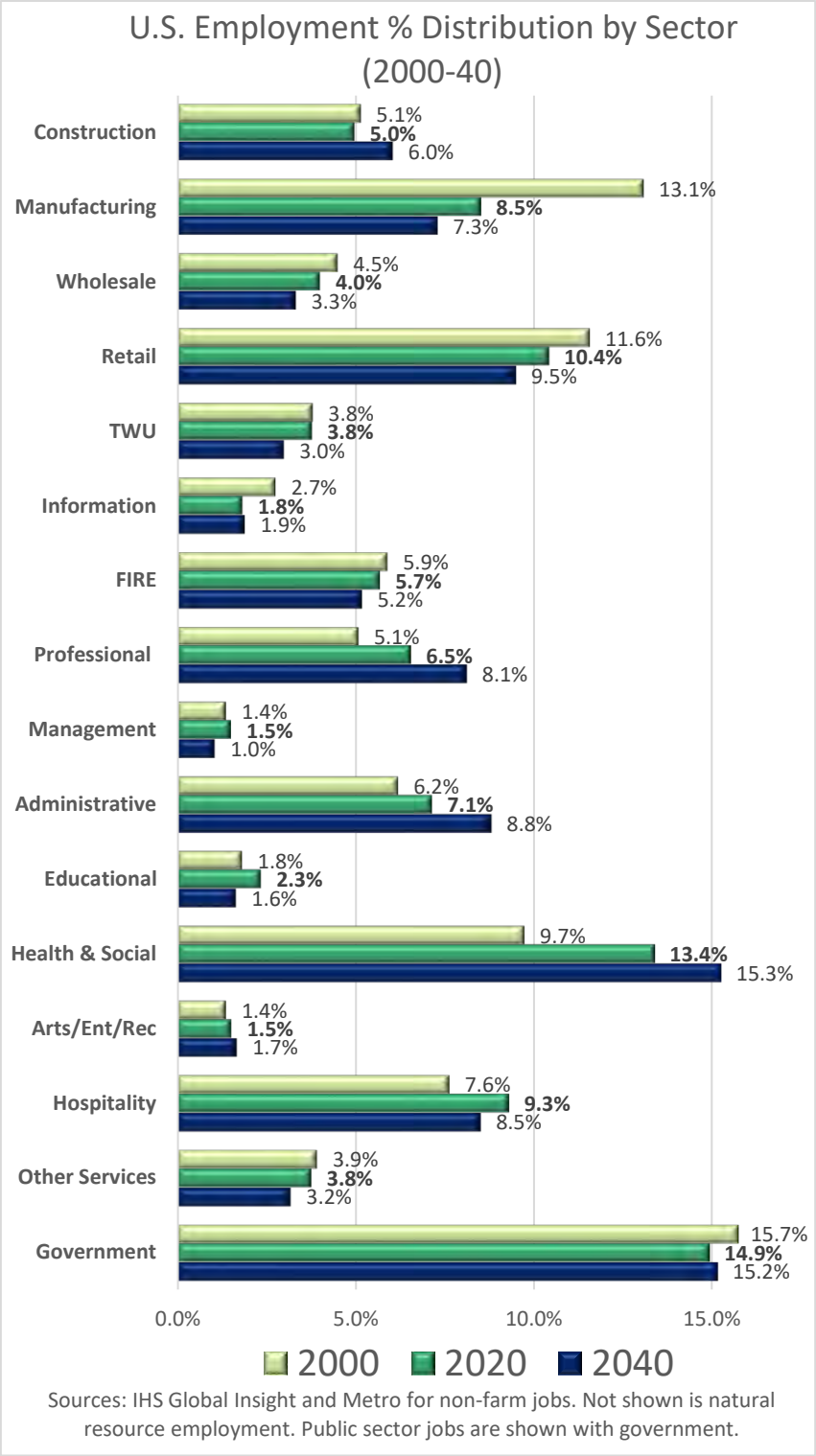
Metro UGR

As depicted by the chart to the right, the composition of employment for the nation has shifted considerably over the last 20 years – with continued change forecast for the years ahead.

From 2000-20, employment in manufacturing was estimated to decline from 13.1% to 8.5% of all non-farm U.S. jobs. **Declining shares of the nation's job base** were also noted for the retail, information, finance/insurance/real estate (FIRE), and other service sectors.

Recent and forecast **gains in employment share** were anticipated for the professional, administrative, health/social, and arts/entertainment/ recreation sectors.

A more **mixed pattern** was indicated for other sectors. Construction experienced a slight declining share of employment in the last 20 years, but with a jobs rebound projected for the next 20 years – as with the



Sources: IHS Global Insight and Metro for non-farm jobs. Not shown is natural resource employment. Public sector jobs are shown with government.

governmental sector. Employment shares were noted as increasing in the last 20 years for management, (private) education, and hospitality sectors but forecast to subsequently decline through 2040.

From 2000-20, employment nation-wide has increased at a compound annual growth rate (CAGR) averaging 0.7% per year. Over the 2020-40 time period, the growth rate has been forecast to decline slightly – to a rate of about 0.6% per year.

The most rapid job growth (in percentage terms) has been anticipated for professional (including technical) services and for administrative sectors, each increasing at a 1.7% annual growth rate – followed by construction at 1.6%. Modest job losses (of 0.1% per year) have been forecast in manufacturing, with more rapid losses indicated for the wholesale trade, TWU, management, education, and other service sectors.

While manufacturing has been anticipated for virtually no net job growth nationwide, there are some differences between specific manufacturing sectors. Employment in electronics-related manufacturing has been declining but expected to remain at about current levels over the next 20 years. However, employment across the U.S. in traditional sectors of wood products, fabricated metals and machinery which were showing job loss have been forecast to experience modest gains in employment going forward. Food products manufacturing also has been anticipated to experience somewhat more rapid job gains in the years ahead.

While Metro's regional forecast reflects many of these national changes, Hillsboro's recent employment experience and its future expectations clearly diverge from what is occurring nationally and regionally. Hillsboro has been experiencing increases in manufacturing employment – its major economic driver over the last economic cycle. Other industrial sectors – notably TWU and wholesale trade – are also experiencing stronger growth, albeit on a smaller base of existing activity to date.

An important caveat is that this national forecast which has served as a basis for current metro employment forecasting with the Urban Growth Report (UGR) process pre-dates the current pandemic and economic recession. Very possibly, future forecast revisions may reflect slowed job growth relative to prior projections, at least to the point of full recovery and return to more normalized conditions.

Also suggested by business activity through the pandemic has been the strength of industrial development especially for warehouse-distribution (TWU) functions. How this recovery potentially plays out for the Portland metro region and Hillsboro is further considered by discussion in the next section of this Appendix.

In any event, when viewed in terms of community economic potentials, the combination of these conditions (even when tempered) positions Hillsboro to continue along a high-wage advanced manufacturing-led path. This includes opportunities for continued growth in what have been historically small but now more important related sectors, possibly including freight-intensive TWU and wholesale-distribution functions.

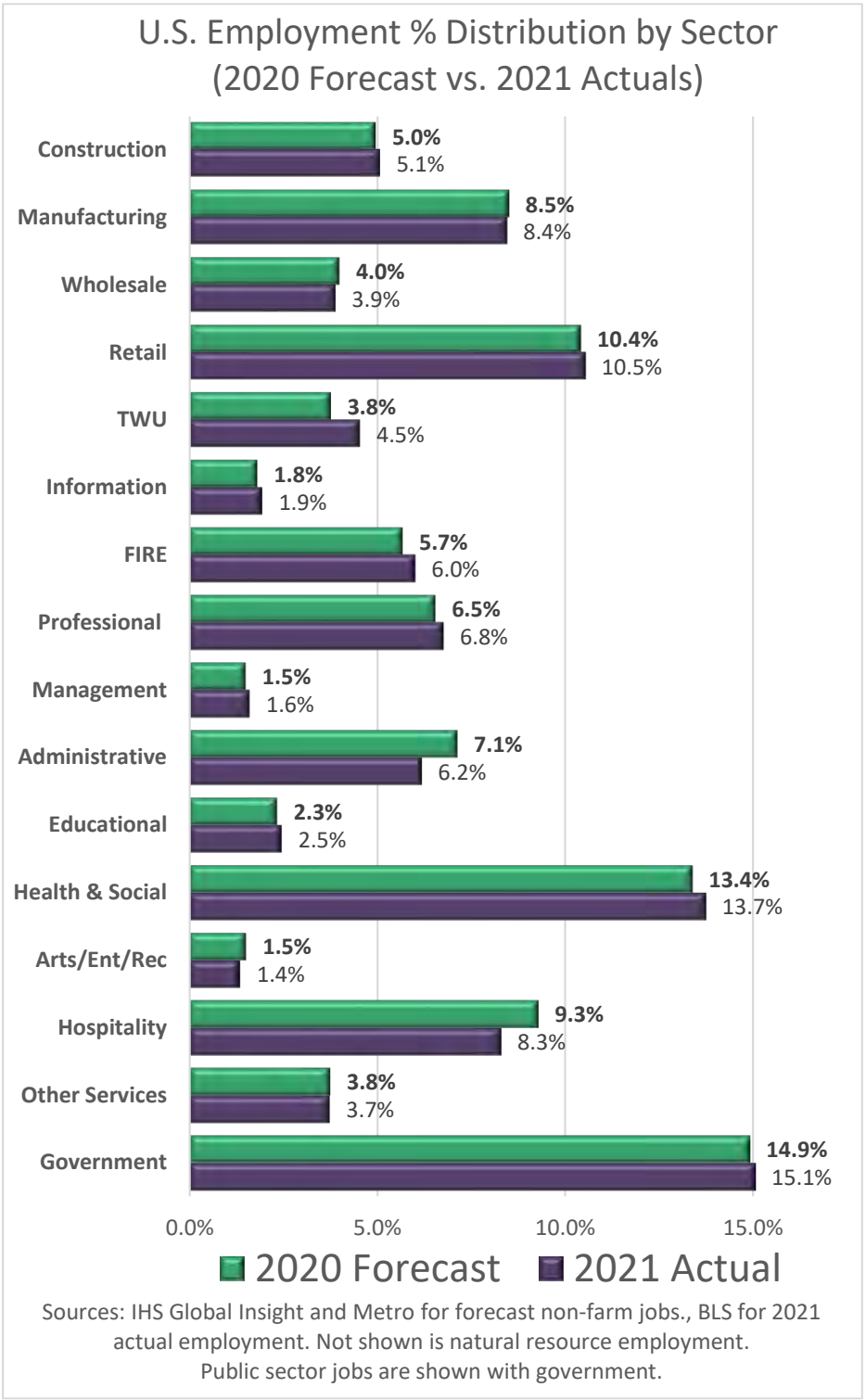
Forecast Comparison with Actual U.S. Employment Distribution

To get a sense of how closely national forecast results utilized with Metro's 2018 UGR have matched with actual outcomes, the following graph compares the national 2020 forecast distribution of employment (utilized for the 2018 UGR) with 2021 outcomes based on the most recent data available from the U.S. Bureau of Labor Statistics (BLS).

As illustrated sector-by-sector, some sectors (as with manufacturing) have come in at **close to the national projections** that Metro utilized for its regional forecast. But there are other sectors for which actual experience differs from the earlier (pre-pandemic) forecast.

Sectors with a significantly **greater share** of U.S. employment than previously forecast include transportation/ warehousing/utilities (TWU), finance/ insurance/real estate (FIRE), professional/ technical services, and health/social services.

Sectors with a **lesser share** of U.S. employment than forecast include administrative services and hospitality (dining and lodging).



Sources: IHS Global Insight and Metro for forecast non-farm jobs., BLS for 2021 actual employment. Not shown is natural resource employment. Public sector jobs are shown with government.

Looking forward, recent events including the COVID pandemic, subsequent supply chain issues, geo-political tensions (especially with China and Russia), market and policy impetus for greatly increased domestic semiconductor production all suggest yet greater opportunity for domestic industrial resilience and re-shoring resurgence than previously anticipated. This shift aligns well with Hillsboro's existing advanced manufacturing base and target industry emphasis.

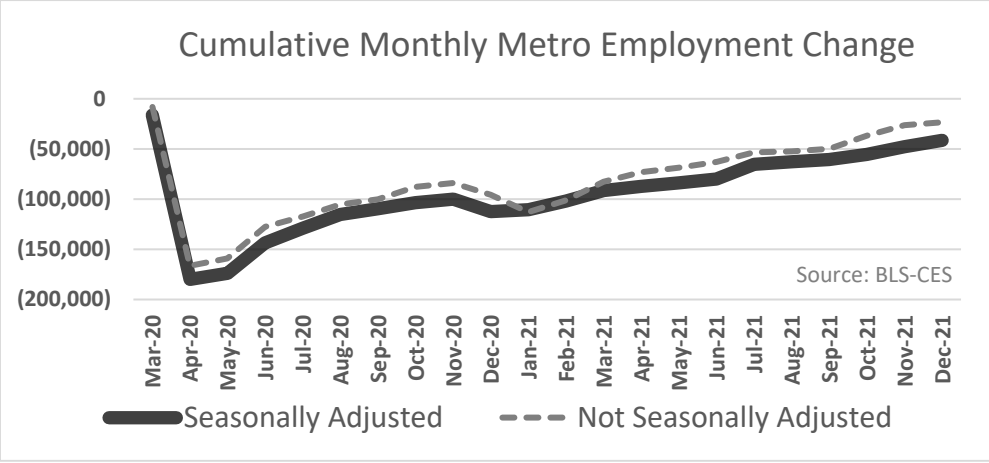
ECONOMIC RESILIENCE WITH PANDEMIC RECOVERY

In the wake of pandemic and economic recession, this 2021 EOA places new emphasis on prospects for metro area and Hillsboro economic recovery, also looking to opportunities for improved resilience in the face of potentially similar unforeseen economic downturns in the future. To assist in this analysis, data has been compiled to compare month-by-month employment starting February 2020 (pre-layoffs) and extending to mid-2021 (as economic recovery has been in progress over multiple subsequent months). Data is provided for the Portland metro area in comparison with U.S. economic performance.

Information is compiled from the U.S. Bureau of Labor Statistics (BLS) current employment survey (CES). Data is illustrated by graphs for all employment, then disaggregated for major employment sectors, then to also include a more detailed focus on manufacturing sectors.

Metro-Wide 2020-21 Employment Experience

The graph below depicts month-to-month changes in non-farm employment for the metro area from February 2020 (as a peak employment month) through year-end 2021. Data is shown in terms of seasonally adjusted and non-seasonally adjusted jobs – with unadjusted data indicating more variation depending on time of year. Employment is survey-based as of the 12th of each month. So, for example, the data indicated for Apr-21 is as of mid-April 2021.



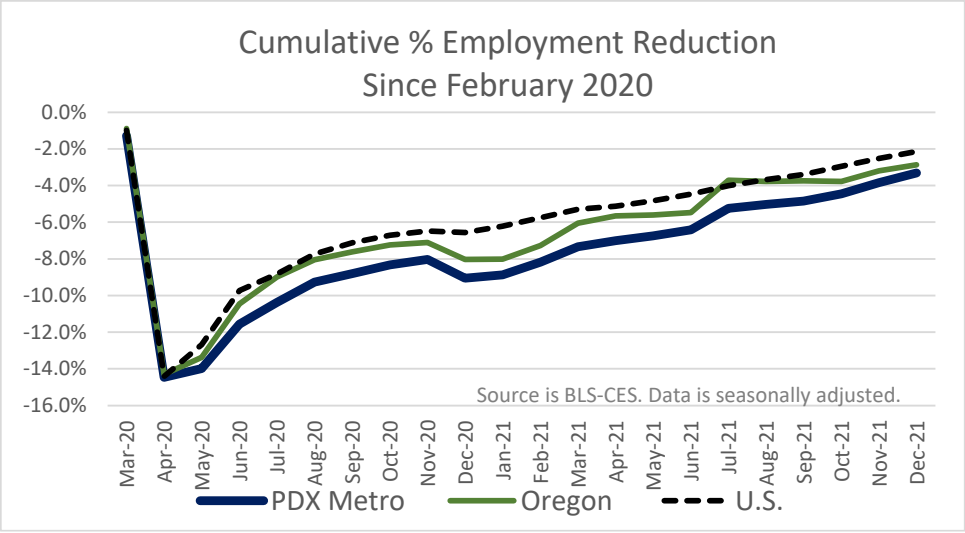
As indicated by the graph, an initial modest employment decline of 16,000 (seasonally adjusted) non-farm jobs was observed from February-March 2020 as business restrictions began to be experienced. By April, the metro area had experienced a cumulative loss of 179,800 jobs (for a 14.5% decline in the metro region's employment in just two months).

Partial job recovery was experienced in subsequent months, with the region re-employing 79,900 by November (recapturing 44% of the initial job loss). Heading into the winter, the metro region experienced renewed employment reductions (losing another 10,400 seasonally adjusted jobs through January 2021). Since that time there has been a pattern of steady job recovery. Over the course of 2021, the region added back another 71,300 jobs, with a remaining 41,200 employees (or 3.3%) below the pre-pandemic February 2020 peak of 1,243,100 total non-farm metro area jobs.

Metro Compared with Oregon & U.S. Pandemic Jobs Experience

In addition to considering the metro area on its own, it is useful to compare this region's experience with that of the entire state and the nation. As shown by the following graph, the metro region, state and U.S. all experienced a similar 14.5% +/- employment decline from February to April 2020. Subsequently, economic recovery experience has diverged – with U.S. employment recovering more quickly than either the Portland metro region or entire state of Oregon.

Of particular note, an end of 2020 renewed job decline experienced regionally and state-wide was more pronounced than nationally. Initially, the state had responded with an uptick more akin to that of the entire U.S. economy but then transitioned to a pattern mirroring the metro region toward the end of 2020.



By mid-2021, the state was closing the gap with the nation – albeit less so for the metro region.

As of year-end 2021, the metro region had 3.3% fewer jobs than in February 2020 versus U.S. under-performance of 2.1%. Up through year-end 2021, Portland metro cumulative job loss has averaged 1.7% points above the nation-wide average. This equates to continued net loss of about 21,200 jobs more than would be the case if the bounce-back were similar to the nation.

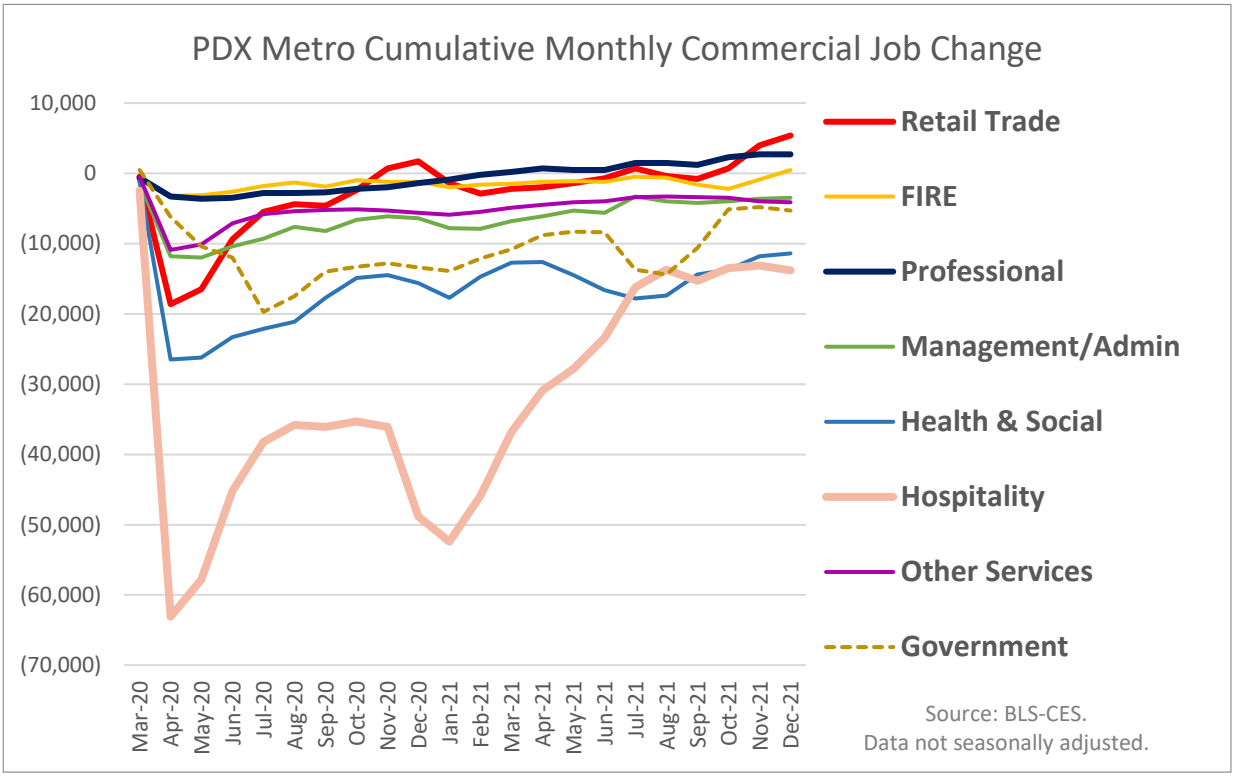
In part, differences in job recovery may be attributable to varied state-by-state and local regulations affecting business operations throughout various phases of the pandemic. Also of importance has been the differential performance of specific sectors of the Portland metro economy over this period. This is a subject to which this review now turns.

Job Change by Employment Sector

Analysis of month-to-month job changes for the Portland metro region can be distinguished between commercially oriented and industrial sectors of the economy. For metro areas of the U.S., BLS reports sector specific data only on a not seasonally adjusted basis. Data is presented starting with the change from February to March 2020, continuing through to June 2021.

Commercial Employment Change. Prior to the pandemic (as of 2018 QCEW data), commercial uses accounted for 71% of PDX metro and 54% of Hillsboro employment. For the metro region, commercial uses have borne the brunt of the economic recession of 2020, accounting for 86% of all metro area jobs lost in April 2020, increasing to more than 100% of remaining cumulative net job loss by year-end 2021 (as industrial jobs by then had more than fully recovered to exceed pre-pandemic levels).

Hospitality (including dining and lodging) has experienced the most severe and uneven impacts. An estimated 63,100 jobs were lost in the March-April time frame of 2020. A sharp but partial bounce-back was experienced over the summer and into fall of 2020, followed by a second round of layoffs by year end. The sector has since again added back employment but remained 13,800 jobs short of pre-pandemic employment as of year-end 2021.



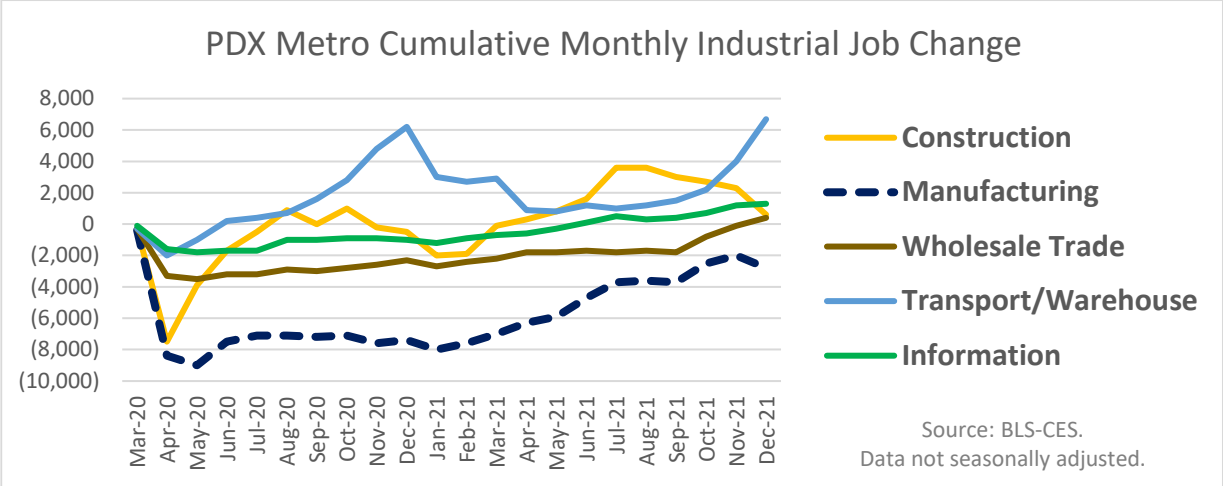
Health/social services, retail and government also experienced sharp (but less substantial) job losses early on but have since unevenly recovered. Professional services, retail and FIRE

(finance/insurance/real estate) represent the only commercial sectors for which employment had fully recovered to pre-pandemic levels by the end of 2021.

Due to potential long-term dampened consumer for *bricks-and-mortar* building space, components of both the retail and hospitality sectors have faced continuing issues, in large part due to measures as for social distancing – albeit with retail faring better than hospitality (especially for larger format retailers). With a lower concentration of jobs in these most at-risk sectors than the rest of the metro region, Hillsboro has been better positioned for continued recovery – due to greater concentration of its employment base in less vulnerable economic sectors. This is evidenced by 2020 jobs data (based on OED updates then available).

One potential question mark relates to the previously rapidly expanding health care sector. There may be more upside potential when health care rebalances to include the full suite of traditional medical services with less set-aside for COVID-related care as the pandemic recedes. Across this sector as with other lower paid commercial sectors, jobs data for 2020 and 2021 indicate increasing challenges with securing adequate workforce. As yet uncertain is the extent to which this proves to be a temporary challenge or represents a longer-term structural shift.

Industrial Employment Change. Pre-pandemic, industrial uses accounted for 29% of PDX metro and about 46% of Hillsboro employment. Industrial uses represented 14% of all metro area jobs lost in April 2020, with overall full recovery experienced by October 2021.



Manufacturing experienced the greatest net loss metro-wide of the industrial grouping – laying off 9,000 workers from February-May 2020 and remaining 2,800 jobs below pre-recession levels as of year-end 2021. However, manufacturing experience has varied depending on the specific sector as further detailed below.

Of the industrial sectors, transportation and warehousing activities proved to be the star performer through the pandemic and recession, up by 6,200 jobs metro-wide over pre-pandemic levels as of December 2020 and increasing to a net gain of 6,700 jobs as of December 2021. This sector benefitted from the new attention to supply chain management coupled with

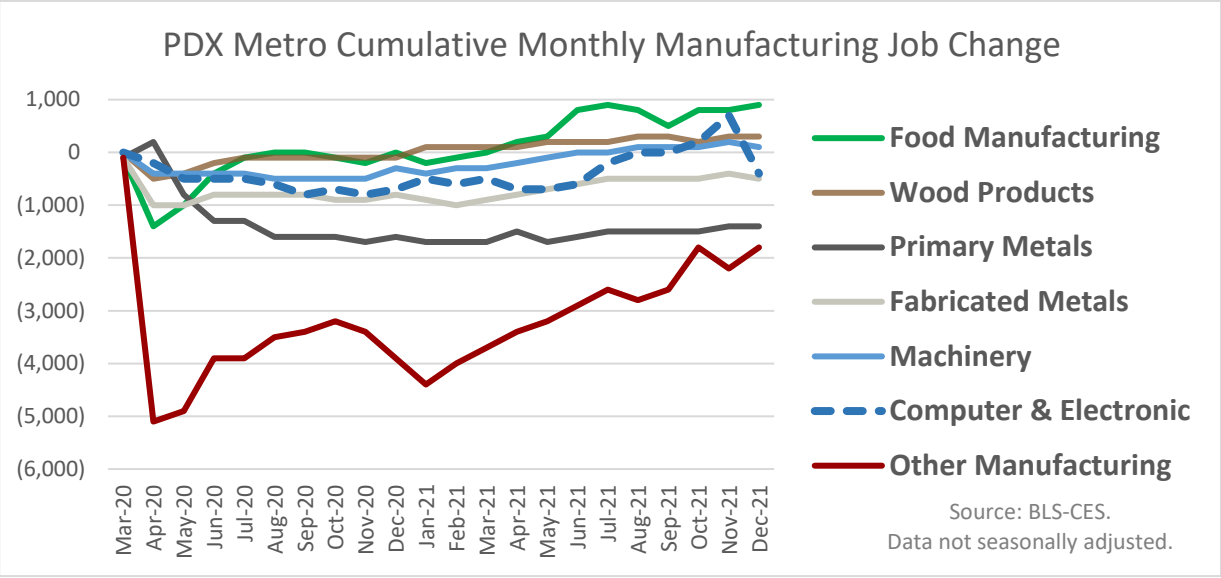
the *Amazon effect* of dramatically increased shipments to residences and newly created home offices as well as to recovering industrial and commercial businesses.

With the exception of transportation and construction, other industrial sectors have maintained relatively stable employment through the pandemic with minimal net job loss. After an initial downturn early in the pandemic, construction employment had more than recovered to 3,600 above pre-recession employment levels as of summer 2021.

Taken together and consistent with national experience, industrial-related employment has proved to be more stable and in many cases a driver of new job potential for the PDX region.

Manufacturing Focus. With this EOA it is also useful to *drill down* a bit further and evaluate changes in metro area manufacturing employment through the period of pandemic related recession and then subsequent recovery. As of 2018, manufacturing uses accounted for 11% of PDX metro and 32% of Hillsboro employment.

Manufacturing represented just 5% of all metro area jobs lost in April 2020, increasing to about 9% of remaining cumulative job loss over a year later, then ranging between 7-9% for most of 2021. As shown by the chart for monthly employment changes for manufacturing employment covered by BLS-CES data, some manufacturing sectors clearly held up better than others.



As of 2018, computer and electronics manufacturing accounted for 85% of manufacturing employment in Hillsboro. Metro-wide, this sector experienced a net job loss of only 200 jobs from February to April 2020. Layoffs continued to a peak of 800 fewer employees by September 2020. As of August 2021, employment was back to 100% of pre-pandemic conditions, increasing thereafter albeit with some drop-off during the last month of 2021.

Other manufacturing sectors experiencing full job recovery as of mid-2021 have included food products, lumber and wood products, and machinery manufacturing. Metals-related and other manufacturing sectors remained below pre-pandemic job level as of year-end 2021.

This metro-wide experience indicates effective resilience through this period coupled with what appear to be strong indicators for further growth ahead – including for semiconductors and other advanced manufacturing. While 2021 jobs data was not yet available as of the date of the 2021 EOA update for geographies below the metro level, OED data for 2020 indicate that Hillsboro fared much better than the metro region for manufacturing job retention in the initial pandemic year of 2020. From 2019-2020, manufacturing employment declined by only 0.5% in Hillsboro as compared to a 6.3% job loss metro-wide.

For Hillsboro and nationally, pandemic related demand has been strong in applications ranging from cloud storage to notebook computers due to more at home office employment – as well as for other end-user products as with the auto industry. There is anticipation of continued strong demand growth due to current semiconductor shortages globally and for emerging new technologies ranging from artificial intelligence (AI) to the internet of things (IoT).

Reshoring of manufacturing capacity to the U.S. has emerged as a clear governmental and industry priority creating added opportunity for Hillsboro firms (led by Intel) provided that Hillsboro remains competitive with other regions of the U.S. for yet further investment and added employment potential.

Food/textile and machinery job levels (including firms with a Hillsboro presence) also held up well through the pandemic across the metro region. Other manufacturing activities experienced greater earlier job losses coupled with subsequent volatility of employment metro-wide, albeit with limited Hillsboro presence.

To summarize, Hillsboro's current and prospective employment mix including recent pandemic experience appears to offer benefits both of economic resilience and long-term growth potential:

- Hillsboro's business and industry mix has demonstrated a path toward economic recovery and resilience beyond what has been achievable across the rest of the metro region.
- The community's nurturing of technology industries aligns well with the best opportunities for economic growth regionally and nationally – in recent years, through the 2020 economic downturn and post-pandemic.

Bottom line, these demonstrated advantages position the community to be an even more significant source of job stability and renewed growth for the PDX metro region and state of Oregon in what may be considered as the *new-new-economy* of the years just ahead. This sets the stage for sharing in the longer-term transition to a more resilient and sustainable global as well as domestic U.S. economy.

WORK COMMUTE CONSIDERATIONS

An issue of growing concern in recent years is reduced effective accessibility of work force to jobs throughout the metro region. While metropolitan areas are defined, in part, on the basis of commuter access to jobs throughout a metro region, this has become more challenging in recent decades due to growing transport congestion.

For example, it is assumed that Hillsboro workers can be drawn from throughout the metro area, including more distant locations such as Clark County. However, as the travel time of these cross-metro commutes increases, this premise becomes more tenuous than previously.

While the COVID pandemic temporarily increased access due to fewer commuters on the freeway system and associated thoroughfares, this is now being offset by an apparent growing preference from workers for better live-work integration, with less tolerance for long commutes than previously.

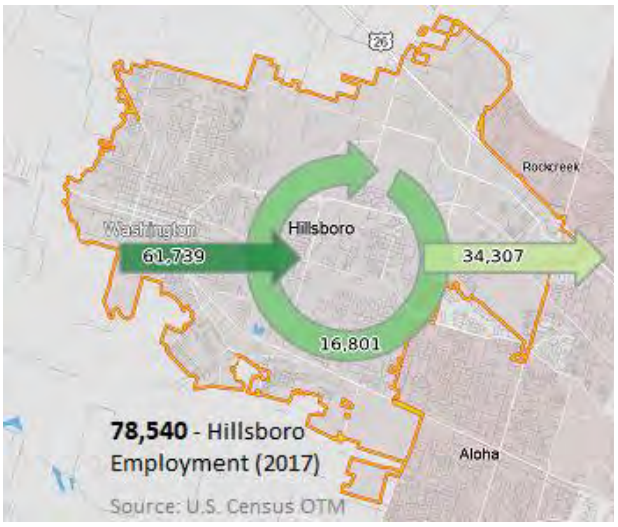
Concerns with the work commute to Hillsboro have repeatedly been identified by stakeholder employers– both initially and with subsequent contacts conducted for this EOA update. The question relates to the effect of regional traffic congestion on work commutes and resulting effective labor-shed available to Hillsboro employers – both historically and going forward.

A synopsis of data compiled and associated observations pertinent to this updated EOA is provided on the following pages.

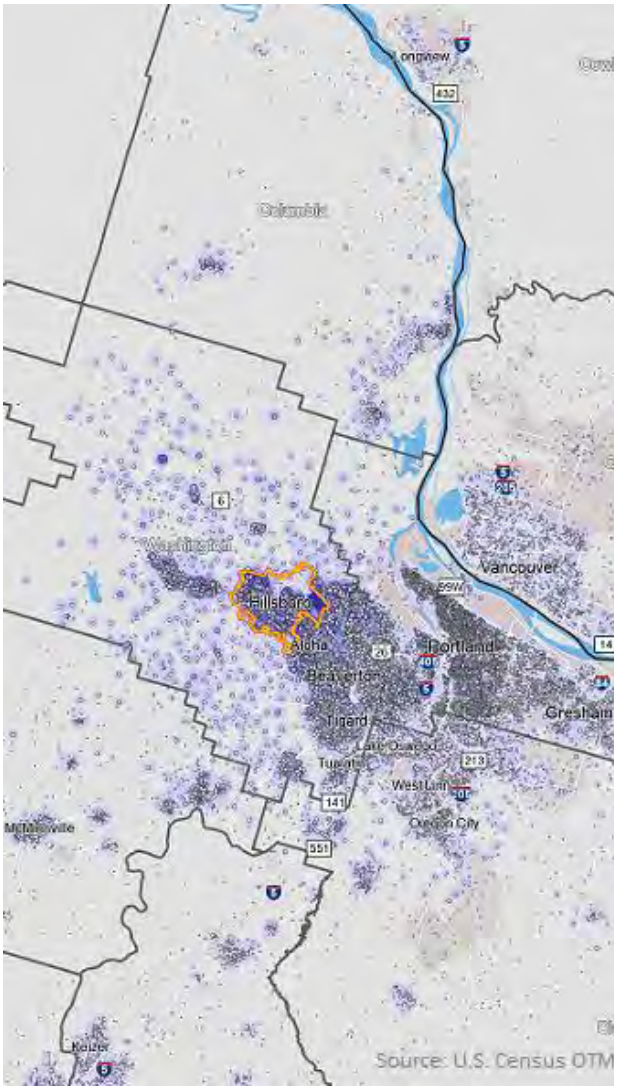
Using data from the U.S. Census *On-The-Map* program, it is possible to profile commute patterns of those who live and those who work in Hillsboro.

- As of 2017, U.S. Census data indicated that out of an estimated 78,540 persons **who work** in Hillsboro, 16,801 (or 21%) also live in Hillsboro while another 61,739 (79%) commute to places of employment in Hillsboro.
- From the perspective of 51,108 workers **who live** in Hillsboro, 16,801 (33%) also work in town while 34,307 (67%) commute out of Hillsboro for employment.
- The residence pattern of those who work in Hillsboro extends south past Keizer, west toward the coast, north into southwest Washington, and east to as far as the Hood River area.
- While 21% of those who work in Hillsboro live locally, Portland accounts for close to 13% of Hillsboro's job base – followed by Beaverton, the unincorporated Aloha and Bethany areas near Hillsboro, and Forest Grove. Taken together, this **close-in commute-shed** accounts for just over half (54%) of those who work in Hillsboro.
- With increased regional congestion especially on the Highway 26 east-west corridor, the commute shed has begun to shift in recent years to more of a north-south orientation – **especially south.**

Inflow & Outflow of Hillsboro Workers

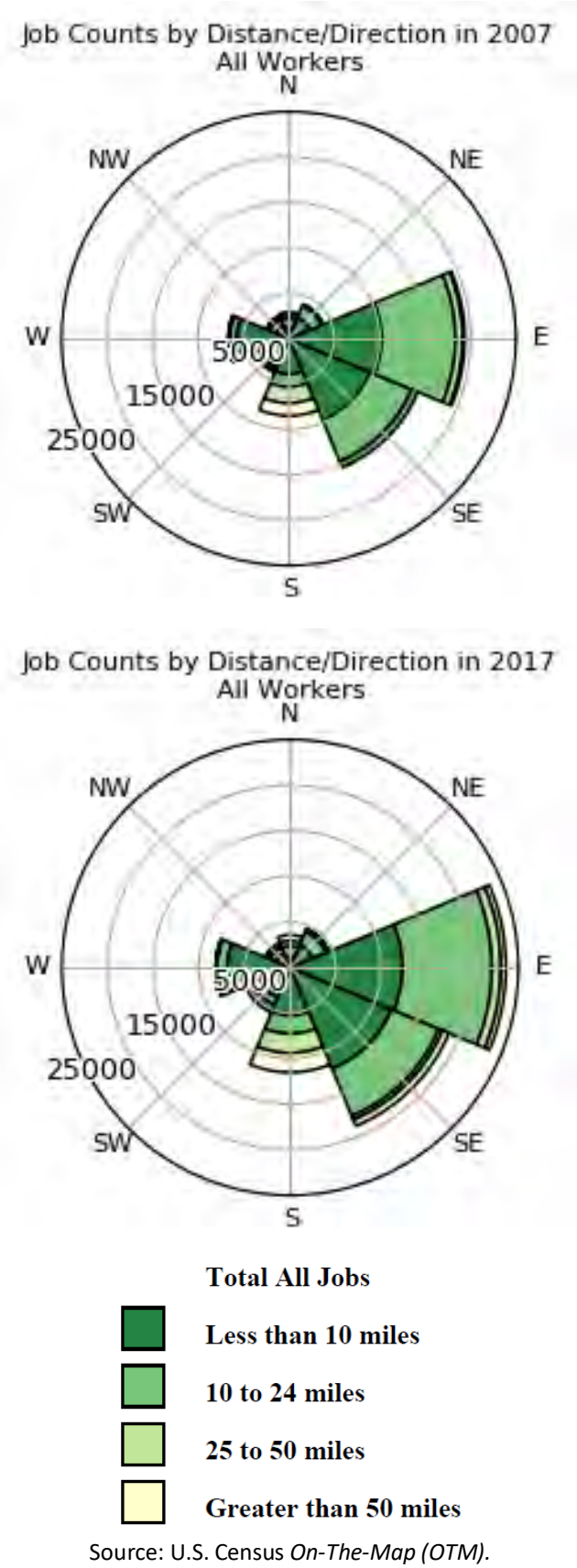


Home Locations of Hillsboro Workforce



Despite experience of the 2007-09 Great Recession, U.S. Census data indicates that that the Hillsboro job count increased over the decade of 2007-17 by 24%.

- The pattern of residential employment now spreads over a **larger geography** as of 2017 than a decade prior. Workers living 25+ miles from Hillsboro accounted for only 11% of all jobs in 2007 but 20% of Hillsboro's net employment growth in the next decade to 2017.
- Due to Hillsboro's location at the northwest edge of the metro region (including challenging transport to the Washington side of the Columbia river), the commute-shed of employers **historically has been focused** primarily to the east and southeast.
- While employment from 2007-17 increased from all residential directions, the commute-shed has begun to **shift to the south** which went from 13% of Hillsboro employment in 2007 to provide 20% of net added workers in the following decade.
- A more nuanced view shows other **varied patterns of growth** depending on direction. The SW accounted for increased job growth at all distances, N at 10+ miles, NE and SE at 25+ miles, W at all but the 25-50 mile distance, and E/NW at 50+ miles.
- Taken together, **the growth corridors/nodes** that served as home base for 23% of Hillsboro's work force in 2007 have accounted for 41% of net job growth since.



Source: U.S. Census *On-The-Map (OTM).*

Also of note are home locations by age of worker and earnings:

- Younger workers (of up to age 29) who live in Hillsboro appear to be more likely to commute out of town than work in Hillsboro – a pattern that has intensified in recent years.
- Hillsboro residents of age 30-54 account for the majority of those who commute out of town for added job opportunity – as well as the majority of non-residents who have taken new positions in Hillsboro.
- Workers age 55+ have accounted for about 42% of the net job growth in Hillsboro associated with local jobs filled by outside workers.
- Lower paying jobs (of $1,250 per month or less) are on the decline in Hillsboro – with the only increase being with positions for local residents who commute out of town for work.
- There has been modest growth over the 2007-17 decade of middle wage jobs (of $1,250-$3,333 per month) in Hillsboro, taken almost exclusively by persons commuting into Hillsboro for work.
- Just over three-quarters (76%) of net added higher paying jobs (earning more than $3,333 per month) over the 2007-17 decade have been taken by non-residents – although this is the predominant wage range for jobs going to Hillsboro residents as well.

To summarize, this data indicates that transportation corridors and congestion are re-shaping the Hillsboro workforce commute-shed. While local employers draw workers from across the region, some areas associated with difficult commutes are clearly under-represented.

Due to increasing congestion within the core of the metro region, a growing share of the workforce is being drawn from the edges of and further beyond to outside the immediate metro area – especially from urban as well as more rural communities to the south.

While improved workforce accessibility depends, in part, on regional transportation improvements, of equal or perhaps greater significance going forward may be the need to provide added and more varied housing product to support continued employment growth within the more immediate Hillsboro community.

EMPLOYMENT SECTOR REVIEW

In review of the 2021 EOA, DLCD staff questioned how the EOA considered and applied compound or CAGR (exponential) versus straight-line (linear) projections of employment growth. This last portion of Appendix A is intended to provide a detailed review of the forecast methodologies considered and applied to preparation of a recommended preferred employment growth scenario. This review is consistent with historical experience and changing opportunities in the aftermath of a global pandemic, economic downturn and as yet in-progress economic recovery.

Approach to Sectoral Analysis

As employment forecasting has been conducted on a sector-by-sector basis, this analysis is similarly driven by sector-specific considerations. As described by the primary 2021 EOA document, work on an updated EOA was initiated in 2019, then subsequently revised to reflect COVID-related experience and changed economic conditions.

Quarterly Census of Employment and Wages (QCEW) trend data was provided by the Oregon Employment Department (OED) in late 2019 with data specific to Hillsboro for 2007 and 2018. This period covered a near full economic cycle with recession starting in 2007 to recovery and then to near a 2019 peak – prior to the subsequent recession associated with the pandemic in 2020.

Process for Goal 9 Compliance. OAR 660-009-0015 for EOAs states that forecast demand is to be based on what could "reasonably be expected to locate or expand in the planning area based on information about national, state, regional, county or local trends." While the OAR does not stipulate the use of a specific methodology, the application of a compound annual growth rate (CAGR) reflects typical practice for EOA employment and land needs analyses.

Most significantly for the Portland tri-county region, Metro's Urban Growth Report (UGR) has been framed in terms of annually compounded job growth rates (described as an APR – Annual Percentage Rate in Metro terminology). This also has been the approach taken, for example, with Portland's EOA as earlier adopted by the City of Portland in 2016.

In communities experiencing relatively slow job growth, there may be relatively little difference in extrapolation of straight-line or annually compounded growth (where each year's growth is built on a higher base from the previous year). Hillsboro presents a different situation as growth rates have been relatively rapid across a number of employment sectors in recent years. In this situation, there can be a more substantial difference in future growth potentials depending on whether the job trend is forecast based on a straight line or CAGR methodology.

Recognizing the potential difference, Hillsboro's EOA was framed around a comparison of straight-line and exponential (CAGR-based) growth rate calculations by major employment sector, described as Scenarios A and B, respectively. Two reference years of jobs data were obtained with 2007 as the starting and 2018 as the end point of the historical data analysis.

With just these two years providing beginning and end-point data, it is not statistically possible to determine whether a straight-line versus exponential (non-linear) growth rate calculation is more relevant to Hillsboro's experience. Making this determination could occur either by obtaining data for each calendar year in the historical dataset and/or by informed judgement including policy and planning objectives of the City of Hillsboro.

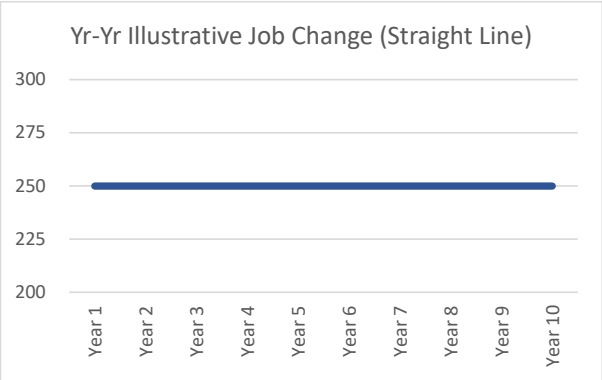
As detailed year-by-year sub-county data is not readily available from OED (without geo-coded special data runs), primary reliance was placed on an approach reliant on informed judgement of City of Hillsboro Economic Development personnel. This led to preparation of a third forecast Scenario C. This scenario was termed as "hybrid growth," based on a more detailed sectoral evaluation of whether each sector appeared to be as yet emergent suggesting exponential annual growth rates ahead or maturing, suggesting a straight-line approach where the % change in jobs actually declines each year of the forecast period, as compared to the year prior.

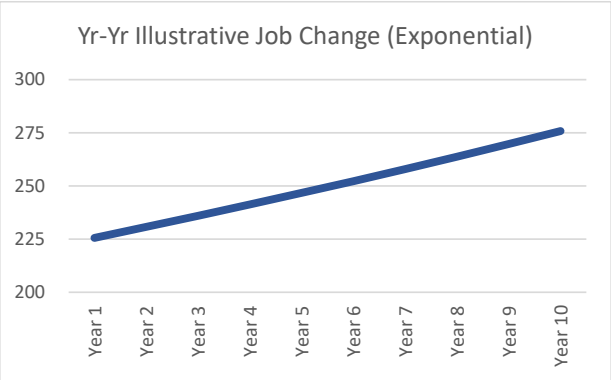
Most significantly for this EOA, sectors with continued strong growth potential include those that align with continuation of Hillsboro's target industry emphasis on tech-driven and traded sector business and industry clusters. The determination of whether a sector's prospects are classified to reflect a straight-line, exponential or mid-point forecast allocation was made in consultation with Economic Development input as best reflecting recent trends together with City of Hillsboro opportunities and strategic priorities.

At the request of DLCD, more detailed year-by-year analysis was completed based on a special supplemental 2022 data run generated by OED to provide year-by-year and industry sector employment data specific to Hillsboro, including updates for the 2019-20 years of QCEW jobs data as subsequently made available. The next section of this review covers both the methodology and the results of this more detailed sector-by-sector analysis together with observations as to the appropriateness of straight-line and/or exponential growth rates utilized with the Hillsboro EOA employment forecast process.

Methodology to Differentiate Straight-Line vs Exponential Job Growth Trend. As a starting point for this analysis, it is useful to describe how year-to-year employment changes can be reviewed to assess whether job growth is occurring on a straight-line versus exponential trajectory. This is **illustrated** by the two graphs on the next page – each assuming a starting year hypothetical base of 10,000 jobs, increasing by 25% to 12,500 jobs within 10 years.

- The graph *to the left* illustrates a hypothetical **straight-line** scenario. The 2,500 added jobs in 10 year occurs in equal increments of 250 added jobs per year.
- In contrast, the graph *to the right* illustrates an **exponential** scenario. Applied to the base year count of an assumed 10,000 jobs, getting to a net 10-year gain of 2,500 is achieved at what calculates to be a compound annual growth rate (CAGR) of 2.26% per year. Employment increases by 226 jobs in year 1 (equal to 10,000 x .0226), adding 231 jobs in year 2 (equal to 1,226 x .0226), and so on … with each year's job growth greater than the year previous as base level employment continues to increase each successive year.





Both approaches start with the same employment number (in this case 10,000 jobs) and end with the same number (12,500 after 10 years). The straight-line approach assumes the same number of net new jobs are added each year. The exponential approach gets to the same end-year result, but with more jobs added each year than the last, with each year's job number increasing at a constant percentage rate above the prior year's base of total employment.

For purposes of assessing whether employment growth has followed a straight-line versus exponential trajectory, **the difference lies in the shape (or slope) of the trend line**. Straight line growth occurs on a relatively flat-line horizontal trajectory (with no upward slope), whereas exponential growth occurs on an upward-sloping path.

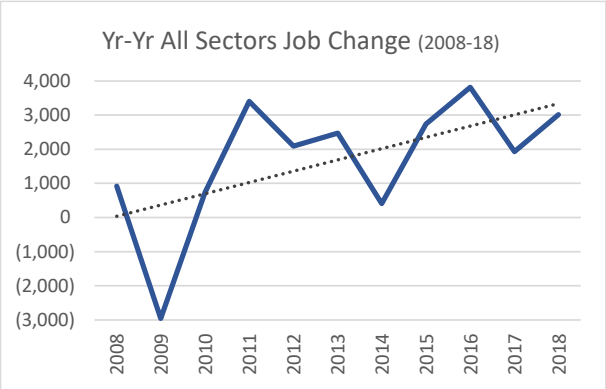
This is particularly important in real-world assessments where job change from one year to the next may be uneven, up one year and down the next. The trend line is based on the trajectory that achieves the "best fit" across the years considered**. Straight-line growth is the trajectory where the "best fit" trend (or regression) averages to roughly equivalent job changes each year. Exponential growth is indicated where the trend-line is upward sloping. This is the approach taken with the remainder of this analysis.**

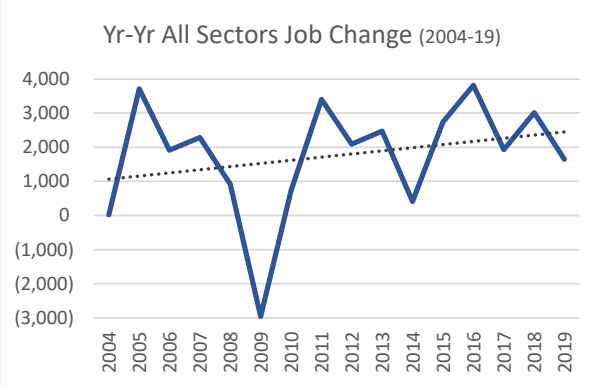
Hillsboro All Sectors Job Change. This methodological approach is now applied to actual employment changes in Hillsboro – first with consideration of all sectors combined and then on an industry sector-by-sector basis. Two sets of graphs are utilized for this review:

- **Job change from 2008-18** – the time period consistent with the EOA dataset as provided by OED in 2019. Note that the year of change is for the year indicated on the graph as compared to the year prior. For example, a 2008 data point shows the numerical change in employment occurring from 2007-08. Actual results are shown by the **solid blue** line.
- **Job change from 2004-19** – as a somewhat expanded time frame based on year-by-year data as recently provided in March 2022 by OED. *Notes:* This time period is based on years for which geo-coded data is available for OED; earlier year geo-coded data is not available. The year of change is for the year indicated on the graph as compared to the year prior. So, for example, a 2004 data point illustrates the numerical change in employment from 2003-04. Also noted is that 2004 Hillsboro job estimates are adjusted per consultation with OED.

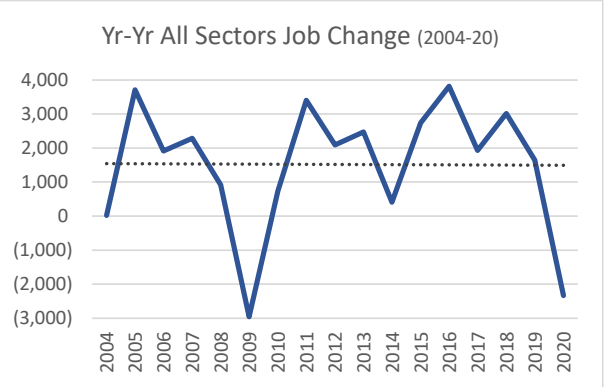
As illustrated below, potential conclusions for trended employment in Hillsboro across all sectors can vary depending on the time frame considered. "Best-fit" experience from 2007-18 (as shown by the **black dotted** line) is consistent with **exponential growth** – using either the experience of 2007-18 or the somewhat longer historic time frame of 2003-19 *(shown below)*.

Hillsboro's 2007-18 experience has the benefit of covering a near-full economic cycle – from recession to near-peak. The longer-term 2003-19 time frame has the benefit of providing more years of data points, albeit offset by the disadvantage of not covering full economic cycles. This somewhat more extensive time series covers just the last part of the pre-2007 jobs run-up and the post 2007-09 recovery (less than two full up-cycles) while capturing two full down cycles.





The most recent dataset available from OED extends through the 2020 year of COVID pandemic and economic downturn (shown by the *added graph to the right*). As of the date of this analysis, full-year 2021 QCEW data was not yet available from OED. However, data for 2020 indicates that employment in Hillsboro declined by 2.8% from 2019, much less than the 6.8% drop experienced metro-wide.



In effect, if experience through the 2020 pandemic and recession year is included, a different trending pattern is observed. However, this represents an incomplete view as it covers two down cycles and only one up-cycle of employment change.

Recognizing that inclusion of 2020 down-cycle data in the absence of subsequent economic recovery may represent an unduly conservative view of long-term growth prospects, DLCD has allowed for exclusion of this anomalous year from Goal 9 EOA reviews underway.

With the detailed sector-by-sector review that follows, this analysis utilizes the 2008-18 and 2004-19 time periods as the primary comparative focus for analysis. In effect, the "best fit" analysis based on either time frame indicates an overall pattern of exponential growth for Hillsboro in recent years. However, rather than apply this overall conclusion across the board to

encompass all sectors, the approach taken with the 2021 EOA is industry *sector-by-sector*, each considered on its own merits – and with both the shorter and longer-time periods reviewed.

Particular focus is placed on traded sector industries including key supporting sectors. In cases where the data supports both linear and exponential growth (depending on the time frame considered), additional discussion is provided together with a rationale for the selected forecast approach as part of the preferred hybrid growth scenario (Scenario C).

While 2020 analysis is not relied on as determinative, in some cases this pandemic-related experience is factored into the discussion – especially for sectors for which there is evidence that the 2020 downturn may presage a longer secular term change rather than a temporary downturn.

Sector Toggle Approach. As described at the outset of this appendix, a *four-phase* sector toggle approach was used to determine the employment forecast outcomes that would be applied to the Scenario C hybrid model:

- Employment sectors for which job loss was experienced from 2007-18 are assumed to experience **no further net change** employment to 2040.
- Sectors for which Scenario A straight-line experience appears most applicable and not comprising a Hillsboro cluster target are assumed to continue experiencing employment growth consistent with the **straight-line** trajectory of the most recent economic cycle.
- Sectors that have experienced job change consistent with Scenario B **exponential growth** including target industry or affiliated sectors are forecast to continue experiencing job growth consistent with the historically based CAGR trajectory.
- Finally, sectors that appear to have experienced or be influenced by exponential growth but for which the two time frames considered suggest both exponential and straight-line patterns may be assigned a **mid-point** result by taking the average of the numerical job growth calculations associated with Scenarios A and B.

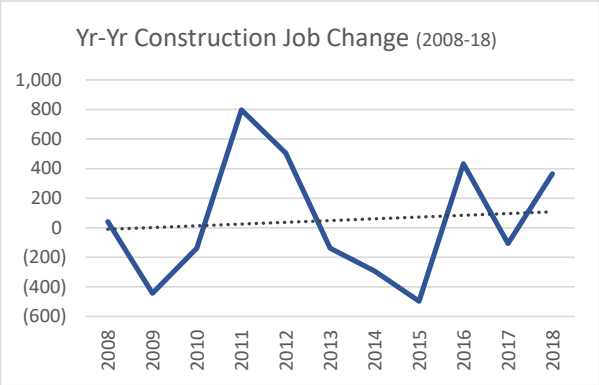
This sector-by-sector analysis now follows, organized by the NAICS industry sectors for which sector-specific employment forecast have been made. For each industry sector considered, discussion includes a brief review of the sector's relative local employment significance, the year-to-year job change (with each of the two retrospective time frames considered), other factors based on both quantitative and qualitative considerations addressed with this EOA, and conclusion as to the approach taken for inclusion with the recommended Scenario C hybrid growth forecast.

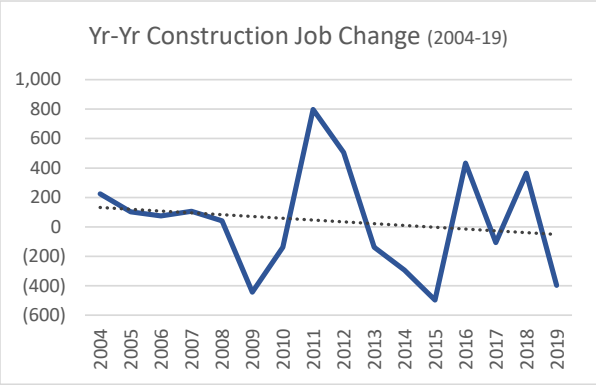
Sectors for which exponential growth is indicated or for which there may be countervailing evidence receive the most detailed attention. Sectors for which straight-line growth is clearly indicated or which have experienced net job loss over the last economic cycle are generally addressed in a more summary fashion.

23 Construction

As of 2018 (pre-pandemic), construction represented about 4% of total employment in Hillsboro – but with overall growth indicated over this last economic cycle of recovery from the previous recession of 2007-09.

As an often volatile sector (in terms of year-to-year changes in job counts), construction well exemplifies the challenges associated with the attempt to determine whether the long-term job trend is linear or exponential. Based on the initial data provided by OED at the outset of EOA analysis in 2019, the 2007-18 job trend indicates some tendency toward exponential growth, albeit at a modest pace (as shown by the *chart below and to the left*).





With the time frame of analysis extended by five years based on added year-to-year data provided by OED in early 2021, a somewhat countervailing trend more indicative of linear growth is depicted (by the *chart to the right*).

Further confounding the analysis is that if 2020 job counts were to be included (as a year of pandemic and overall economic decline), construction employment actually increases rather than decreases when compared to prior year (2018) counts. This is due, in large part, to previously committed construction projects as with Intel Hillsboro expansion then underway.

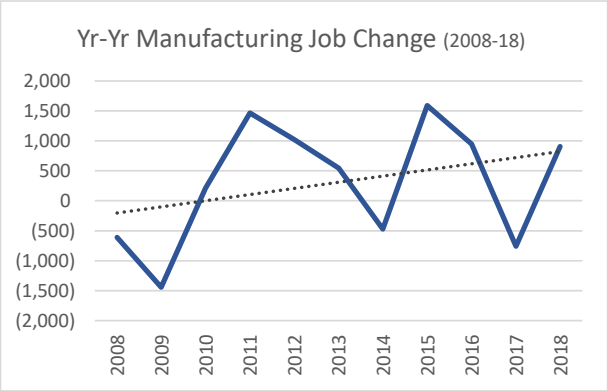
While highly cyclical, the experience of the last economic cycle of 2007-18 appears to be more relevant, especially when considered in context of the surprising 2020 pandemic performance. Consequently, with Scenario C hybrid growth, construction employment has been forecast to continue experiencing growth at exponential CAGRs as experienced over the last economic cycle and even into the pandemic downturn of 2020. This determination is also consistent with the distinct role that the industrial/commercial portion of the construction sector plays in supporting growth in manufacturing and traded sector employment in Hillsboro.

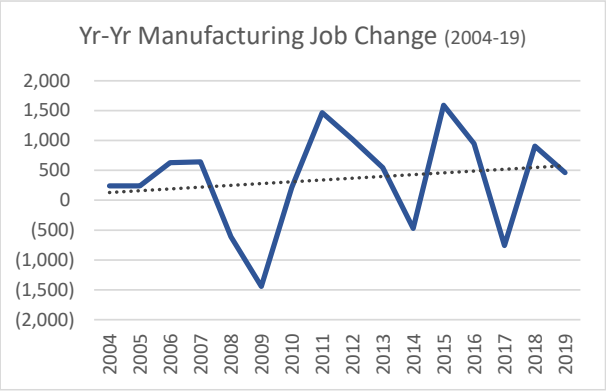
With exponential growth, the compound annual growth rate (CAGR) utilized for the 2020-40 period equates to an average 2.7% increase in employment over the prior employment in the previous year. The result is that Scenario C (exponential growth) extrapolation results in a forecast net addition of 2,350 Hillsboro construction jobs from 2020-40 as compared to a net increase of 1,470 jobs if a straight-line employment projection were to be applied.

31-33 Manufacturing

Unlike most larger cities and metro areas in Oregon, manufacturing represents the dominant employment sector in Hillsboro. This is a traded sector function led by semiconductor manufacturing providing relatively high wages coupled with strong economic multiplier effects regionally and statewide.

As of 2018 (pre-pandemic), manufacturing represented 32% of total employment in Hillsboro – the largest share of any industry sector city-wide. Employment increased by 15% over the 2007-18 period, albeit with manufacturing representing a somewhat declining share of total (all sector) employment.





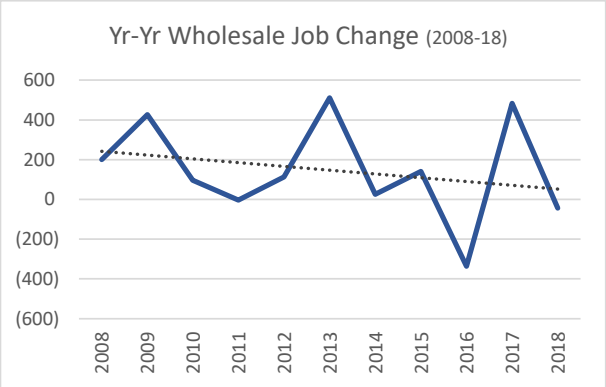
The experience of the last economic cycle (as initially compiled for 2007-18) and the somewhat extended experience (of 2003-19) both support an exponentially based forecast – albeit at a relatively modest CAGR of 1.3% per year (from 2007-18). With the Scenario C hybrid growth forecast, manufacturing has been forecast to continue experiencing growth on a CAGR-based exponential trajectory as experienced over the last economic cycle. Of added note is that semi-conductor and related tech-based manufacturing also represents a key industry priority for Hillsboro.

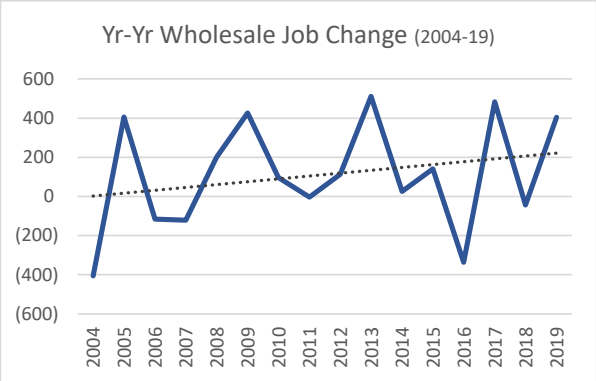
Application of an exponential (CAGR) forecast results in an added 7,770 in-city manufacturing jobs over the 2020-40 twenty-year forecast period. This is about 25% above the 6,200 net added jobs that would be associated with a more conservative straight-line projection.

City economic development staff indicate that even the CAGR-based forecast may prove unduly conservative given the current record of industrial land absorption and continued interest of major advanced manufacturing firms to locate or expand in Hillsboro – provided that land capacity including large master planned sites remain amply available.

42 Wholesale Trade

As with the construction sector, wholesale trade exhibits patterns of both straight-line and exponential employment growth, depending on the historical time frame considered. Wholesale trade accounted for only 4% of Hillsboro pre-pandemic employment, but Hillsboro's job count for this sector doubled over the course of the 2007-18 economic cycle.





The two above charts indicate countervailing trends depending on the time frame considered, with overall priority given to a straight-line forecast based on 2007-18 results of the last economic cycle. With the 2021 EOA, wholesale trade has been conservatively assumed to experience a continuation of straight-line but rapid linear growth in the years ahead (consistent with the above noted retrospective analysis).

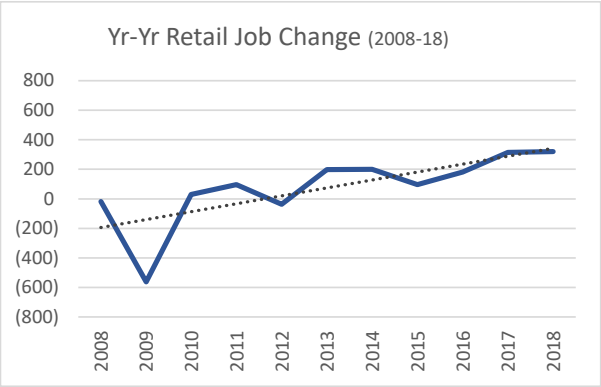
Further expansion of wholesaling activity may represent an important aspect of maturation of the Hillsboro economy, especially to support manufacturing and other local traded sector companies. The more conservative straight-line projection results in an estimated 2,950 added wholesale trade jobs in Hillsboro from 2020-40.

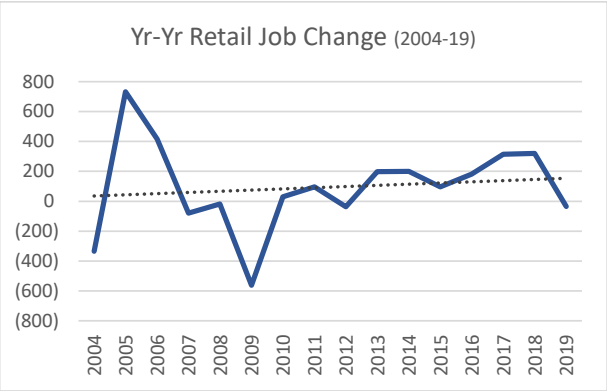
By comparison, extrapolation of CAGR results of job growth averaging 6.7% per year from 2007-18 could lead to need for land to accommodate as many as 9,650 net added jobs in wholesale trade activity by 2040.

While Scenario C Hybrid Growth reflects the more conservative position, recalibration of employment and associated land forecast could be suggested in the event that business and employment growth in this sector continues at an accelerated pace in the years ahead.

44-45 Retail Trade

As is the case nationally, Hillsboro retail may be in the midst of a major transition, the outcome of which is not yet clear – especially when considered in terms of pandemic-related experience together with a longer term trend toward e-commerce. Pre-pandemic, retail trade equated to 9% of Hillsboro employment – 3rd greatest of any sector but with a declining share of in-city employment experienced over the last economic cycle.





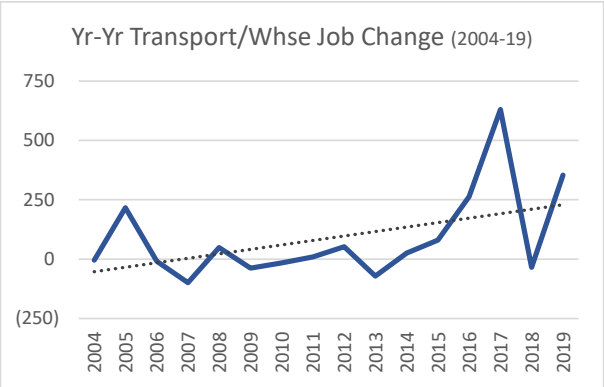
The experience of the last economic cycle (to 2018) indicates support for an exponential approach to future job expectations as does the longer term 2003-19 experience. However, the longer-term experience of 2003-19 comes close to more of a straight-line approach. This is particularly the case if the sharp retail downturn associated with the 2020 pandemic experience were to be taken into account as representing more of a long-term structural shift rather than a temporary one-year anomalous decline.

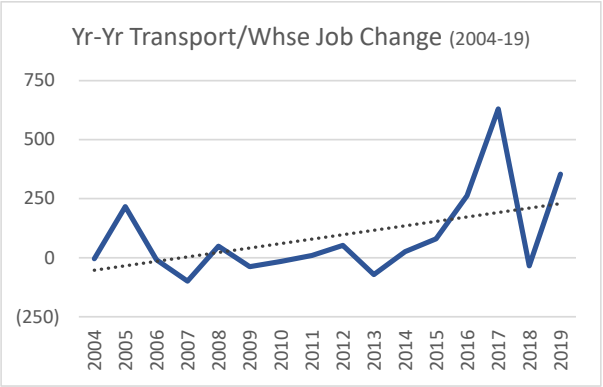
Key factors affecting retail both before and extending through the pandemic include aging of the population (with reduced propensity to spent), shift to internet retail and expansion of multi-channel large-format stores, often at the expense of independent brick-and-mortar retailers. While recent experience indicates some at least temporary potential shift back to in-person shopping, a more cautious overall approach is suggested going forward. As a result, retail has been assumed to experience a pattern of straight-line growth over the 20-year EOA forecast horizon.

With a CAGR of only 1.1% average annual job growth as experienced over the last economic cycle, there is a limited difference between outputs associated with an exponential versus straight-line forecast. Assuming straight-line growth with Scenario C, an estimated 1,490 in-city retail jobs would be added from 2020-40. With an exponential growth, this job target is increased by 21% for 1,810 net added retail jobs over the 20-year EOA planning horizon.

48-49 Transportation & Warehousing

As with wholesale trade, the related sector of transportation and warehousing experienced strong job growth over the last economic cycle – when considered in percentage terms coming off a relatively small initial job base. Pre-pandemic, this sector accounted for just over 2% of total employment in Hillsboro. However, the job count has doubled over the 2007-18 period – a trend further accelerated by the pandemic.





Both of the time frames considered with this analysis are supportive of continued exponential growth for this sector. The case for continued accelerated job growth is further strengthened by the strong job growth in this sector experienced both nationally and locally through the 2020 pandemic period. From 2019-20, employment in this sector metro-wide increased by 7% and in Hillsboro by a remarkable 33%.

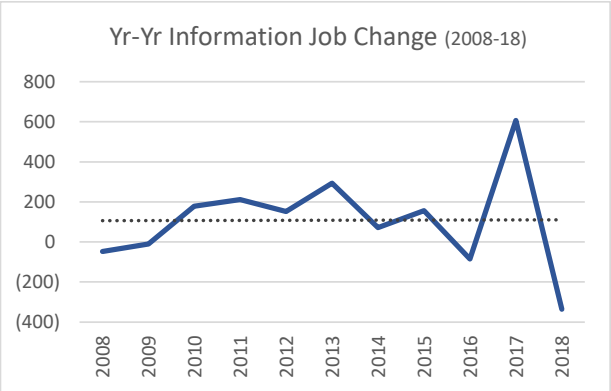
What might be termed as the "Amazon effect" has been replicated across a range of other transportation and distribution functions, most recently indicated with supply-chain issues affecting customers for at-home delivery as well as multi-modal trade flows. For freight dependent businesses in Hillsboro as well as nationally, bringing this transportation and distribution capacity closer to the customer's doorstep rather than elsewhere in the metro region is of greater priority than was the case previously.

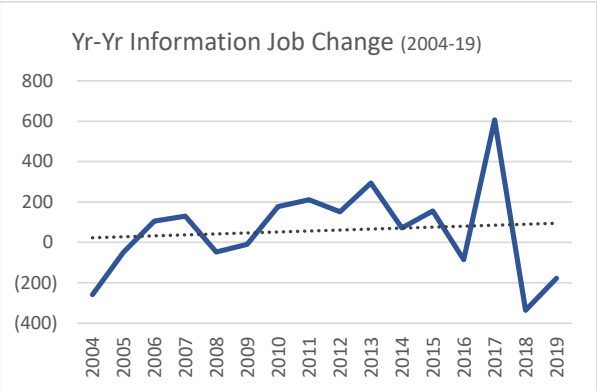
To summarize, transportation and warehousing has been forecast with Scenario C to experience growth at continued exponential rates over the 20-year EOA forecast period – also consistent with pandemic experience of 2020. This leads to a Scenario C Hybrid Growth forecast of up to an added 5,290 added transportation and warehousing jobs from 2020-40, as compared with 1,730 added jobs if a straight-line projection were to be applied.

To some extent and due to the complementary nature of respective business activities, there may be trade-offs between job growth assigned to NAICS 42 wholesale trade (applying a straight-line projection) vis-à-vis a more substantial NAICS 48-49 transportation and warehousing CAGR-based forecast (as determined for Scenario C).

51 Information

This sector comprises a range of media-related businesses ranging from long-standing but declining newspaper publishers to growing software firms – also including internet firms, telecommunications activity and entertainment media. The information sector represented just 3% of Hillsboro employment in 2018, but with the local job count increased by 80% over the last economic cycle – equivalent to a 5.5% average CAGR.





The 2007-18 experience (indicated by the chart to the left) indicates an overall straight-line growth pattern while the more extended 2003-19 time frame (shown to the right) suggests somewhat of an exponential growth trend. While a case could be made for either forecast methodology, the determination in this case is to lean toward the exponential trend.

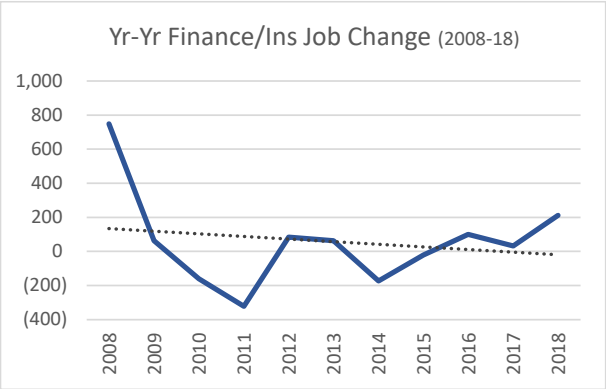
This is because software and information technology represents one of four key industries identified as economic development priorities for the City of Hillsboro. Growing this as-yet still relatively small sector is integral to the community's EOA goals for tech-driven diversification and higher economic multipliers with traded sector firms.

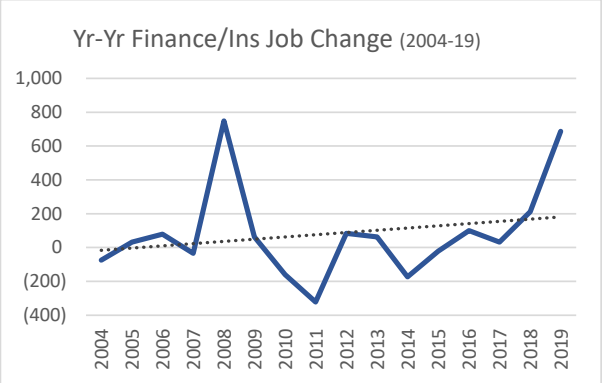
Increasingly complementary relationships can be expected between the hardware and software sides of tech-based industry. This may be especially the case for emerging technologies as with artificial intelligence (AI), electric and driverless vehicles, robotization, digital security and biotechnology. Establishing a stronger software position vis-à-vis other west coast and domestic competition also represents a priority for the Portland metro region, for example, as a target industry cluster of Greater Portland, Inc.

Consequently, with Scenario C this sector has been forecast for job increases at potential exponential rather than straight-line (linear) rates of job growth from 2020-40. Over 20 years, an exponential extrapolation indicates potential for 5,680 added information-related jobs in Hillsboro. This is more than double the 2,160 added job projection associated with a more limited straight-line projection.

52 Finance & Insurance

This sector accounted for 2% of in-city jobs as of 2018 and has experienced job increases at twice the pace of all sectors city-wide over the most recent economic cycle (due in part to reclassification of some employment from NAICS 55 Management in 2012, reflected below).

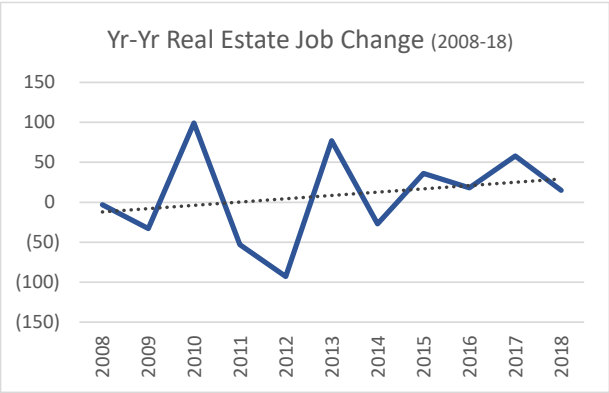


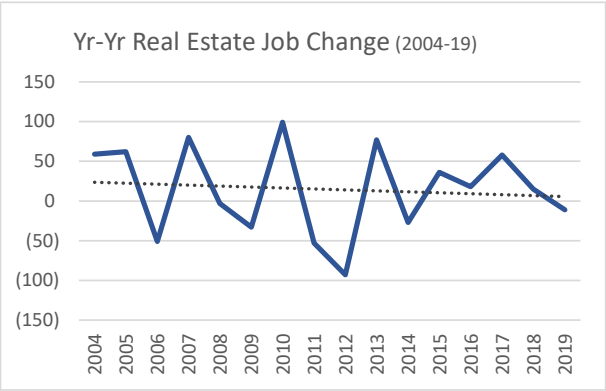


Depending on the time frame considered (as illustrated above), this sector shows countervailing signals as to future growth prospects (with or without inclusion of a noted 2012 reclassification of some employment to this sector). With this 2021 EOA, the finance and insurance support sector has been forecast to experience growth at a mid-point between the linear and CAGR extrapolation models – consistent with the mixed results as indicated above. Scenario A would suggest a 20-year increase of 1,150 jobs, Scenario B 2,530 and the C hybrid mid-point 1,840.

53 Real Estate

This sector accounts for just 1% of QCEW employment in Hillsboro with the job count increasing at just half the rate of all sector job growth from 2007-18.

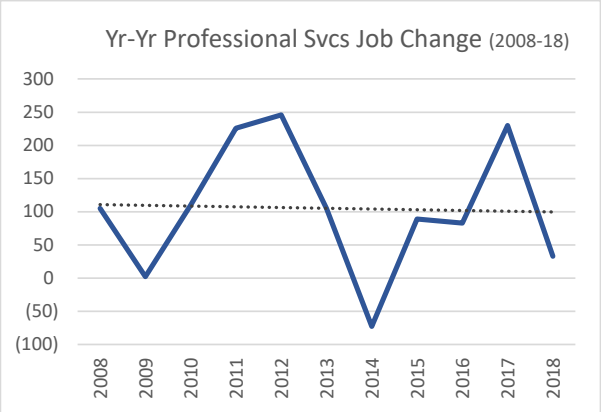


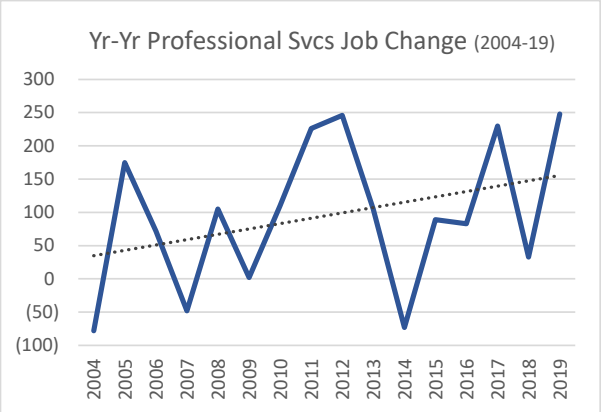


As with finance and insurance, the two time frames of historical observation indicate mixed results – in this case with the short-term experience indicating more positive prospects for this sector going forward. With Scenario C, QCEW (covered) real estate employment in real estate has been forecast to increase exponentially adding 200 jobs in 20 years. This is only 40 jobs more than the also modest 160 job gain indicated with a straight-line option.

54 Professional Services

This sector accounts for 3% of employment in Hillsboro, for a nearly 80% job increase from 2007-18. Jobs in this sector have increased more than twice as fast as for all sectors city-wide.

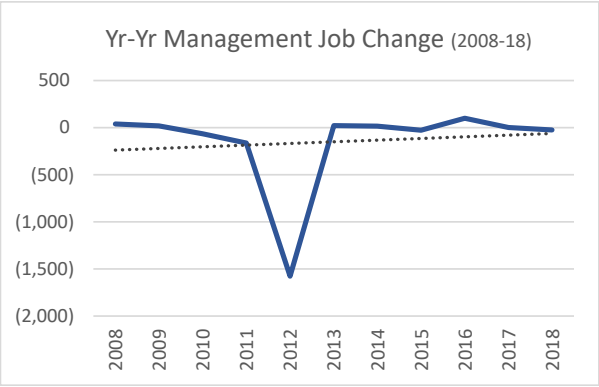


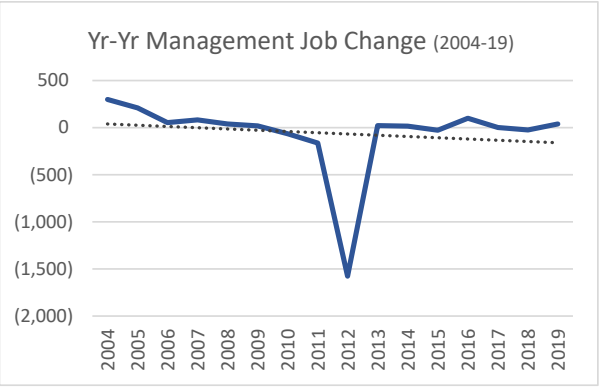


Experience of the last economic cycle of 2007-18 indicates a straight-line growth pattern while the longer-term record is supportive of exponential growth. More than any other support service sector, active expansion and diversification of Hillsboro's professional and business service capacity is pivotal to supporting continued growth of tech-related industry in Hillsboro. Consequently, with Scenario C professional services have been projected for growth at exponentially-associated CAGRs as forecast across the tech-driven ecosystem – adding 5,410 jobs in 20 years, more than double the job growth associated with a straight-line scenario. Professional and technical service firms that reach beyond the local market as traded sector activities also serve to increase economic multiplier benefits for Hillsboro and the metro region.

55 Management

This sector indicates significant job loss (due to NAICS reclassification of some employment in 2012 to 52 Finance and Insurance), accounting for just 1% of all in-city employment as of 2018.

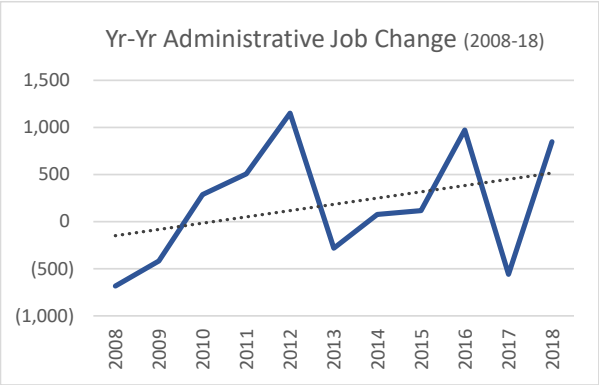


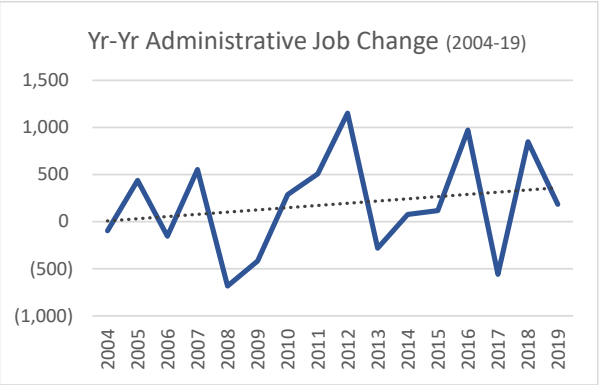


If extrapolated on either a straight-line or CAGR basis (with or without inclusion of the 2012 reclassification), job loss would continue. With Scenario C, no further job loss is forecast over the 20-year forecast period – as also assumed for other sectors experiencing prior year job loss.

56 Administrative

Administrative (including waste management/remediation) services accounted for 8% of in-city employment as of 2018, with the job count increasing 50% more rapidly than for all industry sectors city-wide from 2007-18.



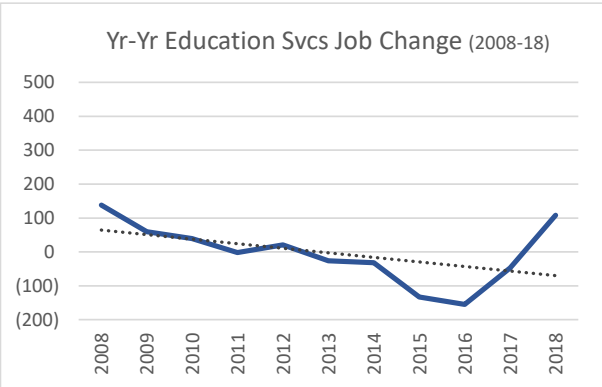


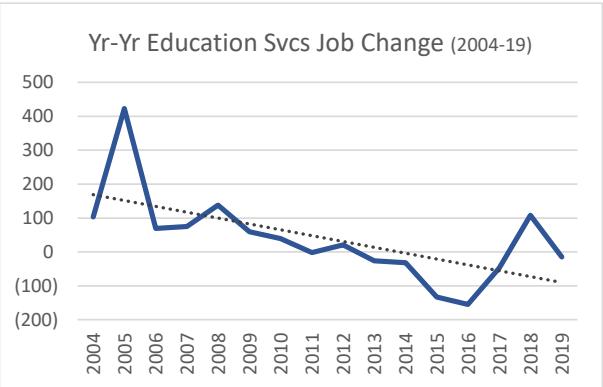
Experience over either of the two time frames considered appears supportive of a potential for continued exponential growth in the years ahead. However, this is counterbalanced by what appears to be more rapid and potentially structural rate of job loss during the subsequent 2020 pandemic year than occurred with most other sectors in Hillsboro except hospitality, arts/entertainment/ recreation, and management.

Consequently, with Scenario C hybrid growth this sector is forecast to experience straight-line (linear) growth of an added 3,640 jobs from 2020-40 as a more conservative view of job growth potential in the years ahead than the potential for 6,670 added jobs associated with Scenario B.

61 Educational Services

Defined as covering both public and private education, this sector accounted for about 3% of all jobs in Hillsboro as of 2018 – with some net job loss experienced over the last economic cycle.

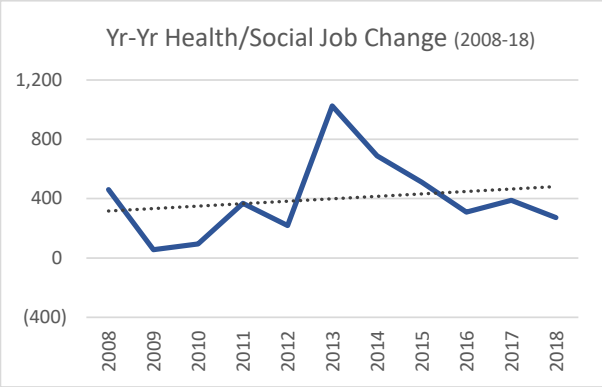


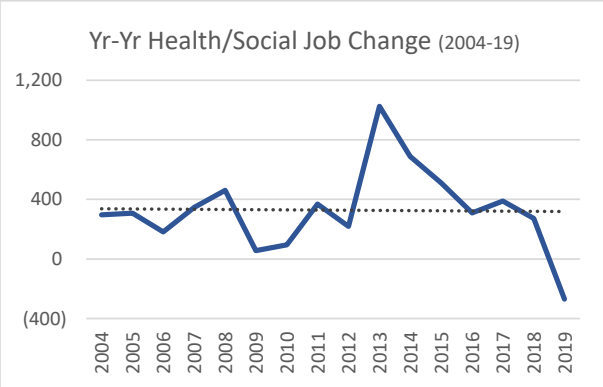


With Scenario C, no further job loss is forecast for this sector going forward. This Scenario C approach of no further employment decline is similar to that taken with other sectors for which job loss has occurred over the most recent economic cycle.

62 Health Care & Social Assistance

Pre-pandemic, this sector accounted for 11% of employment in Hillsboro as of 2018 – second highest of any sector and with employment nearly doubling from 2007-18. Over this time period of the last economic cycle, local employment in health care and social assistance increased by 4,390 jobs, more than for any other economic sector in Hillsboro.





The experience of the most recent economic cycle to 2018 is supportive of an exponential growth trend. However, this is counterbalanced by what appears to be the straight-line longer-term experience of 2003-19 (followed by added job loss during the 2020 pandemic year).

If employment in this sector were to continue increasing at the 6.3% CAGR experienced over the last economic cycle, as many as 24,370 jobs would be added to Hillsboro's job base from 2020-40. By comparison, application of a straight-line projection would indicate a still substantial but smaller increase of 16,175 net added jobs over the same forecast horizon.

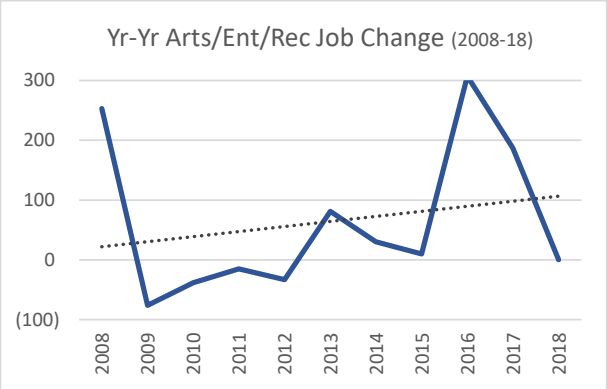
Due to the significant growth as has occurred for this sector and the potential wide variability of outcomes associated with a straight-line versus exponential forecast, an additional cross-check was applied to assist in addressing the potential plausibility of the scenarios considered. As also described by the primary EOA report, this involved comparing scenario outcomes for health care and social service employment in Hillsboro with job growth forecast for this sector metro-wide (as reflected by the 2018 UGR).

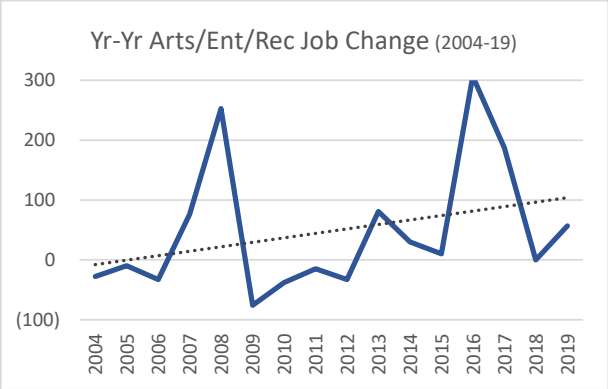
With Scenario A straight-line growth, Hillsboro employment increases from less than 6% of the metro region's employment in this sector as of 2018 to nearly 8% as of 2040. With Scenario B, exponential growth, Hillsboro could increase to just over 15% of the metro-wide job count by 2040. In effect, Hillsboro's share of regional health care jobs would be above its 12% share of employment across all sectors of the metro region which appears as a less plausible outcome.

As a result, for this sector the Scenario C hybrid outcome reflects the mid-point of the Scenario A and B projections – indicating an increase of 16,175 jobs for this sector from 2020-40. This appears more realistic in terms of regional share considerations. With Scenario C, Hillsboro would account for 11-12% of all jobs region-wide in this sector by 2040, comparable to the city's projected 10%+ share of employment across all job sectors metro-wide.

71 Arts, Entertainment & Recreation

This sector is relatively small representing just over 1% of in-city employment but with a higher percentage increase in employment from 2007-18 indicated than for any other industry sector.

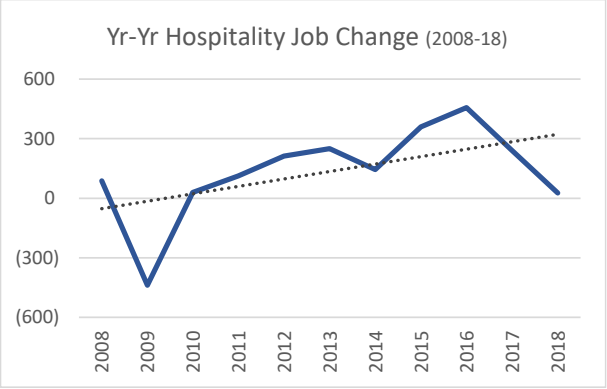


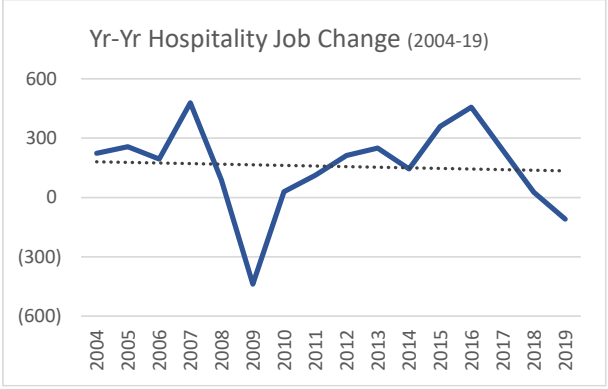


The experience of the last economic cycle appears supportive of exponential growth but is counterbalanced by a large job loss of 36% from 2019-20. With Scenario C hybrid growth, this sector is forecast to experience future job gains reflecting a more conservative straight-line EOA projection going forward – resulting in a projected gain of 1,290 net added jobs from 2020-40.

72 Accommodation & Food Services

Also described as the hospitality sector, lodging accommodation and food service employment represented 7% of all in-city jobs as of 2018 (pre-pandemic) – but experienced the greatest job loss (in numerical terms) of any sector in the 2020 pandemic year. The hospitality sector accounted for almost half of the 2,330 job reduction experienced from 2019-20 in Hillsboro.

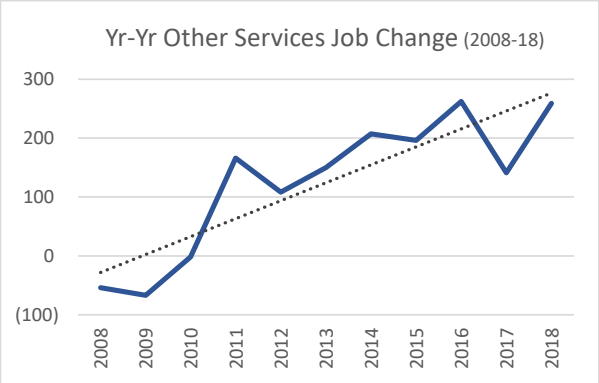


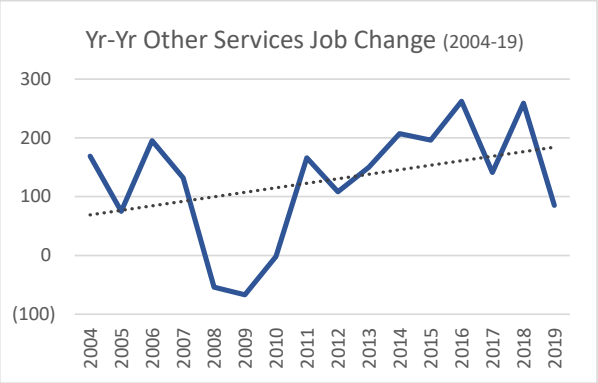


As with some other service sectors, the countervailing experience of exponential versus straight-line job change (depending on the time frame chosen) suggests greater potential variability of outcomes two decades into the future. With continued uncertainty over the extent and pace of hospitality workforce recovery, the hybrid approach of Scenario C assumes a 20-year forecast of growth at a mid-point between the straight-line and extrapolated (CAGR) model outputs – indicating potential for 3,535 jobs added in this sector from 2020-40.

81 Other Services

This sector is dominated by personal services and accounted for 4% of employment in Hillsboro pre-pandemic – with job growth at a pace more than double that of all sectors from 2007-18.

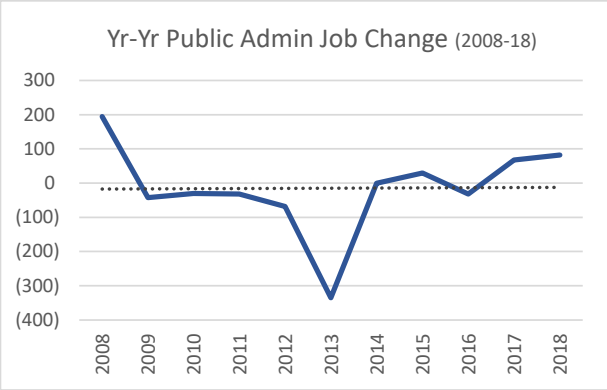


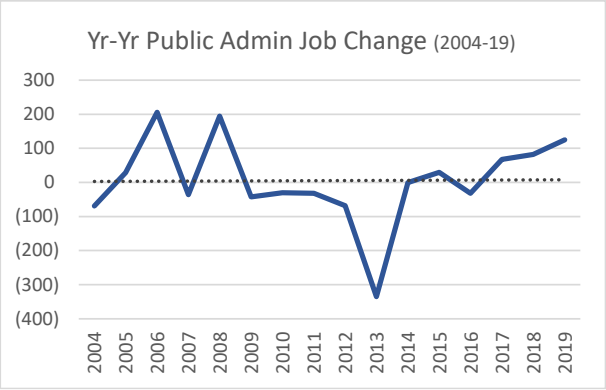


Accelerating job growth in other services is shown both by the 2007-18 and 2003-19 time frames considered. However, this sector experienced significant job loss with 2020 pandemic and potentially faces structural issues with job recovery similar to those of the hospitality sector. Scenario C assumes growth at a mid-point between the CAGR and linear extrapolation models – with 4,275 jobs added from 2020-40.

92 Public Administration

This sector accounts for 5% of in-city employment but is associated with a modestly overall declining job count from 2007-18.





Both of the historical time frames reviewed are consistent with a straight-line projection. As with other sectors that have experienced no growth or net job loss over the last economic cycle, public administration is forecast with Scenario C to experience no further job loss over the 20-year EOA forecast horizon.

11,21,22,99 Other Employment

Other sectors of employment include agriculture (11), mining (21), utilities (22) and unclassified (99) employment. Taken together, these sectors account for less than ½ of 1% of all employment in Hillsboro. Employment in 2020 is less than in 2003 and no job growth is assigned to these other sectors with the current 2021 EOA forecast from 2020-40.

Summary Implications for EOA Employment Forecasts

Hillsboro's updated 2021 EOA has been based on preparation of three alternative employment scenarios:

- **Scenario A** – assuming a straight-line employment projection across all industry sectors
- **Scenario B** – predicated on exponential employment growth across all sectors
- **Scenario C** – as a hybrid approach predicated on evaluating employment trends, market prospects and policy priorities on a sector-by-sector basis

In response to DLCD comments, this sector-by-sector analysis has focused on the appropriateness of the Scenario C hybrid approach – which has been recommended as the **preferred scenario** of Hillsboro's updated 2021 EOA. More specifically, this analysis addresses the question of whether and under what conditions a straight-line versus exponential sector projection is more consistent with prior experience.

While this retrospective analysis draws on more detailed and extensive employment data than utilized with initial EOA preparation as of year-end 2021, it supports the reasonableness of Scenario C projections provided with the EOA – even with anticipation of likely continued year-to-year variations going forward.

APPENDIX B.
COMMUNITY ECONOMIC POTENTIAL

This appendix provides detailed background and qualitative research summarized by Chapter III of the 2021 EOA addressing community economic potential. Topics covered by this appendix include background and approach, qualifying and then identifying factors affecting community economic potential, Hillsboro's competitive position, and target industry clusters.

A key source of information obtained for this review has involved qualitative research including focus group and interview discussion with business and community stakeholders. This is an extended version of the summary discussion provided with Chapter III of the Hillsboro EOA.

BACKGROUND & APPROACH

As initially conceived, the purpose of this this review of community economic potential has been to serve as a *bridge* between the quantitative review of economic and subsequent assessment of anticipated employment land needs together with recommended implementation policies going forward. A major objective is to discuss factors consistent with Oregon Goal 9 guidelines affecting community economic potential including: work force; availability of transportation facilities for access and freight mobility; access to suppliers and utilities; location, size, and buying power of markets; state and federal environmental protection laws; and service infrastructure.

This work was initiated prior to and then was interrupted by the March-April 2020 recognition of the profound health and economic effects of the global COVID-19 pandemic. Much of the assessment was subsequently updated and revised to address pandemic and potential post-pandemic opportunities for economic recovery and resilience.

From Pre-COVID to Post-Pandemic World

The most important change from initial EOA research conducted prior to 2020 is to address reasonably foreseeable changes to community economic potential as a result of the COVID-19 pandemic, ensuing economic downturn and subsequent early phases of economic recovery. When in the middle of sweeping change, it is challenging to reliably assess both short- and long-term prospects for the global economy, let alone implications for any particular jurisdiction. Consequently, greater flexibility in anticipating a wider range of outcomes may be warranted than is typically the case with EOA documentation.

The pivotal question is: *Will the economy re-stabilize to pre-COVID conditions, or is this new-new normal to be fundamentally different from what has occurred over recent business cycles, especially as experienced since the Great Recession of 2007-09?*

This assessment takes an approach that looks to the past as one potential guide to the future while also considering the character and extent of potential transformative change that may now be underway. In effect, the decision of a viable path to pursue involves a risk-reward evaluation reflecting potential multiple economic scenarios.

The analysis and recommendations resulting from this assessment suggest a risk mitigation strategy that might involve elements of both approaches – working to keep the best of the past while being an early adapter of the post-pandemic changes most likely to endure.

QUALIFYING ECONOMIC DEVELOPMENT POTENTIAL

Characterizing economic development potential to this point has been, in large part, driven by the numbers. Addressing the statewiide land use planing Goal 9 Economic Development requires quantification of potential employment change and associated land requirements. However, understanding and preparing for the future is about more than numerical modeling. Qualitative assessment is also important – especially when it comes to setting policies to implement the plan in a way that also will meet broader community objectives.

OAR 660-009-0015 (5) provides guidance to the effect that:

> "Cities and counties are strongly encouraged to assess community economic development potential through a visioning or some other public input process in conjunction with state agencies."

To assist with this qualitative assessment, focus group discussion and stakeholder interviews were conducted with a range of local and regional business and economic development interests. This input process is further augmented by a public hearing process before the City of Hillsboro Planning Commission and City Council with EOA completion.

The stakeholder outreach process has occurred in two phases. An initial round of interviews was conducted in early 2020 (pre-pandemic) with input organized around the following topics:

- Existing or emerging **global to local trends** that Hillsboro should pay attention to for economic development over the next 5, 20 and up to 50 years.
- Hillsboro's greatest **strengths versus weaknesses** affecting business and economic vitality.
- Most promising **opportunitie**s short- and long-term – as compared with **threats** that might undermine realization of these opportunities.
- Short- and long-term needs for **industrial and commercial land.**
- **Other public and private initiatives** as might be considered to support Hillsboro's best opportunities.

A second round of phone interviews was conducted over the summer of 2020, as initial steps toward economic recovery were taking hold. In addition to the topics noted with the first

round, the second round also involved asking participants to comment on two key items – the near-term pace and timing for pandemic-related economic recovery together with implications for sustained economic recovery and resiliency longer-term over the next 5-20 years.

Stakeholder Outreach

Identifying and characterizing community economic development potential involves both quantitative analysis and qualitative understanding of key economic players active in the Hillsboro community.

Firms and organizations that have been interviewed pre-pandemic and/or over the summer of 2020 are identified as follows. The time and participation of these individuals and their respective organizations is gratefully acknowledged.

Firm/Organization	Contact
Applied Materials	Yuri Kucherenco – Operations Manager
Davis Tool	Ron Davis, Jr. – CEO
Edwards Vacuum Systems	Mark Prusiecki – General Manager
Gear Up Sports	Mac Lavier – President & CEO
Genentech	Tim Brown – VP & General Manager
Greater Portland Inc.	Matt Miller – Interim President/CEO
Hillsboro Advanced Manufacturing Work Group	Multiple participants
Hillsboro Chamber of Commerce	Deanna Palm – President
Jacobs Engineering Group	Sig Anderson – Senior Project Manager Dick Sheehy – Director Site Selection
John Southgate Consulting	John Southgate – Principal
Technology Association of Oregon	Skip Newberry – President & CEO
Washington County	Jerry Willey – County Commissioner
Wave Business	Greg Palser – VP Business Development
Westside Economic Alliance	Pam Treece – Executive Director

What follows is a composite synopsis of what was gathered from initial stakeholder conversations conducted pre-pandemic in early 2020 followed by more recent perspectives including added contacts made in over the late summer of 2020 as early steps toward national and local economic recovery were beginning to take hold.

Global to Local Trends

Two major themes emerged from **pre-pandemic** conversations with business and public decision makers:

- **Disruptive technology** – exemplified by emerging opportunities for autonomous vehicles with less parking need, artificial intelligence (AI), internet of things (IoT), 5G telecommunications, exponential growth of data needs, and decarbonization.
- **Live-work connection** – as tech workforce needs to be mobile, work remotely, and cut the commute trip. Workers don't want to get stuck in a location with few options for re-employment if their current job goes away. As millennials age, there also is now a shift in live-work preferences, less toward center cities and more to full-service communities meeting a greater array of family as well as job interests.

Overall, Hillsboro has been described as well positioned to capitalize on these trends over the next 20 years.

Strengths & Weaknesses

For local and regional stakeholders, Hillsboro is widely recognized for what one outside observer described as "a manufacturing center of excellence." A local player notes that "Hillsboro has done a great job of moving the economic development needle."

In addition to a reputation as Oregon's high-tech engine, other **strengths** for economic development include a low-cost metro setting, draw for tech labor force, good internal circulation, increasing diversity of area housing and health services, a large share of the region's industrial land inventory, and record of public-private partnership.

Offsetting these strengths are existing **weaknesses,** including the community's current perceived potential overdependence on one anchor semiconductor firm, local services inadequate to fully meet local needs, lack of a nationally recognized research university, regional congestion, lack of affordable workforce housing, local land inventory inadequate to accommodate forecast job growth, and uncertain tax and regulatory environment.

Interview Take-Aways (Pre-Pandemic)

"Mass manufacturing will not go away … if there continues to be cheap water and electricity as well as good amenities for employees."

"Trucks, deliveries and supply are impacted by congestion on Highway 26 and I-5. It's not reliable."

"Southern Hillsboro is creating so much traffic; Cornelius Pass is getting worse and worse."

"Make transit viable by being faster than car."

"There will be a tipping point in 20-30 years when the region will face some serious changes and we'll either handle that change well and be ahead of it or not."

"Hillsboro's supply chain continues to grow … closer and more accessible"

"Take care of companies we have here now."

"Commercial uses are improving … tired of being underserved."

"E-commerce will continue, but it's not economic development."

"Hillsboro is perceived as leading edge."

"Those who are strategic will become the winners."

"Think big and deliver."

Opportunities & Threats

Focus group and interview participants identified **opportunities** including continued tech-focused manufacturing/products, broader industrial and commercial business diversification, improved jobs/housing balance, and transport innovation. Also supported is the need to extend Hillsboro's economic development vision beyond the state-mandated 20-year planning horizon to encompass a longer-term 50-year planning perspective.

Potential **threats** or barriers cited by those interviewed relate to the risk of losing Hillsboro's semiconductor-oriented and anchor firm competitive edge, issues with workforce displacement, concerns with remaining a less than full-service community, transport gridlock, and non-market regulation.

Working Through & Beyond the Pandemic

For virtually all stakeholders contacted over the summer of 2020, the world of work and business has clearly become a different place than it was pre-pandemic. However, many of the fundamental forces of change already at work globally and locally still appear to remain in place. Existing trends for Hillsboro of **disruptive technology** and **live-work connection** have not necessarily changed, but rather have dramatically accelerated.

As one industry source suggests, changes that would normally occur over a 5-year time horizon have been compressed into five months. This theme of "executing faster" is one that is echoed in various ways by business and community leaders across multiple sectors.

- Hillsboro's **tech-driven and related traded sector industries** appear to have generally held their own – or in some cases performed even better as evidenced by industrial construction and plans for business expansion. The major exception noted is for local businesses linked to what has been a struggling global aerospace sector.
- Somewhat surprisingly, a recurring theme is the continuing if not intensified challenge of **hiring and retaining qualified workforce**. More mention in the second round of interviews was made of the importance of partnering with PCC, OHSU and OSU for apprenticeship and technical training – also internships.
- The pandemic also seems to have heightened interest in the need for improved **transportation logistics.** Partnering with the city, state, Port of Portland and UPS has resulted in major improvements as with the new UPS facility, extended Hillsboro airport runway and dedicated flight service.
- **Service sectors** ranging from retail to dining have been the most adversely affected. Small locally-based business bring "unique flavor and flair" important for community identity but are most at risk now and going forward. There is pressure on tenant capacity to pay rent with resulting implications for landlords and lenders. Capital availability will affect those who survive versus those who have or will close their doors.
- **Health care** providers also have been adversely affected – at least near-term – due to needed prioritization of COVID care over more routine care. The health crisis also is

accelerating the move toward next generation therapeutics and personalized medicine, creating longer-term opportunities ranging from bio-pharma firms to front-line providers.

- **Child care** has emerged as a "fundamental issue" for millennials, especially as schools shifted to virtual learning – requiring at-home adult presence at least for younger children. The question of how families adjust to competing demands of work and childcare can be more pronounced for those individuals who cannot work remotely.
- Of all employment uses, future demand for **office space** appears most uncertain even with economic recovery. If work at home becomes the accepted longer-term norm, demand for traditional office space could shrink dramatically. Conversely, office space reconfiguration to assure social distancing could increase space needs for those returning to the workplace – at least near-term.
- Also on the immediate horizon, there is expected impetus for **housing preferences** to shift from urban to more suburban and exurban locations. This coincides with what employers describe as a continuing if not growing need for more affordable workforce housing extending to outlying communities in and beyond the metro area. Public transit acceptance is challenged pending sustained reduction of COVID infection and hospitalization rates. More broadly, one interviewee suggests: "Traffic won't come back, people won't leave their homes."
- The **role and the capacity of the public sector** to effectively support economic recovery is questioned across a variety of fronts. Issues cited by stakeholders include concerns with land availability and cost, regulatory and tax issues. Needs for a stable tax structure and funding for economic development incentives are noted as being of importance for business retention and recruitment going forward. The City of Hillsboro is complimented for its role in reaching out to local businesses throughout the pandemic, "doing the right thing."

Interview Take-Aways (Early Recovery)

"Data centers will be assembled more like Legos – snap in, snap out."

"We need more vibrant tool sets to help people help themselves … a touchless environment."

"Shipping product by the end of the day to the east coast is a big challenge."

"I worry about declining demand for retail, office space … and mixed-use."

"Need workforce housing."

"Effect (of pandemic) to small businesses has been devastating."

"Portland is losing its luster … with less in-migration."

"Economic recovery, then resilience, still need focus on traded sector, more on equitable outcomes."

"Bullish on manufacturing and logistics."

"If more work remotely, what does it mean for the office?

"What is a virus-proof career path?"

"Want return to normal, but the normal will be new."

"Companies that adapt safely and meet consumer needs will do well."

"Most difficult are the unknowns … each week brings a new nuance."

Industrial & Commercial Land Needs

Recognizing that a primary purpose of this EOA update is to define short- and long-term needs for industrial and commercial land, an important question is: *What employment land needs are most important to address?*

Two overall observations emerge from the stakeholder discussions:

- **First, priority should be placed on assuring that *shovel-ready* land required to accommodate new employment will be there as demand warrants.** Hillsboro has a strong track record of serving major employers with large sites – making possible development that otherwise likely would not have occurred in the metro region. Increasing demand for large sites to accommodate less employment intensive uses such as warehouse-distribution and data center uses can also be expected – as potentially important for tax base, also supporting some other business and consumer needs locally and regionally. Encouraging increased density with vertical development for land-extensive uses is appropriate to consider, though this opportunity may be constrained by still comparatively affordable land prices favoring lower density development – at least in the near-term.

  A stronger case needs to be made to understand the value of land banking for uses needing flexibility or anticipating major expansion in the years ahead. Bottom line, the suggestion is to "be prepared in advance – getting added reserves happens over multiple years, so start now."

  In the wake of the pandemic, there is growing recognition that employment land needs may change in ways not previously expected – ranging from more work-at-home to office reconfiguration and retail downsizing to more large site demand for industrial and distribution functions led by major corporate investment. This suggests a need to be more flexible with land use planning and regulation than in the past, including consideration of mid-course adjustments as the character and extent of these emerging land demand changes become more apparent.
- **Second, there is growing recognition of the need to accommodate both exclusive industrial zones and mixed-use development**. Business requirements and priorities vary depending on the specific characteristics of different industrial and commercial uses. For large industrial users, multi-tenant business parks and some commercial uses with requirements as for extensive truck traffic, night operations and/or need for outside storage, it is important to provide a clear separation from residential development.

  For other smaller scale business uses, there have been clear and increasing benefits to locate as part of mixed-use projects – as at Orenco or in downtown Hillsboro. The opportunity to attract creative service and tech users to Hillsboro may be influenced by enhancement of these opportunities in areas offering good proximity to mixed-use development opportunities. With potential reduced commercial space demand, horizontal rather than vertical mixed-use may become the more pronounced market opportunity at least near-term.

Other Public & Private Initiatives

A final topic of discussion has been on identifying other public and private initiatives that should be considered with this EOA. These are initiatives that extend beyond but support the City's land use policies. Priorities suggested center on the following:

- **Workforce training** – expected to be more important due to rapidly changing technology and career trajectories, across the spectrum of K-12, higher education and on-going workforce training. Specifically referenced is the need for training tied to career and technical education (CTE) programs, linked more explicitly and with greater flexibility to meet employer needs. The desire for workforce training that is yet more customized to employer needs appears to have intensified even through the pandemic.
- **Smart transport investment** – tailored to different needs for internal versus external transport linkages. Connections within and between the city's employment, residential and public/open space areas should emphasize greater walkability and opportunity to cycle, improved transit connections/ride sharing, and preparation for autonomous vehicles – all reducing the need for driving (and associated parking). To the extent and for the duration that COVID risk persists, regaining lost transit ridership will be challenged.

  External connections suggested are for a balanced mix of transit and major highway corridor improvements. Particular emphasis is needed for better freight mobility – especially for time sensitive products reliant on airborne transport. A related long-term objective may be for improvement of the Cornelius Pass connection – as an alternate route to the Portland International Airport (PDX) and the I-5 North freeway system.
- **Long-term utility Investment** – in the area's electric, water, and wastewater systems. Adequate and reliable electric power is essential to major semiconductor firms plus a range of related high-tech industries. Hillsboro has benefitted from strategic, industry-supportive investments by Portland General Electric.

  Similarly, the City of Hillsboro is recognized for having made the right decision 50 years ago with water system investment -- "setting the table" for tech companies as well as overall development that has since occurred. From this perspective, it is again important to now prepare for the next 50 years; as a community, "we need to pay forward."
- **Targeted economic development incentives** – are recognized as having played an important role in attracting industrial investment to Hillsboro. Some suggest that incentives be more narrowly targeted in the years ahead – to businesses that can demonstrate some combination of strong employment, tax revenue, and/or supplemental business leveraging benefits.

FACTORS AFFECTING COMMUNITY ECONOMIC POTENTIAL

An element of the EOA process involves consideration of location or market factors affecting where a particular type of industrial or other employment use may locate. Ad defined by OAR 660-009-0005, these locational factors "include but are not limited to, proximity to raw materials, supplies, labor, services, markets, or educational institutions; access to transportation and freight facilities such as rail, marine ports and airports, multimodal freight or transshipment facilities, and major transportation routes; and workforce factors (e.g., skill level, education, age distribution)."

Separately outlined by OAR 660-009-0015 (4) are potential advantages and disadvantages to be considered with the assessment of community economic development potential that "may include but are not limited to" items (a) to (h) as listed by the following chart. Due to the overlap of the locational and market factors stipulated by OAR Definitions (0005) and Economic Opportunities Analysis (0015), these factors are considered together but organized around topics that have emerged as most germane to Hillsboro's current and prospective community economic potential.

With this EOA, 11 factors are identified as pivotal both now and going forward for economic development in Hillsboro. The relationship of these Hillsboro-specific factors to those outlined by OAR 660-009-0005 are as provided by the following chart.

Relationship of Hillsboro Location & Market Factors to OAR Considerations

Hillsboro Specific Factors	Related OAR Considerations
(1) Globalization/localization	(a) Location, size and buying power of markets
(2) Technology	(a) Location, size and buying power of markets (h) Educational and technical training programs
(3) Workforce	(d) Labor market factors (h) Educational and technical training programs
(4) Vendor & customer networks	(e) Access to suppliers and utilities
(5) Incomes & buying power	(a) Location, size and buying power of markets
(6) Transportation	(b) Availability of transportation facilities for access and freight mobility
(7) Utility infrastructure	(c) Public facilities and public services
(8) Civic infrastructure	(c) Public facilities and public services
(9) Environmental conservation	(g) Limits on development due to federal and state environmental protection laws
(10) Housing	(f) Necessary support services
(11) Quality of life	(f) Necessary support services

Each of the 11 Hillsboro specific factors considered with this EOA is briefly described, in turn. This is followed by a summary assessment of associated strengths, weaknesses, opportunities and threats (or SWOT assessment).

(1) Globalization/Localization

In recent decades, the supply chains of American businesses, especially multinational firms, have become increasingly globalized. More recently, this has coincided with growing consumer orientation to purchase via the internet rather than shop at local *brick and mortar* stores.

However, there are clear signs that this trend may be now headed in reverse, at least for corporate traded sector firms and for the immediate future. A trend back to localized sourcing is occurring for a variety of reasons including more populist governance both domestically and globally, tariffs and related trade conflicts, national security and technology protection concerns, rising wages in emerging markets, automation, desires to reduce corporate carbon footprints, quicker response to changing consumer preferences, and most recently for improved containment of potential pandemic risk.

Over the next several years and possibly beyond, the transition back from global to local may significantly affect manufacturing decisions by re-shoring closer to a U.S. home base. With more suppliers and customers of semiconductor and tech products locating and expanding in Hillsboro, the community's competitive position is further enhanced going forward. An offsetting issue or weakness is the increasingly limited industrial land supply affecting both large scale and smaller firms.

(2) Technology

Technology has been and will be a continued if not primary source of innovation – affecting virtually every aspect of business and consumer choice. Markets have matured for computers and now for smart phones, with new applications affecting both hardware manufacturing (or product space), software/apps and creative services (or service space requiring added footprint including for at-home work).

New manufacturing techniques as with 3D printing offer yet more innovation for customized products benefitting both entrepreneurial and established businesses. Key growth sectors include autonomous and electronic vehicles (AV/EVs), the internet of things (IoT), artificial intelligence (AI), 5G wireless networks, and cloud computing.

Product space tends to require larger sites, typically in suburban or exurban locations. Over the last 10-20 years, service space has gravitated more to urban areas to meet the live/work/recreate preferences of a younger workforce. However, that is now changing in response to COVID-safety concerns and as more millennials start families with some looking for more traditional, larger and less expensive housing options – but with urban amenities close at hand.

Hillsboro can capitalize on these multiple trends to the extent that the community offers diversity of business and residential choice and capacity for adaption to future changes as yet not readily foreseen.

(3) Workforce

Workforce affects business location decisions in at least two key respects. First is the availability of workers. With a large baby boom cohort now moving to retirement, there is a smaller Generation X cohort with significant workforce experience coming in immediately behind.

This may create added advancement opportunity for the relatively large cohort of millennials, especially in regions of the U.S. attractive to younger workers as has been the case for the Portland metro area. However, the next Gen Z cohort now readying to enter the labor force will again be somewhat smaller – placing an added potential premium on labor supply longer-term.

A second consideration relates to workforce skills and training. Despite absence of a nationally recognized full-service research university, this metro region has done well to attract workers with managerial and technical skills, including for those skill sets not as abundant with the existing indigenous labor force. The metro area reportedly performs well with a solid base of workers having experience in diverse manufacturing settings.

For stakeholders contacted most recently as the region was beginning its economic recovery, there appears to be less emphasis by employers on four-year education options, offset by more focus on K-12 workforce orientation to tech industries and, even more critically, to customized community college or technical school options.

These appear to be interests shared across diverse high-tech fields ranging from semiconductors to biotech, for example, with programs for clean room technology. City leadership with encouragement of "gap year" internships is specifically cited and appreciated, with strong support indicated for program continuation. On-going provision and adaptation of workforce training capacity will be important over the planning horizon of this EOA.

(4) Vendor & Customer Networks

While not having the depth of established networks as in some larger metro areas (for example as with the Seattle-Bellevue-Redmond tech cluster), Hillsboro and metro area businesses can draw from other local businesses for key business-to-business relationships where the market is large enough to support added local vendors – especially for larger firms such as Intel and Nike. The end use customer base is not as well populated since major area firms (as with semiconductors) ship a large portion of their output to customers outside the region for product assembly, packaging, marketing and distribution.

Hillsboro's growing base of tech-supportive industries represents greater competitive advantage going forward. A challenge is regional transportation congestion and distance from the Portland International Airport – offset in part by improvements to the Hillsboro airport and attraction of transportation, wholesale and distribution firms to the Hillsboro area.

(5) Incomes & Buying Power

Resident incomes are important for buying power at consumer-oriented retail, dining/ entertainment, and service businesses. While the metro area and state have lagged other major west coast markets, Hillsboro workers are relatively well compensated – with wages that average 46% more than the average wage across the entire metro area.

While high incomes are supportive of greater consumer expenditures, a growing share of consumer expenditure need not occur locally. This is especially the case if the total market area served is more readily accessed from other Washington County or metro area locations or via the internet and associated e-commerce.

(6) Transportation

Transportation access is important to Hillsboro's economic development potential in three key respects. First is the business need for effective, reliable freight transportation via truck or airport access. Rail and marine appear to be lesser considerations due to lack of significant rail access to Hillsboro industries and lack of marine container shipment capacity until subsequently re-introduced on a weekly basis from the Port of Portland.

Reasonable workforce commute access is important as a determinant of the effective labor shed. Commute access is vulnerable due to regional road congestion and possible worker unwillingness to commute long distances (especially for younger workers). This is further documented by information provided with Appendix A.

Convenient transportation access is a consideration for retail and consumer service businesses reliant on trip times competitive with alternative business locations. Hillsboro's location (especially for its downtown) at the edge of the metro area limits its total customer draw relative to other parts of the metro area – as compared with Beaverton/Tigard serving the greater Washington County market or central Portland as serving businesses dependent on a metro-wide customer base. Disruptive technologies as with autonomous/electronic (AV/EV) vehicles may well transform transportation in ways not yet readily foreseen – although timing for regulatory and consumer acceptance remains uncertain.

(7) Utility Infrastructure

Infrastructure important to Hillsboro industry includes electric power (as for semiconductor and other power intensive tech users), redundant fiber for telecommunications, water (as for semiconductor and food processors), and wastewater treatment. The availability, quality and cost of utility infrastructure has been a significant location consideration and draw for major Hillsboro area employers. On-going investment is important to support further growth.

(8) Civic Infrastructure

Included in this category is critical community infrastructure as for City services, K-12 schools, health care, parks/open spaces, and cultural attractions. By most accounts, Hillsboro is well

regarded for the depth and quality of its community infrastructure. This is exemplified in recent years by investments ranging from rapid expansion of local health care facilities to recruitment of a minor league baseball franchise.

Due to the COVID pandemic, access to much of this civic infrastructure locally and nationally was curtailed as a precaution to limit infection spread. Whether and how civic access and engagement fares with effective vaccines and longer-term protocols is not yet fully clear but will be important to re-establish sustained civic involvement and identity.

(9) Environmental Conservation

Conserving the environment yields both business benefits and costs. Protection of wetlands, other critical areas and open spaces can be an amenity – drawing business facilities that value a campus setting as has been the case in Hillsboro over a sustained period.

Conversely, environmental set asides reduce developable land area, contributing to the city's prospective employment land deficit. Permitting processes add time and cost to a development project, especially constraining if viewed as more onerous relative to competitive locations domestically and internationally. In Hillsboro, 5 significant portion of the vacant employment land inventory is categorized as undevelopable due, in part, to wetland and other environmental constraints.

(10) Housing

Due to regional traffic congestion and growing workforce interest in shorter commutes, job-housing balance is of more significance than in the past when the labor shed was considered to be the entire metro region plus adjoining non-urban counties. Affordability is also of growing concern for this metro area as well as others nationwide – a concern of even more pronounced significance through the pandemic and ramp-up of housing demand.

Greater diversity of housing product increasingly factors into the live-work equation. Younger workers are often willing to trade off a large suburban home for smaller house and yard offering immediate walkable access to urban amenities and public open space, albeit with more of the home space allocated to work-related uses in the wake of the COVID pandemic. Hillsboro's competitive position for continued industrial investment depends, in part, on providing the quantity, quality and diversity of housing expected by a changing workforce.

(11) Quality of Life

Quality of life is a largely subjective consideration that can mean different things to different people in varied settings across the U.S. For Oregon residents, a significant part of the quality of life equation is rooted in access to outdoor recreation – both active and passive – including mountains, ocean areas and, more recently, to regional attractions ranging from internationally recognized wineries to locally sourced foods. To attract the workforce of the next generation, it appears important to provide more urban and placemaking amenities in a setting with better integration of work and home then previously.

HILLSBORO'S COMPETITIVE POSITION

OAR 660-009-0015 (4) stipulates that a community's assessment of economic development potential "must consider the planning area's economic advantages and disadvantages." This EOA has taken a focused approach to identify and characterize economic advantages and disadvantages from the perspective of the community's competitive position for investment and employment.

This approach is especially important for a city like Hillsboro which has an unusually high share of traded sector activity – defined by ORS 2855.280 as "industries in which member firms sell their goods or services into markets for which national or international competition exists."

Economic advantages and disadvantages may be considered as a *snapshot in time* – specific to the business mix and locational attributes of the community at the present time. This competitive position assessment also identifies opportunities and threats – conditions reasonably anticipated in the future and often driven or greatly affected by market forces external to the local community.

The assessment of competitive position draws from both the quantitative and qualitative perspectives as provided with this updated Hillsboro EOA. The chart below provides a summary listing of strengths, weaknesses, opportunities and threats (or SWOT), followed by more detailed discussion of each SWOT component.

Summary Hillsboro Economic Strengths, Weaknesses, Opportunities & Threats

Strengths	Weaknesses
• Oregon's high-tech driver	• Overdependence on one anchor semiconductor firm
• Low cost west coast metro setting	• Consumer services not fully meeting local needs
• Attraction to tech labor force	• Lack of nationally recognized research university
• Good internal circulation + Hillsboro airport & MAX	• Regional congestion affecting freight & workforce
• Increased diversity of area housing & health services	• Availability and affordability of workforce housing
• Major portion of regional land inventory for jobs	• Land inventory inadequate for forecast job growth
• Record of public-private partnership	• Uncertain tax & regulatory environment

Opportunities	Threats
• R&D with applied technology manufacturing	• Risk of losing the anchor competitive edge
• Business diversification	• Workforce displacement
• Job/housing balance	• Less than full-service community
• Transport innovation	• Transport gridlock
• Market-driven 50-year urbanization	• Non-market regulation

Source: E. D. Hovee based on stakeholder interviews and quantitative assessments.

Each of these SWOT characteristics are further described, in turn.

Strengths

Key strengths responsible for economic development investments to date and offering continued potential include the following:

- **Oregon's high-tech driver** – as home to Intel, the largest technology firm in the state. While Portland has emerged as a new hotbed for what can be described as "service tech" including green design, Hillsboro offers the hardware side of high tech for manufacturing or "product space." Hillsboro has also emerged as a pivotal trans-Pacific cable landing point for urban-focused data centers.
- **Low cost west coast metro setting** – for land, labor, and power as compared to other west coast choices. Even through the pandemic, some businesses continue to see value in this metro region for west coast proximity but at less cost.
- **Attraction to tech labor force** – especially for experienced personnel seeking a lower cost and/or family-oriented lifestyle. It is still possible to attract "new talent" to the region for perceived quality of life and cost advantages.
- **Good internal circulation + Hillsboro airport & MAX** – a system that offers added choice for getting people around, including increased importance of MAX as connector to Portland and the Hillsboro airport for corporate air connections.
- **Increased diversity of area housing & health services –** with housing a key factor for local quality of life including more urban options as with mixed-use developments oriented to MAX transit stations.
- **Major portion of the metro region's industrial land inventory –** with just 4% of the metro area's population, Hillsboro has 7% of the region's job base and 14% of its industrial land inventory. The community has been able to attract major high tech and related industrial investments by providing shovel-ready sites, often with advance investment in transportation and utility infrastructure.
- **Record of public-private partnership** – Within and outside the metro region, Hillsboro has a

Semiconductor-Led High Tech

Major drivers of emerging semiconductor demand include autonomous and electric vehicles (AV/EVs), internet of things (IoT), artificial intelligence (AI), 5G wireless networks, and cloud computing.

All these sectors will have new requirements and constitute sources of potentially significant demand growth over the readily foreseeable future.

Stakeholder comments:

"Portland metro offers all the attributes needed for IoT – semiconductors, network capabilities, open source, device, software & apps for communication devices. Also smart buildings and battery technology."

"Harder to get financing for hardware, viewed as a commodity. Software is viewed as a service with quicker returns."

"Stay Intel focused."

"Too dependent on Intel."

Tech workers want "food, culture, entertainment and event space."

"Need to get companies that can scale in this metro area."

"A living lab opportunity."

reputation for solution-oriented public-private partnership. As one interviewee notes, "Hillsboro has great leadership." Another says simply that the "City does a good job" including provision of development incentives as with urban renewal and access to Enterprise Zone (EZ) and Strategic Investment Program (SIP) resources.

As observed by one stakeholder, "We have the second most manufacturing economy in the U.S. and Hillsboro is the most important traded sector in Oregon."

Weaknesses

Counterbalancing the strengths are weaknesses that will be important to address over the current 20-year planning cycle. These weaknesses are noted as including:

- **Overdependence on one anchor semiconductor firm** – with Hillsboro's economic prosperity reliant on the cyclical and long-term performance of a single industry, further compounded by primary reliance on the competitive fortunes of a single (albeit dominant) firm in that industry.
- **Consumer services not fully meeting local needs** – with Beaverton offering proximity more central to the full westside residential and business market. By contrast, downtown Hillsboro is situated to serve one side of the city somewhat removed from other major sources of in-city and westside population.
- **Lack of nationally recognized research university** – placing greater reliance on attracting non-local educated workforce for higher skilled and management positions. Interviewees cite a need to broaden the talent pool and address loss of talent as a large cohort of *baby boomer* workers reach retirement.
- **Regional congestion affecting freight & workforce access** – an issue of growing significance unless mitigated by regional highway, transit and future vehicle technology improvements together with added local workforce housing. With regional growth and congestion, more freight and distribution facilities are needed across the metro area.
- **Availability and affordability of workforce housing** – cited as an emerging "economic development issue" requiring new approaches as for a broader range of housing types and possibly company-sponsored housing development.
- **Land inventory inadequate for forecast job growth** – with the existing developable employment land base adequate to handle only 23%-55% of projected employment growth potential for Hillsboro over the next 20 years. In the wake of the pandemic, greater flexibility in land use planning will be needed in the years ahead. As one industry leader commented, the region "is too rigid in how it thinks about land." Another notes that the land use process is simply "too slow," not keeping up with the times. Yet another suggests a "what to do" guide to addressing regulatory requirements.
- **Uncertain tax and regulatory environment** – potentially affecting proposed and other future tax and incentive programs as may affect feasibility of Hillsboro investments, especially with capital intensive fab and related high-tech facilities.

Opportunities

Going forward, key opportunities for realization over the next 5-20 years and perhaps beyond to a 50-year time horizon may reasonably be expected to include:

- **R&D with applied technology manufacturing** – aimed to attract and foster creative and intellectual talent and capital indigenous to Portland as a globally recognized center more on par with Los Angeles, Silicon Valley, and the Puget Sound.
- **Business diversification** – focused on enhanced market presence for the City's targeted industry clusters together with potential for other under-represented sectors that have demonstrated improved competitive position through this most recent economic cycle, then showing resilience through the subsequent pandemic and economic downturn.
- **Jobs/housing balance** – to assure housing opportunity accommodating the full range of local workforce residential needs and preferences. While Portland has been the draw in recent years, stakeholders suggest that the opportunity for live/work balance may now be shifting toward Washington County. Beaverton pops up as perhaps a prototype for a lower density but urban environment of the future, offering synergistic opportunities in combination with Hillsboro's tech-forward manufacturing prowess.
- **Transport innovation** – supporting balanced public transportation options regionally and locally together with industry-driven AV/EV technology pioneered in Hillsboro and the Portland metro market.
- **Market-driven 50-year urbanization** – likely aimed at some employment densification together with more at-home work and reduced on-site parking need coupled with world-class technology and related education/workforce training leadership.

Threats

Potentially offsetting the opportunities are prospective threats or barriers that could serve to undermine continuing and sustained economic vitality for the Hillsboro community, greater Portland metro region and state, including:

- **Risk of losing the anchor competitive edge** – which could result for a variety of reasons, whether specific to Hillsboro's largest firm or from external forces such as off-shore competition and threats to global supply chains. This concern is especially the case for firms that are local because they started local. As one locally grown business owner suggests: "We're here because we live here. But with the new economy, we could be anywhere."
- **Workforce displacement** – for reasons potentially related to automation, need for continuing adult education, reduced potential availability of workplace benefits as for health care, lack of employer-responsive job training and greater childcare issues through at least the duration of the COVID pandemic.
- **Less than full-service community** – with local residents and businesses forced or preferring to leave Hillsboro for a significant portion of their retail and service needs.

- **Transport gridlock** – if out of step with competitive locations, resulting in lost local business investment and employment opportunity (particularly for high wage jobs).
- **Non-market regulation** – ranging from state-wide issues such as potential loss of tax incentives for high value manufacturing and placement of tariffs affecting pricing and competitiveness for local product manufacturing. As expressed by one stakeholder, a concern is that Oregon "may go the way of California."

Transition to a New-New Normal

The aftermath of the 2007-09 Great Recession was focused on the transition to what was termed as a *new normal.* With COVID and economic recession of 2020, the focus now shifts perhaps even more dramatically to what might be considered as a *new-new normal.*

Historical economic data presents often useful guideposts of where the economy has been, but not necessarily of where it is now going. Qualitative evidence from stakeholders provides useful insights as to the transition now underway but not yet with a clear picture of where Hillsboro will be five years from now, let alone over the next 20 or 50 years.

A clear message from business and community leaders is that this next round of a new normal will be about more than economic recovery or a simple return to the business and economic development practices of the last decade. In addition to accelerating trends of disruptive technology and live-work connection, the next decade may well serve to define technologies viewed as most pivotal and further shift current live-work boundaries. These transitions likely will blur traditional distinctions between employment and residential land uses.

The realization of how vulnerable a community can be to external conditions that are well beyond local control places increased emphasis toward better assuring resiliency in the face of unexpected shocks to the local economy. This may mean prioritizing business sectors less vulnerable to downturns or that offset one another – much as is expected with a diversified stock and related investment portfolio. As one stakeholder interviewed during the summer of 2020 observes: "Improved resiliency requires increased diversification of the economic base."

Even with a less than clearly discernable crystal ball, there are some features of this new-new normal that can be outlined – at least in preliminary terms. This discussion can be divided between Hillsboro's expanding tech-driven traded sector industrial base and its resulting service-based economy. Emphasis is placed on potential land use implications.

Tech Driven Traded Sector Industries

Considered are prospects for semiconductor, data center, biotech, software and supportive industrial activity:

- Hillsboro tech has been driven by Intel as its anchor **semiconductor** firm and largest employer. As with others in the industry, Intel has experienced record-breaking sales with tech intensification through the pandemic, but future prospects are perhaps less certain due to rapid technological change, global competitive and policy initiatives.

Future economic vitality and long-term resiliency will depend on facilitating a strong on-going presence and innovation from its anchor firm while also looking for opportunities to diversify with added *leading-edge* semiconductor and related investment activity.

- While there remains uncertainty over the pull-through benefits of **data centers** (DCs) for other high-tech applications, industry sources indicate growing recognition of the need for better spatial planning to reduce the geographic footprint of these facilities, especially in urban centers. One contributing factor may be the transition from air cooling to liquid or other cooling. While cloud storage for consumer applications (as with social media) is likely to continue gravitating to large footprint non-metro sites, urban DCs may become more important to serve business customers requiring high frequency/quantum computing – as for applications with AI, IOT, robotics, telemedicine and financial services. Hillsboro might incent this transition both to improve employment intensity and to encourage clear pull-through benefit for other area firms.
- With Genentech as its initial anchor, the long-term potential for added **bio-tech** locally and regionally remains as yet unproven. However, the growing convergence of electronic tech and bioscience suggests opportunity for added synergy between these potentially complementary sectors. One example noted of this synergy is indicated by the common interest across high-tech fields ranging from semiconductors to biotech for clean room technology with local firms capable of supporting both sectors.
- **Software** and related information technology represents a smaller but growing share of Hillsboro's employment activity. Recent activity (especially for apps) has focused on the *creatives* of Portland's Central City. The metro region has a growing software presence as compared to established centers such as Seattle or the Bay area, "but no ecosystem for it."

Data Center (DC) Challenge

Industry sources indicate that Hillsboro is up and coming as perhaps the west coast's favored DC hub, with proximity to Pacific cable landing sites.

Land intensive with few employees, DCs can yield major tax revenues. Some are going vertical (as in Seattle); land prices may not yet be there for Hillsboro but that may change.

An open question is the extent of the DC draw or "pull-through" benefiting other tech companies.

Stakeholder Comments:

"Data centers drive business to Oregon … attracting other high-tech companies."

"Reduce tax incentives to data centers."

"Data centers getting better about sustainability of their footprint, not a burden on infrastructure."

"Urban DCs a focus for users requiring high processing capability with low latency"

"Proximity to data center could be compelling" for data intensive tech firms.

Hillsboro has opportunity to strengthen its position as some millennials opt for less dense and more family-oriented communities, also possibly for those needing direct contact with computer/electronic and data center capabilities – as for emerging AI, IOT and telemedicine applications.

- **Other supportive industrial activity** includes vendors to Hillsboro's tech firms, logistics and transportation (including air freight) providers, distribution and fulfillment centers, and other diversified manufacturing (for example related to sportswear). Nationally, warehouse/distribution activity has recently performed as the nation's top industrial market segment – but appears increasingly oriented to the nation's largest metro areas (often of larger scale than the Portland metro region). While employment density can vary, catering to uses that support Hillsboro's core traded sector competencies will best reinforce long-run economic recovery and on-going resiliency to future external shocks.

Service Sectors

Sectors covered are office space, retail/hospitality, health care, and workforce housing:

- As noted, prospective demand for **office space** is currently the most uncertain due to short- and long-term outcomes of the pandemic, dependent on whether and to what extent work-from-home becomes viewed as a viable long-term option. This transition is likely to play out as existing tenant leases come up for renewal. Existing office spaces may be reconfigured for greater flexibility including social distancing with priority to key corporate functions. If overall demand decreases, there may be the eventual need to repurpose some office spaces, especially in older facilities toward non-office uses.
- Even before the pandemic, **retail/hospitality space** demand had stalled due to more sales activity occurring via e-commerce. This trend subsequently accelerated, meaning further slowing in retail demand growth. The effect can be severe for small independent retail and dining establishments. Viable retail will involve more on-site pick up. As retail vacancies increase, existing developments as with older strip centers and potentially downtown retail uses may need to be repurposed for other uses, ranging from *last mile* fulfillment centers to residential use. Lodging demand will return albeit slowly with the long-term outlook also uncertain due to possible permanent reduction in business and meeting-related travel (replaced by virtual Zoom and related video conference options).
- While **health care** facilities have experienced financial issues during the pandemic, a return to normal can be expected as vaccine and therapeutic treatments prove effective. Latent demand for procedures foregone during the pandemic can re-emerge. Hillsboro's growth and an aging population should support a return to a more rapid job growth trajectory for providers in the years ahead. However, locations of service may become more decentralized as with smaller store-front clinics and telemedicine.
- While not previously considered as an employment use (except for self-employed), the **worker's residence** may become a significant (perhaps the fastest growing) workplace in the years ahead. Those working at home are already showing desire for increased allocation of distinct work area in the home and millennials are gravitating to ownership away from rentals where financially affordable. This could reverse the trend from multi-family rental occupancy back toward demand for single-family home ownership. If multi-family demand subsides, there still may be a need for larger rental units than have been developed in recent years. Over a 20-50 time horizon, it is possible that the home becomes a primary workplace of choice, potentially even for a majority of Americans.

TARGET INDUSTRY CLUSTERS

Like many communities, Hillsboro has identified target industry clusters for which it is either competitive now or has reason for aspiring to increased economic opportunity in the years ahead. This assessment of community economic development potential involves comparison of local target industry clusters with those of the metro region and the state – followed by suggestion of potential target sector refinements resulting from this EOA.

Comparative Regional to State-Wide Target Industries

In addition to target industries defined for the City of Hillsboro's economic development program, those most relevant for added consideration are similar listings for the metro area as articulated by Greater Portland Inc. (GPI) and statewide targets as defined by the state agency Business Oregon. A summary comparison of current listings is provided by the following chart.

Target Industry Sectors/Clusters

Hillsboro (Key Industries)	Greater Portland Inc (Industry Clusters)	Business Oregon (Target Industry Groups)
• Computers & electronics • Software & information technology • Advanced manufacturing • Bioscience & medical devices	• Computers & electronics • Software • Apparel & outdoor • Metals & machinery • Food & beverage • Climate tech • Design & media	• Advanced manufacturing • Business services • High technology • Outdoor gear & apparel • Food & beverage • Forestry & wood products

Sources: City of Hillsboro, Greater Portland, Inc. (GPI), and Business Oregon. As of 2021.

While the nomenclature of the three target industry listings varies, there is considerable overall correspondence in terms of substantive content. All three organizations favor varied combinations of tech-oriented and advanced manufacturing. More specifically, local and metro-wide focus is also placed on computers, electronics and software.

Some differences are also noted:

- Unlike its counterpart organizations, Hillsboro includes bioscience and medical devices as a key industry.
- For the Portland metro area, GPI includes industry clusters not as strongly represented in Hillsboro – notably apparel and outdoor, metals and machinery, food and beverage, climate tech, and design and media.
- Business Oregon also provides attention to sectors important to metro and non-metro areas of the state but not necessarily represented strongly in Hillsboro – as with business services, outdoor gear and apparel, food and beverage, and forestry and wood products.

Target Sector Refinements

Clearly for Hillsboro, it is advantageous to identify key industries based on existing comparative and competitive advantages of the city's existing business and industry mix – both as complementary to and distinct from the metro region and state.

An added advantage and a challenge posed by target sector listings lies in their seeming ambiguity. Historically defined in terms of readily measurable industry (as with NAICS) categories, target sector listings now often intentionally reach across traditional industry classifications. This approach recognizes the reality of the marketplace – especially where there are opportunities for a particular industry to be supported by local vendors or customers within a related business segment.

As in the past, Hillsboro may modify its industry clusters to reflect and serve new or emerging industry opportunities in the years ahead. This would recognize the potential to step in alongside and encourage sectors that currently may be relatively weakly represented in Hillsboro but with growing competitive presence.

Listed below are examples of already identified emerging industry opportunities including:

- Increased computer chip manufacturing capacity
- Automotive & aerospace applications
- Energy storage
- Data centers
- Artificial intelligence research & deployment
- Supply chain on-shoring & management
- On-shoring national defense manufacturing
- Tangible hardware
- Bio-tech expansion
- Climate technology
- Digital security

The listing is intended to be illustrative and not to preclude other as yet unforeseen but future potential prospects not yet on the horizon.

Priority consideration for business targeting might be provided to these emerging sectors (or specific businesses) offering potential for strong employment, tax revenue, and/or supplemental business leveraging (or "pull-through") benefits. Hillsboro's target industries also represent traded sector functions with higher economic multipliers – creating more indirect and induced added employment and income opportunities – above what are typically realized from local consumer-oriented service sectors. Consistent with a hybrid development scenario, an adaptive industry cluster approach can be positioned to address international, domestic and regionally-driven opportunities.

APPENDIX C.
EMPLOYMENT LAND NEEDS

This appendix comprises detailed background and tabular results associated with the Chapter IV EOA discussion of employment land needs. Topics covered by this appendix include analysis purpose and approach, description of Hillsboro's employment buildable lands inventory (BLI), employment and land demand forecast scenarios, and employment-driven land need.

ANALYSIS PURPOSE & APPROACH

The determination of needs for commercial and industrial employment lands draws on results of the employment forecast scenarios coupled with the more qualitative perspectives describing community economic potential. In effect, this portion of the EOA analysis compares land supply with projected employment driven demand to assess site availability over 5- and 20-year planning horizons with alternate employment scenarios considered. Also included is summary consideration of potential longer-term, 50-year potential employment land needs.

The land needs analysis is intended to identify and characterize the demand and supply for industrial and commercial sites. Also described are the types of sites needed to accommodate targeted growth industries and existing employers that could potentially expand – together with opportunities for spin-off employers and entities that provide support for existing clusters.

The analysis aims to further identify specific site sizes, special site requirements or other characteristics affecting the needed land supply. The readiness of the existing land supply for industrial/manufacturing and other types of employment development is also addressed.

HILLSBORO'S EMPLOYMENT BLI

The City of Hillsboro has coordinated with Metro to evaluate the city's supply of buildable lands available for employment uses. The City has utilized Metro's Buildable Land Inventory (BLI) methodology to revise portions of the 2018 Draft Urban Growth Report (UGR) pertaining to Hillsboro's Urban Growth Boundary (and future growth areas).

BLI Approach & Methodology

Hillsboro's employment BLI has been updated utilizing an approach similar to that of Metro. However, the exact methodology applied for this update differs somewhat from Metro's 2018 analysis since the City does not have direct access to the Metroscope model in-house. The resulting supply focused BLI was prepared by the City of Hillsboro in late 2019. This approximated the time period of data availability for employment as a driver of land demand.

The 2021 EOA was adopted in 2022 and was appealed to the Land Use Board of Appeals (LUBA) by 1000 Friends of Oregon (Friends) and Metro. While Friends and Metro raised several

assignments of error relating to employment growth forecasting and the Comprehensive Plan status, most of these arguments were denied by LUBA. However, LUBA agreed with Friends that the 2019 buildable lands inventory (BLI) for employment land that was included in the 2021 EOA did not apply the correct analysis for determining the redevelopment potential of "developed lands." LUBA thus remanded the decision to the City to address that issue.

Consequently, this 2021 EOA has been amended to incorporate an employment BLI based on December 2020 data as prepared by the planning firm MIG in compliance with the terms of the LUBA remand. The results of the amended BLI dated May 13, 2024 as provided by the planning firm MIG are included as Appendix E.

Appendix E describes the methodology utilized for the amended employment BLI together with quantitative **land supply** results. This Appendix C document focuses on the **demand side** of the land needs analysis, specifically the conversion of employment forecasts associated with alternative scenarios into associated building space and employment land needs. The combined supply-demand outputs are brought together and summarized with Chapter IV of the main EOA report document.

What now follows is a more detailed discussion of the process for translating forecast employment growth into associated land needs.

EMPLOYMENT & LAND DEMAND FORECAST SCENARIOS

Three employment scenarios have been identified and quantified with this 2020 EOA – each involving substantially different potential forecast outcomes per Chapter III of the EOA report:

- **Scenario A Straight-Line Growth**
  (forecast for a net addition of 36,910 Hillsboro jobs from 2020-40)
- **Scenario B Exponential Growth**
  (with net addition of as many as 87,800 net new jobs from 2020-40)
- **Scenario C Hybrid Growth**
  (focused on target industry sectors with 65,975 net new jobs from 2020-40)

The initial model alternatives formulated were Scenarios A and B. Scenario C was then developed as a hybrid composite of Scenarios A and B. This Appendix focuses on detailed quantification of the initial scenarios – A and B. Chapter IV of the full EOA compares and contrasts summary outputs of all three scenarios.

For purposes of this EOA, forecast scenario results may be categorized in three separate ways – by NAICS (or overall employment sector), by building type (a primary focus of this EOA) and by overall Comprehensive Plan designation (as summarized in Chapter IV of the EOA report).

NAICS Categories

The employment trends analysis has been based on employment categories of the North American Industry Classification System (NAICS) – as this is the industry classification system most used for defining employment uses locally, statewide and nationally.

Key differences between Scenarios A and B can be found in potential job growth associated with sectors including health care/social assistance, wholesale trade, transportation and warehousing, information, professional services, administrative, arts/entertainment/recreation, and other services – as discussed with EOA Chapter II. These are all sectors for which recent job growth has been particularly rapid post-recession. If extrapolated over the next 20 years with Scenario B, net job growth is at least double that of Scenario A job outcomes.

As shown by the chart to the right, a related means of categorization is that of Metro's 2018 UGR – with four aggregated super sectors of retail, service, industrial, and other employment. Using this means of categorization, the highest growth super sectors are for "other" employment and service employment, followed by industrial and retail employment increases.

Hillsboro Employment Change Scenarios (2020-40)

Super Sector	NAICS Involved	Job Add (2020-40)	
		Scenario A	Scenario B
Retail	44-45, 71-72	5,470	12,530
Service	22, 51-56, 81	11,450	26,160
Industrial	31-33, 48-49	7,930	13,060
Other	11, 21, 23, 42, 61-62, 92	12,060	36,050
Total	**All Sectors**	**36,910**	**87,800**

Source: E. D. Hovee. Forecast scenarios are preliminary and subject to revision.

As these aggregated NAICS categories are not of great utility for understanding Hillsboro's employment drivers in the context of local zoning, an alternate methodology is provided as part of the supply/demand reconciliation discussion included with this Hillsboro EOA – categorization by building type.

Categorization of Employment by Building Type

The primary selected important means of categorizing employment and land use is by the type(s) of buildings that a particular employment sector typically inhabits. This categorization system was first applied with Metro's 2009 UGR as a means of translating employment growth to building and associated land needs. This methodology also was applied with the most recent 2017 Hillsboro EOA.

For purposes of this EOA, seven employment-related building types are identified – covering office, institutional, flex/business park, general industrial, warehouse, data center and retail uses. NAICS specific employment is allocated to each of these building types using an allocation matrix that cross-references building type by employment sector.

The following matrix chart provides the distribution of NAICS employment by building typology utilized for this 2021 EOA update.

Distribution of NAICS Employment by Building Typology

NAICS	Employment Sector	Office	Institu-tional	Flex/BP	General Industrial	Ware-house	Data Center	Retail	Total
23	Construction	14%	0%	18%	40%	18%	0%	10%	*100%*
31-33	Manufacturing	8%	0%	24%	60%	8%	0%	0%	*100%*
42	Wholesale Trade	8%	0%	22%	20%	40%	0%	10%	*100%*
44-45	Retail Trade	5%	1%	6%	0%	12%	0%	76%	*100%*
48-49	Transportation & Warehousing	15%	0%	12%	13%	55%	0%	5%	*100%*
51	Information	20%	0%	20%	30%	0%	20%	10%	*100%*
52	Finance & Insurance	72%	1%	5%	1%	1%	0%	20%	*100%*
53	Real Estate	72%	1%	5%	1%	1%	0%	20%	*100%*
54	Professional Services	72%	1%	5%	1%	1%	0%	20%	*100%*
55	Management	79%	5%	8%	0%	0%	0%	8%	*100%*
56	Administrative	72%	1%	5%	1%	1%	0%	20%	*100%*
61	Educational Services	30%	53%	5%	1%	1%	0%	10%	*100%*
62	Health Care & Social Assistance	30%	53%	2%	0%	0%	0%	15%	*100%*
71	Arts, Entertainment & Recreation	35%	0%	10%	0%	0%	0%	55%	*100%*
72	Accommodation & Food Services	20%	1%	7%	1%	1%	0%	70%	*100%*
81	Other Services	72%	1%	5%	1%	1%	0%	20%	*100%*
92	Public Administration	43%	35%	5%	1%	1%	0%	15%	*100%*

Sources: E. D. Hovee with 2009 UGR, as amended to included data centers with 2017 Hillsboro EOA.

Charts showing the resulting allocations of forecast Scenario A and B employment consistent with the above distribution matrix are as provided on the next page.

By building typology, office buildings are expected to account for the largest share of forecast employment growth – 31% of job growth with Scenario A and 33% in Scenario B. Retail/storefront space accounts for 20% of anticipated job growth, general industrial for 12-16%, flex/business park (BP) space for 10-11%, and institutional for 11-15% (depending on the scenario). Warehouse space accounts for 9% of employment growth and data center uses for a remaining 1%.

While not directly shown with charts on the next page, Scenario C hybrid growth allocations generally come in at between the Scenario A and B results. Exceptions are that with Scenario C, retail space accounts for 18% of employment growth (below Scenario A/B results) and data center employment comes in at 2% of total job growth (above Scenario A/B results).

Scenario A Employment Growth by Building Typology (2020-40)

NAICS	Employment Sector	Office	Institu-tional	Flex/BP	General Industrial	Ware-house	Data Center	Retail	Total
23	Construction	206	--	265	588	265	--	147	1,470
31-33	Manufacturing	496	--	1,488	3,720	496	--	--	6,200
42	Wholesale Trade	236	--	649	590	1,180	--	295	2,950
44-45	Retail Trade	75	15	89	--	179	--	1,132	1,490
48-49	Transportation & Warehousing	260	--	208	225	952	--	87	1,730
51	Information	432	--	432	648	--	432	216	2,160
52	Finance & Insurance	828	12	58	12	12	--	230	1,150
53	Real Estate	115	2	8	2	2	--	32	160
54	Professional Services	1,505	21	105	21	21	--	418	2,090
55	Management	(190)	(12)	(19)	--	--	--	(19)	(240)
56	Administrative	2,621	36	182	36	36	--	728	3,640
61	Educational Services	(15)	(27)	(3)	(1)	(1)	--	(5)	(50)
62	Health Care & Social Assistance	2,394	4,229	160	--	--	--	1,197	7,980
71	Arts, Entertainment & Recreation	452	--	129	--	--	--	710	1,290
72	Accommodation & Food Services	538	27	188	27	27	--	1,883	2,690
81	Other Services	1,793	25	125	25	25	--	498	2,490
92	Public Administration	(125)	(102)	(15)	(3)	(3)	--	(44)	(290)
Total	**All Sectors**	**11,620**	**4,227**	**4,048**	**5,890**	**3,190**	**432**	**7,505**	**36,910**

Scenario B Employment Growth by Building Typology (2020-40)

NAICS	Employment Sector	Office	Institu-tional	Flex/BP	General Industrial	Ware-house	Data Center	Retail	Total
23	Construction	329	--	423	940	423	--	235	2,350
31-33	Manufacturing	622	--	1,865	4,662	622	--	--	7,770
42	Wholesale Trade	772	--	2,123	1,930	3,860	--	965	9,650
44-45	Retail Trade	91	18	109	--	217	--	1,376	1,810
48-49	Transportation & Warehousing	794	--	635	688	2,910	--	265	5,290
51	Information	1,136	--	1,136	1,704	--	1,136	568	5,680
52	Finance & Insurance	1,822	25	127	25	25	--	506	2,530
53	Real Estate	144	2	10	2	2	--	40	200
54	Professional Services	3,895	54	271	54	54	--	1,082	5,410
55	Management	(308)	(20)	(31)	--	--	--	(31)	(390)
56	Administrative	4,802	67	334	67	67	--	1,334	6,670
61	Educational Services	(15)	(27)	(3)	(1)	(1)	--	(5)	(50)
62	Health Care & Social Assistance	7,311	12,916	487	--	--	--	3,656	24,370
71	Arts, Entertainment & Recreation	2,219	--	634	--	--	--	3,487	6,340
72	Accommodation & Food Services	876	44	307	44	44	--	3,066	4,380
81	Other Services	4,363	61	303	61	61	--	1,212	6,060
92	Public Administration	(116)	(95)	(14)	(3)	(3)	--	(41)	(270)
Total	**All Sectors**	**28,736**	**13,046**	**8,715**	**10,173**	**8,281**	**1,136**	**17,714**	**87,800**

Sources: E. D. Hovee with 2009 UGR, as amended to included data centers with 2017 Hillsboro EOA.

EMPLOYMENT-DRIVEN LAND NEED

The next steps in this demand or needs analysis require the translation of employment growth into associated employment land need. The analysis begins with discussion of the conversion factors utilized, followed by presentation of resulting land need outputs for Scenarios A and B.

Conversion Factors

Translating employment growth to land demand involves three sets of conversion factors:

- Conversion of **employment need to building space requirement** – by applying typical ratios of building square footage per employee suitable to each building typology.
- Conversion of **building space need to associated land demand** – by applying a floor area ratio (FAR) factor specific to each building typology.
- Application of a **market vacancy factor** – recognizing space turnover at normalized occupancy typical for each building type.

As indicated by the following chart, a fourth line provides the resulting implied overall employment density factors associated with each typology including adjustment for market vacancy. Ratios applied are those previously used with Hillsboro's 2017 EOA. These factors are generally consistent with conversion factors first applied with Metro's 2009 UGR (including sub-regional variations), but with some modifications apparent with the city's 2017 EOA – including addition of market vacancy factors.

Employment to Land Need Conversion Factors by Building Typology

Employment to Land Need Conversion Factor	Office	Institu-tional	Flex/BP	General Industrial	Ware-house	Data Center	Retail
Density (Bldg Sq Ft/Job)	350	600	990	600	1,850	5,000	500
Floor Area Ratio (FAR)	0.40	0.25	0.25	0.25	0.25	0.35	0.35
Market Vacancy	10%	0%	10%	5%	5%	0%	10%
Implied Density (Jobs/Net Acre)	*44.8*	*18.2*	*9.9*	*17.2*	*5.6*	*3.0*	*27.4*

Sources: E. D. Hovee and 2009 UGR, as subsequently modified and expanded with 2017 Hillsboro EOA.

For industrial uses, employment densities range from 3.0 employees per acre with data center uses to about 17 jobs per acre for general industrial. With commercial uses, densities range from 18 jobs per acre for institutional to nearly 45 jobs per acre with institutional uses. These conversion factors are applied to job forecasts with all scenarios considered.

Employment-Driven Land Needs by Scenario

With the straight-line growth forecast of Scenario A, close to 2,230 net acres of employment land would be required from 2020-40. This is similar to the 2,336 acre 20-year need estimated with the prior 2017 EOA. With a more robust compound growth rate (CAGR) applied based on experience of the current economic cycle as shown by Scenario B, the employment land need more than doubles to a net total of nearly 5,330 acres over the same 2020-40 time horizon.

Summary land need projections, categorized **by building typology**, are provided by the following chart. A more detailed matrix break-out of potential land needs by building typology and NAICS employment classification is provided by the two tables on the following page.

Net Hillsboro Employment Acreage Need by Scenario (2020-40)

Employment Scenario	Office	Institu-tional	Flex/BP	General Industrial	Ware-house	Data Center	Retail	Total Acres
Scenario A	259.3	232.9	408.9	341.6	570.4	141.7	273.5	2,228.2
Scenario B	641.4	718.8	880.3	590.0	1,480.8	372.6	645.5	5,329.2

Sources: E. D. Hovee and 2009 UGR, as subsequently modified and expanded from the 2017 Hillsboro EOA. See Chapter IV of EOA report for summary results including Scenario C at 3,840-acre net land demand.

With either Scenario A or B, the largest single source of land need would be for warehouse-related uses – at 26-28% of total demand (depending on the scenario). This is followed by flex/BP need at 17-18%, and general industrial demand at 11-15%.

With Scenarios A and B, data center acreage demand is estimated at 6-7% of the total employment land need. Major generators of commercial related demand are institutional building needs at 10-13% of net land need, with office and retail each at about 12%. Scenario C generally falls within these ranges except for a higher allocation to data center use, somewhat less for flex/business park and retail uses.

When considered by **NAICS employment sector** (as detailed on the next page), the largest source of land demand with Scenario A would be manufacturing – at 21% of the net acreage total. Other major sources of land demand would be health care and social assistance (16%), wholesale trade (15%), information (11%), and transportation/warehousing (10%).

With Scenario B, the relative ordering of employment land needs changes somewhat – with wholesale trade and health care and social assistance each accounting for as much as 20% of total land need. Information and transportation would each account for 12% of land need with manufacturing at 11%. The manufacturing land need does not change as much as for the other significant employment land uses noted between Scenarios A and B.

As indicated, results of Scenario C Hybrid Growth generally fall in-between Scenarios A and B as described by the EOA report. Further and more detailed information regarding reconciliation of land need and capacity is also covered by EOA Chapter IV discussion of employment land needs. Factors relevant to assessing sector-specific employment growth rates as applied with the hybrid Scenario C approach are detailed as part of Appendix A.

Scenario A Employment Land Acreage Needs by Building Typology (2020-40)

NAICS	Employment Sector	Office	Institu-tional	Flex/BP	General Industrial	Ware-house	Data Center	Retail	Total
23	Construction	4.6	--	26.7	34.1	47.3	--	5.4	118.1
31-33	Manufacturing	11.1	--	150.3	215.7	88.7	--	--	465.8
42	Wholesale Trade	5.3	--	65.6	34.2	211.0	--	10.7	326.8
44-45	Retail Trade	1.7	0.8	9.0	--	32.0	--	41.3	84.8
48-49	Transportation & Warehousing	5.8	--	21.0	13.0	170.1	--	3.2	213.1
51	Information	9.6	--	43.6	37.6	--	141.7	7.9	240.4
52	Finance & Insurance	18.5	0.6	5.8	0.7	2.1	--	8.4	36.0
53	Real Estate	2.6	0.1	0.8	0.1	0.3	--	1.2	5.0
54	Professional Services	33.6	1.2	10.6	1.2	3.7	--	15.2	65.5
55	Management	(4.2)	(0.7)	(1.9)	--	--	--	(0.7)	(7.5)
56	Administrative	58.5	2.0	18.4	2.1	6.5	--	26.5	114.0
61	Educational Services	(0.3)	(1.5)	(0.3)	(0.0)	(0.1)	--	(0.2)	(2.3)
62	Health Care & Social Assistance	53.4	233.0	16.1	--	--	--	43.6	346.2
71	Arts, Entertainment & Recreation	10.1	--	13.0	--	--	--	25.9	49.0
72	Accommodation & Food Services	12.0	1.5	19.0	1.6	4.8	--	68.6	107.5
81	Other Services	40.0	1.4	12.6	1.4	4.5	--	18.1	78.0
92	Public Administration	(2.8)	(5.6)	(1.5)	(0.2)	(0.5)	--	(1.6)	(12.1)
Total	**All Sectors**	**259.3**	**232.9**	**408.9**	**341.6**	**570.4**	**141.7**	**273.5**	**2,228.2**

Scenario B Employment Land Acreage Needs by Building Typology (2020-40)

NAICS	Employment Sector	Office	Institu-tional	Flex/BP	General Industrial	Ware-house	Data Center	Retail	Total
23	Construction	7.3	--	42.7	54.5	75.6	--	8.6	189
31-33	Manufacturing	13.9	--	188.4	270.4	111.2	--	--	584
42	Wholesale Trade	17.2	--	214.4	111.9	690.3	--	35.2	1,069
44-45	Retail Trade	2.0	1.0	11.0	--	38.8	--	50.1	103
48-49	Transportation & Warehousing	17.7	--	64.1	39.9	520.3	--	9.6	652
51	Information	25.4	--	114.7	98.8	--	372.6	20.7	632
52	Finance & Insurance	40.7	1.4	12.8	1.5	4.5	--	18.4	79
53	Real Estate	3.2	0.1	1.0	0.1	0.4	--	1.5	6
54	Professional Services	86.9	3.0	27.3	3.1	9.7	--	39.4	169
55	Management	(6.9)	(1.1)	(3.2)	--	--	--	(1.1)	(12)
56	Administrative	107.2	3.7	33.7	3.9	11.9	--	48.6	209
61	Educational Services	(0.3)	(1.5)	(0.3)	(0.0)	(0.1)	--	(0.2)	(2)
62	Health Care & Social Assistance	163.2	711.6	49.2	--	--	--	133.2	1,057
71	Arts, Entertainment & Recreation	49.5	--	64.0	--	--	--	127.1	241
72	Accommodation & Food Services	19.6	2.4	31.0	2.5	7.8	--	111.7	175
81	Other Services	97.4	3.3	30.6	3.5	10.8	--	44.2	190
92	Public Administration	(2.6)	(5.2)	(1.4)	(0.2)	(0.5)	--	(1.5)	(11)
Total	**All Sectors**	**641.4**	**718.8**	**880.3**	**590.0**	**1,480.8**	**372.6**	**645.5**	**5,329.2**

Source: E. D. Hovee, based on methodology as described by this appendix.

APPENDIX D. IMPLEMENTATION POLICIES

This Appendix provides a detailed review of the implementation framework for existing and prospective City of Hillsboro policies affecting economic development implementation city-wide. This review is conducted in support of the summarized recommendations as provided by the Chapter V implementation policies discussion of the 2021 Hillsboro EOA. Topics covered by this appendix are background and approach, current framework for Hillsboro economic development, key drivers of economic development change, EOA recommended implementation policies and measures, and updating of Comprehensive Plan goals and policies.

BACKGROUND & APPROACH

As stipulated by OAR 660-009-0020, these policies are to provide a statement of community development objectives, commitment to provide a competitive short-term supply of land for industrial and other employment uses, and a commitment to provide adequate sites and facilities.

Related OAR provisions address strategies within a metro area to meet short-term supply needs, maintain existing levels of industrial and other employment use, support expansion and increased productivity of existing firms, include brownfield redevelopment and address prime industrial land. Cities also are encouraged to adopt plan policies covering additional implementation approaches including but not limited to tax incentives, land use controls, preferential tax assessments, capital improvements, property acquisition techniques, public/private partnerships and intergovernmental agreements.

CURRENT FRAMEWORK FOR HILLSBORO ECONOMIC DEVELOPMENT

City policy related to economic development is covered primarily from two documents – a 2017 *Economic Opportunities Analysis* (EOA) and the subsequent updated *Hillsboro Comprehensive Plan* (dated November 21, 2017 and effective as of January 2, 2018). Also of significance – albeit with less specific land use detail – is the more recently completed *Hillsboro 2035 Community Plan.*

2017 EOA

The most recent Hillsboro EOA dated February 7, 2017 did not include a direct statement of community economic development objectives as stipulated by *OAR 660-009-0020* but did address a series of recommendations organized around three topics – capacity, business environment and recruitment/retention. As stated by the EOA, provided was a "summary list of implementation measures to encourage effective utilization of the City's employment capacity." 2017 EOA recommended implementation measures are detailed by the listing on the following page.

2017 EOA Recommended Implementation Measures

Capacity:

- Ongoing planning and infrastructure investments in the North Hillsboro Industrial Area
- Maintain and expand infrastructure necessary to support employers and realize the City's development capacity
- Support additional investment in existing employment areas, including programs supporting adaptive re-use
- Review current zoning and entitlements to ensure they are supportive of desired development outcomes
- Evaluate parking management programs where appropriate to potentially free up additional property and/or allow for intensification of employment densities
- Seek increased flexibility in site usage requirements, to better match demand and supply over time.
- Monitor land consumption and usage patterns within the City over time, and periodically update need forecasts
- Periodically update identified target industries, and match industry needs with local siting options
- Maintain a competitive and suitable inventory of readily available sites and space for a wide range of current and prospective employers
- Work at a regional and statewide level to assure that the City's available land assets are adequate for both short- and long-term needs

Business Environment:

- Workforce
    - Maintain quality educational institutions
    - Facilitate collaboration between employers and institutions
- Regulatory climate
- Encourage the maintenance and development of local housing options for workforce and executive needs
- Support ongoing development of downtown Hillsboro and the Tanasbourne/ AmberGlen area to provide urban amenity concentrations
- Encourage self-help methods and programs for business districts, including support for and formation of business associations and self-assessment districts

Recruitment/Retention:

- Work with local, regional, and statewide economic development, business organizations, and major employers to coordinate economic development efforts

Source: Johnson Economics for City of Hillsboro, *Economic Opportunities Analysis,* February 7, 2017.

2018 Hillsboro Comprehensive Plan

Chapter 11 of the *Hillsboro Comprehensive Plan* addresses "Building Economy & Infrastructure" including five goals, each of which is supported by more specific and detailed policy measures. The adopted five goals read as follows:

- **Goal 1 – Competitive Advantage:** Diversify and expand the economy to give Hillsboro, the region, and the state a competitive advantage.
- **Goal 2 – Facilities, Utilities & Services:** Catalyze economic development through high-quality public facilities, utilities and services.
- **Goal 3 – Land Supply:** Manage land supply to meet short and long-term economic development needs of Hillsboro, the region, and the state.
- **Goal 4 – Equity:** Promote economic development opportunities for individuals and small and emerging businesses to ensure equitable access to resources.
- **Goal 5 – Livability:** Develop and sustain a vibrant City to support economic development.

On the following two pages are provided the goals and associated economic development (ED) policies of Hillsboro's Comprehensive Plan as currently adopted.

Hillsboro 2035 Community Plan

Building on the success of the original award-winning *Hillsboro 2020 Vision and Action Plan*, in 2020 the City completed an updated *Hillsboro 2035 Community Plan* as representing "a shared vision for a sustainable future." **Economy and Infrastructure** comprises the first of five focus areas for 2035 accompanied by a goal statement representing continued high aspirations:

> Hillsboro's world-class economy, advanced technical training, and innovative, business-friendly culture attracts investment and supports businesses of all sizes. State of the art infrastructure systems including communications, roads, transit, and water supply are in place and continually updated to accommodate the city's growth and evolution. Hillsboro is a vibrant, regional destination for arts, recreation, cuisine, and entertainment.

Five supportive initiatives and actions are detailed as part of this updated Community Plan:

- **Initiative 1:** Promote Hillsboro's business-friendly culture and proactive workforce development initiatives.
- **Initiative 2:** Encourage and support the growth of emerging industries, small business, and the spirit of entrepreneurship.
- **Initiative 3:** Expand shopping, entertainment, and dining destinations.
- **Initiative 4**: Continue efforts to develop a vibrant, mixed-use downtown as a unique attraction.
- **Initiative 5:** Implement efforts to ease congestion in and around Hillsboro.

Current Comprehensive Plan Economic Development Goals & Policy Statements

GOAL 1	**COMPETITIVE ADVANGAGE:** Diversify and expand the economy to give Hillsboro, the region, and the state a competitive advantage.
ED 1.1	**Competitive advantage.** Maintain and strengthen the City's competitive economic advantages, including access to a highly-skilled workforce; vibrant local workforce development; business diversity; competitive business climate; quality educational institutions; and globally-competitive public facilities, utilities, and services.
ED 1.2	**Diverse range of employment opportunities.** Foster a diverse range of employment opportunities to benefit Hillsboro, the region, and the state.
ED 1.3	**Employment land supply.** Pursue an ample employment land supply to benefit Hillsboro, the region, and the state.
ED 1.4	**Traded-sector and target industry retention, expansion, and recruitment.** Sustain the ongoing vitality of the City's traded-sector and targeted industries by aligning plans and investments to retain, expand, and recruit employers and investment in Hillsboro.
ED 1.5	**Business innovation.** Facilitate scale-up and business innovation opportunities where new or incubating companies can create a sense of place and benefit from co-location, proximity to transit, affordable space, mentorship, and shared services.
ED 1.6	**Partnerships.** Leverage program and resource partnerships with local, regional, and statewide stakeholders, such as governments, educational institutions, economic development and business organizations, and major employers, to attract and retain employment and investment.
ED 1.7	**Economic resiliency.** Pursue collaborative and innovative approaches to strengthen and sustain Hillsboro, the region, and the state's economic resiliency.
ED 1.8	**Energy, water, and environmental challenges.** Reduce the vulnerability of Hillsboro, the region, and the state's economies to energy, water, and environmental challenges.
GOAL 2	**FACILITIES, UTILITIES & SERVICES:** Catalyze economic development through high quality public facilities, utilities, and services.
ED 2.1	**Competitive utilities**. Maintain existing public utility assets and invest in the expansion of high-quality utilities to catalyze economic development.
ED 2.2	**High-quality public facilities and services.** Maintain and invest in expansion of high-quality public facilities and services to catalyze economic development.
ED 2.3	**Multi-modal transportation.** Develop safe, well-connected, and efficient multi-modal transportation facilities that improve access to employment areas.
ED 2.4	**Hillsboro Airport.** Leverage the long-term viability of the Hillsboro Airport facility and support the long-term growth of critical airport infrastructure.
ED 2.5	**Freight facilities**. Support the development of a transportation system that places a strong emphasis on facilitating freight movement capabilities for economical and efficient goods movement.
ED 2.6	**Coordination of public facilities, utilities, and services.** Coordinate the type, design, timing, and location of public facilities, utilities, and services with other public agencies, utilities, the private sector, and property owners to move employment land closer to development-ready status.
ED 2.7	**Financing of public facilities, utilities, and services.** Adopt additional funding methodologies, as needed to fund the necessary extension of public facilities, utilities, and services.
GOAL 3	**LAND SUPPLY:** Manage land supply to meet short and long-term economic development needs of Hillsboro, the region, and the state.
ED 3.1	**Supply of developable employment sites and flexibility.** Sustain a supply of developable employment sites and adequate flexibility to meet the short- and long-term needs of Hillsboro, region, and state.

ED 3.2	**Employment land designation.** Adopt land use designations in a manner that accommodates projected employment growth.
ED 3.3	**Employment land lot sizes.** Manage employment land to provide a range of available and developable lot sizes to accommodate a variety of uses, industry clusters, and emerging market opportunities.
ED 3.4	**Higher density employment land.** Pursue development of higher employment densities in areas with planned or existing enhanced transportation connectivity; access to transit; and public facilities, utilities, and services.
ED 3.5	**Health and education campuses**. Promote the stability and growth of health and education campuses as essential service providers, centers of innovation, workforce development providers, and major employers that can also provide amenities to surrounding neighborhoods.
ED 3.6	**Revitalization and reinvestment.** Support additional investment in existing Employment Areas, Regional Centers, Town Centers, and along targeted Corridor areas, such as assembly of existing small employment parcels for redevelopment, programs supporting adaptive reuse, and identification of options to mitigate and/or redevelop sites and structures.
ED 3.7	**Employment land supply.** Pursue additional employment land when the Hillsboro Planning Area will not accommodate the 20-year projected demand to meet local, regional, and state needs.
GOAL 4	**EQUITY:** Promote economic development opportunities for individuals and small and emerging businesses to ensure equitable access to resources.
ED 4.1	**Individual training.** Encourage collaboration between local K-12 schools, trade schools, colleges, and employers to facilitate individuals' access to cutting-edge career development, workforce programs, technology, and other high-quality educational opportunities.
ED 4.2	**Entrepreneurial opportunities.** Expand opportunities for small business and business development across our diverse community.
ED 4.3	**Retain existing businesses.** Create strategies to retain existing businesses and mitigate displacement resulting from redevelopment and/or increasing land values.
GOAL 5	**LIVABILITY:** Develop and sustain a vibrant City to support economic development.
ED 5.1	**High-quality public realm.** Plan, develop, and enhance a high-quality public realm that complements adjacent development and uses.
ED 5.2	**Development impacts.** Ensure architectural and site designs that enhance and complement surrounding neighborhoods and that respect the fundamental characteristics of applicable Hillsboro design type designations.
ED 5.3	**Innovative architecture and site design**. Facilitate innovative architectural and site designs that complement and enhance the public realm, particularly at the edges of development sites, to enhance their integration into adjacent uses.
ED 5.4	**Distribution of commercial areas.** Disperse the types and sizes of commercial opportunities throughout the City in proportion to the needs of the area.
ED 5.5	**Shopping, dining, entertainment, and recreation options.** Facilitate and disperse an array of shopping, dining, entertainment, and recreation options throughout the City that help attract and retain employers.
ED 5.6	**Employee housing choice.** Provide a wide range of housing choices to accommodate employees with diverse needs who want to work and live in Hillsboro.
ED 5.7	**Locational compatibility.** Focus economic development in Employment Areas, Regional Centers, Town Centers, Neighborhood Centers, and along Corridors.
ED 5.8	**Innovation economy.** Plan for new and innovative economic trends, such as the sharing economy.
ED 5.9	**Environmental sustainability.** Pursue environmental sustainability actions that aim to preserve natural resources and reduce environmental impacts.

Source: *2018 Hillsboro Comprehensive Plan.*

Comparability of Implementation Listings

While the 2017 EOA and 2018 Comprehensive Plan listings are comparable in terms of overall policy direction, there is little direct consistency in terms of topic organization or the details of specific policies. The areas of greatest alignment appear to be with respect to themes as for target industry prioritization, business recruitment/retention, employment land supply, infrastructure support for economic development, and employee housing choice.

Overall, the Comprehensive Plan policies cover more topics and tend to be more detailed. However, the prior EOA implementation recommendations also provide detail regarding such items as infrastructure investments in the North Hillsboro Industrial area and encouragement of parking management programs to free up additional property or increase employment densities – items not as directly addressed with the Comprehensive Plan ED policies.

Neither the EOA nor the Comprehensive Plan provide much of a direct link to the City of Hillsboro's active economic development programs, specifically the application of development incentives to assist in meeting the City's goals for building economy and infrastructure. As an added note, neither the EOA recommendations nor the Comprehensive Plan policies are organized in a manner that provides ready comparability to the implementation policy framework outlined as guidance by OAR 660-009-0020.

The approach taken through the rest of this implementation appendix follows what could be considered as a *three-step process* to:

- Focus on key economic and local conditions that have changed in the recent years or remain as unmet challenges, meriting added attention with an update to Hillsboro's economic development policies
- Address topics as outlined by the Division 9 LCDC guidance
- Place and arrange resulting recommended policies into the existing framework of the Chapter 11 portion of Hillsboro's existing or updated Comprehensive Plan

While there undoubtedly are other approaches that might be considered to organize an updated set of economic development implementation policies, this 2021 EOA aims both to reinforce adopted City-wide planning priorities and identify new initiatives as appropriate.

KEY DRIVERS OF ECONOMIC DEVELOPMENT CHANGE

This update reflects key drivers of economic development changes globally that have emerged since the 2017 EOA, notably:

- The COVID pandemic and economic downturn which have accelerated temporary and likely lasting changes to work and shop from home at the expense of brick-and-mortar commercial office and retail space – but also creating demand for upsized housing.
- Resurgence of industrial space demand due to e-commerce distribution, accelerated technological change, data center needs, and re-shoring of traditional manufacturing.

- Changing competitive advantage of tech leadership with semiconductors, to the recent disadvantage of American firms including Intel as Oregon's largest private employer, albeit with additional planned investment as renewed corporate and national priorities.
- Governmental commitment to a reinvigorated semiconductor industry exemplified by passage of the federal *CHIPS and Science Act of 2022* coupled with August 2022 findings and recommendations of the Oregon Semiconductor Competitiveness Task Force.

Hillsboro has great opportunity to capitalize on these emerging trends as Oregon's economic engine – to the extent that it maintains and builds on its core semiconductor technology manufacturing prowess. But there is also new downside risk, dependent on the changing fortunes and continued industry leadership of the community's major employer. And on local and regional capacity to better leverage the next waves of tech-forward investment.

EOA Recommended Implementation Policies & Measures

Implementation policies are organized to cover topics stipulated by OAR 660-009-0020 to reflect key issues and objectives associated with this 2021 EOA update. Topics covered are employment land use, transportation and utility infrastructure, target and supporting industry clusters, economic development incentives, workforce readiness, and partnership opportunity. The relationship of these categories to specific subsections of the OAR are noted as follows:

660-009-0020 Industrial and Other Economic Development Policies

EOA Policy Topic	Pertinent OAR-660-009-0020 Subsection
Employment Land Use	(1) (b) Short-term supply (1) (c) Adequate sites & facilities (2) Plans for cities within a metropolitan planning organization (6) Policies pertaining to prime industrial land (as for large acreage sites) (7) (b) Land use controls and ordinances Also addresses 660-009-0025: Designation of Lands for Industrial and Other Employment Uses
Transportation & Utility Infrastructure	(1) (c) Adequate sites & facilities (7) (d) Capital improvement programming
Target & Supporting Industry Clusters	(3) Policies to maintain industrial and other employment uses including downtowns/central business districts (7) (b) Land use controls and ordinances
Work Force Readiness	(4) Increased productivity to facilitate economic development
Economic Development Incentives	(5) Brownfield redevelopment strategies (7) (a) Tax incentives and disincentives (7) (c) Preferential tax assessments (7) (d) Capital improvement programming (7) (e) Property acquisition techniques
Partnership Opportunity	(7) (f) Public/private partnerships (7) (g) Intergovernmental agreements

Each of these EOA policy topics are discussed together with implementation recommendations, in turn.

Employment Land Use

Following the articulation of community economic development objectives, the first policies identified by OAR 660-009 are to provide an adequate employment land inventory with priority emphasis on short term supply defined as "suitable land that is ready for construction within one year of an application."

Attention is also needed to assure total land supply as determined to be "adequate to accommodate industrial and other employment uses for a 20-year planning period." Cities are to provide at least 25% of the total land supply within their UGB as short-term supply – albeit with exceptions noted for jurisdictions unable to meet this target.[3]

2017 EOA. Hillsboro's 2017 EOA forecast employment of 40,000 net new jobs over a 20-year planning horizon. This resulted in a projected short-term need for 663 acres and long-term need for 2,952 acres (including 195 acres on non-employment land). The reconciliation of employment needs and available capacity indicated an adequate 20-year supply of industrial land but an inadequate supply of land for commercial uses.

The EOA also indicated that vacant land alone was inadequate to meet 20-year needs. Assuring adequate supply would mean that capacity from redevelopment and infill would need to represent nearly half (46%) of all employment land capacity. Inclusion of redevelopment and infill lands appeared adequate to provide capacity for less than 15 years of the 20-year planning period. A further conclusion was that: "The heavy reliance upon redevelopment and infill to meet employment needs represents a significant risk," suggesting a need for ongoing land inventory monitoring and refinements of employment capacities as better data becomes available.

With regard to short-term needs, the 2017 EOA appears to be less definitive, albeit noting that the "limited supply is indicative of short-term supply challenges and suggests that new urban areas will be critical in maintaining a competitive land supply." The report also noted that: "Because potential infill land with existing urban services is a large share of short-term inventory, this condition could be limiting Hillsboro's ability to maintain a market ready inventory of sites."[4]

2021 EOA. This updated EOA is based on employment forecast scenarios and an amended employment buildable lands inventory (BLI) with data from December 2020 was prepared by MIG as of March 2024. As amended, the BLI results in an estimate of 1,225 net buildable acres on vacant lands together with portions of partially developed sites suitable for added development. Of this, 91.3% is zoned for industrial, 2.2% for commercial and 6.5% for mixed commercial and residential use. Of the net buildable acreage, 46% is currently outside the Hillsboro city limits but within the community's Urban Growth Boundary (UGB). Results of this refined BLI have been compared with three alternative 20-year employment forecast scenarios:

- **Scenario A Straight-Line Growth** – from a base of an estimated 84,390 jobs as of 2020, this scenario would involve an increase of an increase of 36,910 jobs over the 2020-40 time period, resulting in 121,300 jobs by 2040. Scenario A results in a need for nearly 2,230 acres over 20 years – with a resulting deficit of 1,004 acres (particularly for commercial lands).
- **Scenario B Exponential Growth** – extrapolating growth forward on an exponential basis could result in an increase of as many as 87,800 added jobs over 20 years, effectively doubling employment in Hillsboro by 2040 to 173,570 in-city jobs. If realized this scenario would result in a prospective need for as much as 5,330 acres over 20 years – with the total employment land deficit quadrupling to about 4,105 acres.
- **Scenario C Hybrid Growth –** resulting in an estimated 146,975 jobs in Hillsboro by 2040, based on assumption of compounding growth for industries associated with cluster targets versus lesser rates of growth for other sectors. Of the year 2040 estimate, 61,895 net new jobs would be added over the two decades from 2020-40. Scenario C results in a need for just over 3,840 acres over 20 years – with a resulting deficit of 2,617 acres.

With any of these scenarios, Hillsboro also would not be able to satisfy the short-term (5-year) need with reliance on existing in-city lands only. As with the prior 2017 EOA, the greatest land shortfall (in percentage terms) is for lands zoned for commercial or mixed-use – potentially placing pressure for conversion of some industrial land to commercial development.

Implementation Options. With both the prior 2017 and 2021 EOAs, the clear indication is that Hillsboro likely does not have adequate employment land capacity to accommodate either short-term (5-year) or long-term (20-year) employment growth. Several mitigation options have been outlined with this EOA – together with identification of associated advantages and disadvantages -- as a potential means to better reconcile employment land demand and supply. These might include any or some combination of the following:

- **Reduce the EOA employment forecast to match current BLI capacity** – essentially discarding Scenarios B/C and reducing the Scenario A jobs forecast by about 45%. This option may avoid the need to expand Hillsboro's UGB and future annexations of land for industrial development – but at the expense of foregoing significant high-wage job potential for Hillsboro, the metro region and state in the years ahead.
- **Focus EOA forecast reductions on the most land extensive sectors** – likely resulting in reduced allocations for lower job density uses as for data centers, warehouse and some flex/business park uses. This option may reduce but not necessarily eliminate the impetus for added land outside of Hillsboro's current city boundaries even from higher density major potential employers. Lack of property inventory for some land-extensive supply-chain uses may also dampen the appeal of Hillsboro for major tech employers.
- **Adjust employment to land need conversion factors toward a more urban profile** – emphasizing increased building FAR and job densities together with site redevelopment. factors. This option is associated with advantages and disadvantages similar to those

with focused on discouraging land extensive sectors (as noted above). Also possible would be to eliminate the market vacancy factor which is not explicitly included in some EOA analyses.

- **Increase the planned BLI supply, especially for growth areas around Hillsboro** – most notably with further annexation and urban service provision but also via mitigation measures to increase net to gross acreage use ratios – as a significant portion of the vacant and partially vacant employment land inventory is categorized as undevelopable due, in part, to wetland and other environmental constraints. This approach to increasing in-city land supply might be accomplished, for example, with off-site mitigation but would depend on significant and regional planning and regulatory review and approvals.
- **Pursue Metro region and statewide recognition of Hillsboro's strategic significance** – for long-term competitiveness and high wage jobs as integral to long-term economic vitality, both metro and state-wide. Of the options considered, this is perhaps the most pivotal to ensuring the continued competitiveness of Hillsboro as Oregon's center of high-tech investment but depends on broad recognition of current and prospective benefits for sustained community and economic vitality regionally and statewide.

As a result of the pandemic and changing work patterns, another option might be considered – allocating more of employment growth (on an FTE equivalent basis) away from work to home sites. There are two potential downsides with this option: a) no sustained experience as yet post-pandemic to determine the extent of a permanent shift to work from home (primarily affecting office workers); and b) uncertainty as to whether and how much space needs in traditional single use employment settings may change per on-site employee (either decreasing or increasing floor space requirements as from robotization and improved supply change management), especially for manufacturing and warehouse/distribution uses.

Implementation Measures. On a preliminary basis the following measures are recommended for consideration:

- **As a minimum measure, adopt a 20-year jobs and land use forecast similar to Scenario C Hybrid Growth.** This scenario best serves Hillsboro's existing and prospective competitive advantages for sectors targeted to business-cluster growth opportunities.
- **Annex and serve added employment land as needed to meet at least the 5-year Scenario A Straight-Line short-term supply requirement.** While it is possible that a slow or delayed economic recovery may dampen demand near-term, this is less likely for industrial than commercial use. Having the full complement of *shovel-ready* site supply in place also better positions Hillsboro and the region from the mutual and reinforcing perspectives of economic recovery and resilience.
- **Utilize the Scenario B forecast as an initial means to begin determination of longer-term needs for added industrial reserves and land capacity.** This will help set the stage for 20-50 year UGB expansions – adjusted as needed to reflect actual experience with economic recovery and sustained economic vitality going forward.

- **Provide more opportunity to accommodate both exclusive industrial zones and mixed-use development.** For large industrial users, it can be important to provide a clear separation or buffer from residential development and other non-industrial uses that would pose an unreasonable risk to public health or safety. For smaller scale uses as with creative and support service firms together with potential reduction in commercial space demand, horizontal rather than vertical mixed-use may become the more pronounced market opportunity for closely linked live-work-recreate communities – so long as total employment capacity is maintained at or above current forecast levels. Also noted is that much of the demand for office as a component of commercial demand can be met with industrially zoned sites.
- **Provide opportunity for large acreage, major employer campuses of up to 600+ acres consistent with national trends but not readily available regionally in Oregon.** This is of pivotal importance and a national priority for semi-conductor and related tech employers, exemplified by recently publicized plans of Intel for additional manufacturing facilities both domestically and internationally.

  Within the U.S., Intel in 2021 announced plans for two new fabrication plants in Chandler, Arizona. Situated on an approximately 700 acre "mega-factory" site, the campus is planned to be Intel's largest manufacturing complex globally. Subsequently, in January 2022, Intel announced plans for construction of two leading-edge chip factories on a nearly 1,000-acre site near Columbus, Ohio as the "largest single private-sector investment in Ohio history." The site will provide capacity for up to eight fab facilities at eventual full build-out planned over the next decade.[5]
- **Orient state and local incentive measures to support increased employment land utilization and redevelopment together with attraction and retention of target industries.** This may include accounting for the potential of as yet unknown permanent shift to work at home, especially for office workers – as well as for potential reduction in commercial *brick-and-mortar* commercial space needs, at least near-term. Also involved may be short- and long-term incentives for increased efficiency of employment land use including reduction of at-grade parking footprints when shown to be feasible.

While retention of Hillsboro's leading tech manufacturing edge is not guaranteed, success will be dependent on a more expansive land base than is currently available. Initial suggestions as to how these implementation measures might be incorporated into Comprehensive Plan goals and economic development policies are outlined as the last section to this EOA appendix.

Transportation & Utility Infrastructure

Transportation and utility infrastructure is critical to assuring development readiness of industrial and other employment sites. DLCD Division 9 guidance calls for "policies, through public facilities planning and transportation system planning, to provide necessary public facilities and transportation facilities for the planning area."

Transportation and utility Infrastructure of importance to Hillsboro-based business is provided both by public and private entities. Compared to other locales regionally and nationally,

Hillsboro is better positioned competitively with respect to utility than transportation infrastructure – though that may be changing in the wake of the COVID pandemic and potential temporary or longer-term shift to more work from home.

Transportation Infrastructure. Key elements of Hillsboro's transport infrastructure can be described as comprising:

- **Interstate/Highway Access** – U.S. Highway 26 provides the major freeway access directly to Hillsboro, notably for the city's major industrial firms situated in close proximity. U.S. 26 feeds directly into Interstate freeways I-405, I-5 and I-84 approximately 18 miles east (as well as to the 217 freeway which runs south through Beaverton, then connecting with I-5 south).
- **Air Travel** – Portland International Airport (PDX) provides regularly scheduled domestic and international commercial air service about 30 miles east of Hillsboro. Local businesses also are served by Hillsboro's own general aviation airport – Oregon's 2nd busiest after PDX. Due to freight shipping concerns at congested periods across the metro region, a new air cargo service now connects Hillsboro airport to PDX every day for business customers shipping by air. The Hillsboro Airport also includes a U.S. Customs and Border Protection office for international flights and has three fixed-base operators.
- **Public Transit** – The regional transit agency Tri-Met serves Hillsboro with bus and light-rail options including the MAX Blue Line. Bus service includes the *North Hillsboro Link*, a shuttle providing employee transportation to the North Hillsboro Industrial Area.

Looking ahead, smart transport investment can be expected to be increasingly customized to different needs for internal versus external transport linkages. Connections within and between the city's employment, residential and public/open space areas could emphasize greater walkability and opportunity to cycle, improved transit connections/ride sharing, and preparation for autonomous vehicles – all reducing the need for driving (and associated employee parking). In the near term, while COVID risk persists, regaining lost transit ridership will be challenged.

Suggested is a balanced mix of transit and major highway corridor improvements. Special emphasis is needed for better freight mobility – especially for time sensitive products reliant on air transport. A related long-term objective may be for improvement of the Cornelius Pass connection – as an alternate or reliever route to the Portland International Airport (PDX) and the I-5 North freeway system.

Utility Infrastructure. The strong role that public-private partnerships and intergovernmental arrangements have played is clearly evidenced with key elements of Hillsboro's existing and planned infrastructure for local business and industry:

- **Water** - The City of Hillsboro Water Department provides water west of Cornelius Pass Road and south of Highway 26. The Tualatin Valley Water District (TVWD) provides

water east of Cornelius Pass Road and north of Highway 26. The Joint Water Commission operated by the City and TVWD is the largest conventional water treatment plant in Oregon, capable of treating up to 75 million gallons per day. Of specific note are steps that the City and TVWD are taking to build infrastructure necessary for improved water supply reliability and system resiliency over the next 50 years.

- **Wastewater** – Clean Water Services cleans and recycles wastewater, provides industrial pre-treatment, and manages surface and storm water systems.
- **Electric Power** – As the largest investor-owned utility in Oregon, Portland General Electric (PGE) provides electrical service to the region with three high-reliability substations to serve tech and other industries in Hillsboro's industrial district. PGE offers multiple clean energy options, including renewables of hydroelectric, wind and solar energy.
- **Natural Gas** – As the largest independent natural gas utility in the Pacific Northwest, Northwest Natural serves Hillsboro's natural gas needs.
- **Digital Infrastructure –** Hillsboro has the most dense network of international (trans-Pacific) and domestic cable service in the Pacific Northwest, with low latency data capacity a major reason for attraction of data centers as well as with finance, media, health care, e-commerce and IT users to the area. The City and area business are well-served by multiple national "last mile" telecommunications carriers providing fiber optic data, voice and wireless internet service.[6]

Both short- and long-term, utility investment has been and will need to be continued with the area's electric, water, and wastewater systems. Adequate and reliable electric power is essential to major semiconductor firms plus a range of related high-tech industries. Hillsboro has benefitted from strategic, industry-supportive investments by Portland General Electric.

Similarly, the City of Hillsboro is recognized for having made the right decision 50 years ago with water system investment – "setting the table" for tech companies as well as overall development that has since occurred. From this perspective, it is important to again prepare for the next 50 years; as a community we "need to pay forward."

Implementation Measures. Key implementation measure recommendations for consideration would be to:

- **Target added local transport and utility infrastructure in conjunction with annexation to meet short-term employment land supply forecasts.** Ideally, infrastructure should be provided in a phased manner ahead of or coterminous with prospective development, creating ready-to-build sites.
- **Provide explicit policy support for a regional transportation system that effectively supports the movement of raw materials, manufactured goods and workforce to and through Hillsboro's employment areas.** This is a topic of growing significance not only regionally but more extensively due to supply chain and associated workforce issues impeding sustained economic recovery both nationally and globally.

- **Increase policy emphasis on north-south access and reduction of work-force commutes (to maximize Hillsboro work-force commute-shed accessibility).** Increasing regional congestion makes it more challenging for Hillsboro to draw substantial work-force from across the metro area; more of the local workforce is shifting to residence locations in Hillsboro or in communities to the north and south.
- **Provide explicit policy support to further strengthen Hillsboro's competitive advantage as a Pacific Northwest data hub for low latency, data intensive firms offering high "pull-through" potential.** Building on Hillsboro's existing position as a major west coast data hub, greater value add can be created by using data center investments to leverage higher employment uses increasingly reliant on data hub proximity especially with transition to data intensive research and applications as for AI, autonomous and EV vehicles.

Target & Supporting Industry Clusters

DLCD Division 9 guidance indicates that: "Plans may include policies to maintain existing categories or levels of industrial and other employment uses including maintaining downtowns or central business districts." Unlike many jurisdictions across the state, Hillsboro's Comprehensive Plan clearly emphasizes the importance of traded-sector and associated target industry retention, expansion and recruitment.

Continued prioritization of traded sector investment is warranted as a primary means for local economic prosperity and wealth creation. However, the pandemic has disproportionately and adversely affected local service businesses important to support the community's traded sector industry clusters. This suggests a bifurcated policy approach going forward – both for traded sector industry and for supporting industry clusters.

Traded Sector Target Industry Clusters. As in most communities, industry sectors targeted for business expansion and recruitment tend to change over time based on market dynamics – often in conjunction with public policy and/or incentive preferences. As shown by the following chart, Hillsboro's current **key industry** list is different and more streamlined than what was envisioned with the 2017 EOA.

Comparative Hillsboro Target Industry Clusters

2017 EOA Target Industry Clusters	Current Key Industries
• Computers & electronics manufacturing	
• Software & media	• Computers & electronics
• Health sciences & technology	• Software & information technology
• Health services	• Advanced manufacturing
• Data centers	• Bioscience & medical devices
• Amenity retail, recreation & hospitality	

Sources: 2017 EOA and City of Hillsboro website:
https://www.hillsboro-oregon.gov/our-city/departments/economic-development/key-industries

As in the past, Hillsboro may modify its priority industry clusters to reflect and serve new or emerging industry opportunities in the years ahead. This is similar to the approach that has been taken by Greater Portland, Inc. which also includes a key sector category for emerging industries.

For Hillsboro, this would recognize the potential to step in alongside and encourage sectors that are currently relatively weakly represented in Hillsboro but showing or with the potential to demonstrate growing competitive presence. Examples as identified by the employment trends analysis include the manufacturing sectors of food/textile, wood, chemical/plastic and non-metallic mineral manufacturing.

Priority consideration for business targeting might be provided to those emerging **traded sector** industries (or specific businesses) offering potential for strong employment, tax revenue, and/or supplemental business leveraging (or "pull-through" benefits).

Supporting Industry Clusters. Non-manufacturing sectors that have been under-represented but with growing local presence are construction, wholesale trade, transportation/warehousing, FIRE, professional, health/social and arts/entertainment/ recreation services. While many of these non-manufacturing firms serve primarily local markets, firms or industry segments that have a strong traded sector orientation to North American and/or global markets may be well positioned also to receive priority assistance.

Service sectors ranging from retail to dining have been most adversely affected throughout the pandemic and economic downturn. Small locally based business bring "unique flavor and flair" important for community identity but are most at risk now and going forward. There is pressure on tenant capacity to pay rent with resulting implications for landlords and lenders. Through the pandemic and now economic recovery, capital availability may affect those who survive versus those who have or will close their doors.

Implementation Measures. Recommended with this EOA are four implementation policies:

- **Periodically modify and update Hillsboro's current target industry listing to reflect and serve new or emerging traded sector industry opportunities in the years ahead.** This will yield greater opportunity and flexibility to respond to changing market conditions together with local needs and opportunities beyond what is currently most readily foreseen. Along with Hillsboro, Metro and state economic development organizations are showing increased flexibility in adjusting target industry and business clustering priorities as the need arises – a practice that Hillsboro can also apply based on state/regional priorities balanced by Hillsboro's own distinctive competitive attributes.
- **Retain existing businesses including those at risk of displacement from pandemic and/or economic downturn.** The goal is for a more resilient service sector economy, especially for retail, lodging and dining businesses that were disproportionately disadvantaged with the pandemic-related economic downturn.

- **Add policy language to expand business opportunities for minority- and women-owned businesses.** This can occur via programs that encourage small business investment and longer-term improvement of supplier linkages with tech employers.
- **Add a policy priority for community amenities that support traded sector business investment, talent recruitment/retention and high wage job potential.** This is of special importance for attracting and retaining younger workforce to Hillsboro as more of a full-service live-work-recreate community.

Workforce Readiness

While not explicitly called out by DLCD Division 9 administrative rules, workforce readiness is clearly indicated as an economic development resource to be addressed in conjunction with plan policies that may "emphasize the expansion of an increased productivity from existing industries and firms as a means to facilitate local economic development."

Workforce availability and skills (or readiness) is an issue of growing concern as documented by stakeholders with a range of local industries. Key issues include continuing retirement of the large *baby boomer* generation, workforce disruption by the pandemic (particularly as relates to child-care), lack of a nationally recognized metro area research university, and needed skills training for entry-level manufacturing workers.

In interviews with a range of business and community leaders, a recurring theme is the continuing if not intensified challenge of hiring and retaining qualified workforce. Despite these limitations, Hillsboro has the highest labor force participation rate in the metro area – including quality skill sets for bioscience, clean tech, information technology, and manufacturing industries.

Workforce training is expected to be increasingly important due to rapidly changing technology and career trajectories across the spectrum of K-12, higher education and on-going workforce development. Specifically referenced is the need for training tied to career and technical education (CTE) programs, linked more explicitly and with greater flexibility to meet employer-specified needs. This desire for workforce training that is ever more customized to employer needs appears to have intensified even through the pandemic.

Frequent mention with stakeholder interviews is made of the importance of partnering with interested institutions such as PCC, OHSU, PSU, OSU and Pacific University for apprenticeship and technical training – also internships. In addition to these higher education resources, the City of Hillsboro works with a range of local as well as state-level resource providers, including:

- **WorkSource Oregon**, sponsored by the Oregon Employment Department offers a one-stop solution to businesses for finding and retaining qualified employment candidates.
- **Worksystems, Inc.** designs and coordinates workforce development programs and services through a network of local partners – including employers, labor groups, community colleges, high schools and community-based and economic development organizations.

- **Enterprise Zone Workforce Development Program –** offers classroom and on the job training for groups of employees available through businesses located within Hillsboro's Enterprise Zone.
- **Prosperidad Economic Empowerment Center –** represents an alliance of community partners focused on employment and self-employment strategies.

Implementation Measures. Due to pandemic related business curtailments coupled with other economic fallout, the workers most adversely affected have been those in lower wage sectors including retail, hospitality and dining. These sectors also often have higher proportions of women and minorities – as employees and/or as small business owners. Key suggested implementation measures are to:

- **Include retraining emphasis for employees displaced in times of economic disruption and transition.** Getting workers up to speed with rapidly changing work force skills will persist as a higher priority with continued economic recovery and to maintain Hillsboro's long term competitive position for tech-adaptive existing and new employers.
- **Add policy language to expand employment opportunities for under-represented members of the community including racial/ethnic minority groups, women and veterans.** Attention to under-represented populations better addresses not only individual and community vitality objectives but also positions Hillsboro for greater diversity of talent going forward.
- **Coordinate with Washington County to evaluate the most effective Workforce Board arrangements in support of community workforce needs.** This could include partnership initiatives often utilizing existing resources as with the Hillsboro Advanced Manufacturing Work Group.
- **Support efforts to create new workforce development programs meeting the needs of target and emerging industries.** This suggests placing greater priority on reducing the time lag between industry-identified needs and workforce training delivery.
- **Pursue designation as a Center of Innovation Excellence and Regional Technology Hub to support Hillsboro's leadership role in research and development with expanded benefits to the community.** Hillsboro provides a unique opportunity to advance a key strategic objective of Oregon's *10-Year Innovation Plan* completed in 2021 to "support centers of innovation excellence that leverage Oregon's existing traded sector strengths and emerging market opportunities."

Economic Development Incentives

DLCD Division 9 guidance addresses plan policies that "include additional approaches" in support of economic development that cover but are not limited to such mechanisms as tax incentives and disincentives, preferential tax assessments, and property acquisition techniques. Also strongly encouraged are brownfield redevelopment strategies.

With an active in-house economic and community development department, the City of Hillsboro offers a variety of state and local incentive programs aimed to reduce a firm's cost of doing business. Some of the most prominent are noted as including:[7]

- **Enterprise Zone** – providing 100% property tax abatement for eligible businesses on new qualified capital assets (not currently on the tax rolls) within the designated enterprise zone for a three- to five-year period.
- **Strategic Investment Program** - exempting a portion of large new capital investments by *traded sector* businesses from property taxes for 15 years. A community service fee is paid each year to the local jurisdiction equal to 25 percent of the tax savings, up to a maximum of $2 million per year.[8]
- **Loan, Loan Guarantees and Bond Programs** – administered by Business Oregon and usually backed by Oregon Lottery funds.
- **Vertical Housing Development Zone** - offering a partial property tax exemption to mixed-use residential development within City-specified zones and extending larger tax incentives for development that includes affordable housing. Administered by the State until the end of 2017, the City has developed its program in concordance with Senate Bill 310, passed during the 2017 legislative session, giving control of the program to local jurisdictions.
- **Strategic Reserve Fund** – A discretionary Business Oregon incentive program focused on job creation/retention.
- **Business Expansion Program** – another Business Oregon resource available to existing companies expanding their operations in Oregon or new companies coming to the state. The program is cash based, usually in the form of a "forgivable loan" tied to the estimated increase in income tax revenue from new hiring associated with the project.
- **Opportunity Zones** – a federal program for properties within designated zones allowing investors to receive a capital gains benefit for investments made into historically impoverished areas.
- **Storefront Improvement Grants** – Grants administered and issued by Hillsboro using Downtown Urban Renewal dollars to match owner investment up to a maximum amount for storefront and building façade improvements.
- **Tenant Improvement Grants** – A matching fund grant administered by the City for tenant improvements involving existing food services businesses.

In addition to these direct tax and other funding incentive programs, the City of Hillsboro is actively engaged in or supporting other programs offering business and industry support – most notably for workforce and training, power utilities benefits, and large water user SDC deferrals/financing.

The role and the capacity of the public sector to effectively support economic recovery has been called into question across a variety of fronts. Issues cited by stakeholders include concerns with land availability and cost together with regulatory and tax issues.

Needs for a stable tax structure and funding for economic development incentives are noted as being of importance for business retention and recruitment going forward. The City of Hillsboro is complimented for its role in reaching out through the pandemic, "doing the right thing."

Bottom-line, targeted economic development incentives are recognized as having played an important role in attracting industrial investment to Hillsboro. Some industry and economic development stakeholders suggest that incentives be more narrowly targeted in the years ahead – to businesses that can demonstrate some combination of strong employment, tax revenue, and/or supplemental business leveraging benefits.

Implementation Measures. Suggested with this EOA is added policy language regarding implementation measures to:

- **Provide a more prominent position for incentive mechanisms as integral to supporting or facilitating achievement of economic goals and policies.** This can occur with active utilization of federal, state and regional programs together with publicized Hillsboro-specific economic development incentives.
- **More specifically include incentives as a means to leverage increased density with uses that currently are associated with relatively low job per acre counts.** Assumed is a long-term shift to more urbanized densities, transition from drive-alone commuting, potential for reduced at-grade parking footprint, and impetus for recycling of obsolete or redundant facilities – especially as current or prospective feasibility is demonstrated.
- **Advance incentives focused on land readiness together with land aggregation as needed for industrial expansion and recruitment.** A particular focus is on assuring capacity to serve expansion and attraction of major high-wage employers requiring large acreage sites.

Partnership Opportunities

This final topic is aimed to cover public-private partnerships and intergovernmental frameworks as objectives to be addressed in local jurisdiction EOAs. Public-private and intergovernmental partnerships have long been part of Hillsboro's civic and economic development DNA. The best opportunities going forward are to maintain and build on the partnerships already in place, adapted to new challenges that have emerged with the pandemic and attendant economic dislocation – extending beyond to longer term recovery and resilience.

Implementation Measures. As implementation measures, policy recommendations are to:

- **Include urban renewal as a potential economic development funding tool within designated renewal districts.** As has been demonstrated region-wide, broader application can extend use of this well-tested public/private investment tool beyond urban placemaking to also assist projects offering job-creating high wage employment.

- **Add policy language to more explicitly encourage Metro and state-wide support for Hillsboro tech-focused economic development as an economic engine of significance and benefit regionally and statewide.** Cited last but not least, obtaining support for tech-led Hillsboro investment may represent an increasingly pivotal commitment to raising the bar for economic vitality locally, regionally, and state-wide.

  Hillsboro's economic significance regionally and statewide might be further documented as with economic impact analysis. Analysis of direct and indirect effects could serve to demonstrate the interconnectedness of the metro and state economy and the roles that Hillsboro's leading edge tech industries play – not only for key traded sector industries but also with respect to region-wide housing location, transportation planning and related infrastructure investments.

  More recently, the impetus for statewide support for expanded semiconductor manufacturing is highlighted by recommendations of the Oregon Semiconductor Competitiveness Task Force in conjunction with federally authorized *CHIPS and Science Act of 2022.*

UPDATING COMPREHENSIVE PLAN GOALS & POLICIES

The approach taken with this 2021 EOA is to assure that updated economic development goals and objectives are integrated into the framework of the existing Comprehensive Plan rather than as separate stand-alone objectives/policies statements. Also assumed is an approach that may well involve refinement of the existing Comprehensive Plan goal/policy framework, rather than a wholesale re-work.

The chart provided on the next three pages re-states the goals and economic development policies cited earlier but with the addition of potential updates that reflect the policy recommendations made with this 2021 EOA – labelled within the following summary chart as ***EOA Update Notes***. Specific revisions to text language are not provided at this time but are appropriate for consideration as next steps with EOA adoption.

Current Comprehensive Plan Economic Development Goals & Policy Statements

GOAL 1	**COMPETITIVE ADVANGAGE:** Diversify and expand the economy to give Hillsboro, the region, and the state a competitive advantage.
ED 1.1	**Competitive advantage.** Maintain and strengthen the City's competitive economic advantages, including access to a highly-skilled workforce; vibrant local workforce development; business diversity; competitive business climate; quality educational institutions; and globally-competitive public facilities, utilities, and services.
ED 1.2	**Diverse range of employment opportunities.** Foster a diverse range of employment opportunities to benefit Hillsboro, the region, and the state.
ED 1.3	**Employment land supply.** Pursue an ample employment land supply to benefit Hillsboro, the region, and the state.
ED 1.4	**Traded-sector and target industry retention, expansion, and recruitment.** Sustain the ongoing vitality of the City's traded-sector and targeted industries by aligning plans and investments to retain, expand, and recruit employers and investment in Hillsboro.
ED 1.5	**Business innovation.** Facilitate scale-up and business innovation opportunities where new or incubating companies can create a sense of place and benefit from co-location, proximity to transit, affordable space, mentorship, and shared services.
ED 1.6	**Partnerships.** Leverage program and resource partnerships with local, regional, and statewide stakeholders, such as governments, educational institutions, economic development and business organizations, and major employers, to attract and retain employment and investment.
ED 1.7	**Economic resiliency.** Pursue collaborative and innovative approaches to strengthen and sustain Hillsboro, the region, and the state's economic resiliency.
ED 1.8	**Energy, water, and environmental challenges.** Reduce the vulnerability of Hillsboro, the region, and the state's economies to energy, water, and environmental challenges.
EOA Update Notes:	*Perhaps most important is to maintain and enhance Hillsboro's tech-forward edge & reputation:* • *Amend 1.1 to include high quality community amenities that support business investment & jobs* • *Amend 1.3 to indicate the role that adequate Hillsboro supply has in business investment regionally and regional/statewide need for large acreage, major employment campus sites* • *Amend 1.4 to list plans, <u>incentives</u> and investments; amend to reference current target industry clusters including emerging traded sector industries; also amend for periodic updating of target industry list and for land readiness including land aggregation as needed for industry expansion* • *Amend 1.5 to also indicate potential benefit from infrastructure investment for advanced technology* • *Amend 1.6 or add 1.9 to more explicitly encourage Metro and Oregon support for Hillsboro tech-focused economic development as an economic engine of significance regionally and statewide* • *Amend 1.7 to address the role Hillsboro's industrial base plays in supporting regional resiliency*
GOAL 2	**FACILITIES, UTILITIES & SERVICES:** Catalyze economic development through high quality public facilities, utilities, and services.
ED 2.1	**Competitive utilities**. Maintain existing public utility assets and invest in the expansion of high-quality utilities to catalyze economic development.
ED 2.2	**High-quality public facilities and services.** Maintain and invest in expansion of high-quality public facilities and services to catalyze economic development.
ED 2.3	**Multi-modal transportation.** Develop safe, well-connected, and efficient multi-modal transportation facilities that improve access to employment areas.
ED 2.4	**Hillsboro Airport.** Leverage the long-term viability of the Hillsboro Airport facility and support the long-term growth of critical airport infrastructure.

ED 2.5	**Freight facilities**. Support the development of a transportation system that places a strong emphasis on facilitating freight movement capabilities for economical and efficient goods movement.
ED 2.6	**Coordination of public facilities, utilities, and services.** Coordinate the type, design, timing, and location of public facilities, utilities, and services with other public agencies, utilities, the private sector, and property owners to move employment land closer to development-ready status.
ED 2.7	**Financing of public facilities, utilities, and services.** Adopt additional funding methodologies, as needed to fund the necessary extension of public facilities, utilities, and services.
EOA Update Notes:	*Much of Hillsboro's infrastructure focus is working well, except for inter-regional transport access:* • *Amend 2.1 to add "…or as needed to meet short-term land supply objectives"* • *Amend 2.3 or add new policy to encourage north-south access and reduced work-force commutes* • *Amend 2.7 to directly include urban renewal as a funding tool within designated renewal areas* • *Add 2.8 to encourage further strengthening Hillsboro's competitive advantage as a PNW data hub*
GOAL 3	**LAND SUPPLY:** Manage land supply to meet short and long-term economic development needs of Hillsboro, the region, and the state.
ED 3.1	**Supply of developable employment sites and flexibility.** Sustain a supply of developable employment sites and adequate flexibility to meet the short- and long-term needs of Hillsboro, the region, and the state.
ED 3.2	**Employment land designation.** Adopt land use designations in a manner that accommodates projected employment growth.
ED 3.3	**Employment land lot sizes.** Manage employment land to provide a range of available and developable lot sizes to accommodate a variety of uses, industry clusters, and emerging market opportunities.
ED 3.4	**Higher density employment land.** Pursue development of higher employment densities in areas with planned or existing enhanced transportation connectivity; access to transit; and public facilities, utilities, and services.
ED 3.5	**Health and education campuses**. Promote the stability and growth of health and education campuses as essential service providers, centers of innovation, workforce development providers, and major employers that can also provide amenities to surrounding neighborhoods.
ED 3.6	**Revitalization and reinvestment.** Support additional investment in existing Employment Areas, Regional Centers, Town Centers, and along targeted Corridor areas, such as assembly of existing small employment parcels for redevelopment, programs supporting adaptive reuse, and identification of options to mitigate and/or redevelop sites and structures.
ED 3.7	**Employment land supply.** Pursue additional employment land when the Hillsboro Planning Area will not accommodate the 20-year projected demand to meet local, regional, and state needs.
EOA Update Notes:	*This is probably the most pivotal section addressed with this EOA update. Potential policy revisions:* • *Amend 3.2 to indicate need for annexation and added served employment sites short-term* • *Amend 3.3 to provide opportunity for large acreage, major employer campuses of up to 600+ acres consistent with national trends but not readily available regionally in Oregon* • *Amend 3.4 to provide short- and long-term incentives for increased density with existing or prospective low density uses, increasing efficiency of employment land use where feasible* • *Amend 3.7 to indicate need for UGB expansion to meet the need for Scenario C projected demand; also to address longer-term 50-year or Scenario B potential* • *Add 3.8 to consider mixed-use without loss of job potential & where compatible with adjoining uses and not posing unreasonable risk to public health or safety* • *Add 3.9 monitoring provision to allow for changed land use forecast with next EOA update based on post-pandemic experience with work-at-home, FAR and changed transportation/parking patterns*

Current Comprehensive Plan Economic Development Goals & Policy Statements

GOAL 4	**EQUITY:** Promote economic development opportunities for individuals and small and emerging businesses to ensure equitable access to resources.
ED 4.1	**Individual training.** Encourage collaboration between local K-12 schools, trade schools, colleges, and employers to facilitate individuals' access to cutting-edge career development, workforce programs, technology, and other high-quality educational opportunities.
ED 4.2	**Entrepreneurial opportunities.** Expand opportunities for small business and business development across our diverse community.
ED 4.3	**Retain existing businesses.** Create strategies to retain existing businesses and mitigate displacement resulting from redevelopment and/or increasing land values.
EOA Update Notes:	*Emphasized is the need to improve equitable outcomes for those displaced by pandemic & downturn:* • *Amend 4.1 to address retraining for employees displaced in times of economic disruption & transition, also coordination with the Workforce Board, support of target and emerging industries, and pursuing designation as a Center of Innovation Excellence and Regional Technology Hub* • *Amend 4.2 to explicitly reference minority and women-owned businesses* • *Amend 4.3 to add measures to mitigate displacement due to pandemic and/or economic downturn*
GOAL 5	**LIVABILITY:** Develop and sustain a vibrant City to support economic development.
ED 5.1	**High-quality public realm.** Plan, develop, and enhance a high-quality public realm that complements adjacent development and uses.
ED 5.2	**Development impacts.** Ensure architectural and site designs that enhance and complement surrounding neighborhoods and that respect the fundamental characteristics of applicable Hillsboro design type designations.
ED 5.3	**Innovative architecture and site design**. Facilitate innovative architectural and site designs that complement and enhance the public realm, particularly at the edges of development sites, to enhance their integration into adjacent uses.
ED 5.4	**Distribution of commercial areas.** Disperse the types and sizes of commercial opportunities throughout the City in proportion to the needs of the area.
ED 5.5	**Shopping, dining, entertainment, and recreation options.** Facilitate and disperse an array of shopping, dining, entertainment, and recreation options throughout the City that help attract and retain employers.
ED 5.6	**Employee housing choice.** Provide a wide range of housing choices to accommodate employees with diverse needs who want to work and live in Hillsboro.
ED 5.7	**Locational compatibility.** Focus economic development in Employment Areas, Regional Centers, Town Centers, Neighborhood Centers, and along Corridors.
ED 5.8	**Innovation economy.** Plan for new and innovative economic trends, such as the sharing economy.
ED 5.9	**Environmental sustainability.** Pursue environmental sustainability actions that aim to preserve natural resources and reduce environmental impacts.
EOA Update Notes:	*Revise to reflect ways in which public perceptions of livability may change, as for a younger demographic:* • *Amend 5.1 to also support public health and safety* • *Amend 5.4 to encourage business repositioning and resizing to meet changing consumer needs* • *Amend 5.6 to reference affordability and include those who want to live in close proximity to work* • *Amend 5.8 to include more work-at-home options and pioneering role for tech-forward communities* • *Possibly amend 5.9 to encourage mitigation options for improved site coverage & job density*

Sources: City of Hillsboro Comprehensive Plan &. E.D. Hovee. ***Update notes*** are preliminary, subject to refinement.

APPENDIX E. EMPLOYMENT BUILDABLE LANDS INVENTORY

As described in the 2021 EOA report and by Appendix C to this appendices document, and in response to the LUBA remand related to redevelopment potential with "developed lands," the City of Hillsboro retained the planning firm MIG to prepare an amended employment Buildable Lands Inventory (BLI). The following memorandum of May 13, 2024 describes the methodology and resulting outputs of this amended inventory.

The amended BLI reflects employment BLI conditions as of December 2020. This is consistent with the 2020-40 time frame considered as the 20-year forecast planning horizon for Hillsboro's 2021 Economic Opportunities Analysis.

Outputs of this amended BLI have been incorporated as the supply determinations included with the Chapter IV EOA evaluation of Employment Land Needs.

HILLSBORO EMPLOYMENT BUILDABLE LANDS INVENTORY

Memorandum

May 13, 2024

Introduction

This memorandum describes the methodology and draft results of the Employment Buildable Lands Inventory (Employment BLI) for the City of Hillsboro conducted in 2023/2024 to support the City's long-range planning for employment lands. This information will inform an update of the City's 2021 Economic Opportunities Analysis (EOA), prepared by E.D. Hovee & Company, LLC.

Generally, this methodology is based on the approach used in the 2018 Metro Buildable Lands Inventory[1] with updates as noted.

The BLI is conducted in the following steps:

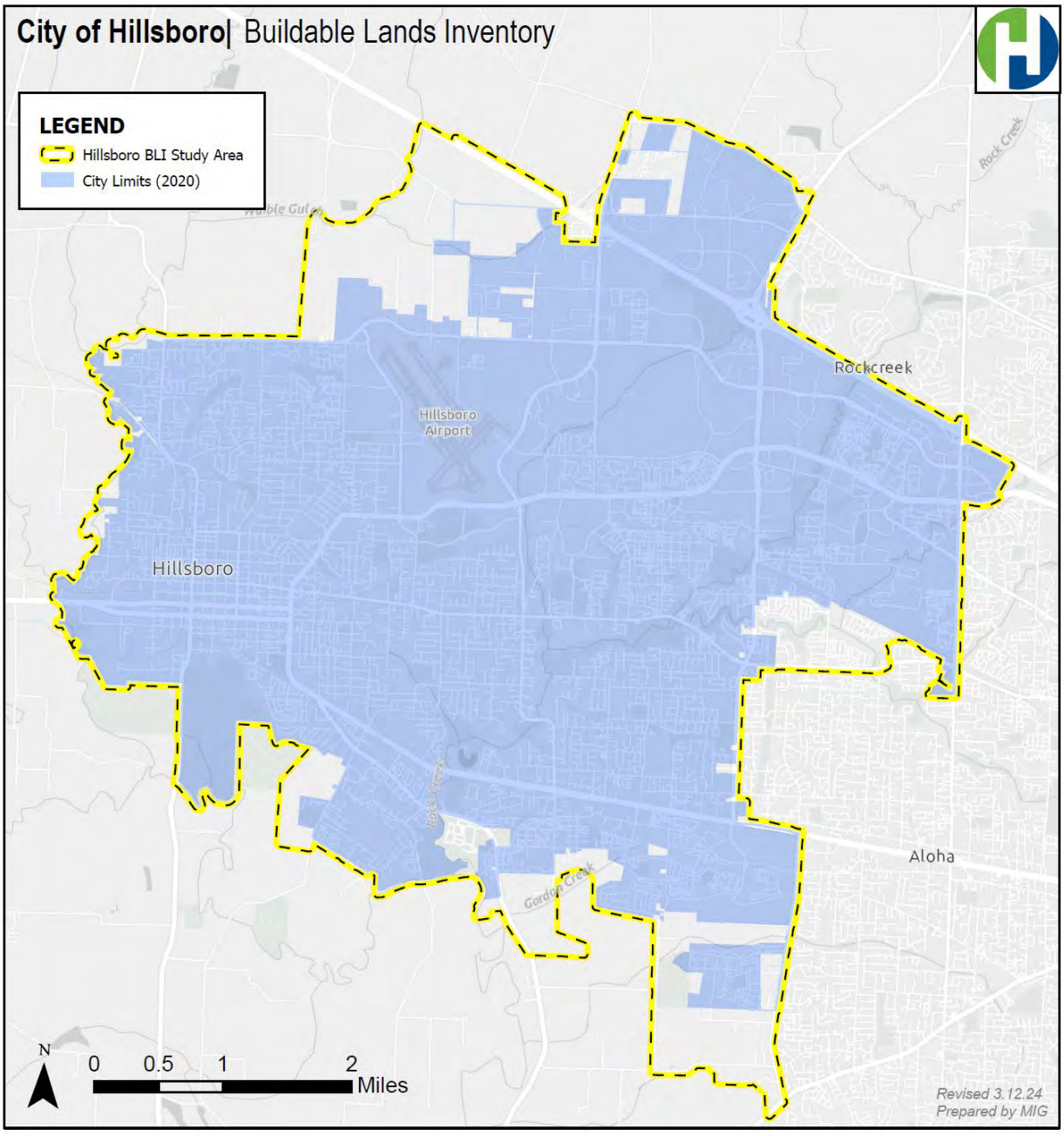
- **Step 1: Land classification.** This step identifies the land in the City that is available for employment uses.
- **Step 2: Constraints to Development.** This step identifies constraints such as natural resources, steep slopes, and utility easements that limit development.
- **Step 3: Development Status.** This step assigns a "Development Status" of vacant, partially vacant, or developed to tax lots in the inventory.
- **Step 4: Net Buildable Area.** This step removes land for future rights-of-way and other land needs to provide a net number of acres for each City zoning designation.
- **Step 5: Redevelopment.** This analysis includes an assessment of potentially redevelopable sites in the City and adjacent growth areas.

[1] https://www.oregonmetro.gov/sites/default/files/2018/07/03/UGR_Appendix2_Buildable_Lands_Inventory.pdf

Study Area

The study area for this analysis is shown in Figure 1. The study area includes land within the Hillsboro City Limits, as well as adjacent areas within the Urban Growth Boundary (UGB) around Hillsboro.

FIGURE 1. STUDY AREA MAP



Step 1: Land Classification

Parcels in the inventory are categorized based on their Comprehensive Plan designations, zoning designations, property ownership, and other characteristics. These classifications are described below.

Comprehensive Plan and Zoning Districts

A list of the City of Hillsboro's Comprehensive Plan Districts is shown in Table 1. Commercial, Industrial, and Mixed Use lands are included in this inventory.

TABLE 1. CITY OF HILLSBORO COMPREHENSIVE PLAN AND ZONING DISTRICTS

Comprehensive Plan Designations	Implementing Zones	Purpose
C: Commercial	• C-G Commercial – General • C-N Commercial – Neighborhood • MU-C Mixed-Use – Commercial	Provides for retail, service, and office commercial developments in small-scale neighborhood nodes to serve daily community needs or at larger scales along highways and transit routes, or in downtown and other employment areas, for more convenient access to goods and services by various transportation modes.
IN: Industrial	• I-G Industrial General • I-P Industrial Park • I-S Industrial Sanctuary • SSID Shute Road Special Industrial District • ESID Evergreen Area Special Industrial District • HSID Helvetia Area Special Industrial District	Provides for all types of research and development, manufacturing, warehouse, and wholesale industrial, which may take a traditional form concentrated along highways and freight and transit routes, or as industrial park neighborhoods or mixed commercial business parks with high-amenity multi-modal access.
MU: Mixed-Use	• MU-N Mixed-Use – Neighborhood • MU-C Mixed-Use – Commercial • MU-VTC Mixed-Use – Village Town Center • UC-NC Urban Center – Neighborhood Center	Provides for a mix of commercial and residential uses on the same site, either horizontally side-by-side or vertically in the same structure, in appropriate locations to shorten transportation trips and facilitate multi-modal development.
MU-UR: Mixed-Use – Urban Residential	• UC-RM Urban Center – Residential Medium Density • UC-MU Urban Center – Mixed-Use Urban Density	Provides for a range of medium- to high-density housing types (e.g., townhomes, apartments, and condominiums) with an urban character, constructed at or near the

Comprehensive Plan Designations	Implementing Zones	Purpose
		street frontage and sidewalk, while also accommodating complementary office and retail, and schools, assembly facilities, and parks.
MU-UC: Mixed-Use – Urban Commercial	• UC-AC Urban Center – Activity Center	Provides for a vibrant mix of retail, restaurants, civic, cultural, entertainment, and recreational uses, complemented by secondary office and residential uses, creating focused activity served by high-capacity transit and active street frontages that provide visual and physical connections to other activity centers.
MU-UE: Mixed-Use – Urban Employment	• UC-MU Urban Center – Mixed-Use Urban Density • UC-OR Urban Center – Office/Research	Provides concentrated opportunities for office and research employment to complement residential, retail, and commercial services within high intensity areas of the City served by transit that provide visual and physical connections to other activity centers.
MU-I: Mixed-Use – Institutional	• UC-MU Urban Center – Mixed-Use Urban Density • UC-OR Urban Center – Office/Research • UC-RP Urban Center – Research Park	Provides for a range of research, development, and testing laboratory; educational; medical research and clinical; and high-tech and bio-tech research and applied technology uses, encouraging a transit-supportive, pedestrian-sensitive campus environment, and preventing conflicts among the mix of uses and activities.
SCPA: Station Community Planning Area	• SCR-LD Station Community Residential Low Density • SCR-OTC Station Community Residential Orenco Townsite Conservation • SCR-DNC Station Community Residential Downtown Neighborhood Conservation • SCR-MD Station Community Residential – Medium Density • SCR-HD Station Community Residential – High Density	Provides for medium- to high-density transit-oriented and pedestrian-sensitive mixed-use developments, authorized at more intensive land use densities and floor area ratios than other residential zones, in areas within reasonably close proximity of light rail transit stations.

Comprehensive Plan Designations	Implementing Zones	Purpose
	• SCC-DT Station Community Commercial – Downtown • SCC-SC Station Community Commercial – Station Commercial • SCC-MM Station Community Commercial – Multi-Modal • SCR-V Station Community Residential Village • SCBP Station Community Business Park • SCI Station Community Industrial • SCFI Station Community Fair Complex Institutional	
RL: Residential Low Density	• R-10 Residential • R-8.5 Residential • R-7 Residential • R-6 Residential	Primarily large to moderate lot, detached residential development, middle housing, and accessory dwelling units.
RM: Residential Medium Density	• R-4.5 Residential • MR-1 Multi-Dwelling Residential	Primarily a mix of small-lot single detached dwellings, second dwellings, duplexes, triplexes, quadplexes, townhomes, cottage clusters and lower density multi-dwelling units.
RH: Residential High Density	• MR-2 Multi-Dwelling Residential	Primarily higher density middle housing or multi-dwelling developments.
RMR: Residential Mid-Rise Density	• MR-3 Multi-Dwelling Residential	Primarily higher density middle housing or multi-dwelling developments.
OS: Open Space	• All base zones are considered implementing zones.	Provides usable open space for active or passive recreation (e.g., parks, golf courses, playgrounds) and unusable open space for natural resource preservation as an important aspect of livability, public health, and well-being for residents, employees, and customers.
FP: Floodplain	• All base zones are considered implementing zones. The corresponding RFO Regulatory Floodplain Overlay zone may be applied.	Identifies the boundaries of the 100-year base flood maps by the National Flood Insurance Program for agricultural, wetland, or recreational use, or some

Comprehensive Plan Designations	Implementing Zones	Purpose
		underground utility or accessory structures in order to protect the public from damage to life and property from flooding.
PF: Public Facility	• SCFI Station Community Fair Complex Institutional	Provides for public facilities such as airports, schools, fire stations, police stations, public buildings (e.g., libraries, public offices), public utilities (e.g., wastewater treatment center) and similar types of public uses and facilities.

FIGURE 2. CITY OF HILLSBORO COMPREHENSIVE PLAN DESIGNATIONS

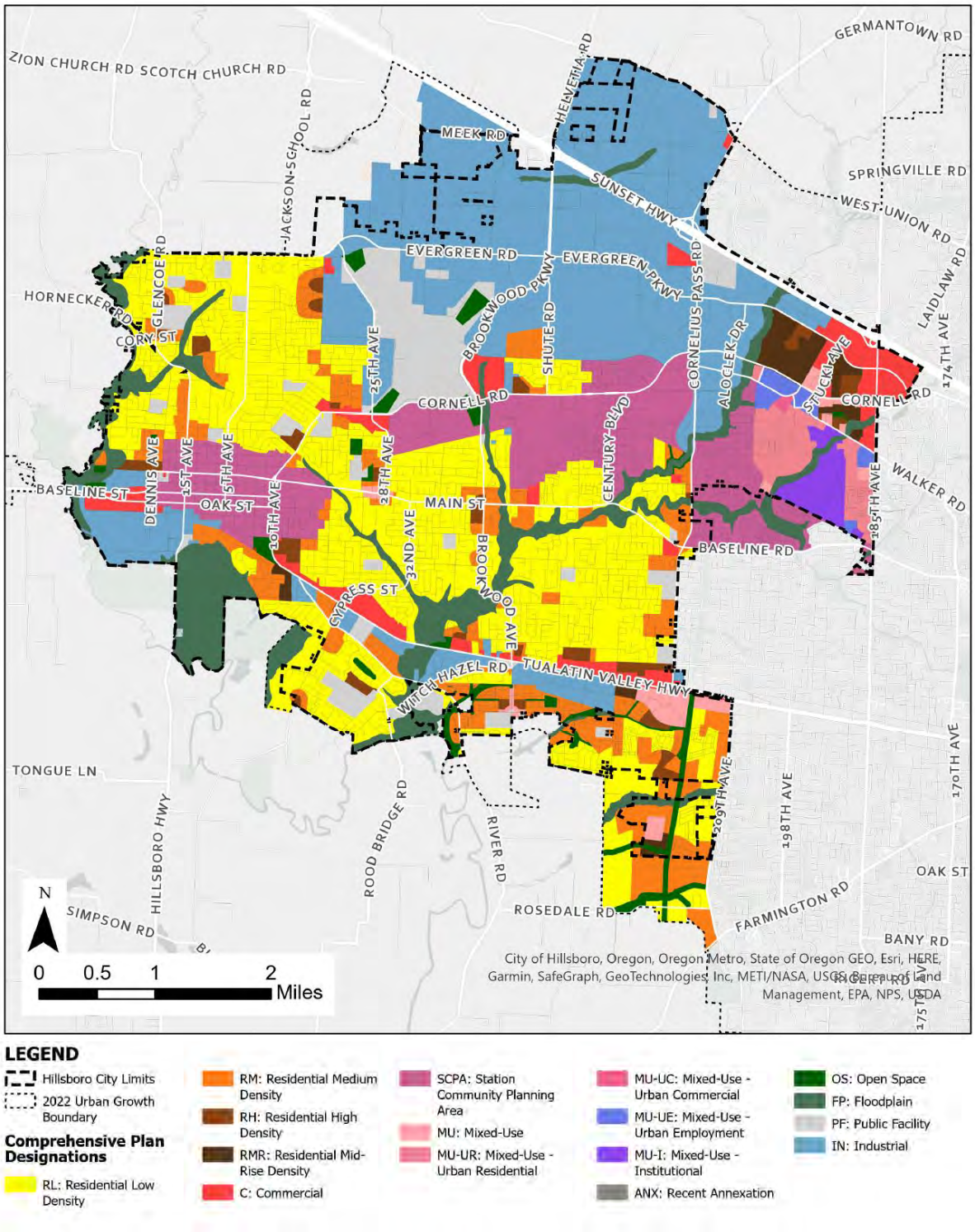
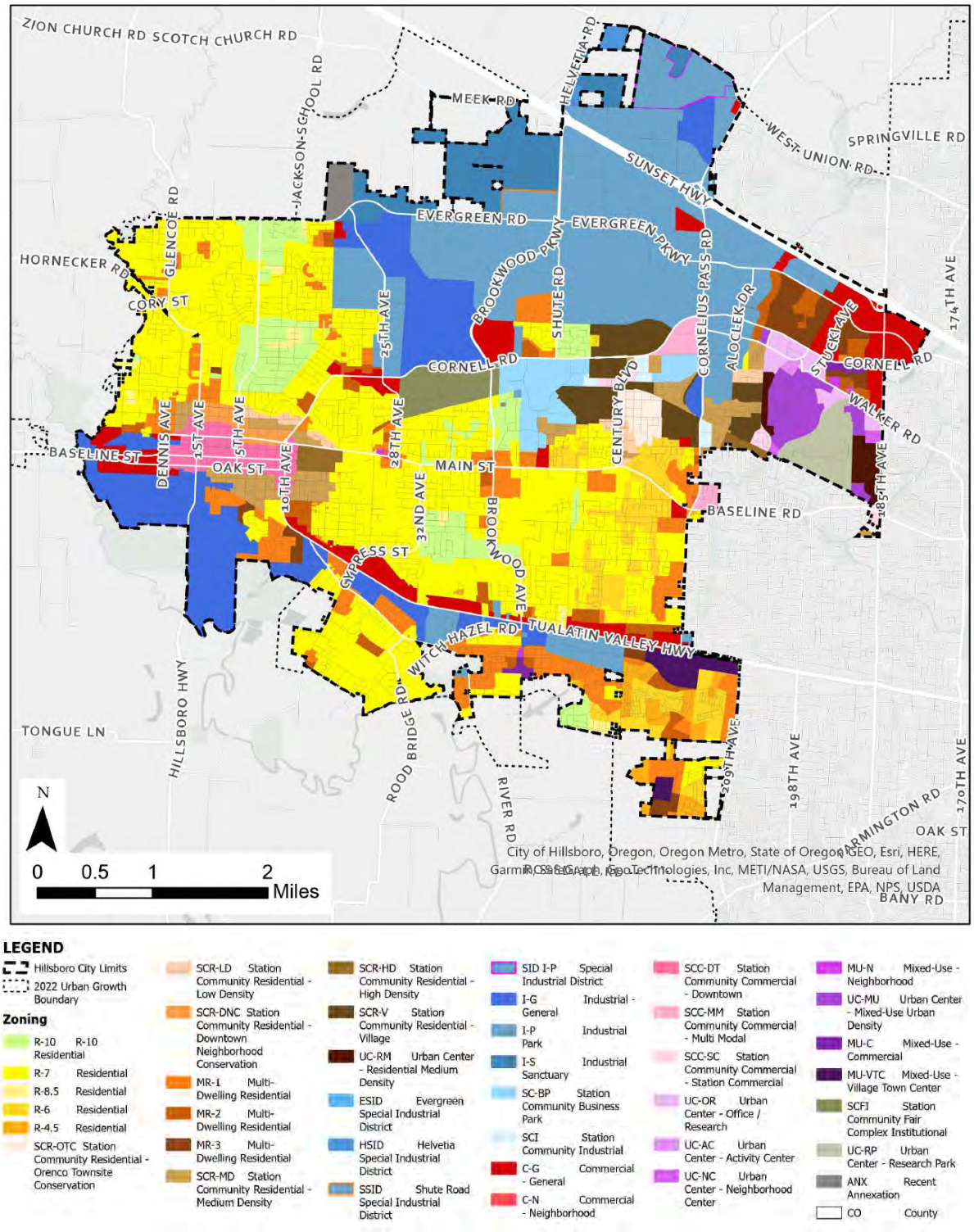


FIGURE 3. CITY OF HILLSBORO ZONING DESIGNATIONS



LEGEND

- Hillsboro City Limits
- 2022 Urban Growth Boundary

Zoning

- R-10 R-10 Residential
- R-7 Residential
- R-8.5 Residential
- R-6 Residential
- R-4.5 Residential
- SCR-OTC Station Community Residential - Orenco Townsite Conservation
- SCR-LD Station Community Residential - Low Density
- SCR-DNC Station Community Residential - Downtown Neighborhood Conservation
- MR-1 Multi-Dwelling Residential
- MR-2 Multi-Dwelling Residential
- MR-3 Multi-Dwelling Residential
- SCR-MD Station Community Residential - Medium Density
- SCR-HD Station Community Residential - High Density
- SCR-V Station Community Residential - Village
- UC-RM Urban Center - Residential Medium Density
- ESID Evergreen Special Industrial District
- HSID Helvetia Special Industrial District
- SSID Shute Road Special Industrial District
- SID I-P Special Industrial District
- I-G Industrial - General
- I-P Industrial Park
- I-S Industrial Sanctuary
- SC-BP Station Community Business Park
- SCI Station Community Industrial
- C-G Commercial - General
- C-N Commercial - Neighborhood
- SCC-DT Station Community Commercial - Downtown
- SCC-MM Station Community Commercial - Multi Modal
- SCC-SC Station Community Commercial - Station Commercial
- UC-OR Urban Center - Office / Research
- UC-AC Urban Center - Activity Center
- UC-NC Urban Center - Neighborhood Center
- MU-N Mixed-Use - Neighborhood
- UC-MU Urban Center - Mixed-Use Urban Density
- MU-C Mixed-Use - Commercial
- MU-VTC Mixed-Use - Village Town Center
- SCFI Station Community Fair Complex Institutional
- UC-RP Urban Center - Research Park
- ANX Recent Annexation
- CO County

Employment Land

Employment land includes the sub-categories of **Commercial Land** and **Industrial Land**, described below.

Commercial Land

Commercial land is identified as land within the C comprehensive plan designation or zoning designations of C-G or C-N. This land is intended to provide for retail, service, and office commercial developments.

Industrial Land

Industrial land is identified as land within the IN designation, intended to provide for all types of research and development, manufacturing, warehouse, and wholesale industrial uses.

Mixed Use Land

Mixed Use land can be developed to meet the City's residential and employment needs – sometimes within the same structure. It includes land within the SCPA, MU, MU-UR, MU-UC, MU-UE, MU-I designations, unless it meets the criteria for "Public/Other" land. Mixed-use land is assumed to be partially available for employment uses as described in later steps.

Non-Employment Land

Non-employment land includes land designated for residential uses, land that is owned by a public or semi-public entity and not set aside for employment uses, and certain other categories as follows.

Residential Land

Residential land has a comprehensive plan of RL, RM, RH, and RMR designations. Residential land is assumed to be unavailable for employment uses.

Publicly Owned/Other

This category of land includes the PF and OS designations, as well as land in the following categories:

- Land in another Comprehensive Plan designation under City, County, State, Federal, or Special District Ownership
- Land commonly held in HOA ownership, such as required open space.
- Private driveways and ROW

Parcels in this category may be included in other classifications if information is available to suggest development capacity for residential or employment uses.

Step 2: Constraints to Development

One of the primary tasks of this BLI is to identify land that is constrained by one or more of the following physical constraints. Constraints may overlap one another spatially – in this case the more restrictive constraint applies.

Constraints are described in **Error! Reference source not found.** 2 and shown on Figure 4.

FIGURE 4. CONSTRAINTS TO DEVELOPMENT

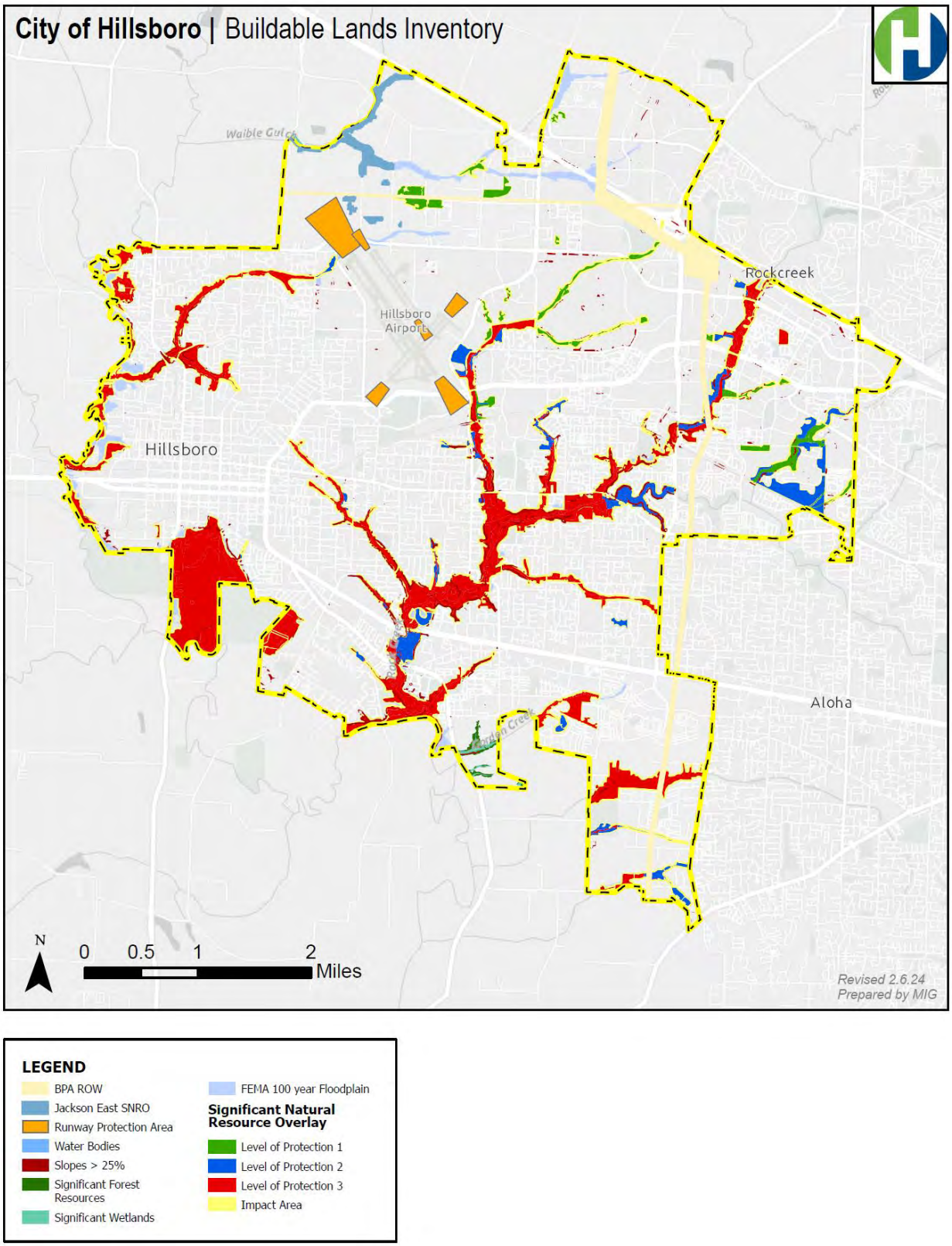


TABLE 2. DEVELOPMENT CONSTRAINTS

Constraint	Description	Developable Portion
Steep Slopes	Slopes greater than 25%	0% Developable
Water Bodies	Includes lakes, streams, other areas of open water	0% Developable
FEMA Floodway	The channel of a river or watercourse and adjacent lands that must be reserved in order to convey floodwaters	0% Developable
FEMA 100 Year Floodplain	The floodway plus floodway fringe, calculated to convey a 2% annual chance (100-year) flood	0% Developable
Significant Wetlands	Areas identified in City wetland inventories.	0% Developable
Significant Forest Resources	Areas identified in Significant Forest Resources inventories	0% Developable
Significant Natural Resources Overlay (SNRO)	Disturbances greater than 500' generally require permit and mitigation per Development Code 12.27.220	0% Developable
Jackson East SNRO	Overlay to protect natural resources in the Jackson East area	0% Developable
BPA easements	Land controlled by the Bonneville Power Administration; development is very limited.	0% developable
Airport Runway Protection Area	Airport Runway Protection Area prohibits most uses, and is identified as a constraint. Other airport zones can develop with some restrictions.	0% developable

Each taxlot in the study area receives the following attribute fields based on the location of constraints.

- GIS Acres – Total size of the parcel
- Constrained Acres – Acreage of constrained areas, per Table 2.
- Unconstrained Acres – GIS acres minus Constrained Acres

Step 3: Development Status

Each parcel in the study area is categorized as Vacant, Developed, or Partially Vacant.

Vacant parcels (including parcels with low-value structures) are assumed to have development capacity equal to the area unconstrained by natural resources, minus additional set-asides for future Right-of-Way and infrastructure.

Developed parcels are subject to further screening for redevelopment potential, described below and in Step 5.

Partially Vacant parcels have existing development but some portion of the site is available for future employment uses.

These parcels are identified as follows:

- Industrial Zones: Site has greater than 1 acre of unconstrained vacant land, as visible on aerial photo
- Commercial Zones: Site has greater than ½ acre of vacant land, as visible on aerial photo
- Mixed Use Zones: Site has greater than ½ acre of vacant land, as visible on aerial photo
- Jackson East Area: This portion of the city has many existing rural homes, which are generally excluded from the developable area.

Additionally, “Developed” parcels received two screens to determine whether a portion of the site would support additional employment area, in which case the parcel was recategorized as "Partially Vacant.”

- Parcels were compared to the Metro Regional Land Inventory System (RLIS) inventory of vacant land, and tax lots intersecting vacant areas (as identified by GIS polygons) were recategorized as "Partially Vacant."
- Aerial Photo Review. Employment parcels were reviewed based on aerial photography. Land with remaining developable acreage categorized as "Partially Vacant" and capacity was estimated on a case-by-case basis.

Estimates of developable area have been created on these parcels using aerial photo review, comparison to Metro Vacant Land Inventory, and City staff input.

Approximating Development Status of December 2020

This Employment BLI was prepared by MIG with input from the City of Hillsboro in 2023 using data from 2023. In order to be consistent with employment forecasts and other information in the 2021 EOA, the City of Hillsboro updated the inventory to reflect the development status of parcels as of December 2020, as follows:

Inputs:

- 2023 EBLI (prepared by MIG, see Step 1 through Step 3 in this methodology)
- December 2020 UGB (reproduced from Metro RLIS UGB History data set)
- December 2020 Hillsboro city limits (provided by City of Hillsboro)

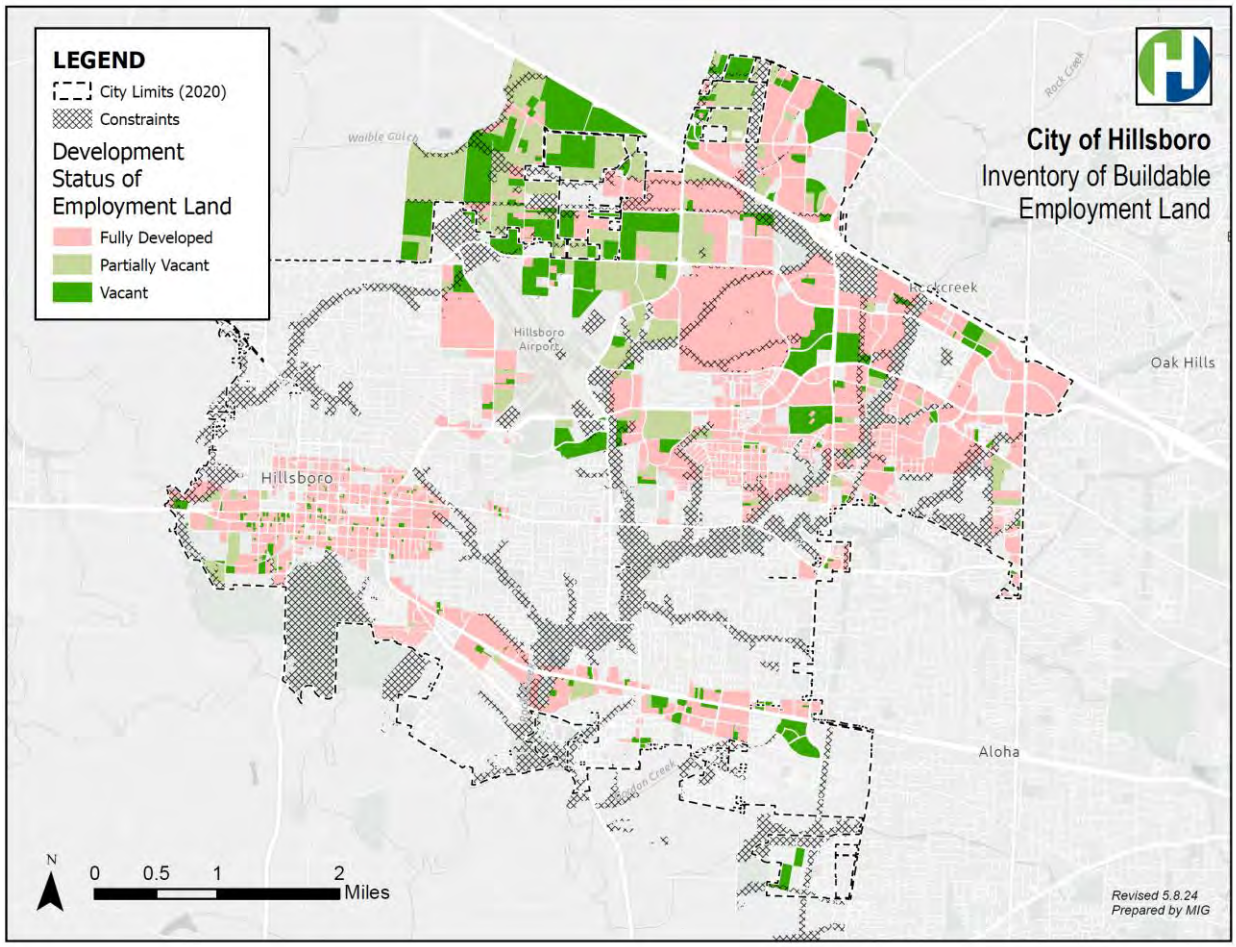
- November 2020 tax lots (provided by Metro)
- December 2020–February 2021 aerial image (provided by Metro)
- Aerial imagery:
    - December 2020–February 2021 aerial image (provided by Metro)
    - July 2020 aerial image (provided by City of Hillsboro)
    - July 2021 aerial image (provided by City of Hillsboro)
    - June 2023 aerial image (provided by City of Hillsboro)
- Report of issued permits for which Transportation Development Tax (TDT) was assessed in North Hillsboro between January 1, 2019 and December 31, 2020 (provided by City of Hillsboro)
- Hillsboro Airport's Runway Protection Zone (provided by City of Hillsboro)

Methodology to update Development Status:

1. Imported 2023 EBLI, December 2020 UGB, December 2020 Hillsboro city limits, November 2020 tax lots, aerial imagery, and Hillsboro Airport's Runway Protection Zone.
2. Isolated November 2020 tax lots within the December 2020 Hillsboro city limits and within expansion areas inside the December 2020 UGB.
3. Added 2020 development status field to November 2020 tax lots.
4. Applied 2023 development statuses to November 2020 tax lots.
5. Updated 2020 development status field to reflect changes both visible in aerial imagery and from November 2020 tax lot building values (e.g., development of previously vacant tax lots, demolition of structures on previously developed tax lots, etc.).
6. Updated 2020 development status field to reflect vacant or partially developed tax lots that received permits between January 1, 2019 and December 31, 2020.
7. Updated 2020 development status field to "Public/Other" for tax lots significantly constrained by the Hillsboro Airport Runway Protection Zone.

Development status of land in the study area is shown in Figure 5. Table 3 describes the development status of employment land in the inventory.

FIGURE 5. DEVELOPMENT STATUS



Step 4: Converting Gross Acreage to Net Employment Area

Right of Way and Other Set-Asides

As part of the development process, land for roads, infrastructure, open space and other needs reduce the gross acres into a net developable acreage. This BLI uses the following assumptions to calculate net developable acreage for each parcel.

- Commercial zones: 25%
- Industrial Zones: 25%
- Mixed use zones: 25%

Residential Mix in Mixed Use Designations

The following assumptions address the proportion (by land area) of development in mixed use zones that is expected to occur as employment uses, the remainder of which is assumed to be developed with non-employment uses.

TABLE 3. RESIDENTIAL AND EMPLOYMENT MIX ASSUMPTIONS FOR MIXED-USE AREAS

Mixed Use Zone	Employment Percentage	Residential Percentage
Mixed Use – Commercial	40%	60%
Mixed Use – Neighborhood	20%	80%
Mixed Use – Village Town Center	40%	60%
Station Community – Business Park	100%	0%
Station Community Commercial – Downtown Zone	70%	30%
Station Community Commercial – Multi-Modal Zone	60%	40%
Station Community Commercial -Station Commercial	50%	50%
Station Community Residential – Downtown Neighborhood Conservation	10%	90%
Station Community Residential – High Density	20%	80%
Station Community Residential – Low Density	10%	90%
Station Community Residential – Medium Density	15%	85%
Station Community Residential – Orenco Town Center	10%	90%
Station Community Residential – Village	20%	80%
Urban Center – Activity Center	40%	60%
Urban Center – Mixed-Use Urban Density	20%	80%
Urban Center – Residential Medium Density	20%	80%

Step 5: Redevelopment

This Employment BLI evaluates the redevelopment potential of employment parcels categorized as "Developed." This test is an estimate commonly used to evaluate redevelopment potential at a high level, though there are many factors that will ultimately determine the redevelopment of a given parcel.

1. **Strike Price Analysis.** The "strike price" is a value per square foot at which a developer can afford to purchase the property and theoretically redevelop profitably. The 2018 Metro Urban Growth Report's BLI estimated strike prices for various land uses and locations throughout the region. Strike prices used for this analysis are greater than those identified for suburban jurisdictions in the 2018 report to account for inflation of land values between 2018 and 2020. Acreage thresholds remain the same; industrial land less than 1 acre and commercial land less than .25 acres is excluded. Mixed use land is assumed to develop partially with residential uses as described in Table 2. Redeveloping parcels are not assumed to have further takeouts for right-of-way and other infrastructure.

   The results of the strike price analysis are summarized in Table 4. There are a total of 65 taxlots that meet the size and strike price, encompassing an estimated 143 acres of

employment land in the study area. Roughly 85% of the redevelopable land in this analysis is in industrial categories.

TABLE 4 STRIKE PRICE SIZE AND VALUE THRESHOLDS

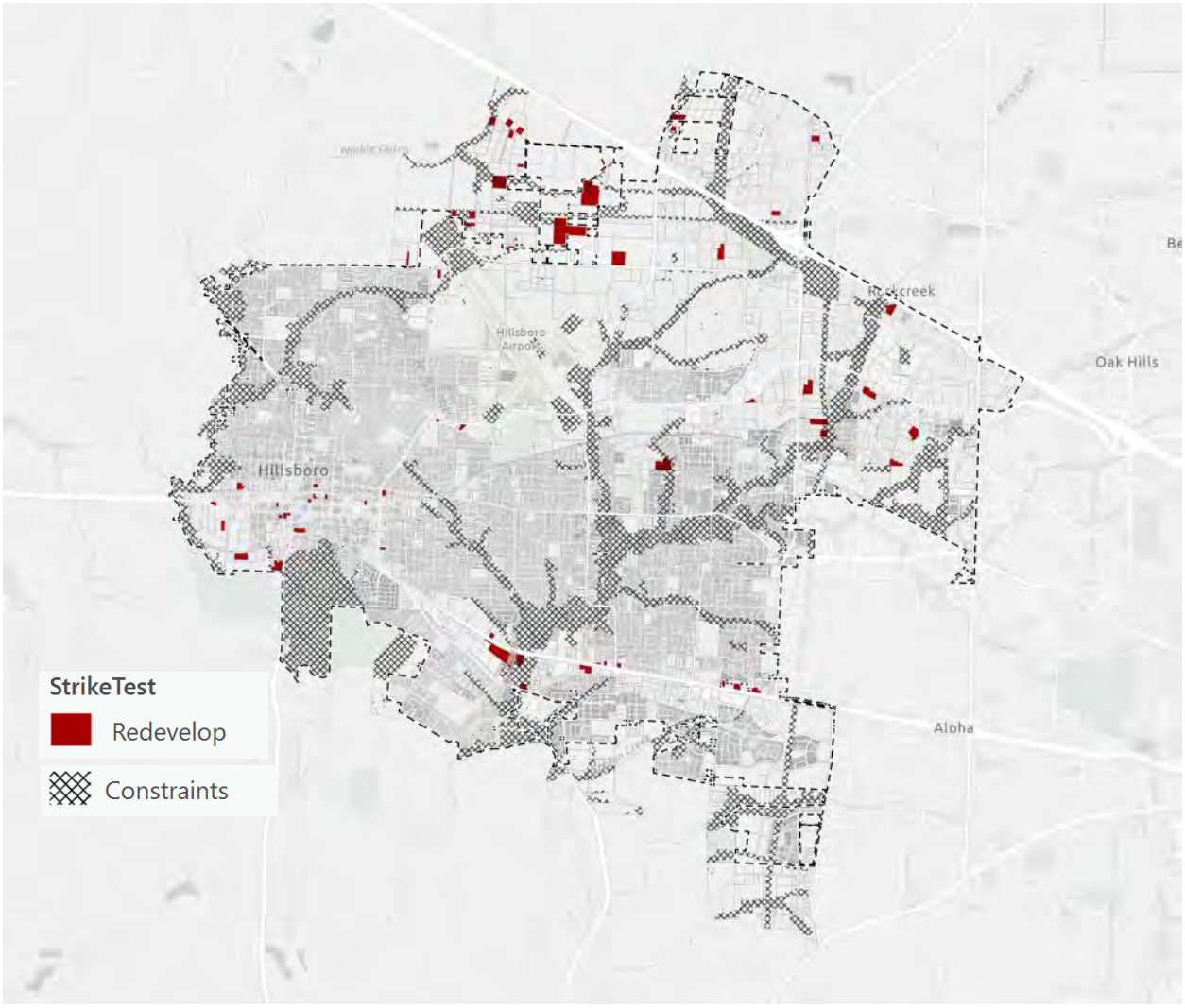
Category	Zone	Value/SF	Size (Acres)
Commercial	C-G	$13	0.25
Commercial	C-N	$13	0.25
Industrial	I-G	$8	1
Industrial	I-P	$10	1
Industrial	I-S	$10	1
Industrial	SC-BP	$10	1
Industrial	SCI	$10	1
Industrial	SSID	$10	1
Industrial	ESID	$10	1
Industrial	HSID	$10	1
Industrial	SID-IP	$10	1
Industrial	N/A (Outside City Limits)	$8	1
Mixed Use	SCC-DT	$15	0.25
Mixed Use	SCC-MM	$15	0.25
Mixed Use	SCC-SC	$15	0.25
Mixed Use	MU-C	$15	0.25
Mixed Use	UC-OR	$15	0.25
Mixed Use	UC-MU	$15	0.25

TABLE 5. STRIKE PRICE ANALYSIS SUMMARY – PARCELS AND ACREAGE WITH REDEVELOPMENT POTENTIAL

Zone	Number of Taxlots	Total Acreage	Unconstrained Acreage	Gross Employment Area
Industrial	**39**	**150.7**	**122.9**	**122.9**
Outside City Limits (Industrial)	14	31.9	18.1	18.1
I-G	9	44.4	30.6	30.6
I-P	7	23.0	18.5	18.5
I-S	4	33.5	43.2	43.2
SC-BP	2	7.3	1.9	1.9
SID I-P	1	2.2	2.2	2.2
SSID	2	8.4	8.4	8.4
Commercial	**12**	**10.1**	**10.1**	**10.1**
C-G	11	9.7	9.7	9.7
C-N	1	0.4	0.4	0.4
Mixed Use	**14**	**18.2**	**18.2**	**10.4**
SCC-DT	10	5.7	5.7	4.4

Zone	Number of Taxlots	Total Acreage	Unconstrained Acreage	Gross Employment Area
SCC-MM	1	1.2	1.2	0.9
UC-MU	2	7.0	6.9	2.8
UC-OR	1	4.3	4.3	2.4
Total	**65**	**179.0**	**151.2**	**143.4**

FIGURE 6. PARCELS WITH REDEVELOPMENT POTENTIAL THROUGH STRIKE PRICE TEST



Summary and Use of Redevelopment Information

There are many variables that determine whether an individual site will redevelop, including property owner willingness, the availability of other suitable sites, and macroeconomic factors. This analysis has identified roughly 143 gross acres of land on which redevelopment for employment uses may be economically viable, based on available data. The EOA report discusses the extent to which this redevelopment information can be relied upon to accommodate future employment needs for the City.

Summary

The results of this inventory are described in the following tables. Key points include:

- The study area contains a total of **1,225 acres of net employment acreage**, accounting for constrained areas, lots with remaining capacity, and future rights-of-way and infrastructure needs. This amount does not include the 143 acres of potentially redevelopable land from Table 5.
- **Over 90% of this land is in industrial designations**, and about half of this land is outside the 2020 City Limits.
- **Over half of the net employment acreage** is on lots with a gross area of 20 acres or greater.

FIGURE 7. SUMMARY OF BUILDABLE EMPLOYMENT LAND BY ZONE

	DEVELOPED		PARTIALLY VACANT		VACANT		TOTAL			
	Number of Lots	Total Acres	Number of Lots	Total Acres	Number of Lots	Total Acres	Number of Lots	Total Acres	Buildable Area	Net Employment Area
Industrial	**871**	**2,098.9**	**105**	**1,063.8**	**168**	**1,060.6**	**1,144**	**4,223.3**	**1,490.6**	**1,117.9**
HSID	-	-	-	-	6	35.7	6	35.7	32.7	24.5
I-G	444	230.8	18	68.4	37	46.6	499	345.7	53.5	40.1
IND (Jackson East)	53	80.2	52	540.2	37	422.3	142	1,042.6	748.7	561.5
I-P	347	1,522.2	27	315.1	60	294.3	434	2,131.6	352.1	264.1
I-S	9	165.6	4	83.5	14	117.7	27	366.9	143.1	107.3
SCFI	-	-	1	5.9	6	42.2	7	48.0	42.6	31.9
SID I-P	16	91.7	2	5.9	6	81.6	24	179.2	83.7	62.7
SSID	2	8.4	1	44.9	2	20.3	5	73.6	34.3	25.7
Commercial	**299**	**528.6**	**7**	**26.8**	**40**	**31.0**	**346**	**586.4**	**36.6**	**27.4**
C-G	277	520.2	7	26.8	37	29.9	321	576.9	35.5	26.6
C-N	22	8.4	-	-	3	1.1	25	9.5	1.1	0.8
Mixed Use	**5,836**	**1,125.8**	**16**	**112.4**	**153**	**161.9**	**6,005**	**1,400.1**	**165.4**	**79.2**
MU-C	78	19.3	-	-	3	5.0	81	24.3	5.0	1.5
MU-N	42	7.9	-	-	2	3.1	44	11.0	2.8	0.4
MU-VTC	-	-	-	-	14	55.8	14	55.8	51.9	15.6
SC-BP	200	87.0	4	71.6	8	64.0	212	222.6	65.4	49.1
SCC-DT	428	128.2	-	-	68	13.1	496	141.3	13.1	6.9
SCC-MM	174	62.8	-	-	2	1.3	176	64.2	1.3	0.6
SCC-SC	340	14.7	-	-	2	1.2	342	15.9	1.1	0.4
SCI	5	19.2	2	7.5	-	-	7	26.7	2.0	1.5
SCR-DNC	292	49.9	-	-	5	0.3	297	50.3	0.3	0.0
SCR-HD	160	44.4	-	-	3	2.2	163	46.6	2.2	0.3
SCR-LD	363	55.7	1	3.3	8	2.1	372	61.1	2.1	0.2
SCR-MD	1,666	179.7	4	0.6	21	4.8	1,691	185.2	4.7	0.5
SCR-OTC	188	49.2	2	0.3	10	2.6	200	52.2	2.6	0.2
SCR-V	1,485	188.1	-	-	2	2.4	1,487	190.5	2.4	0.4
UC-AC	2	6.2	-	-	2	3.1	4	9.3	3.1	0.9
UC-MU	26	94.3	1	18.9	1	-	28	113.2	2.2	0.3
UC-NC	1	9.6	-	-	-	-	1	9.6	-	-
UC-OR	17	73.1	1	2.1	-	-	18	75.3	1.5	0.1
UC-RM	369	36.4	1	7.8	2	0.8	372	45.1	1.6	0.2
Total	**7,006**	**3,753**	**128**	**1,203**	**361**	**1,254**	**7,495**	**6,210**	**1,693**	**1,225**

FIGURE 8. NET EMPLOYMENT AREA BY LOT SIZE

Gross Lot Size	Number of Lots	Net Employment Acres	
>50 Acres	9	261	21%
20-50 Acres	34	401	33%
10-20 Acres	57	175	14%
5-10 Acres	159	156	13%
2-5 Acres	337	156	13%
1-2 Acres	280	45	4%
.5-1 Acres	280	16	1%
.25-.5 Acres	472	9	1%
<.25 Acres	5,868	7	1%
Total	**7,496**	**1,225**	**100%**

FIGURE 9. NET EMPLOYMENT AREA BY TYPE ANNEXATION STATUS

	Total	% of Total	City Limits (2020) Inside	Outside
Total number of employment-designated lots	7,495		7,352	143
Total Acres of Employment Land:	6,210	100%	5,167	1,043
Developed	4,517	73%	4,223	294
Total Buildable Employment Area	1,692.5	27%	944	749
Net Buildable Area	1,224.6	20%	663	561
Net Industrial Area	1,117.9	91%	556.4	561.5
Net Commercial Area	27.4	2%	27.4	0.0
Net Mixed Use area (for employment)	79.2	6%	79.2	0.0

END NOTES

[1] Using data from the U.S. Bureau of Economic Analysisi, the 2017 EOA estimated that non-covered workers averaged 16% of the employment base of Washington County over the 2010-14 time period.

[2] The IHS Global Insight 2020 forecast projections for Metro's 2018 UGR were prepared in advance of the pandemic and so do not reflect actual conditions experienced as a result of the 2020 economic downturn.

[3] Exceptions to the 25%+ short-term land supply proviso are noted by OAR 660-009-0025 as follows:

(3) Short-Term Supply of Land. Plans for cities and counties within a Metropolitan Planning Organization or cities and counties that adopt policies relating to the short-term supply of land must designate suitable land to respond to economic development opportunities as they arise. Cities and counties may maintain the short-term supply of land according to the strategies adopted pursuant to OAR 660-009-0020(2).

(a) Except as provided for in subsections (b) and (c), cities and counties subject to this section must provide at least 25 percent of the total land supply within the urban growth boundary designated for industrial and other employment uses as short-term supply.

(b) Affected cities and counties that are unable to achieve the target in subsection (a) above may set an alternative target based on their economic opportunities analysis.

(c) A planning area with 10 percent or more of the total land supply enrolled in Oregon's industrial site certification program pursuant to ORS 284.565 satisfied the requirements of this section.

[4] With regard to short-term supply, the 2017 EOA also noted (at page 62) that:

> Redevelopment capacity is often not counted in determining short-term needs, as this property is often difficult to develop and not readily available. Redevelopment is difficult to project, and subject to a number of property specific variables. These include owner disposition, lease restrictions, and market factors.

[5] Information on the Chandler Arizona sites is per Intel fact sheet dated March 23, 2021 titled "Intel Announces $20 Billion Investment for Two New Arizona Fabs." Information on planned Ohio facilities is per January 21, 2022 Intel newsroom information titled "Intel Announces Next US Site with Landmark Investment in Ohio."

Other U.S. locations cited from varied industry sources as having 200+ acre site availability include New York state and the metro areas of Austin, Sacramento, San Jose, Denver, Salt Lake City and Seattle-Tacoma.

[6] As was further described by a City web link: https://www.hillsboro-oregon.gov/our-city/departments/economic-development/strategic-advantages/infrastructure-utilities (as of 2021-22):

> Hillsboro Data Center Ring II, a pioneering fiber optic network in Oregon was scheduled to be completed in 2020. Hillsboro is already home to Wave Business's Ring I, a cross-connect facility for several transpacific submarine cables that currently connects six data centers. Together, Ring I and II has been planned to connect up to 14 existing or planned data centers and will service 7 transpacific submarine cable systems. Transpacific destinations involving the submarine cable systems include China, Taiwan, Japan, Korea, Guam, Hawaii, New Zealand, Australia, and American Samoa. Additional destinations that were to be added in 2020 included the Philippines and Alaska, with New Caledonia to be added in 2021.

[7] Information on incentive programs for qualified Hillsboro business investment can be found at the web site: https://www.hillsboro-oregon.gov/our-city/departments/economic-development/choose-hillsboro/taxes-incentives

[8] Noted is that the Strategic Investment Program (SIP) cannot be used in combination with the E- Zone Program.

Exhibit D
Findings of Fact
Case File No. HCP-003-22 2021 Economic Opportunities Analysis
As Supplemented May 2024

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I. BACKGROUND INFORMATION

These findings are associated with Case File No.: HCP-003-22, 2021 Economic Opportunities Analysis (EOA), which proposes a text amendment to the Hillsboro Comprehensive Plan (HCP), Ordinance No. 6249, as amended. The text amendment, attached as Exhibit A modifies the HCP to replace the 2016 EOA, referenced in the HCP and hereto as "2017 EOA" and provides an updated reference to the 2021 EOA as supplemented in May 2024.

This decision comes before the City on remand from the State of Oregon Land Use Board of Appeals (LUBA) following an appeal by 1000 Friends of Oregon (Friends) and Metro of City Council approval of HCP-003-22 and adoption of Ordinance No. 6420. While Friends and Metro raised several assignments of error relating to employment growth forecasting and the Comprehensive Plan status, most of these arguments were denied by LUBA. In their final opinion, LUBA affirmed the City's decision in adoption of Ordinance No. 6420 in every respect except two and these findings are limited to those. The issues now under consideration are limited to compliance with the Hillsboro Community Development Code (CDC) Section 12.80.164 – Comprehensive Plan Minor Text Amendment and the standards in State law for the buildable lands inventory, Oregon Statewide Planning Goal 9 – Economy, and OAR 660-009-0015 (3). LUBA agreed with Friends that the 2019 Buildable Lands Inventory (BLI) for employment land that was included in the 2021 EOA did not apply the correct analysis for determining the redevelopment potential of "developed lands."

These findings are limited to and demonstrate compliance with:

- Hillsboro Community Development Code (CDC) Section 12.80.164
- Oregon Statewide Planning Goal 9, Economy, and OAR 660-009-0015 (3)

The 2019 BLI was initiated because the City witnessed a noticeable increase in industrial property absorption as suppliers to Hillsboro's Computer and Electronics, Advanced Manufacturing, and other target sectors including Software and Information Technologies, expanded with strong growth in all these sectors and more. Additional demand increases have also been noted in sectors such as freight and distribution, and bio-technology leading to a reduced short-term supply of land, as well as, rapid absorption of total land supply. To better understand what the City was witnessing and to best position its programs, policies, and land supply to compete for these significant changes in economic development opportunities, the City began this 2021 EOA review to update the 2017 EOA, which was adopted with the 2018 Hillsboro Comprehensive Plan.

The 2021 EOA has been supplemented to incorporate an amended employment BLI completed in March 2024 and based on December 2020 data prepared by the planning firm

MIG in compliance with the terms of the LUBA remand. 2021 EOA edits are primarily found in Chapter 4 – Employment Land Needs. Other portions of this 2021 EOA remain essentially as previously provided with a 20-year forecast focused on the 2020-40 timeframe. Other minor revisions have been made throughout 2021 EOA documentation as appropriate to reflect results of the amended BLI. The 2021 EOA Technical Appendix E provides additional details on the amended BLI. The amended BLI is referenced hereto as "2020 BLI".

In the remand order, LUBA found that the 2019 BLI was "not supported by an adequate factual basis," with respect to the redevelopment potential of "developed lands." The definition of "vacant land" at OAR 660-009-0005(14) includes (1) any lot or parcel larger than one-half acre that is completely undeveloped, and (2) any lot or parcel larger than five acres with at least four and one-half acres undeveloped. "Developed lands" is defined as "non-vacant land that is likely to be redeveloped during the planning period." OAR 660-009-0005(1). The 2020 BLI evaluates the redevelopment potential of "developed lands" consistent with the rule's definition and in compliance with the standards in State law, including whether the developed portions of lots and parcels is "likely to be redeveloped". These changes are further described in the findings below.

The proposed Hillsboro Comprehensive Plan Amendment will modify provisions of the HCP in the following way:

Part III: Chapter 14 - Section 23 Incorporated by Reference

In accordance with State statute and regulations implementing the Statewide Planning Goals, the following documents are hereby incorporated into the Comprehensive Plan by reference:

Section 23.4 Economic Opportunities Analysis/Buildable Lands Inventory – Employment.

*The "City of Hillsboro, EOA (Oregon Statewide Planning Goal 9) ~~February 2017~~ **2021**," providing an employment analysis and inventory supporting the goals and policies within the Economic Development Section and other sections of the Comprehensive Plan including employment-related policies, is incorporated into the Comprehensive Plan in its entirety.*

II. PROCEDURAL REQUIREMENTS

This minor amendment to the Hillsboro Comprehensive Plan (HCP) Ordinance No. 6249, as amended, classified as a legislative amendment as defined by the Hillsboro Community Development Code (CDC) Section 12.070.060 (B) and 12.70.020-1.

This proposed amendment is a Comprehensive Plan Minor Text Amendment because it only involves a text amendment to replace the "2017" EOA with the "2021" EOA in the Comprehensive Plan Section 23.4 "Economic Opportunities Analysis/Buildable Lands Inventory – Employment." The CDC, Section 12.80.164, provides in relevant part:

A. Purpose. A Comprehensive Plan Minor Text Amendment provides a process to consider small-scale legislative amendments to the text of the Comprehensive Plan whenever the evidence of the need for such a revision is documented, and the amendment does not have significant effect beyond an immediate site or area. Such amendments may be necessary to reflect changing community conditions, needs, and desires; to fulfill regional obligations; or to address changes in State law.

D. Approval Criteria. To approve a Comprehensive Plan Minor Text Amendment, the Review Authority shall make findings of fact, based on the evidence provided, that the following criteria are satisfied:

1. This proposed Comprehensive Plan Minor Text Amendment is necessary to reflect changing community conditions, needs, and desires, to fulfill regional obligations, and to address changes in State law.

2. The proposed text supports the goals and policies of the Comprehensive Plan.

A comprehensive plan "minor" amendment is distinguished from a "major" amendment. According to CDC Section 12.80.166, a Comprehensive Plan Major Amendment is either a Major Amendment-Significant Change or a Major Amendment-Plan Revision:

B. Major Amendment-Significant Change. ...A "significant change" is one that amends or refines both the Plan text and map, affects a large geographic area and is likely to have significant environmental, energy, economic and social consequences.

C. Major Amendment-Plan Revision. …A "Plan Revision" means a revision(s) to the entire Comprehensive Plan text or map initiated; (1) under a Periodic Review Program pursuant to ORS 197.628; (2) to implement an adopted Regional Framework Plan or Metro Functional Plan; or (3) as part of a comprehensive evaluation of the Comprehensive Plan.

A Major Amendment-Significant Change proposes a significant change that amends or refines both the Comprehensive Plan text and map, affects a large geographic area and is likely to have significant environmental, energy, economic and social consequences. A significant change includes but is not limited to Plan amendments that incorporate community plans as part of the Comprehensive Plan or incorporate portions of a public facility plan as part of the Comprehensive Plan in accordance with State statute and regulations implementing Statewide Planning Goal 11. A Major Amendment-Plan Revision proposes a revision(s) to the entire Comprehensive Plan text or map.

Here, the proposed amendment does not amend the plan map, and does not have significant environmental, energy, economic and social consequences. It simply replaces the 2017 EOA with the 2021 EOA. Therefore, it is not a Major Amendment-Significant Change. In addition, it does not revise the entire comprehensive plan, is not proposed as part of periodic review, does not implement Metro's functional plan or framework plan, and is not part of an overall evaluation of the comprehensive plan. Thus, it also is not a Major Amendment-Plan Revision.

A Comprehensive Plan Minor Text Amendment application is reviewed using the Type IV procedure described in CDC Section 12.70.060. The proposed amendment was initiated through approval of the Planning Commission Order No. 8370 on May 11, 2022, acknowledging that due to changes in land use activity, growth projections, future employment needs, and other "changing community conditions, needs, and desires," an update of the EOA through a Minor Comprehensive Plan Text Amendment application process was appropriate to maintain the Comprehensive Plan land use inventories. These changes are further described in the findings below.

On April 20, 2022, a Post Acknowledgement Plan Amendment (PAPA) was sent to the Department of Land Conservation and Development (DLCD) consistent with OAR 660-018-0020 and CDC Section 12.070.060.F (1). A public hearing before the Planning Commission was held on May 25, 2022, in accordance with CDC Section 12.070.060 (E).

The Planning Commission hearing was continued to June 8, 2022, then to June 22, 2022, then to July 27, 2022, then to September 14, 2022, and finally to October 12, 2022. On October 12, 2022, the Planning Commission reopened the public hearing, accepted public testimony, and voted unanimously to recommend approval of the text amendments through Order No. 8374.

The City Council considered the Planning Commission's recommendation at its regular meeting on November 15, 2022, and voted to adopt the 2021 EOA and the Technical Appendices by approval of Ordinance No. 6420. The decision of the City of adopt Ordinance No. 6420 was appealed to LUBA and remanded on July 20, 2023. A public hearing was scheduled for May 8, 2024, to continue HCP-003-22 to address the limited issues on remand from LUBA.

Notice of the May 8, 2024, public hearing was published in the April 18, 2024, and April 25, 2024, editions of the News-Times covering Forest Grove and Hillsboro, a newspaper of general circulation as required in CDC Section 12.70.060. Notice of the public hearing was sent to all parties who previously provided testimony on HCP-003-22 on April 30, 2024.

On May 8, 2024, the Planning Commission opened the public hearing and continued the hearing to May 22, 2024. On May 22, 2024, the Planning Commission accepted public

testimony, deliberated on the proposed minor text amendment to the Hillsboro Comprehensive Plan, and voted unanimously to recommend approval of the text amendment through Order No. 8348.

III. APPLICABLE APPROVAL CRITERIA

1. Hillsboro Community Development Code Section 12.80.164

In order to adopt the proposed amendments, the City must demonstrate that the amendments are consistent with CDC Section 12.80.164.D, which specifies the approval criteria for a proposed Comprehensive Plan Minor Text Amendment as follows:

D. Approval Criteria. *To approve a Comprehensive Plan Minor Text Amendment, the Review Authority shall make findings of fact, based on evidence provided, that the following criteria are satisfied:*

1. The proposed text is necessary to reflect changing community conditions, needs, and desires, to fulfill regional obligations, or to address changes in State law.

Finding: The HCP minor text amendment proposes to replace the reference to the 2017 EOA with an updated EOA. There are several reasons the City initiated an update on the EOA. First has been the continued growth of Hillsboro's population and employment base, which continue to grow more quickly than the region. Hillsboro's population increased from 88,300 in 2007 to 108,800 residents in 2021, an increase of approximately 20%. During that same 14-year period, employment in Hillsboro has grown from 62,430 to 81,000, approximately 30%, double the 15% for the region. Since the initiation of an updated EOA, the City has continued to see increased population and employment growth, especially in multiple manufacturing areas, including but not limited to the Computer, Electronics, Bioscience, and Advance Manufacturing sectors. These policy changes, drive a substantial change in the economic opportunities of the City and warranted an amending of the Comprehensive Plan.

In addition to the rapid population and employment increases, vacant employment land has seen quick absorption. The City has seen approximately 800 acres of employment land absorbed in the North Hillsboro Community Plan area in the past ten years due to the success of the North Hillsboro Industrial Park and Industrial Renewal District.

Further changes to the City's economic landscape include emerging federal policy and work trends, including automation, onshoring of logistics and suppliers, and remote work.

The national economic policy was changing before the COVID-19 pandemic, with Federal regulatory tariffs incentivizing manufacturers, and suppliers, to reshore to the United States. Efforts to accelerate the re-shoring of critical national security traded-sector manufacturing and particular high-tech manufacturing leverages the City's existing

strength in this employment area. With the passage of the federal CHIPS ACT in August 2022, it is likely that because the Portland region has the largest concentration of semiconductor industry workers in the U.S., and Hillsboro has the largest concentration of firms and employees in the Portland region that more investments will occur, and at a higher trend then seen over the past 20 years. Taken separately and when viewed together, these initiatives are consistent with the robust strategy of the Hillsboro EOA for continued rapid tech industry investment and jobs.

All these changes necessitated the City to initiate an updated EOA to provide updated information for City decision-makers to understand strengths, weaknesses, opportunities, and threats while considering possible policy implementation choices. Considering all these changes and to address the requirements of State Land-use Goal 9, Economy, and to help inform Hillsboro's discussions with Metro's Urban Growth Report (UGR) in 2023, the City has completed an update of the City's EOA.

Additionally, the City has witnessed various work trends since initiating the 2021 EOA due to the COVID-19 pandemic. The first is that many manufacturing workers do not work from home and must still be physically present on the job site. The managers of manufacturing facilities need to be close to their jobs for on-site problem-solving. Suppliers also increasingly need to be located close to customers as supply chain disruptions and leading edge innovations occur. There has also been an acceleration in e-commerce leading to a rapid absorption of existing industrial buildings driving Hillsboro Industrial vacancies to approximately 2% based on CoStar July 2022 along with increased development of warehouse and distribution facilities on vacant land. Additionally, the Hillsboro community continues to grow in population as workers seek homes with more indoor space for offices and more outdoor space to ensure social distancing as necessary. The ongoing population growth locally with more residents working from home, positively impacts the demand for local service sector jobs, with employers following their employees from Central City or creating small satellite offices.

Staff find that this criterion is met.

2. The proposed text supports the goals and policies of the Comprehensive Plan.

Finding: The HCP minor text amendment supports the following Comprehensive Plan goals and policies:

Public Involvement (PI) Goal 1 Engagement*. Implement and maintain a comprehensive public information and involvement program to spread outreach and engagement in land-use and transportation-related projects, decisions, and initiatives.*

Policy PI 1.1 Ongoing dialog. *Ensure and encourage ongoing dialog between the public and the City regarding land-use planning and decision-making.*

Policy PI 1.2 Develop consistent procedures. *Develop and utilize a consistent set of procedures for notifying and soliciting input from the public as appropriate to the scale and type of the proposed action.*

Finding: The proposed HCP text amendment followed the adopted HCP and CDC notice procedures to provide the public an opportunity to participate in the updating of the EOA. In addition to the standard public notice, the project consultant met with over a dozen small and large Hillsboro business representatives and conducted a Hillsboro business focus group to solicit quantitative and qualitative information and feedback which is incorporated in the proposed 2021 EOA. Additionally, two public Planning Commission work sessions were held, and feedback was incorporated into the document.

The City received both written and verbal feedback from DLCD, Metro, and Friends . Additional discussion also occurred with the City of North Plains regarding economic opportunity in Washington County.

The adoption of the 2021 EOA provides a technical and factual update to replace the EOA that was adopted in 2017 as part of the HCP update that included extensive public involvement. Because no policy changes are proposed with this technical update, more extensive public involvement would occur at such time as the applicable Comprehensive Plan Goals and policies are proposed for amendment.

The public involvement process to develop and adopt the 2021 EOA meets the intent of HCP PI GOAL 1 and Policy PI 1.1 and 1.2.

Urbanization (UR) Goal 1 Growth. *Accommodate long-range population and employment growth within the Hillsboro Planning Area.*

Policy UR 1.2 Designate land for projected growth. *Designate land-uses in a manner that accommodates projected population and employment growth.*

Policy UR 1.3 Facilitate infill. *Facilitate the infill development of vacant or underutilized land consistent with City Comprehensive Plan land-use designations.*

Policy UR 1.7 Range of employment lot sizes. *Manage employment land to provide a range of lot sizes that accommodate a variety of employment types.*

Policy UR 1.8 Routinely verify supply of developable land. *Routinely verify whether the City's supply of developable land is sufficient to meet short- and long-term employment and housing needs.*

Policy UR 1.9 Request additional lands for projected growth. *Request additional lands for urbanization when the Hillsboro Planning Area will not accommodate the 20- year projected demand for employment and/or housing.*

Finding: There are three foundational documents required by state law to establish and accommodate land needs for a range of population and employment growth within the Hillsboro plan area; these documents include a Buildable Lands Inventory (BLI), EOA, and a Housing Needs Analysis (HNA). The 2020 BLI and the 2021 EOA are the first two steps in updating all three reference documents consistent with the HCP.

The EOA is required by OAR 660-009-0015(2) to conduct an analysis and identify required site types by the number that can be expected to be needed to accommodate the expected employment growth based upon typically expected uses. This analysis is found in 2021 EOA Section 4 (Exhibit B), with supporting documentation in the 2021 EOA Technical Appendices (Exhibit C). These findings support both *Policy's UR 1.3,* Infill, and *UR 1.7*, by maintaining a complete understanding of the economic need for both large and small lot sites to maintain a strong and diverse economy for the City.

To complete the updated EOA, the staff conducted a new BLI. This data, combined with other quantitative and qualitative trends data, was used to complete the 2021 EOA and provide a refreshed understanding of Hillsboro's current and future economy from the previous 2017 EOA. Completion and adoption of the 2021 EOA into the HCP supports *Policy UR 1.8* by providing City policy and decision-makers with the current supply of developable land in all employment categories, including industrial, commercial, office, and mixed-use. The EOA finds and describes that if current trends were to continue, the City does not have a 20-year land supply as required by State Goal 9, Economic Development and implementing OARs.

The 2021 EOA was developed consistent with OAR 660-009 and the four specific components required by OAR 660-009-0015 (1-4). Hillsboro staff, working with the project consultant, initially evaluated two scenarios, prepared just prior to the pandemic.

The first, "Scenario A," was established using the growth rate of the most recent economic cycle (2007-2018), based on the addition of 18,570 jobs over this 11-year period. This equates to an annual percentage employment growth rate of 1.9%.

A second scenario, "Scenario B," was developed based on a combination of national and local data. Hillsboro has experienced an increasing pace of land absorption and development combined with the opportunities seen by Hillsboro Economic Development Staff for targeted traded sector industries that correspond with national and industry trends, making reasonable the evaluation of an exponential growth opportunity scenario, forecast

separately for each of 17 employment sectors. The resulting overall growth rate used for Scenario B was a Compound Annual Growth Rate (CAGR) of 3.5%.

Hillsboro staff and the project consultant then developed a third "Scenario C," which is a hybrid of CAGR, and straight-line average growth and corresponding land factor conversions based on the "reasonably be expected to locate or expand within the planning area based on national, state, regional, county or local trends." Scenario C used a "toggle switch" forecast methodology (explanation on EOA page 29) based on a detailed evaluation of historic employment experience from approach to determine whether job growth for each sector reflected a straight-line or exponential employment growth pattern, using detailed data extending back to 2003 (the earliest date available) as provided by the Oregon Employment Department (OED).

OAR 660-0024 allows but does not require a "safe harbor" employment projection and based on a local employment growth trend; Hillsboro chose a 1.9% as its baseline growth rate (or minimal expectation) based on the most recent 11-year growth cycle pattern rather than the regional safe harbor growth rate of 1.6%. Because Hillsboro job growth has consistently been able to outperform the region, using the safe harbor approach would understate the employment opportunities.

Using a CAGR is common practice in creating EOAs throughout the state and is especially pertinent when job growth rates are accelerating or demonstrated to be above the surrounding county or region for a specific City. As Eric Hovee, who has prepared EOAs across Oregon for over 40 years described at the September 14, 2022, Planning Commission hearing, CAGR calculations have been used by Metro's UGR but are commonly referenced as "Annual Percentage Rate" (APR). The City of Portland used this approach in its 2016 EOA in a similar methodology. Often it is a matter of terms between CAGR, Annual Percentage Growth Rate (APGR), or Annual Percentage Growth Rate (APGR), but the math remains the same as each year builds on the previous year.

The exponential employment and land forecast are based more on the possibility of all-sector compounding growth. Thus, using the CAGR and Exponential forecasts are reference points, a Hybrid forecast was developed by combining the Exponential forecast with a sector-by-sector analysis. The sector-by-sector analysis is explained on page 30 of the 2021 EOA. On page 31 of the EOA, there is a summary table that describes which forecast was used by employment sector and why that aligns with Hillsboro's experience and with existing and targeted industrial employment policies to determine the preferred path toward continued realization of Hillsboro's economic opportunities. The EOA Technical appendix pages 25 through 42 provide additional detail how the "four-phase" sector toggle approach using OED year to year review of employment for each sector.

The results of the 2021 EOA are similar to the previous 2009 Hillsboro EOA conducted by Johnson Reid Land-use Economist in preparation for the Metro Urban / Rural Reserve process and the 2017 EOA prepared by Johnson Economics for the 2017 HCP update.

These previous reports projected an employment land deficit in the 20-year planning horizon. It should be noted that the 2017 EOA, using the OAR 660-009 "safe-harbor" forecast, still forecast a 900-acre land need deficit in the 20-year planning horizon.

The proposed 2021 EOA provides policymakers with the information necessary to determine a course of action in planning for a 20-year employment land supply within the Hillsboro Planning Area (HCP Section 34). Consistent with Policy UR 1.7 the 2021 EOA evaluated, reported the current employment land supply, and described the importance of the City to continue to maintain a range of lot sizes.

The 2021 EOA is consistent with UR 1.8 and UR 1.9 because it provides, through an analysis of the 2020 BLI, an updated evaluation of the Hillsboro land supply against the current national, state, regional, and local economic trends and has identified the City does not have an adequate 20-year land supply.

Staff find the 2021 EOA is consistent with UR 1.1 – UR 1.2 and UR 1.7-UR 1-9.

Urbanization (UR) Goal 2 Consistency. *Ensure local planning consistency with the region and the state.*

Policy UR 2.1 Local and regional plans consistency. *Ensure consistency with the Metro Urban Growth Management Functional Plan.*

Finding: The proposed 2021 EOA provides consistency with the Metro Urban Growth Management Functional Plan (UGMFP) Title 4 by providing an updated forecast of Hillsboro employment land needs consistent with State Goal 9 and OAR 660-009. The 2021 EOA reinforces the importance of maintaining a strong regional economy by identifying the ongoing need for suitable sites to retain expanding traded sector industries and attract new firms to the well-established hi-tech cluster located in Hillsboro and Washington County. The 2021 EOA is consistent with Metros' UMGFP by demonstrating the importance of protecting the Regionally Significant Industrial Land policy, considering the identified need for more employment land in Hillsboro over the 20-year planning horizon. The 2021 EOA demonstrates further compliance with Metros' UGMFP with suggested policy choices to balance economic demand and land availability combined with strategies for efficient land-use.

Staff find the 2021 EOA is consistent with UR 2.1.

Economic Development (ED) Goal 1 Competitive Advantage. *Diversify and expand the economy to give Hillsboro, the region, and the state a competitive advantage.*

Policy ED 1.1 Competitive advantage. *Maintain and strengthen the City's competitive economic advantages, including access to a highly skilled workforce; vibrant local workforce development; business diversity; competitive business climate; quality educational institutions; and globally-competitive public facilities, utilities, and services.*

Policy ED 1.2 Diverse range of employment opportunities. *Foster a diverse range of employment opportunities to benefit Hillsboro, the region, and the state.*

Policy ED 1.3 Employment land supply. *Pursue an ample employment land supply to benefit Hillsboro, the region, and the state.*

Policy ED 1.4 Traded-sector and target industry retention, expansion, and recruitment. *Sustain the ongoing vitality of the City's traded-sector and targeted industries by aligning plans and investments to retain, expand, and recruit employers and investment in Hillsboro.*

Policy ED 1.5 Business innovation. *Facilitate scale-up and business innovation opportunities where new or incubating companies can create a sense of place and benefit from co-location, proximity to transit, affordable space, mentorship, and shared services.*

Policy ED 1.6 Partnerships. *Leverage program and resource partnerships with local, regional, and statewide stakeholders, such as governments, educational institutions, economic development and business organizations, and major employers, to attract and retain employment and investment.*

Policy ED 1.7 Economic resiliency. *Pursue collaborative and innovative approaches to strengthen and sustain Hillsboro, the region, and the state's economic resiliency.*

Finding: The 2021 EOA is written within the context of the existing HCP Economic policies. The 2021 EOA describes the current employment opportunities and the current and future benefits of maintaining policies that expand those opportunities both within employment land inside the Urban Growth Boundary (UGB) and outside the Hillsboro municipal boundary.

The 2021 EOA provides specific findings that address each of the HCP Economic Development Goal 1, Competitive Advantage. Section III of the EOA goes into a detailed assessment of Hillsboro's current competitive position drawn from both quantitative and qualitative assessments. The strengths are well known to benefit not only Hillsboro but the Portland region and the state by providing private and public partnerships for additional

job growth and support wages that allow more households to afford basic needs such as housing and education. The EOA identifies target industry clusters that, if continued to be supported, are projected to grow, and support local service-sector economic benefits.

Recent industry trends reinforce the need to have prime industrial land made serviceable within adjacent areas to existing industry centers. Hillsboro has utilized its land in areas suitable to regional transportation routes and well-planned infrastructure to support and realize a variety of traded sector investment into the area. Over time this has increased the locational desirability of land in and around the North Hillsboro Industrial Area for future planning and urbanization to support critical economic development opportunities for the City and the state. These efforts paired with strengthening locational factors by target industries which require investment or expansion in and around similar industry users and industry ecosystems supports the findings of the EOA and asserted land needs for future planning and development.

Staff find that the proposed HCP is consistent with ED Goal 1 and ED policies 1.2 -1.7.

Economic Development (ED) Goal 3 Land Supply. *Manage land supply to meet short- and long-term economic development needs of Hillsboro, the region, and the state.*

Policy ED 3.1 Supply of developable employment sites and flexibility. *Sustain a supply of developable employment sites and adequate flexibility to meet the short- and long-term needs of Hillsboro, the region, and the state.*

Policy ED 3.2 Employment land designation. *Adopt land-use designations in a manner that accommodates projected employment growth.*

Policy ED 3.3 Employment land lot sizes. *Manage employment land to provide a range of available and developable lot sizes to accommodate a variety of uses, industry clusters, and emerging market opportunities.*

Policy ED 3.4 Higher density employment land. *Pursue development of higher employment densities in areas with planned or existing enhanced transportation connectivity; access to transit; and public facilities, utilities, and services.*

Policy ED 3.5 Health and education campuses. *Promote the stability and growth of health and education campuses as essential service providers, centers of innovation, workforce development providers, and major employers that can also provide amenities to surrounding neighborhoods.*

Policy ED 3.6 Revitalization and reinvestment. *Support additional investment in existing Employment Areas, Regional Centers, Town Centers, and along targeted Corridor areas, such as assembly of existing small employment parcels for redevelopment, programs supporting adaptive reuse, and identification of options to mitigate and/or redevelop sites and structures.*

Policy ED 3.7 Employment land supply. *Pursue additional employment land when the Hillsboro Planning Area will not accommodate the 20-year projected demand to meet local, regional, and state needs.*

Finding: As required by State Land-use Goal 9 and consistent with OAR 660-009, the 2021 EOA's primary purpose is to evaluate the existing employment BLI and City policies to create a 20-year forecast for employment land needs.

The 2021 EOA is based upon the 2020 BLI that was created consistent with the Metro BLI used for the 2018 UGR, to provide a 20-year land forecast that includes an evaluation of existing parcel size and the importance of maintaining large sites to attract traded-sector industries seeking campus-style development. The 2021 EOA identifies the need to maintain a supply of diverse size employment land and Prime Industrial Land to ensure that firms of all sizes have opportunities to locate in Hillsboro and to fill unmet needs and expand as businesses grow. The 2020 BLI provides an analysis consistent with the standards called out in OAR 660-009 and OAR 660-24.

The 2021 EOA's identification of land needs is consistent with the City's ongoing efforts to support and locate high-density employment nodes in Hillsboro's Tanasbourne/AmberGlen Regional and Downtown Hillsboro Regional Centers that have access to regional transit. The 2021 EOA also recognizes that many traded sector industries, especially manufacturing, are often limited in how high density they can be due to operational specifics, spacing requirements, and site logistical needs. Hillsboro has seen many traded sector entities and manufacturers develop at 1 to 3 stories, but facilities at higher densities are not currently achievable and requirements for this type of development form will negatively impact the locational considerations and realization of these industries in the planned industrial areas.

The 2021 EOA identifies the ongoing strength of employment growth in the health care sector in Hillsboro. The City's support of both the OHSU / Pacific Health and Education District in Downtown Hillsboro, Kaiser Westside Medical Campus, OHSU West Campus and the Vaccine and Gene Therapy Institute, and private medical device manufactures are demonstration of the City's commitment to this policy. Additionally, the City actively supports the ongoing growth of the bio-pharma employment cluster along with the retention and expansion of existing medical device manufacturers.

To address short-term employment land supply, the City adopted the Comprehensive Plan and Hillsboro Zoning designations to the Jackson East Plan Area in August 2022, which will add approximately 550 gross acres of developable employment land and provides the opportunity for varying parcel sizes. Additionally, the City has deployed local tools and utilized state programs to increase the development readiness of existing land capacity. This has led to planned industrial lands being serviceable and the market has responded with absorbing much of this land in support of local, regional and state level policies.
The proposed HCP text amendments support and are consistent with the purpose of the project to update the EOA and provide policy decision-makers with the most up-to-date information from which to evaluate future policy choices.

The EOA is required by OAR 660-009-0015(2) to conduct an analysis and identify required site types by a number that can be expected to be needed to accommodate the expected employment growth based upon typically expected uses. This analysis is found in 2021 EOA Section 4 (Exhibit B), with supporting documentation found in the 2021 EOA Technical Appendices (Exhibit C). These findings support both *Policy's UR 1.3*, Infill, and *UR 1.7* by maintaining a full understanding of the economic need for both large and small lot sites to maintain a strong and diverse economy for the City. The BLI and EOA further emphasize the need for effective and efficient use of all parcels, large and small, and the available capacity being serviceable overtime to capture market opportunities.

To complete the update for the EOA, the staff completed an updated BLI. This data, combined with other quantitative and qualitative trend data completes the 2021 EOA and provides a refreshed understanding of Hillsboro's current and future economy from the 2017 EOA. Completion and adoption of the 2021 EOA by reference to the Comprehensive Plan supports *Policy UR 1.8* for City policy and decision-makers regarding the current supply of developable land in all employment categories, including industrial, commercial, office, and mixed-use. The EOA describes that if current trends were to continue, the City does not have an adequate 20-year land supply as required by State Goal 9, Economic Development and implementing OARs.

The 2021 EOA provides consistency with the Metro 2040 Plan by providing information that is necessary to fully understand the policy choices by local and regional decision-makers. The EOA further supports, as discussed in greater detail, the critical need for supporting and protecting employment lands of all types but particularly around traded sector employment.

The proposed HCP text amendment supports the Economic Development Section and other sections of the HCP including employment-related policies by providing updated data from

which to evaluate existing policies and consider whether new policies are necessary to meet the community's employment needs over the planning period.

Staff find that the proposed HCP is consistent with ED Goal 3 and ED policies 3.1. through 3.7.

Land Use Planning and Procedures (LU) Goal 2: A well-structured, working plan. *Strive for a Comprehensive Plan grounded in fact, comprised of coordinated components, and designed to be clear and accessible, and that is reviewed regularly to respond to changing conditions, shifting community needs and priorities, and newly enacted laws.*

Policy LU 2.7 Analyses and inventories. *Refine policy recommendations using analyses and inventories related to economic development, housing, and natural resources and adopt these analyses and inventories as part of the Comprehensive Plan, including:*

a) *Economic Opportunities Analysis,*
b) *Housing Needs Assessment,*
c) *Buildable Lands Inventory, and*
d) *Natural Resources Inventory.*

Policy LU 2.11 Regular review. *Regularly review and modify the Comprehensive Plan, as necessary, to reflect updated land-use processes and regulations, integrate best practices and the best available data, and improve service provision to the community.*

Finding: The proposed HCP text amendment supports and is consistent with the purpose of the project to provide decision-makers with the most up-to-date information from which to evaluate existing and future policies and have informed policy discussions with the Metro and State officials. The 2021 EOA is one of three foundational documents that the City uses to direct land use policy decisions.

The 2021 EOA provides an updated analysis of the national, state, regional, and local trends for industrial, office, and commercial employment consistent with OAR 660-009 methodology, including an updated BLI, that provides a basis a refreshed analysis and inventory of the land needed to support the policies and goals of the Hillsboro Comprehensive Plan and target industries.

The City completed the 2020 BLI in compliance with the terms of the LUBA remand, using the Metro UGR BLI. As with the initial 2019 BLI, the amended 2020 BLI based on data from December 2020, utilizes GIS analysis based on Washington County tax parcel data (limited to the City of Hillsboro and associated future growth areas). The 2020 BLI focuses on parcels for which some form of employment use is permitted, differentiated between

COM commercial, IND Industrial, and MUR mixed use residential and commercially zoned properties (with employment capacity varied to reflect allocations differentiated by mixed use zoning designation). Both the initial and amended BLI inventories reflect land use conditions as of 2019-20 consistent with the baseline year for forecasting of employment growth over the ensuing 2020-40 time period. As noted, the amended BLI reflects employment land inventory conditions as of December 2020.

The 2020 BLI (included in full as Appendix E of Exhibit C) is summarized as part of a five-step process. Step 1 *Land Classification* identifies the land in the City that is available for employment uses. Step 2 *Constraints to Development* identifies constraints such as natural resources, steep slopes, and utility easements that limit development. Step 3: *Development Status* assigns a "Development Status" of vacant, partially vacant, or developed to tax lots in the inventory. Step 4 *Net Buildable Area* removes land for future rights-of-way and other land needs to provide a net number of buildable acres for each City zoning designation. Step 5: *Redevelopment* screens developed parcels for redevelopment potential.

Parcels in the inventory are categorized based on their Comprehensive Plan designations, zoning designations, property ownership, and other characteristics. Employment classifications include designation of lands with Comprehensive Plan designation as industrial, commercial and as a portion of mixed use land. Residential as well as publicly owned and other uses not consistent with employment activity are excluded from the employment BLI.

Employment land that is constrained from development is excluded from net buildable acreage based on constraints including steep slopes, water bodies, FEMA floodway, FEMA 100 Year floodplain, significant wetlands, significant forest resources, the City's significant natural resources overlay (SNRO), BPA easements, and Hillsboro Airport's runway protection area. Unconstrained or buildable areas of parcels are defined as vacant or partially vacant sites minus constrained acreage.

To calculate net developable acreage for each parcel, an overall 25% reduction was applied to commercial, industrial and mixed use zones for roads, infrastructure, open space and other needs. Parcels in mixed use zones were further reduced based on the proportions of land area expected to occur as employment uses (with varied deductions applied specific to each of 16 applicable mixed use zones).

Each parcel in the study area is categorized as vacant, partially vacant, or developed. Vacant parcels (including parcels with low-value structures) are assumed to have development capacity equal to the area unconstrained by natural resources, minus additional set-asides for future Right-of-Way and infrastructure. Partially vacant parcels have existing development but with some portion of the site identified as potentially available for future development subject to minimum site or use requirements for development suitability (as

specific to industrial, commercial and mixed use zones). Developed parcels are subject to further screening for redevelopment potential, using the "Strike-Price analysis. The "strike price" is a value per square foot at which a developer can afford to purchase the property and theoretically redevelop profitably. The 2018 Metro Urban Growth Report's BLI estimated strike prices for various land uses and locations throughout the region. This test is an estimate commonly used to evaluate redevelopment potential at a high level, though there are many factors that will ultimately determine the redevelopment of a given parcel.

The City project consultant combined that baseline information with national, state, regional, and local trend data and local business qualitative information to arrive at the projected employment growth and land need for the 2021 EOA.

Staff find that the 2021 EOA is consistent with policy LU 2.7 and 2.11.

Land Use Planning and Procedures (LU) Goal 3 Plan Implementation. *Utilize a variety of implementation tools addressing plan management to area- and site-specific measures that are consistent with and work cooperatively to execute the goals and policies in the Comprehensive Plan.*

Policy LU 3.1 Implementation plan. *Develop, maintain, and regularly update an implementation plan that includes measures carrying out the Comprehensive Plan in a flexible format that supports monitoring, progress tracking, and periodic updates.*

Finding: The update of the technical reports that are underpinning the HCP is consistent with this LU Goal 3 and Policy 3.1. The updated information included in the 2021 EOA, both in quantitative and qualitative analysis, provides the information for decision-makers to evaluate whether existing employment land-use policies remain sufficient to execute the goals and policies of the Comprehensive Plan.

Staff find that 2021 EOA is consistent with policy LU 3.1.

2. Oregon Statewide Planning Goal 9 - Economic Development

Goal 9 outlines the importance of coordinated Comprehensive Plan policies to create a stable and healthy economy. The goal directs that City's maintain a working inventory of employment land for industrial and commercial development. The rule also directs that economic land planning consider a 20-year land supply for employment uses that the community is targeting based on a reasonable likelihood that these uses could locate in the community.

Finding: The update of the Hillsboro EOA was developed consistently with State Goal 9, Economic Development, and OAR 660-009 and specifically as outlined below in OAR

660-009-0015 (3) as it relates to the buildable land inventory. The proposed HCP amendment is to update Chapter 14 – Section 23.4 by replacing the reference to the previous 2017 EOA with the 2021 EOA.

A) OAR 660-009-0015 (3)

(3) Inventory of Industrial and Other Employment Lands. Comprehensive plans for all areas within urban growth boundaries must include an inventory of vacant and developed lands within the planning area designated for industrial or other employment use.

(a) For sites inventoried under this section, plans must provide the following information:
(A) The description, including site characteristics, of vacant or developed sites within each plan or zoning district;
(B) A description of any development constraints or infrastructure needs that affect the buildable area of sites in the inventory; and
(C) For cities and counties within a Metropolitan Planning Organization, the inventory must also include the approximate total acreage and percentage of sites within each plan or zoning district that comprise the short-term supply of land.

(b) When comparing current land supply to the projected demand, cities and counties may inventory contiguous lots or parcels together that are within a discrete plan or zoning district.

(c)Cities and counties that adopt objectives or policies providing for prime industrial land pursuant to OAR 660-009-0020 (Industrial and Other Employment Development Policies)(6) and 660-009-0025 (Designation of Lands for Industrial and Other Employment Uses)(8) must identify and inventory any vacant or developed prime industrial land according to section (3)(a) of this rule.

Finding: Hillsboro must "review and as necessary, amend" our comprehensive plan to provide an Economic Opportunities Analysis contained in OAR 660-009-0015 (1-4). OAR 660-009-0015 (3) requires an EOA to "include and inventory of vacant and developed lands within the planning area designated for industrial or other employment use, which we refer to as a Buildable Lands Inventory (BLI).

Further analysis is required of the inventory of developable land is required including descriptions of vacant and developed land within each zoning district; a description of development site constraints and infrastructure needs; and, for those cities within a

Metropolitan Planning Organization (MPO), the inventory must include the approximate total acreage and percentage of sites within a discrete plan or zoning district.

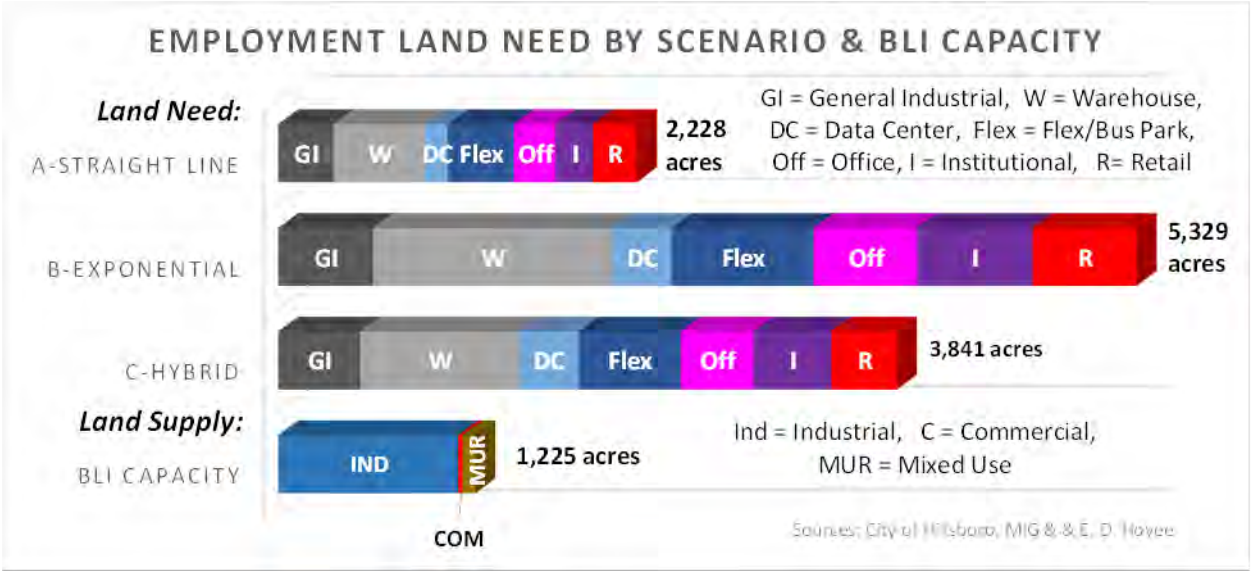
Hillsboro's 2020 BLI pre-recession comprises a total of just under 6,210 gross acres. Of this, over 3,753 acres (60%) are already developed – leaving 2,457 acres (40%) as not yet developed. Of the undeveloped acreage, the City's BLI model indicates that approximately 1,232 acres (20% of the inventory) represent unbuildable portions of vacant and partially vacant sites due to constraints and future infrastructure set-asides. This includes lands that are environmentally constrained and/or allocated for rights-of-way and utilitarian functions. The remaining 1,225 acres comprise Hillsboro's remaining buildable area for employment use. Further additional detailed analysis is contained in both the 2021 EOA and 2021 EOA Technical Appendix.

The 3,753 acres of developed land was further screened for redevelopment potential using the "strike price" analysis. A total of 65 parcels meet the size and strike price for potential redevelopment. Taken together, these parcels account for an estimated 143 acres of potentially redevelopable employment land. Roughly 85% of this potentially redevelopable land is zoned for industrial use. If redevelopment of these 143 acres were to occur, it would increase Hillsboro's buildable acreage (or net employment land) by up to about 12%. Given the numerous variables that determine whether an individual site will redevelop, including property owner willingness, the availability of other suitable sites, and macroeconomic factors, the 143 acres of potentially redevelopable land was not included in the 1,225 acres of Hillsboro's remaining buildable area for employment use.

Out of more than 6,210 acres of gross employment designated land area, more than 2,456 acres (40% of the total) consist of tax parcels that are vacant or partially vacant with potential for some amounts of added employment development (before environmental, infrastructure, and other set-asides are taken into consideration). An estimated 128 parcels are considered partially vacant. Taken together, these partially vacant properties account for an estimated 1,203 acres. Of this amount 398 acres are viewed as potentially developable with 805 considered unbuildable. Overall average parcel size for these parcels that are partially vacant is about 9.4 acres. A total of 361 vacant land parcels comprises 1,253 acres with average parcel size of just 3.5 acres. Of this, approximately 826 acres are estimated as net buildable with 427 acres classified as unbuildable. In effect, while Hillsboro's vacant inventory is comprised of relatively small parcels, a higher proportion of this vacant lot inventory is assumed to be ultimately developable than with remaining partially vacant sites. Industrial lands identified as suitable for future employment use average about eight acres per remaining land parcels for which development potential is noted as compared with only 1.2-1.6 acres per lot for the average commercial/ mixed uses sites, respectively.

This chart from the EOA illustrates a significant Hillsboro land supply shortage across all three employment growth scenarios considered. This supply gap affects Hillsboro's future capacity to attract continued investment, especially from major employers requiring

campus sites, and to retain existing businesses as they seek to expand beyond their current footprints.



As detailed by the EOA in Section IV Employment Land Needs (Exhibit B), summary observations from these comparisons are three-fold:

- Forecast land demand over 20 years is 1.8 times existing BLI land supply with Scenario A, more than four times greater with Scenario B, and three times greater with Scenario C.
- With the limited supply of BLI capacity comprised primarily of industrially designated land, not only is supply inadequate for potential industrial use but there may be pressure – including the potential to realize higher land values – with the conversion of some industrial land to commercial development as well as added redevelopment incentive.
- The commercial development that does occur on non-industrial lands is more likely to occur with Mixed-Use and Commercial designated sites.

The observations of employment land acreage demand and resulting employment land deficits are further highlighted in the following table found in the 2021 EOA page 50:

Demand/Supply Factor	Net Acres by Scenario & Time Horizon			Comments
	A-Straight Line	B-Exponential	C-Hybrid	
20-Year Plan Horizon (Long-Term):				
Employment BLI Capacity	1,224.6	1,224.6	1,224.6	In-city & future growth area
less Employment Land Need	(2,228.2)	(5,329.2)	(3,841.2)	Preliminary, subject to revision
equals Net Surplus/(Deficit)	(1,003.6)	(4,104.6)	(2,616.6)	
5-Year (Short-Term):				
Employment BLI Capacity	663.1	663.1	663.1	In-city lands only
less Employment Land Need	(557.0)	(1,332.3)	(960.3)	Assumed @ 1/4 long-term need
equals Net Surplus/(Deficit)	106.1	(669.2)	(297.2)	
% of 5-Yr Demand Accommodated	119%	50%	69%	

Short-term, in-city lands could accommodate essentially all of 5-year demand, assuming the lower growth of the Scenario A forecast scenario. However, substantial deficits occur over a 20-year forecast horizon. Even greater deficits are indicated over both 5- and 20-year forecast periods – with either the high growth Scenario B or hybrid Scenario C projection. In effect, securing more land becomes pivotal as a key step toward realization of Hillsboro's full employment potential – also for added higher wage regional job opportunities.

IV. TESTIMONY FROM PARTIES

The City received a total of two letters of testimony. These two letters were from Friends regarding the proposed HCP amendment to update the 2017 EOA reference to the 2021 EOA, as supplemented May 2024.

1. Friends submitted a letter dated May 7, 2024. In this letter, Friends requested that the May 8th public hearing be continued to May 22, 2024 to allow more time to review the materials and that they be added to the mailing list to receive all materials related to this item.

Finding: At the May 8th public hearing, the Planning Commission granted staff's request to continue the hearing to May 22, 2024. After mailing the materials for the May 8th hearing to Friends, staff was made aware that the mailing address and contact information on file with the City for Friends was out of date. Staff updated the mailing information for Friends and provided the revised documents to Friends in advance of the continued public hearing on May 22, 2024.

2. Friends submitted a letter dated May 22, 2024. This letter highlighted three specific areas of concern: 1) The City erred by failing to review the proposed amendment as a

major amendment; 2) The City proposed planning horizon is too long, growth assumptions unrealistic, and not based in fact; and 3) The City's Buildable Lands Inventory (BLI) is inadequate.

Finding: Friends argues that the City erred by failing to review the proposed amendment as a major amendment. Friends asserts that the decision to replace the 2017 EOA with the 2021 EOA does not qualify as a minor amendment to the comprehensive plan and should instead be processed as a major amendment. This was raised in their argument against adoption of the 2021 EOA at the Land Use Board of Appeals (LUBA) hearing. The 2021 EOA was remanded in part on this issue. Staff has compiled findings attached to this staff report (Exhibit D) that clarify why the proposed amendment is considered "minor" and not a "major" amendment and demonstrate compliance with CDC Section 12.80.164 – Minor Text Amendment.

In order to be a major text amendment, the proposed change must amend or refine both the Plan text and map. This amendment does not amend both, and therefore is a minor amendment. Further, the City has discretion in interpreting its own code, and in this case, the City is simply replacing the 2017 EOA with the 2021 EOA, which the City does not believe has significant environmental, energy, economic, or social consequences.

Additionally, Friends argues that the City's proposed planning horizon is too long, and growth assumptions are unrealistic and not based in fact. Friends argues that the City may not plan beyond a 20-year projection and that the use of a compounded annual growth rate (CAGR) to determine anticipated land needs in Scenarios B & C has no factual basis. It is well established by case law that Friends cannot bring a new issue that is beyond the scope of the remand and could have been raised previously at a different stage of this proceeding. Therefore, Friends may not make this argument before the Planning Commission. Alternatively, Friends fails to cite any law when making this argument, instead relying on its own personal opinions. It is in the nature of planning to look ahead, and without citing a specific law or regulation, this argument is not valid.

Finally, Friends believes the City's BLI to be inadequate. Friends makes three arguments to this point.

a) <u>The City fails to evaluate development and redevelopment potential of developed land.</u> This is a conclusory statement, not an argument. Friends is simply restating 1 of 2 of LUBA's conclusions that resulted in this remand that the City is addressing with the amended Buildable Lands Inventory and EOA. Staff and the City's consultant have supplemented the 2021 EOA and 2021 EOA Technical Appendices with additional Employment Buildable Lands Inventory (BLI) analysis and language regarding the redevelopment potential of developed lands. Additionally, staff has compiled findings that demonstrate compliance Oregon Statewide Planning Goal 9, Economy, and OAR 660-009-0015 (3) as it relates to the Employment BLI and the redevelopment potential of developed lands.

b) The City fails to correctly consider certain types of land in its employment assessment. Friends argues that the City should have included residential land and land for other uses not consistent with employment activity in the land needs analysis. This argument is beyond the scope of this remand and, like in point 2 above, should have been raised by Friends at a different stage of these proceedings. LUBA concludes that the City must evaluate in the BLI whether the developed portions of lots and parcels are likely to redevelop on remand. However, LUBA does not open the door to a full re-evaluation of other elements or aspects of the BLI. Therefore, Friends may not make this argument before the Planning Commission. Alternatively, the BLI is an inventory of lands within the planning area designated for industrial or other employment use. Schools are not designated as an industrial or employment use, they are a civic use. In addition, schools practically would have a nominal effect on the BLI. Therefore, the City still fulfilled its obligations under OAR 660-009-0015(3) because it considered all lands designated for industrial or employment uses.

c) City failed to account for high-tech companies' growth on developed land. Friends argues that the City did not account for the growth and investments tech companies have been making on their existing developed land as part of investments approved under the recent CHIPS act funding. Like mentioned above, this argument is beyond the scope of remand (as provided above) and also beyond the scope of this matter before the decision-makers. The Planning Commission is deciding whether the BLI complies with relevant administrative rules (OAR 660-009-0015(3) by inventorying designated industrial and employment lands within the planning area. It is beyond the scope of this decision to look at how other counties are approaching the CHIPs act's impact on buildable lands or UGBs, or whether this may affect the City's UGB. This will be handled in subsequent decision-making processes.

V. ADDITIONAL MATERIALS CITED BY REFERENCE AND INCLUDED BY REFERENCE IN FINDINGS

- Planning Commission Supplemental Staff Report 7 dated April 30, 2024, with associated attachments.
- Planning Commission Supplemental Staff Report 8 dated May 14, 2024, with associated attachments.
- Planning Commission Supplemental Staff Report 9 dated May 22, 2024, with associated attachments.
- City Council Staff Report dated June 4, 2024, with associated attachments.

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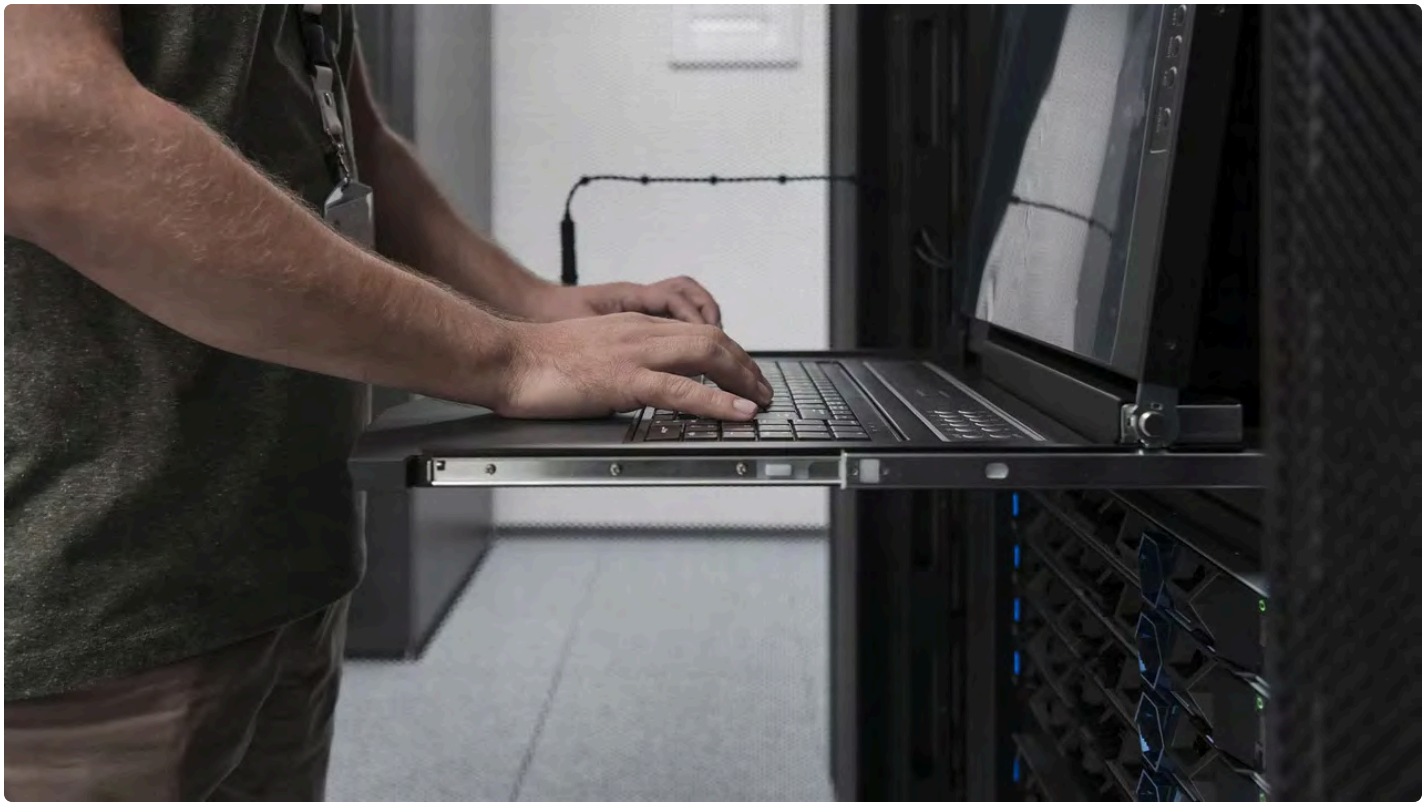
How Many Jobs Do Data Centers Create? It Depends

Data centers create jobs, but how many? We examine the variables affecting employment numbers and why the impact varies dramatically across different facilities.



Christopher Tozzi, Technology Analyst
August 28, 2025

4 Min Read



Data centers create varying levels of employment depending on facility type, location, and operational needs – from construction jobs to technical roles. IMAGE: ALAMY

Data centers have frequently been criticized for creating few permanent jobs in relation to their footprint – and this criticism might not be entirely unfounded. In general, data centers generate relatively few jobs compared to the cost of building and operating a typical facility or the amount of land it occupies.

On the other hand, the number of jobs resulting from data centers can vary widely depending on factors like facility type and location. It's a little narrow-minded to conclude that data centers are always total busts when it comes to job creation.

To understand why, let's look at the extent to which data centers do or don't spawn new employment opportunities.

How Do Data Centers Create Jobs?

Data centers can generate jobs in two primary ways:

Temporary, contracted employment opportunities during data center construction. A large facility might keep thousands of construction workers busy, at least for the year or two that it takes to build.

Permanent jobs for staff inside data centers. Once a data center is up and running, it usually requires some on-site technicians to handle tasks like setting up and managing IT equipment. Typically, however, the total data center staff number is only several dozen.

Related: Leadership Updates: Key Data Center & Cloud Appointments (Q3 2026)

So, while data centers may create many jobs in the short term, most result in relatively few permanent jobs – hence why critics tend to highlight the generous tax abatements that data centers often receive. They tend to argue that local communities receive few economic benefits from becoming home to a new data center.



Job creation from data centers extends beyond direct employment, supporting broader economic growth through digital infrastructure for countless businesses. Image: Alamy

Variables in Data Center Job Creation

However, it would be inaccurate to conclude that meaningful employment opportunities spawned by data centers are always negligible. The actual relationship between data centers and job creation can vary widely depending on factors like the following.

Data Center Density

Areas that are home to a large and growing number of data centers stand to benefit more from data center job creation. In places where new data centers are always going up, workers employed in constructing facilities are more likely to find ongoing employment opportunities.

In contrast, if a region hosts just one data center, the temporary jobs created by building the facility will disappear forever once it's up and running.

Dedicated vs. Colocation Data Centers

In general, a dedicated data center owned and used by just one company will generate fewer permanent jobs than a shared colocation facility. In the latter type of data center, multiple companies can deploy servers, and each of those companies will need a way to manage its hardware. Hiring local technicians is one way to meet this challenge.

Related: Colocation vs. Public Cloud: Cost, Performance, and How to Choose

In addition, even if a company that rents space in a colocation facility outsources equipment management to a third-party provider, it's still helping to support jobs at the provider.

Bare-Metal Data Centers

Data centers that are home to a large number of bare-metal workloads may also contribute to more permanent job growth. Bare-metal servers are more likely to require technicians to be physically present to maintain equipment, deploy applications and so on.

Modern data center automation solutions make it possible to perform many tasks remotely or automatically, even when working with bare-metal hardware. Still, having "boots on the ground" tends to be more important when deploying applications on bare metal than when working with software-defined virtual infrastructure.

Maintenance Needs

The age and complexity of the physical infrastructure inside a data center play a role in how many permanent jobs it creates. For example, a facility with dated HVAC systems may require more technicians on-site to maintain components and address failures, although this may produce only a handful of additional jobs relative to a facility that requires minimal maintenance.

Related: Will AI Agents Push Enforcement Back into the Database?

Data Centers Do Create Jobs – Just Not Always at Scale

It would be wrong to say that data centers are massive engines of job creation. The typical data center results in an almost negligible number of permanent jobs relative to its scale.

But it's also wrong to conclude that data centers never create a meaningful number of jobs. Under the right circumstances, data centers can contribute a fair number of employment opportunities to local communities. A single facility won't put thousands of people to work forever, but ongoing data center construction, along with data centers that require especially high numbers of staff, can result in large-scale ongoing employment.

Importantly, while this article focused on direct employment within data centers, we should also consider their broader economic impact. Data centers power countless businesses, organizations, and essential services. From this perspective, data centers support jobs across the entire economy – from small local businesses to major enterprises – by providing the digital infrastructure they need to operate in today's world.

About the Author



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Technology Analyst

Christopher Tozzi is a technology analyst with subject matter expertise in cloud computing, application development, open source software, virtualization, containers and more. He also lectures at a major university in the Albany, New York, area. His book, "For Fun and Profit: A History of the Fr...

Recommendations

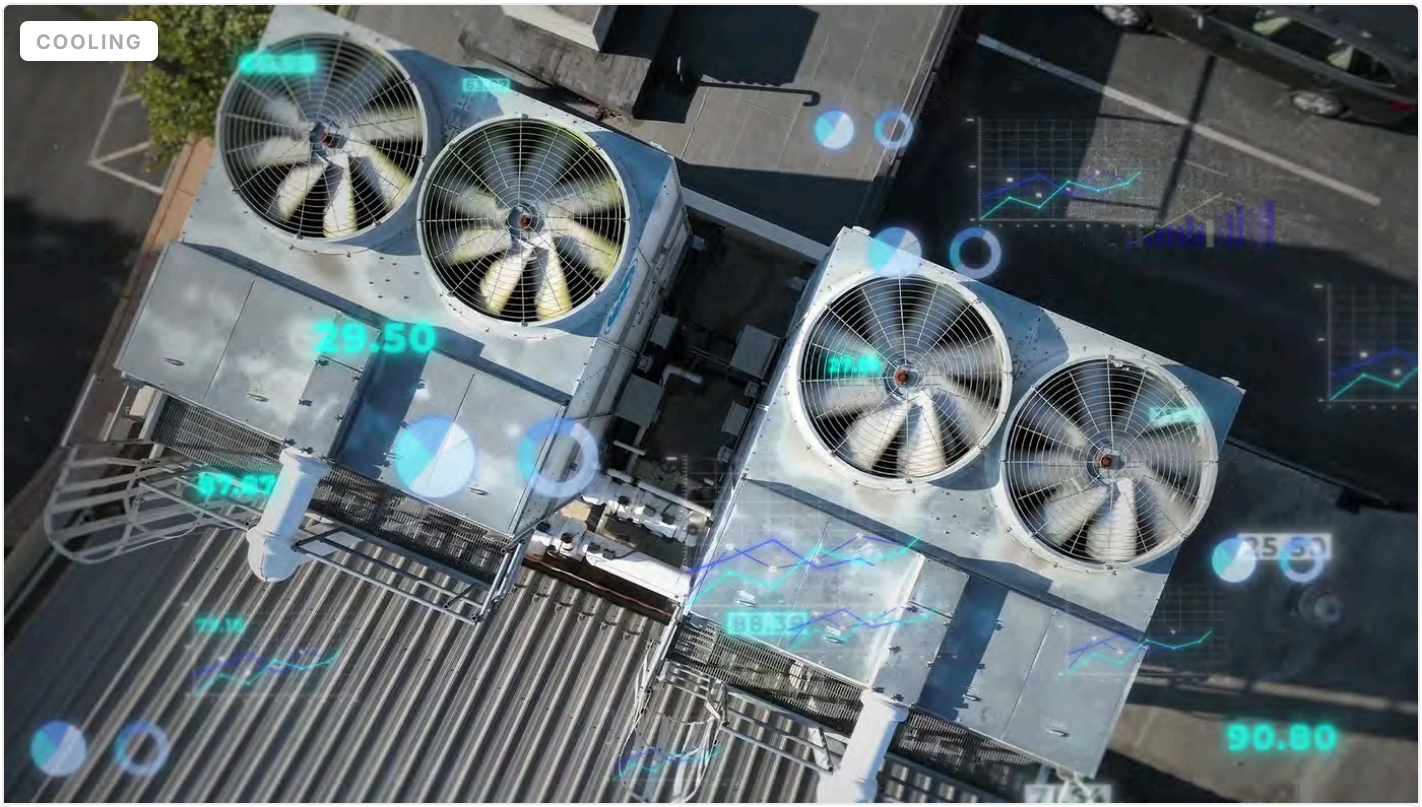
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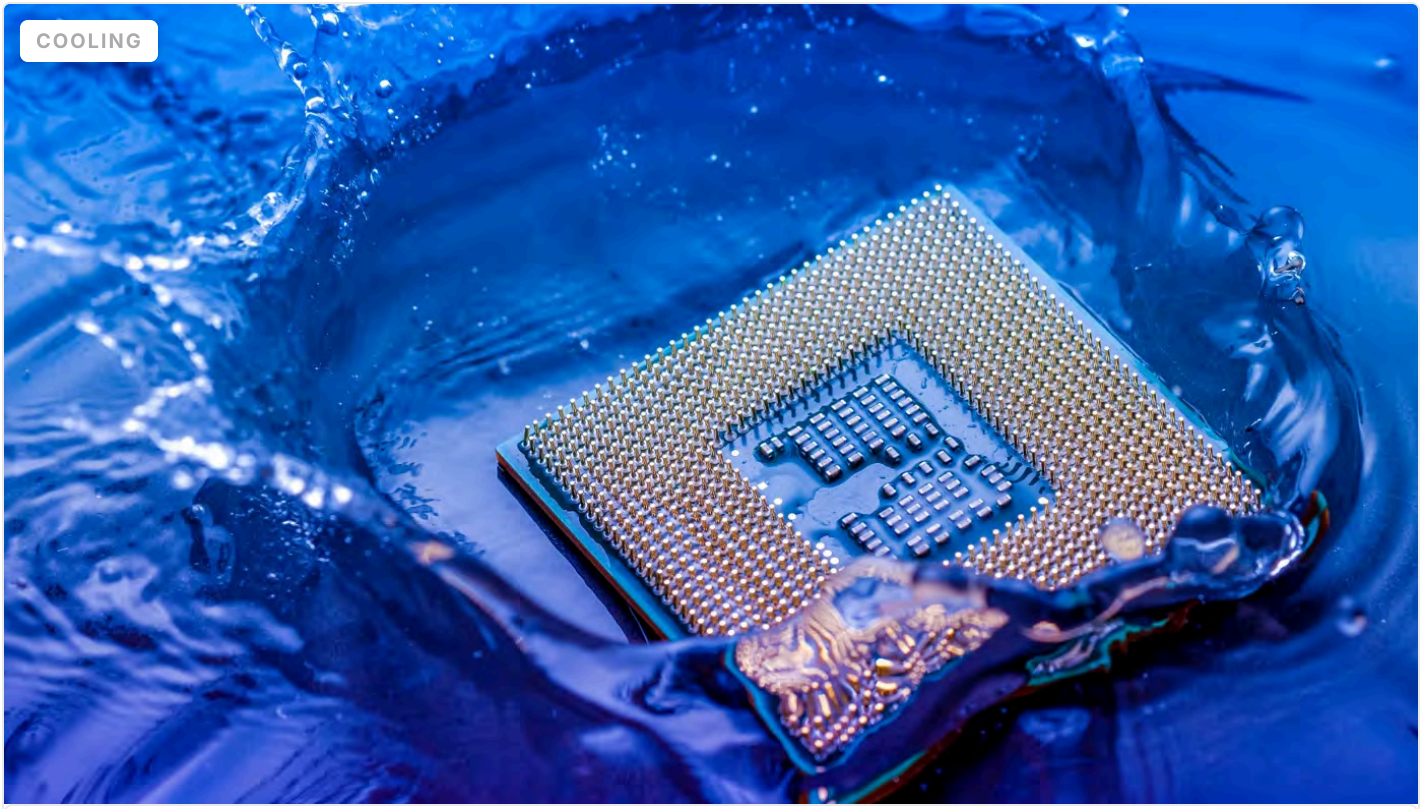
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2025 EMPLOYMENT SITE READINESS STUDY

To
Clackamas County

For

Office of Economic Development

Dated
June 26, 2026

Project Number
2250163.00

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I. EXECUTIVE SUMMARY

In order to support Clackamas County's economic development efforts, Mackenzie reviewed, analyzed, and mapped employment lands throughout the county through several different tasks. This document includes three chapters, one with findings from each task. Some of the tasks build off of one another while others are discrete and separate tasks, but all are summarized here together in one large report.

Chapter 1: Vacant Industrial Parcel Analysis

For the first task of this project, Mackenzie performed a desktop analysis of vacant and/or redevelopable industrially zoned parcels greater than 5 acres in unincorporated Clackamas County to better understand land availability and potential for future industrial development in the County. The analysis identified a total of 23 parcels that fit into one of four categories for development potential (Development-ready, Developable with constraints, Unlikely to develop due to constraints, and Active business use present). These parcels add up to approximately 457 acres.

Approximately 90% of all inventoried parcel acreage (19 out of 23 parcels) are in Category 4: *Active business use present*. Additionally, 43% of parcels (10 of the 23 parcels inventoried) are impacted by environmental constraints such as steep terrain, wetlands, and flood hazard zones. There are two parcels in the most promising category (Category 1: Development-ready), both owned by Clackamas County Development Agency (parcels 1 and 2). Mackenzie put additional consideration into development potential for these two parcels, including re-grouping the bisected and disconnected parcel segments and aggregating the parcel segments with adjacent smaller parcels under the same ownership to create two potential development-ready parcels.

Chapter 2: Economic Opportunity Analysis (EOA) Summary

For the second task of this project, Mackenzie reviewed Economic Opportunity Analyses (EOAs) for ten incorporated cities within Clackamas County: Estacada, Lake Oswego, Milwaukie, Canby, Happy Valley, Molalla, Sandy, Tualatin, West Linn, and Wilsonville (EOAs completed between 2011 and 2025). Findings from each city's Buildable Land Inventory (BLI) were extracted to compare and aggregate the buildable land available for industrial and commercial uses (vacant and redevelopable), as well as the forecasted land demand in the EOAs, and the resulting surplus or deficit for each city. This analysis illustrates that there is a wide range of forecasted land scenarios for cities within Clackamas County, with some cities forecasted to have surpluses of hundreds of acres, and other cities forecasted to have deficits of hundreds of acres.

Mackenzie tabulated the total buildable employment land for both commercial and industrial land for all these cities within Clackamas County, resulting in a total of 2,051 acres (AC) of buildable industrial land and 627 AC of buildable commercial land. After accounting for the three cities that are in Clackamas County but are also a part of another county (Lake Oswego, Tualatin, and Wilsonville), the adjusted total by share of cities' area within Clackamas County is 1,404 AC of buildable industrial land, and 601 AC of buildable commercial land. (The methodology for accounting for multi-county cities is detailed in Appendix 5.)

Combining the forecasted needs for each of the cities highlighted overall deficits for both industrial and commercial land: a deficit of 194 AC of industrial land and a deficit of 169 AC of commercial land across

the cities within Clackamas County.[1] After accounting for multi-county cities, the adjusted overall deficits by share of cities' area within Clackamas County are a deficit of 841 AC of industrial land, and a deficit of 196 AC of commercial land.

Chapter 3: BLI Mapping and Analysis

After summarizing these ten EOAs in task 2, Mackenzie analyzed and mapped the Buildable Land Inventory (BLI) for Canby, Estacada, Gladstone, Happy Valley, Johnson City[2], Lake Oswego, Milwaukie, Molalla, Oregon City, Sandy, Tualatin[2], West Linn, and Wilsonville.[3] This analysis involved identifying the status of the buildable employment land as vacant, partially vacant/infill, or redevelopable based on 2024 data from Metro and data from the jurisdictions outside of Metro (from various years between 2019 and 2025). Important attributes such as parcel size and zoning classification were recorded. Additionally, to highlight potential impact of parcel aggregation, Mackenzie identified parcels which may be suitable candidates for aggregation based on shared property boundaries in order to create larger development sites.

Mackenzie found that the analyzed jurisdictions have approximately 930 parcels of buildable employment land (commercial, industrial, and mixed use). Approximately 68% of the identified parcels are smaller than one (1) acre in size and another 22% are in the 1-4.99-acre size range, meaning fewer than 10% of the analyzed parcels are larger than 5 acres. Importantly, this analysis is a snapshot in time, using the best available data, and may not be reflective of current conditions.

The analysis and technical findings are detailed in the following report and in the appendices, which include the map packages, spreadsheet deliverables, and in-depth methodologies.

[1] Goal 9 does not have a required method for employment forecasting. Each city has different approaches to forecasting demand scenarios, creating difficulty in direct comparison. Professional judgement was used to select the most similar forecast for each city for this analysis, selecting the forecasts based on OED employment growth trends and industry trends, or whatever forecast was available when only one was provided. The process for selecting comparable scenarios is detailed in Appendix 5.

[2] No buildable employment land parcels were identified by Metro in Johnson City and Tualatin (the portion of the City within Clackamas County). Therefore, these two jurisdictions have not been included in further steps of this study.

[3] Only the portions of Lake Oswego, Tualatin, and Wilsonville within Clackamas County were studied in this analysis.

II. CHAPTER 1: VACANT INDUSTRIAL PARCEL ANALYSIS

Purpose

To support Clackamas County's economic development effort, Mackenzie performed a desktop analysis of vacant and/or redevelopable industrially zoned parcels greater than 5 acres in unincorporated Clackamas County. This analysis can help County staff better understand land availability and potential for future industrial development in the region.

Findings Summary

The analysis identified a total of 23 parcels that fit into one of four categories for development potential. These parcels add up to approximately 457 acres. Approximately 90% of all inventoried parcel acreage (19 out of 23 parcels) are in Category 4: *Active business use present* and have a lower likelihood of redevelopment. Additionally, 43% of parcels (10 of the 23 parcels inventoried) are impacted by environmental constraints such as steep terrain, wetlands, and flood hazard zones. There are two parcels in the most promising category (Category 1: *Development-ready*), both owned by Clackamas County Development Agency (parcels 1 and 2). Mackenzie put additional consideration into development potential for these two parcels, including re-grouping the bisected and disconnected parcel segments and aggregating the parcel segments with adjacent smaller parcels under the same ownership to create two potential development-ready parcels.

The following section shares a summary of the methodology and findings of this analysis. More technical information and findings, along with the maps, can be found in the below appendices:

- Appendix 1 – Spreadsheet summary of inventoried parcels
- Appendix 2 – Map package of inventoried parcels
- Appendix 3 – County wide map of inventoried parcels

Methodology Summary

To complete this analysis, Mackenzie utilized Geographic Information System (GIS) data from Clackamas County and Metro Regional Land Information System (RLIS). Clackamas County provided a dataset with all industrially zoned parcels of 5 acres or larger in the unincorporated areas of the County, which was created by County staff in the summer of 2025. There were 108 total parcels in this dataset, totaling 1,404 AC. Mackenzie reviewed each of these parcels to identify the parcels that were entirely vacant or were partially vacant but have at least 5 acres of contiguous vacant land. Parcels that were already fully in use were removed from analysis.

Additional spatial layers were added to the analysis, including Flood Hazard Zones, wetlands, and streams, which revealed significant development constraints on some parcels.[4] Mackenzie also assembled additional details for each parcel, including identifying existing operations through internet searches and incorporating ownership (taxpayer) information and aerial photography. Discussions with Clackamas County staff about parcel context, surrounding uses, and (re)development potential helped further refine the list of parcels.

Based on this analysis, all parcels were placed into one of four categories:

[4] Flood hazard zone data provided by FEMA. Wetland and stream data provided by Metro RLIS.

Category 1. Development-ready

- Vacant parcel, zoned for industrial development, without constraints (wetlands, floodplain, topography, etc.).
- Parcels in this category present no significant development constraints, have infrastructure at or near the property boundary, and entitlements are already in place or can be easily obtained.

Category 2. Developable with constraints

- Vacant parcel, zoned for industrial development, with some constraints (wetlands, floodplain, topography, etc.) that may or may not need to be mitigated prior to development.
- Parcels in this category could become viable for development within approximately three years, contingent upon addressing reasonable development constraints, securing necessary entitlements, and/or extending required public infrastructure.

Category 3. Unlikely to develop due to constraints

- Vacant parcel, zoned for industrial development, with significant constraints (wetlands, floodplain, topography, etc.), covering the majority of the parcels.
- Parcels in this category are significantly constrained, face challenges in obtaining entitlements, or are landlocked from viable public infrastructure. Examples include parcels with steep slopes, former quarry sites, or riverside locations with significant development restrictions.

Category 4. Active business use present

- Vacant or partially in use parcel owned by an existing business. Property may be partially in use by existing business or vacant but being held for future business needs/expansion.

Technical Analysis Findings

The analysis identified 23 industrially zoned parcels greater than 5 acres that are vacant, partially vacant, or have opportunity for expansion of nearby business operations. See Table 1 for a summary of results.

TABLE 1. INVENTORIED PARCEL OVERVIEW	
Number of Inventoried Parcels	23 AC
Range of Parcel Sizes	5-152 AC
Average Parcel Size	Roughly 20 AC
Average Parcel Size (Category 1-3)	11 AC
Median Parcel Size	11.50 AC

The summary of how all 23 parcels were categorized is shown in Table 2.

TABLE 2. PARCEL CATEGORIZATION SUMMARY		
Category	**Number of Parcel**	**Total Parcel Area (AC)**
Category 1 (Development-ready)	2	Roughly 20
Category 2 (Developable with constraints)	0	0
Category 3 (Unlikely to develop due to constraints)	2	Roughly 23.5
Category 4 (Active business use present)	19	Roughly 413
Total	**23**	Roughly **455**

There were two parcels in Category 1, meaning only two parcels stand out as being vacant and development ready. These two parcels are further analyzed in the subsequent section. Additionally, of the +/-455 total acres in all categories, approximately 413 acres are in Category 4 (Active business use present). Furthermore, eight of these parcels in Category 4 are heavily impacted by flood hazard zones and/or wetlands.

Only one of the parcels identified in this analysis is considered "vacant" in Metro's Buildable Land Inventory (BLI) from the 2024 Urban Growth Report Regional Forecast. This one parcel is Parcel #3, a 12-acre parcel owned by Clackamas River Water District that has significant environmental constraints (steep terrain and majorly impacted by flood hazard zones).

Table 3 presents more information about each of the 23 inventoried parcels, including the parcels impacted by environmental constraints. See Appendix 1 for more detailed parcel inventory spreadsheet with addresses and parcel numbers and Appendix 2 for more detailed parcel maps with contours and flood hazard zones.

TABLE 3. OVERVIEW OF INDIVIDUAL INVENTORIED PARCELS						
Parcel Number	Gross Parcel Acreage	Owner/Taxpayer	City	Active Business Use	Topography and/or Environmental Constraints	Category
1	7.71	Clackamas County Development Agency	Clackamas			1
2	12.68	Clackamas County Development Agency	Clackamas			1
3	12.08	Clackamas River Water Dist.	Clackamas		✓	3
4	11.55	Clackamas Education Service District	Clackamas		✓	3
5	8.3	North Clackamas Parks & Rec. Dist.	Portland	✓	✓	4
6	5.44	Spitznagel Family LLC	Clackamas	✓		4
7	13.72	Tyler Family Limited Partnership	Boring	✓		4
8	8.59	Smith Larry D Trustee	Boring	✓		4
9	5.61	MVGD LLC	Clackamas	✓		4
10	7.93	Eagle Foundry Co.	Eagle Creek	✓		4
11	22.81	Eagle Foundry Co.	Eagle Creek	✓		4
12	6	Mckee Holdings II LLC	Eagle Creek	✓	✓	4
13	5	Day Portland Building LLC	Eagle Creek	✓	✓	4
14	7.01	Day Portland Building LLC	Eagle Creek	✓		4
15	62.03	Glacier Northwest Inc	Canby	✓	✓	4
16	17.48	Glacier Northwest Inc	Canby	✓	✓	4
17	10.17	B & Co Properties LLC	Canby	✓	✓	4
18	15.56	Canby Sand & Gravel Co	Canby	✓	✓	4
19	15.52	Fip Master Funding XIV LLC	Mulino	✓	✓	4
20	8.11	Sanders Wood Products Inc	Molalla	✓		4
21	25.26	Sanders Wood Products Inc	Molalla	✓		4
22	152.64	Sanders Wood Products Inc	Molalla	✓		4
23	16.23	Pacific Fibre Products Inc	Molalla	✓		4

Further Analysis of Category 1 Parcels

The two parcels that are in Category 1 (development-ready) are owned by the Clackamas County Development Agency. These two parcels are made up of irregular and disconnected segments which are also bisected by Highway 224. To better understand development potential for this area, Mackenzie examined what would happen if parts of the parcels were re-grouped, creating two parcels: Parcel 1 could be made up of the parcel segments on the east side of Highway 224 and Parcel 2 could be made up of the parcel segments on the west side of Highway 224. Next, Mackenzie examined aggregating the parcels with additional adjacent industrially zoned parcels with shared ownership that had not been included in the previous analysis because they are smaller than 5 acres. With the addition of these smaller parcels, the approximate size of hypothetical Parcel 1 is 9.38 AC and the approximate size of hypothetical Parcel 2 is 12.66 AC. Property line adjustments are necessary to deliver these as graphically shown.

The parcel aggregation of each new potential aggregated site is detailed in Table 4 and 5 and graphically depicted in Appendix 2.

TABLE 4. PARCEL 1 AGGREGATION Parcel Segments East of Highway 224			
Parcel Segment Number	**Assessor Parcel Number (APN)**	**Parcel Segment Area (AC)**	**Included in Original Inventory Analysis**
1a	22E09A 00800	6.41	✓
1b	22E09AB 00100	1.55	✓
1c	22E09AB 00100	0.78	✓
1d	22E09A 00101	0.64	
	Total Parcel 1 AC:	**9.38**	

TABLE 5. PARCEL 2 AGGREGATION Parcel Segments West of Highway 224			
Parcel Segment Number	**Assessor Parcel Number (APN)**	**Parcel Segment Area (AC)**	**Included in Original Inventory Analysis**
2a	22E09AB 00100	9.82	✓
2b	22E09AB 00100	0.52	✓
2c	22E09A 00800	1.3	✓
2d	22E09AB 00200	0.61	
2e	22E09A 00101	0.41	
	Total Parcel 2 AC:	**12.66**	

Conclusion

After reviewing approximately 1,404 AC of industrially zoned parcels greater than 5 acres throughout unincorporated Clackamas County, Mackenzie identified 20.39 AC of development-ready land (Category 1), representing approximately 1.45% of all land studied. These 20.39 AC of developable land are all located on two nearby parcels (Parcel 1 and Parcel 2), both owned by Clackamas County Development Agency.

More detailed analysis of these Category 1 parcels led Mackenzie to examine aggregating the parcels with adjacent parcels under shared ownership that were less than 5 acres (and therefore not included in original inventory analysis). This aggregation could add approximately 1.66 AC, for a total of 22.05 AC of development-ready land (Category 1), representing approximately 1.57% of studied land.

III. CHAPTER 2: ECONOMIC OPPORTUNITY ANALYSIS (EOA) SUMMARY

Purpose

Mackenzie's review of industrially zoned parcels greater than 5 acres in unincorporated Clackamas County yielded limited opportunities for industrial development. Given these findings in *unincorporated* Clackamas County, the next phase of this work was to investigate employment lands in *incorporated* Clackamas County.

To do this, Mackenzie reviewed Economic Opportunity Analyses (EOAs) for 10 cities within Clackamas County: Estacada; Lake Oswego; Milwaukie; Canby; Happy Valley; Molalla; Sandy; Tualatin; West Linn; and Wilsonville. Findings from each city's Buildable Land Inventory (BLI) were extracted to compare and aggregate the buildable land available for industrial and commercial uses (vacant and redevelopable), as well as the forecasted land demand in the EOAs, and the resulting surplus or deficit for each city.

The following section discusses the findings of this analysis along with data visualizations of these findings. More technical information on the methodology and findings can be found in the appendices:

- Appendix 4 – EOA Summary and Analysis Matrix
- Appendix 5 – EOA Summary Methodology and Assumptions

Findings

This analysis illustrates that there is a wide range of forecasted land needs for cities within Clackamas County, with some cities forecasted to have surpluses of hundreds of acres (e.g., Estacada), and other cities forecasted to have deficits of hundreds of acres (e.g., Milwaukie and Canby).

Countywide Analysis

Mackenzie summed up the total buildable land for both commercial and industrial land for all the cities within Clackamas County, resulting in a total of 2,051 acres (AC) of buildable industrial land and 627 AC of buildable commercial land. After accounting for the three cities that are in Clackamas County but are also a part of another county, the adjusted total by share of cities' area within Clackamas County is 1,404 AC of buildable industrial land, and 601 AC of buildable commercial land. (The methodology for accounting for multi-county cities is detailed in Appendix 5.)

Combining the forecasted needs for each of the cities resulted in overall deficits for both industrial and commercial land: a deficit of 194 AC of industrial land and a deficit of 169 AC of commercial land across the cities within Clackamas County.[5] After accounting for multi-county cities, the adjusted overall deficits by share of cities' area within Clackamas County are a deficit of 841 AC of industrial land, and a deficit of 196 AC of commercial land.

The findings are summarized in Table 6 below, and the full analysis can be found in Appendix 2.

[5] Goal 9 does not have a required method for employment forecasting. Each city has different approaches to forecasting demand scenarios, creating difficulty in direct comparison. Professional judgement was used to select the most similar forecast for each city for this analysis, selecting the forecasts based on OED employment growth trends and industry trends, or whatever forecast was available when only one was provided. The process for selecting comparable scenarios is detailed in Appendix 5.)

TABLE 6. COUNTYWIDE ANALYSIS	
Summary of all cities within Clackamas County, as entire city and by share of area within Clackamas County.	
Total acreage of buildable **industrial** land	
By share of cities' area within Clackamas County	1,404 AC
Entire cities	2,051 AC
Total acreage of buildable **commercial** land	
By share of cities' area within Clackamas County	601 AC
Entire cities	627 AC
Reconciliation: Surplus (+) or Deficit (-)	
Industrial	
By share of cities' area within Clackamas County	-841AC
Entire cities	-194 AC
Commercial	
By share of cities' area within Clackamas County	-196 AC
Entire cities	-169 AC

Subtotals

Given the variation of cities across Clackamas County – in size, location, and character – the findings were divided into three groups. Tables 7, 8, and 9 show subtotals of these three groupings, with subtotals of acreage of buildable industrial and commercial land, and the subtotals of the surplus or deficit this group of cities face given industrial and commercial land demand.

The first group, "Small Cities," includes Estacada, Canby, Molalla, and Sandy which are all outside of the Metro boundary. The second group, "Inside Metro," includes Milwaukie, Happy Valley, and West Linn, which are within the Metro boundary. The third group, "Multi-County Cities," includes Lake Oswego, Tualatin, and Wilsonville, which are all part of two counties, and therefore need an additional layer of analysis.

TABLE 7. SMALL CITIES (OUTSIDE OF METRO) SUBTOTAL	
Summary of Estacada, Canby, Molalla, and Sandy	
Total acreage of buildable **industrial** land	761 AC
Total acreage of buildable **commercial** land	308 AC
Reconciliation: Surplus (+) or Deficit (-)	
Industrial	0 AC
Commercial	+122 AC

TABLE 8. INSIDE METRO SUBTOTAL	
Summary of Milwaukie, Happy Valley, West Linn	
Total acreage of buildable **industrial** land	230 AC
Total acreage of buildable **commercial** land	122 AC
Reconciliation: Surplus (+) or Deficit (-)	
Industrial	-483 AC
Commercial	-150 AC

TABLE 9. MULTI-COUNTY SUBTOTAL	
Summary of Lake Oswego (95% of area is within Clackamas. County) Tualatin (9% of area is within Clackamas. County.) Wilsonville (89% of area is within Clackamas. County.)	
Total acreage of buildable **industrial** land	
By share of cities' area within Clackamas County	413 AC
Entire cities	1,060 AC
Total acreage of buildable **commercial** land	
By share of cities' area within Clackamas County	171 AC
Entire cities	197 AC
Reconciliation: Surplus (+) or Deficit (-)	
Industrial	
By share of cities' area within Clackamas County	-358 AC
Entire cities	+771 AC
Commercial	
By share of cities' area within Clackamas County	-167 AC
Entire cities	-141 AC

City by City Summaries

- **Estacada (EOA completed in 2019 through forecast year 2038):** Approximately 370 AC of buildable industrial land and 100 AC of buildable commercial land. Despite the city seeing growth, there is projected to be surpluses of over 300 AC of industrial land, and surpluses of between 85 and 100 AC of commercial land.
- **Lake Oswego (EOA completed in 2013 through forecast year 2035):** Approximately 39 AC of buildable industrial land and 120 AC of buildable commercial land. Forecasted to have surplus of approximately 35 AC of industrial land and between 77 and 100 AC of commercial land in low and medium growth scenarios, but deficits of 32 AC of industrial land and 68 AC of commercial land in the high growth scenario.
  - 5% of Lake Oswego's area (land mass) is located within Multnomah County. After accounting for only 95% of Lake Oswego being within Clackamas County, the adjusted buildable industrial land by share of area within Clackamas County is 36 AC of industrial land and 113 AC of commercial land. The approach to accounting for multi-county cities is detailed in Appendix 5.
- **Milwaukie (EOA completed in 2017, but City generated updated data in 2026 for this analysis, through projected year 2035):** Approximately 12 AC of buildable industrial land and 14 AC of buildable commercial land. City is projected to have significant deficits of between 576 and 593 AC of industrial land and between 158 and 239 AC of commercial land.

- **Canby (EOA completed in 2023 through forecast year 2043):** Approximately 163 AC of buildable industrial land and 16 AC of buildable commercial land. City is projected to have deficits of between 81 and 474 AC of industrial land and between 4 and 8 AC of commercial land. Canby is currently under evaluation for an Urban Growth Boundary (UGB) expansion.
- **Happy Valley (EOA completed in 2011 through forecast year 2035):** Approximately 207 AC of buildable industrial land and 76 buildable commercial land. City is projected to have a surplus of industrial land between 91 and 152 AC. City is projected to have surplus of commercial land in low and medium growth scenarios (between 3 and 21 AC), but a 16 AC deficit of commercial land in the high growth scenario.
- **Molalla (EOA completed in 2025 through forecast year 2045):** Approximately 175 AC of buildable industrial land, and 55 AC of buildable commercial land. City is projected to have a 97 AC surplus of industrial land, and a 15 AC deficit of commercial land. Molalla is currently under evaluation for an Urban Growth Boundary (UGB) expansion.
- **Sandy (EOA completed in 2024 through forecast year 2044):** Approximately 54 AC of buildable industrial land and 142 AC of buildable commercial land. City is projected to have a deficit of 9 AC of industrial land and a 52 AC surplus of commercial land.
- **Tualatin (EOA completed in 2019 through forecast year 2040):** Approximately 668 AC of buildable industrial land and 15 AC of buildable commercial land. City is forecasted to have a slight deficit of 9 AC of industrial land, and a large deficit of 171 AC of commercial land.
    - 91% of Tualatin's area is located within Washington County. After accounting for only 9% of Tualatin being within Clackamas County, the adjusted buildable industrial land by share of area within Clackamas County is 61 AC of industrial land and 1 AC of commercial land. The approach to accounting for multi-county cities is detailed in Appendix 5.
- **West Linn (EOA completed in 2016 through forecast year 2036):** Approximately 12 AC of buildable industrial land and 32 AC of buildable commercial land. City is forecasted to have a slight surplus of industrial land, between 0.5 and 8.5 AC, and a slight surplus of commercial land, between 5 and 7 AC.
- **Wilsonville (EOA completed in 2025 through forecast year 2046):** Approximately 353 AC of buildable industrial land and 63 AC of buildable commercial land. The city is projected to have a surplus of 32 AC of industrial land and a deficit of 47 AC of commercial land.
    - 11% of Wilsonville's area is located within Washington County. After accounting for only 89% of Wilsonville being within Clackamas County, the adjusted buildable industrial land by share of area within Clackamas County is 315 AC of industrial land and 56 AC of commercial land. The approach to accounting for multi-county cities is detailed in Appendix 5.

Gladstone and Oregon City are not included in this analysis due to lack of publicly available data at the time of this report. Oregon City does not have an updated EOA that includes data that could be utilized in this analysis, similar to other jurisdictions. Oregon City's BLI data is included in the project scope's subtask 7, which uses data from Metro and is detailed in Chapter 3. The City of Gladstone EOA is from 1979, which was determined to be no longer relevant.

Data Visualizations

Buildable Land

*Part of city is located within a different county.

^Milwaukie's EOA was completed in 2017, but their BLI methodology was re-run to produce updated data in 2026

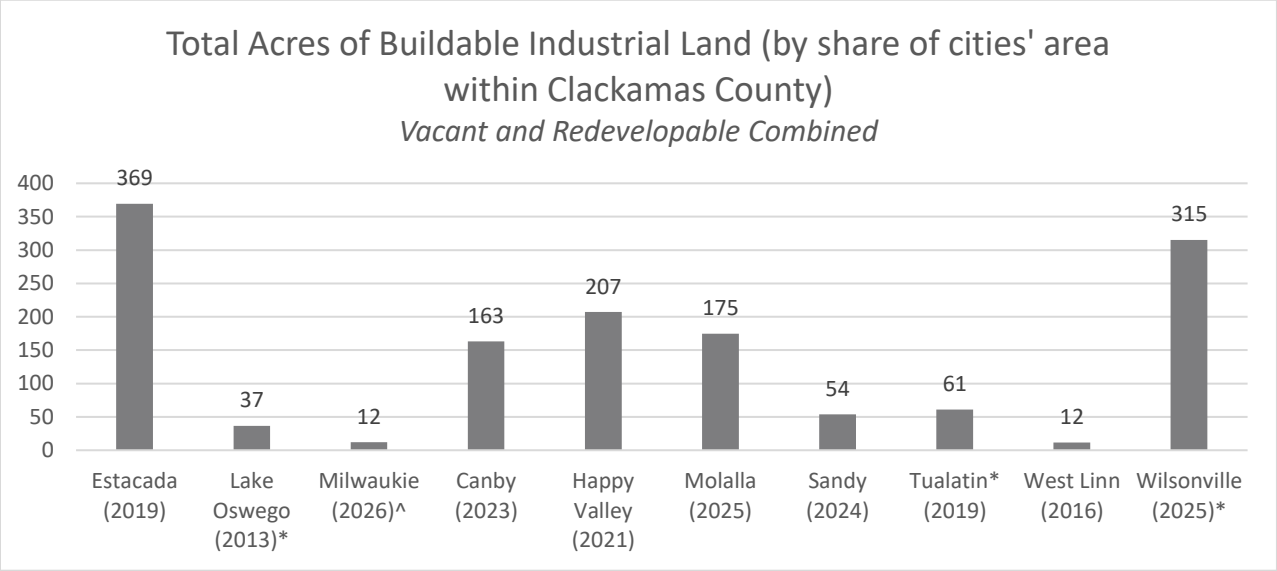


Figure 1. Total Acres of Buildable Industrial Land (by Share of Cities' Area within Clackamas County)

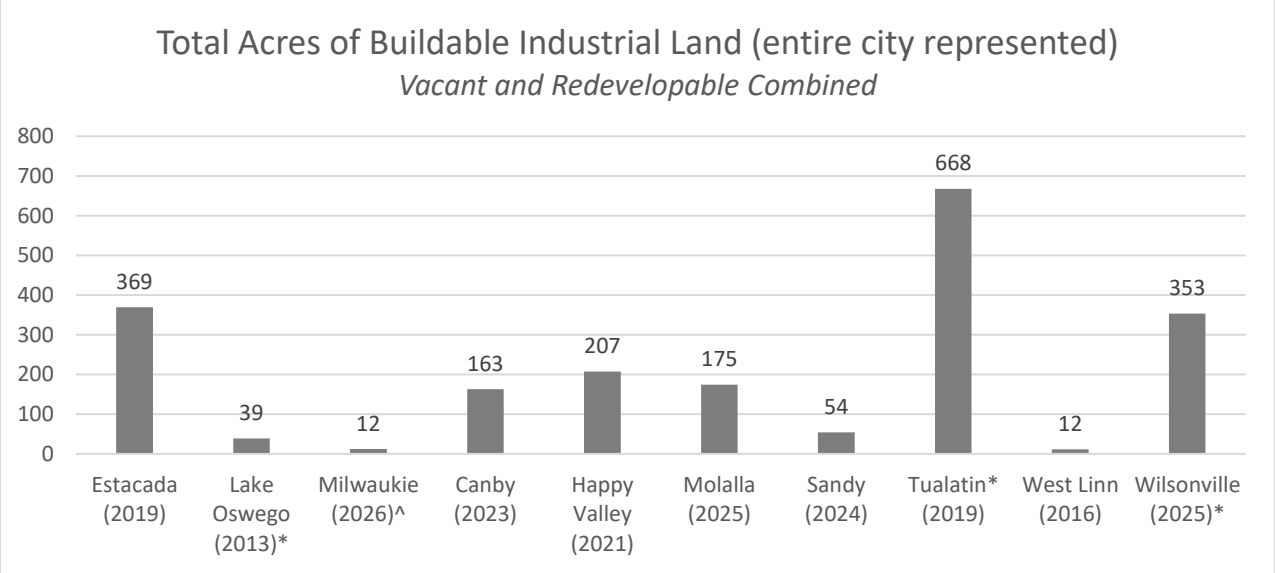


Figure 2. Total Acres of Buildable Industrial Land (Entire City Represented)

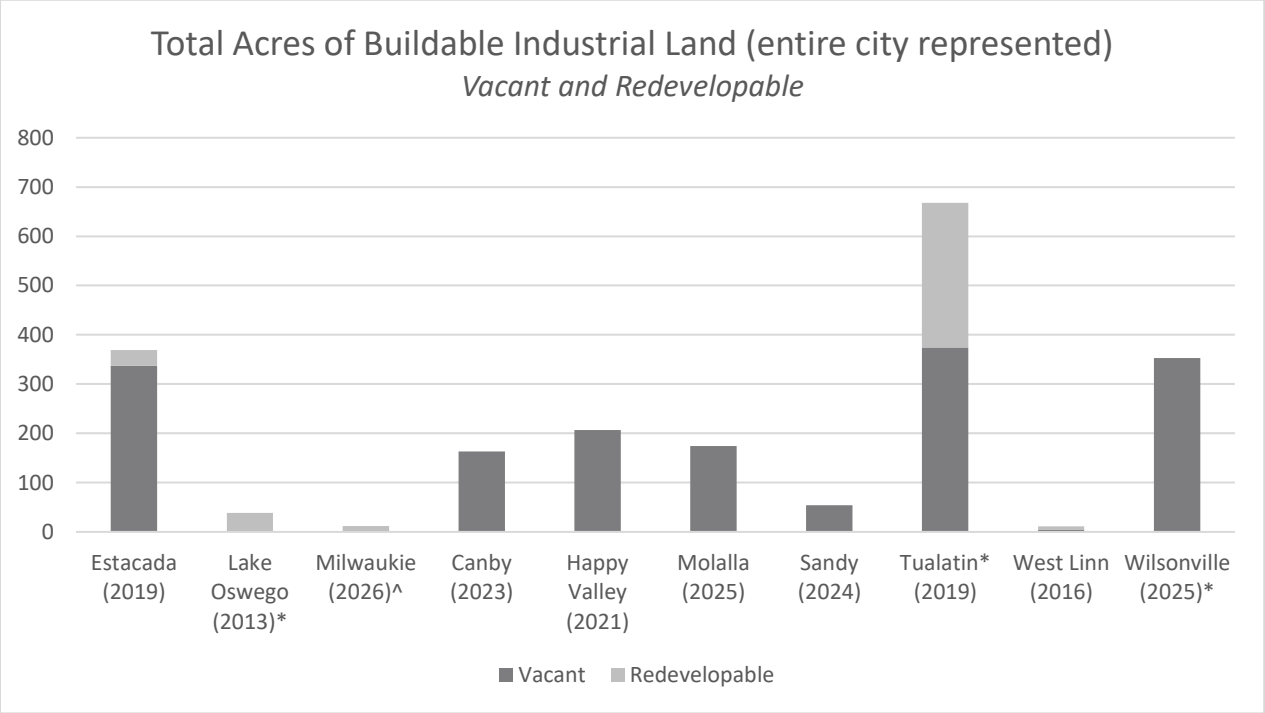


Figure 3. Total Acres of Buildable Industrial Land (Entire City Represented) by Status

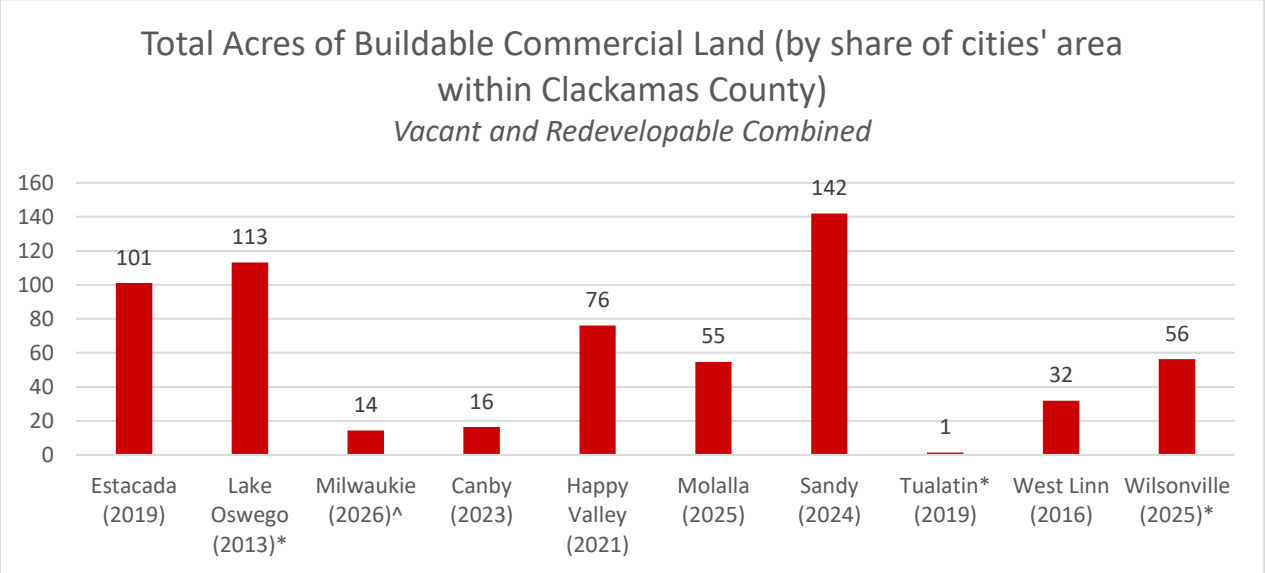


Figure 4. Total Acres of Buildable Commercial Land (by Share of Cities' Area within Clackamas County)

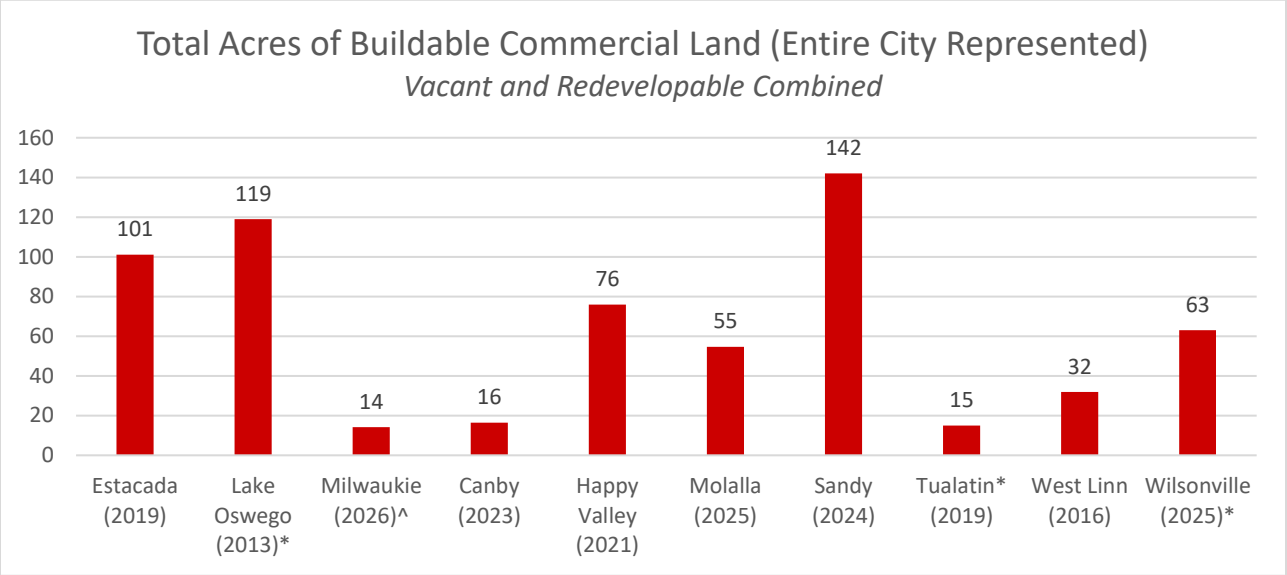


Figure 5. Total Acres of Buildable Commercial Land (Entire City Represented)

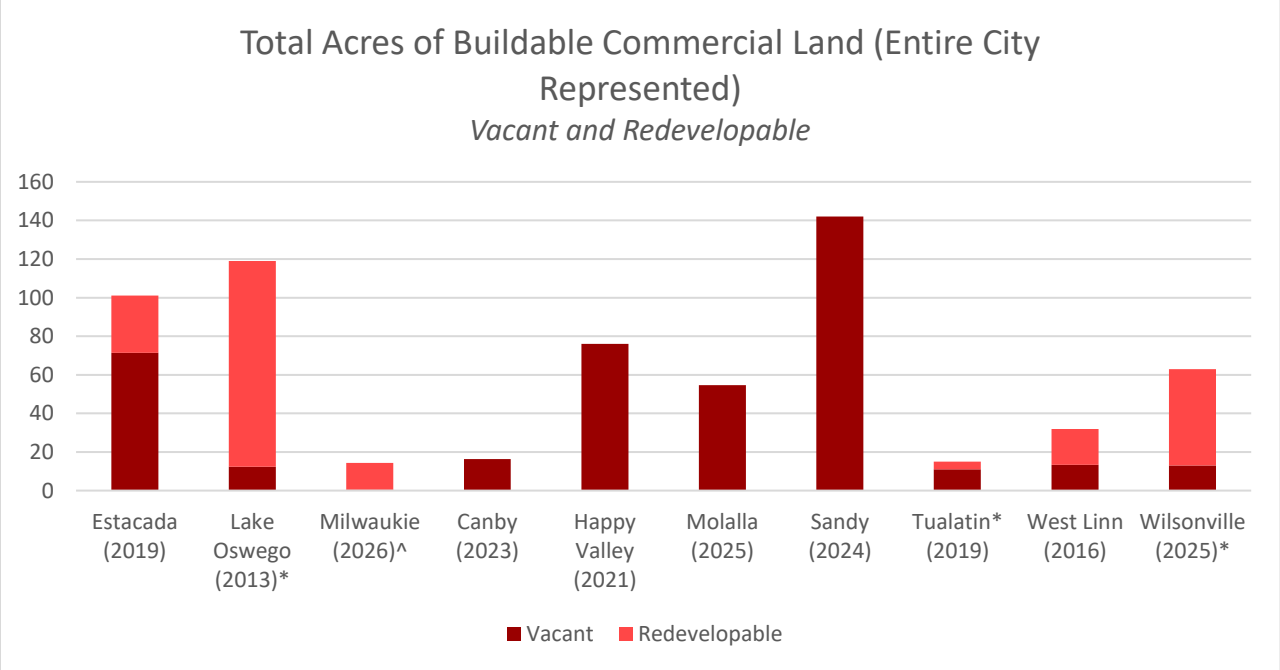


Figure 6. Total Acres of Buildable Commercial Land (Entire City Represented) by Status

Land Demand

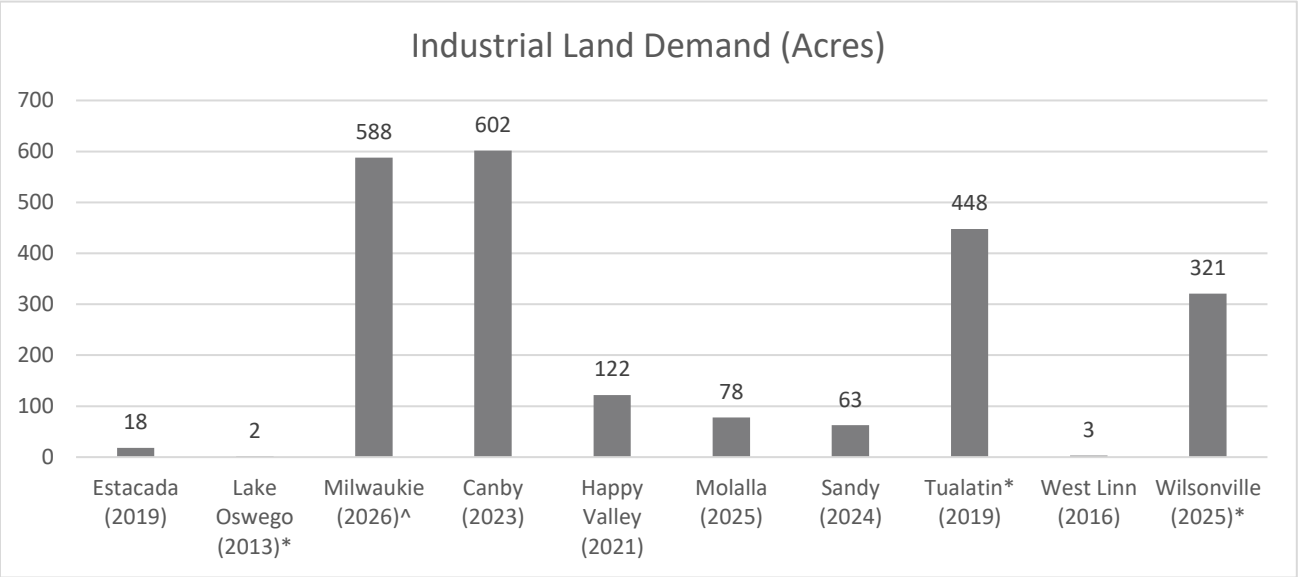


Figure 7. Industrial Land Demand (Acres) by City

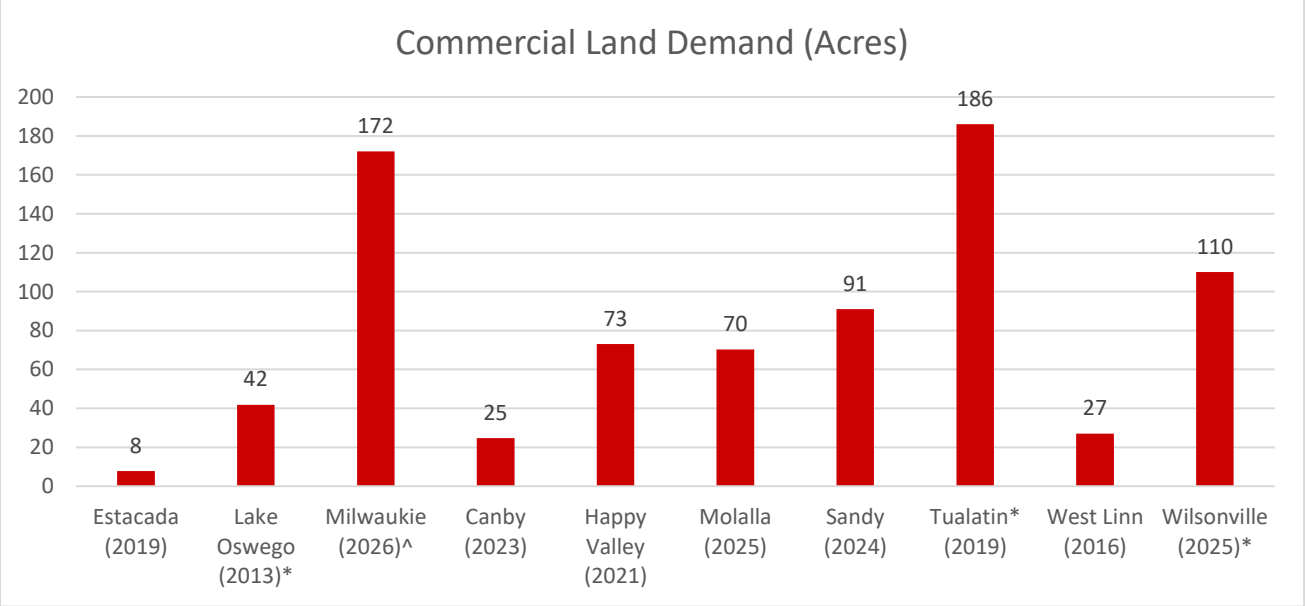


Figure 8. Commercial Land Demand (Acres) by City

Reconciliation

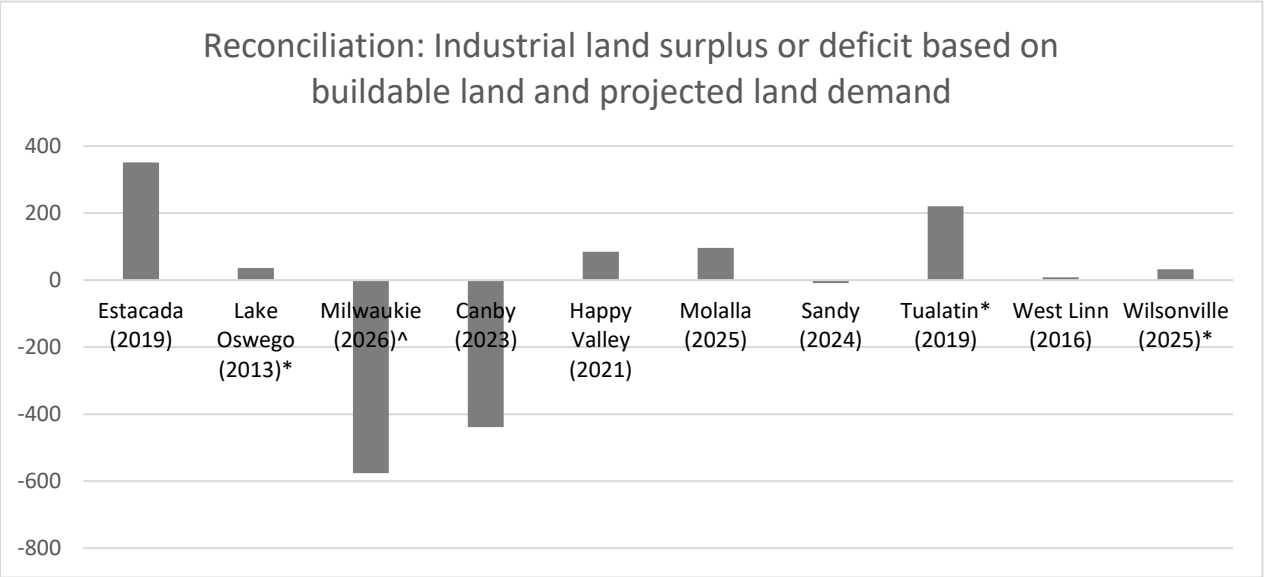


Figure 9. Reconciliation: Industrial Land Surplus or Deficit

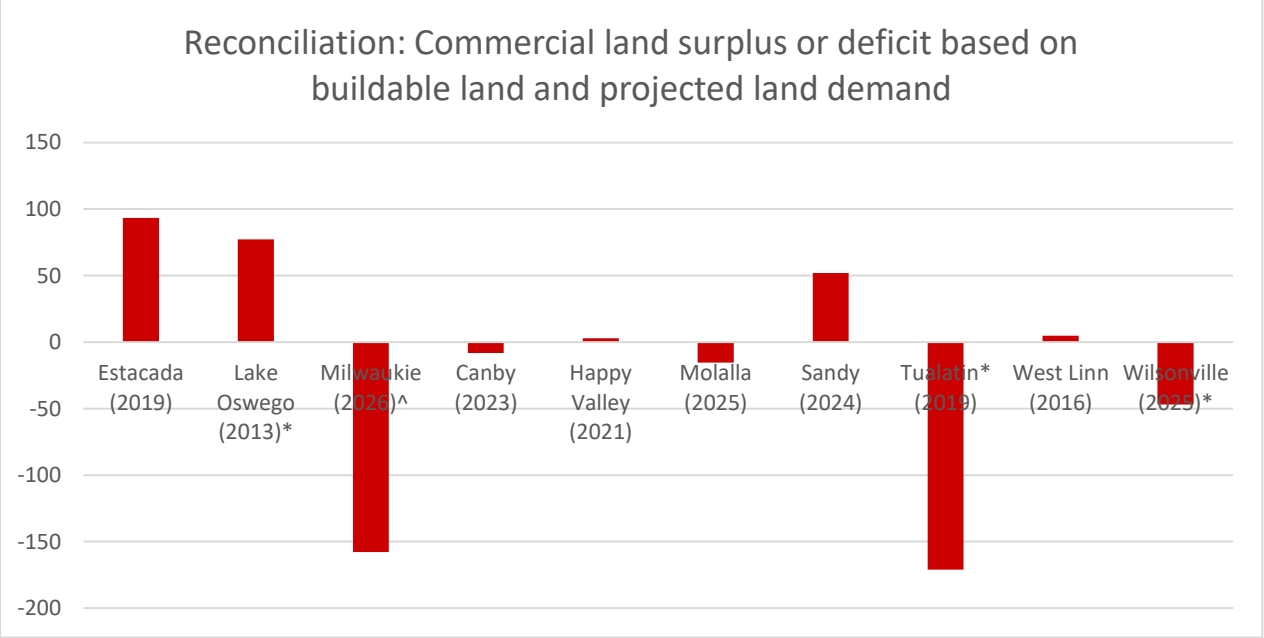


Figure 10. Reconciliation: Commercial Land Surplus or Deficit

IV. CHAPTER 3: BUILDABLE LAND INVENTORY (BLI) MAPPING AND ANALYSIS

Purpose

After reviewing and analyzing the Economic Opportunity Analysis (EOAs) for ten cities within Clackamas County and summing up the supply, demand, and surplus/deficit of employment land throughout these ten cities, Mackenzie mapped the Buildable Land Inventories (BLI's) to further analyze and illustrate the buildable employment land. The purpose of this analysis is to further the economic development objectives of Clackamas County through providing an analysis of buildable employment land within Canby, Estacada, Gladstone, Happy Valley, Johnson City[6], Lake Oswego, Milwaukie, Molalla, Oregon City, Sandy, Tualatin, West Linn, and Wilsonville. Only the portions of Lake Oswego, Tualatin, and Wilsonville within Clackamas County have been studied in this analysis.

To do so, Mackenzie identified the status of buildable employment land as vacant, partially vacant/infill, and redevelopable based on data from Metro and the jurisdictions outside Metro. Important attributes such as parcel size and zoning classification were recorded. Additionally, to highlight potential impact of parcel aggregation, Mackenzie identified parcels which may be suitable candidates for aggregation based on shared property boundaries in order to create larger development sites.

Importantly, the land in the Buildable Employment Land (BLI) datasets includes industrial, commercial, and mixed use and is considered "buildable," but not necessarily "development-ready." "Buildable Land" may have one, or more barriers to development (e.g. infrastructure availability). This should be taken into account when considering site suitability and development feasibility.

Additionally, this analysis does not include land in unincorporated Clackamas County, because the County does not have an Economic Opportunity Analysis (EOA), however, Metro's Buildable Land Inventory (BLI) does include urban and unincorporated areas within Metro's jurisdiction. See the first chapter of this report for an analysis of available industrially zoned parcels over 5 acres in unincorporated Clackamas County. The second chapter of this report analyzed the EOAs for jurisdictions within Clackamas County, taking into account forecasted needs and subsequent deficits and surpluses. Due to the lack of a County EOA, a next project phase may include an investigation of commercial and mixed use inventory in unincorporated Clackamas County, which would be a more robust county-wide perspective of available and buildable land inventories.

The following section shares both a summary of the key findings and a more detailed discussion of the technical findings along with recommended next steps. The map package and more technical information on the methodology can be found in the below appendices:

- Appendix 6 – Map package of BLI by jurisdiction
- Appendix 7 – BLI Mapping Methodology and Assumptions

Findings Summary

- The analyzed jurisdictions have approximately 930 parcels of buildable employment land (commercial, industrial, and mixed use).

[6] No buildable employment land parcels were identified by Metro in Johnson City and Tualatin (the portion of the City within Clackamas County). Therefore, these two jurisdictions have not been included in further steps of this study.

- Approximately 68% of the identified parcels are smaller than 1 acre in size and another 22% are in the 1-4.99-acre size range, meaning fewer than 10% of the analyzed parcels are larger than 5 acres. These 5 acres and larger parcels (89 total) make up more than 1,000 acres of the 1,700 acres identified in this report.
- As shown in Figure 11, below, approximately 66% of the identified buildable employment land is located within the four jurisdictions outside of Metro (Canby, Estacada, Molalla, and Sandy).
- Within Metro, Happy Valley, Oregon City, and Wilsonville each have over 100 acres of identified buildable employment land, with most parcels, 276 out of 373 (74%), smaller than 1 acre.
- The average parcel size of all identified parcels is 1.7 acres, and the median parcel size is 0.25 acres.
- In total, the analyzed jurisdictions have approximately 1,700 acres of buildable employment land (commercial, industrial, and mixed use).
    - Approximately 75% of the 1,700 buildable employment land acreage is found in the jurisdictions' industrial zones (not commercial or mixed use).
- The largest parcel of all identified parcels is approximately 50 acres, and the largest site (after aggregating parcels) is approximately 94 acres. Both the largest parcel and largest site are located in Estacada (notably, these parcels are not impacted by the 2023 rezone).[7] Although this study found one site greater than 100 AC (103 AC in Estacada), the site was rezoned in 2023 and is now less than 100 AC in size.
- This analysis found 17 parcels within the incorporated cities of Clackamas County that are larger than 20 acres. Parcel aggregation could result in 8 additional sites over 20 acres.
- Of the 5,800 acres of employment land identified by Metro in the 2024 Urban Growth Report, approximately 1,300 acres (22%) are within the Clackamas County Metro jurisdictions.

Data and Methodology Considerations

- For the jurisdictions in Metro, much of the employment land is impacted by one or more environmental constraints, including slope, wetlands, or floodplain. However, the acreage figures in this analysis are the net unconstrained acres after removal of the constrained areas.
- Many jurisdictions use different criteria to classify land as vacant, partially vacant/infill, or redevelopable. This presents a challenge when comparing jurisdictions evenly. These classifications are explained in the methodology appendix (Appendix 7) as reference.
- This analysis is a snapshot in time, with source data from different years, ranging from 2019 to 2025. Therefore, the status of parcels may be outdated and not reflective of current parcel status, due to the age of the best available data used in this report.

Figure 11 below summarizes the total buildable employment land for each jurisdiction analyzed.

[7] This analysis uses the City of Estacada's BLI, which was completed in 2019. In 2023, approximately 100 acres of Industrial land in the City of Estacada was rezoned to residential and an additional 100 acres of industrial land was redesignated for commercial and mixed-use. Accordingly, 100 acres of Employment land should be subtracted from the total acreage presented in this report.

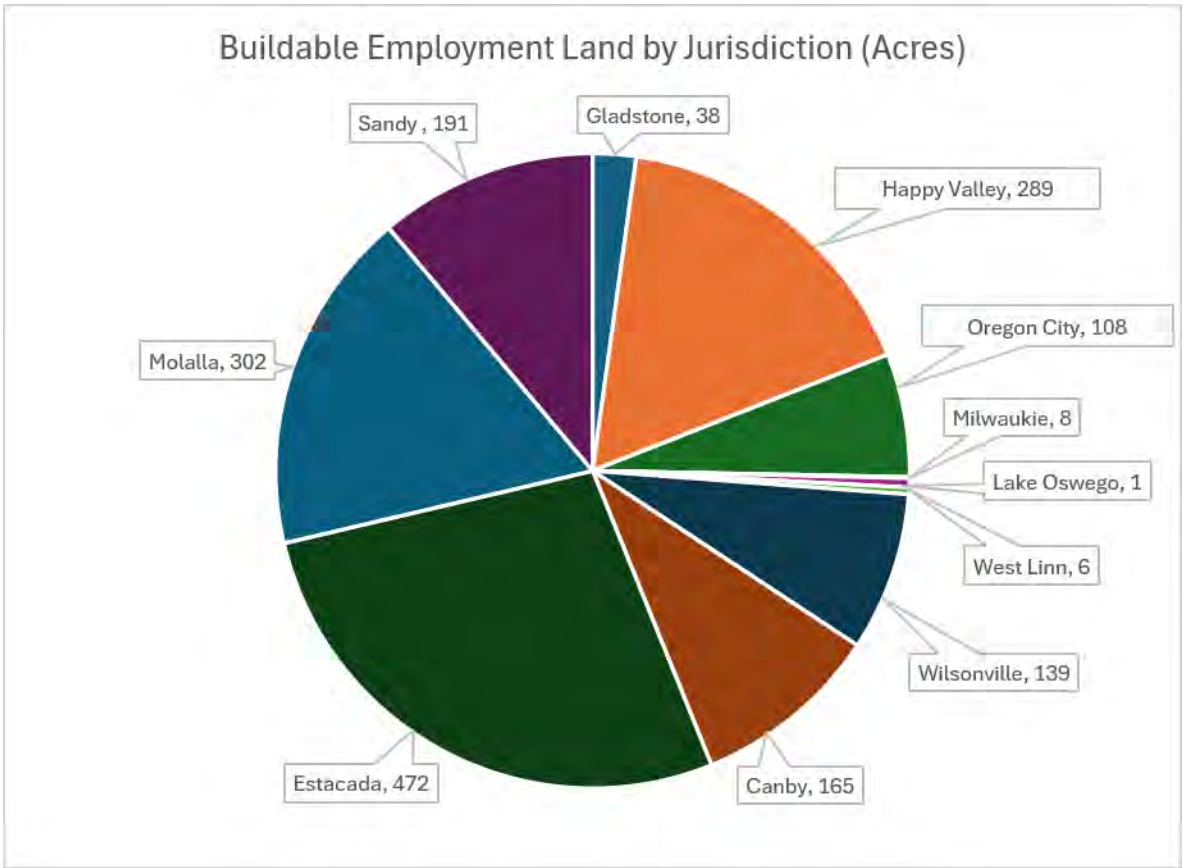


Figure 11. Buildable Employment Land by Jurisdiction

Technical Analysis Findings

Mackenzie analyzed employment land supply data for 13 jurisdictions to provide detailed findings regarding the inventory of buildable lands for the incorporated jurisdictions in Clackamas County. The source of the buildable employment land data for Gladstone, Happy Valley, Johnson City[8], Lake Oswego, Milwaukie, Oregon City, Tualatin, West Linn, and Wilsonville was the 2024 Metro Buildable Lands Inventory, provided by Metro. The source of buildable employment land data for Canby (2023), Estacada (2019), Molalla (2025), and Sandy (2024), was each City's respective Buildable Land Inventory (dates provided in parentheticals), provided by Clackamas County. Refer to Appendix 7 for further details on methodology and assumptions.

The initial step in the analysis was to filter Geographic Information System (GIS) data to identify parcel status as vacant, partially vacant/infill, and redevelopable. This analysis focused on parcels with employment zoning designations, including mixed use since office development is allowed in most mixed-use zones.

Once parcel status was analyzed, Mackenzie tabulated the acreage by zone classification and parcel size. Additionally, in situations where a parcel had a shared property line of over approximately 100' with another parcel, these parcels were aggregated into sites to illustrate how parcel aggregation could impact

[8] No buildable employment land parcels were identified by Metro in Johnson City and Tualatin (the portion of the City within Clackamas County). Therefore, these two jurisdictions have not been included in further steps of this study.

the supply of employment lands. Parcel aggregation did not take into consideration ownership, access, or infrastructure, or other development related requirements.

Technical findings are summarized in charts and detailed in the tables and figures below. Additionally, Appendix 6 contains a series of maps and tables showing the vacant, partially vacant/infill, and redevelopable sites in the studied jurisdictions.

Parcel and Site Size Distribution

To provide a more complete picture of the County's buildable employment land's development potential, Mackenzie sorted the identified parcels and sites into the following acreage size ranges to see the distribution of parcel and site size:

- Smaller than 1 acre.
- 1-4.99 acres.
- 5-9.99 acres.
- 10-19.99 acres.
- Larger than 20 acres.

The findings of this analysis are provided in Table 10, below.

TABLE 10: EMPLOYMENT PARCEL AND SITE SIZE BY JURISDICTION (COUNT)								
		Acres	1<	1-4.99	5-9.99	10-19.99	>20	Total
Inside Metro	Gladstone	Parcels	31	0	0	0	1	**32**
		Sites	24	0	0	0	1	**25**
	Happy Valley	Parcels	112	28	13	3	3	**159**
		Sites	77	7	2	0	4	**90**
	Oregon City	Parcels	81	17	7	1	0	**106**
		Sites	57	4	1	2	2	**66**
	Lake Oswego	Parcels	14	0	0	0	0	**14**
		Sites	12	0	0	0	0	**12**
	Milwaukie	Parcels	34	3	0	0	0	**37**
		Sites	27	2	0	0	0	**29**
	West Linn	Parcels	17	3	0	0	0	**20**
		Sites	11	0	1	0	0	**12**
	Wilsonville	Parcels	83	19	3	0	3	**108**
		Sites	70	8	5	0	3	**86**
Inside Metro Subtotals		**Parcels**	**372**	**70**	**23**	**4**	**7**	**476**
		Sites	**278**	**21**	**9**	**2**	**10**	**320**
Outside Metro	Canby	Parcels	47	22	4	0	3	**76**
		Sites	18	13	5	1	2	**39**
	Estacada	Parcels	89	42	16	4	6	**157**
		Sites	26	9	2	1	6	**44**
	Molalla	Parcels	88	50	12	3	0	**153**
		Sites	27	12	5	3	5	**52**
	Sandy	Parcels	36	25	7	2	1	**71**
		Sites	16	8	1	2	2	**29**
Outside Metro Subtotals		**Parcels**	**260**	**139**	**39**	**9**	**10**	**457**
		Sites	**87**	**42**	**13**	**7**	**15**	**164**
Totals		**Parcels**	**632**	**209**	**62**	**13**	**17**	**933**
		Sites	**365**	**63**	**22**	**9**	**25**	**484**

Key Takeaways:

- As shown in Table 10, the analyzed jurisdictions have 933 parcels of buildable employment land (commercial, industrial, and mixed use) which can be aggregated into 484 sites.
- Approximately 68% of the identified parcels are smaller than 1 acre in size and another 22% are in the 1-4.99-acre size range, meaning fewer than 10% of the parcels are larger than 5 acres.
- There are several jurisdictions where most employment acreage (both parcels and sites) is in the 1 acre and smaller category (Gladstone, Lake Oswego, Milwaukie, and West Linn).
- This analysis found 17 parcels (fewer than 2%) within the incorporated cities of Clackamas County that are larger than 20 acres. Parcel aggregation could increase that number to 25.
- Often, mid-size parcels (5-9.99 and 10-19.99 acres) can be aggregated to achieve sites larger than 20 acres. Though this aggregation creates larger sites, it can lead to a reduction in the number of mid-size parcels.

- When aggregating adjacent parcels, more large sites were able to be created in only one category: 20 acres and larger (25 compared to 17). In the other acreage categories, site aggregation resulted in fewer sites compared to parcels as small parcels were aggregated with other smaller parcels, and barely resulting in a larger aggregated site. The aggregated sites were reduced by nearly 50% compared to individual parcels (484 versus 933). While this was expected, the difference in some jurisdictions is very large (Happy Valley, Oregon City, Wilsonville, Canby, Estacada, Molalla, and Sandy), meaning that property aggregation will be key to providing larger development sites.
- The average parcel size of all identified parcels is 1.7 acres, and the median parcel size is 0.25 acres. The largest parcel of all identified parcels is approximately 50 acres, and the largest site (after aggregating parcels) is approximately 94 acres. Both the largest parcel and largest site are located in Estacada (notably, these parcels are not impacted by the 2023 rezone).
- The share of buildable parcels that is smaller than 1 acre is higher for jurisdictions within Metro (between 70% to 100%) than for jurisdictions outside of Metro (between 51% to 62%).
- In jurisdictions where site aggregation yielded a large reduction in the number sites (compared to individual parcels), this indicates the jurisdiction has a highly parcelized employment land base. Accordingly, parcel aggregation may have more impact in these jurisdictions.

Employment Land Acreage

TABLE 11: BUILDABLE EMPLOYMENT LAND BY JURISDICTION (ACRES)														
	Inside Metro								Outside Metro					
	Gladstone	Happy Valley	Oregon City	Lake Oswego	Milwaukie	West Linn	Wilsonville	Inside Metro Subtotal	Canby	Estacada	Molalla	Sandy	Outside Metro Subtotal	Total
Commercial	**1**	**0**	**12**	**0**	**0**	**0**	**6**	**19**	**13**	**101**	**91**	**137**	**342**	**361**
Vacant	1	0	0	0	0	0	4	**5**	11	61	54	53	**178**	183
Partially Vacant/ Infill	0	0	11	0	0	0	0	**11**	0	11	37	85	**132**	143
Redevelopable	0	0	1	0	0	0	2	**3**	2	30	0	0	**32**	35
Industrial	**37**	**273**	**86**	**0**	**8**	**6**	**133**	**543**	**152**	**371**	**211**	**54**	**788**	**1,331**
Vacant	0	180	28	0	1	3	47	**259**	112	212	131	23	**479**	738
Partially Vacant/ Infill	37	92	56	0	7	1	86	**279**	30	126	80	30	**267**	546
Redevelopable	0	1	2	0	1	1	0	**5**	9	32	0	0	**41**	46
Mixed Use	**0**	**16**	**10**	**1**	**0**	**0**	**0**	**27**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**27**
Vacant	0	16	10	1	0	0	0	**27**	n/a	n/a	n/a	n/a	**n/a**	27
Partially Vacant/ Infill	0	0	0	0	0	0	0	**0**	n/a	n/a	n/a	n/a	**n/a**	0
Redevelopable	0	0	0	0	0	0	0	**0**	n/a	n/a	n/a	n/a	**n/a**	0
Total	**38**	**289**	**108**	**1**	**8**	**6**	**139**	**589**	**165**	**472**	**302**	**191**	**1130**	**1,719**

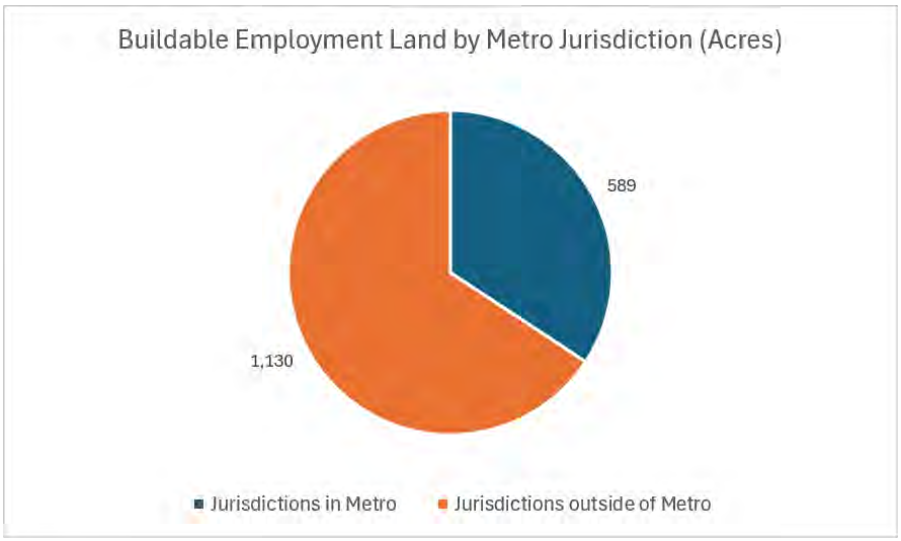


Figure 12. Buildable Employment Land by Metro Jurisdiction (Acres)

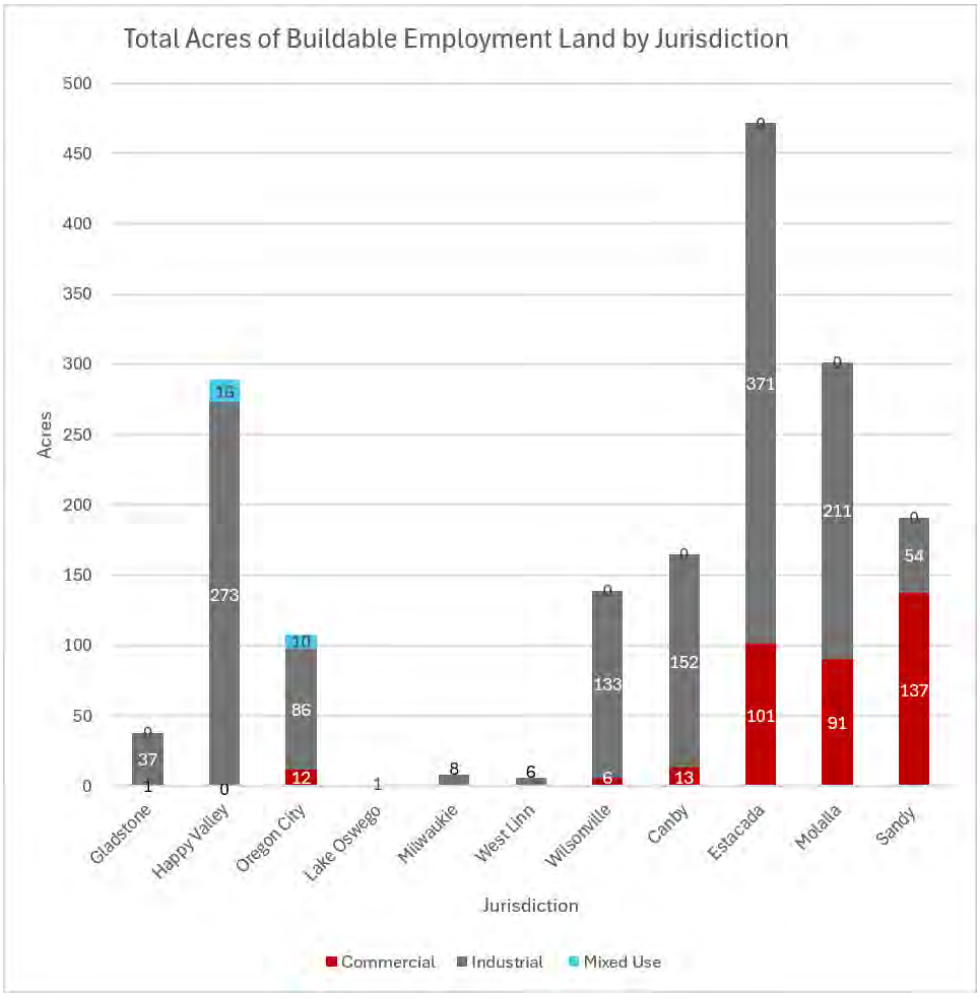


Figure 13. Total Acres of Buildable Employment Land by Jurisdiction

Key Takeaways:

- As shown in Table 11, the analyzed jurisdictions have 1,719 acres of buildable employment land (commercial, industrial, and mixed use).[9]
- Over 75% of the buildable employment land acreage (1,331) is found in the jurisdictions' industrial zones and approximately 20% is found in the commercial zones. Mixed use zones were the remaining 1.5%.
- As shown in Figure 12, approximately 66% of the identified buildable employment land is located within the four (4) jurisdictions outside of Metro (Canby, Estacada, Molalla, and Sandy).
  - As shown in Figure 14 and Figure 15, approximately 60% of identified 1,331 AC of buildable *industrial* land is located within the four (4) jurisdictions outside of Metro (Canby, Estacada, Molalla, and Sandy).
  - As shown in Figure 16 and Figure 17, approximately 95% of identified 361 AC of buildable *commercial* land is located within the four jurisdictions outside of Metro (Canby, Estacada, Molalla, and Sandy).
- Within Metro, Happy Valley, Oregon City, and Wilsonville each have over 100 total acres of identified buildable employment land. The average parcel sizes range from 1 to 1.8 AC.

Data and Methodology Considerations

- Many jurisdictions use different criteria to classify land as vacant, partially vacant, or redevelopable. This presents a challenge when comparing jurisdictions evenly/consistently/ uniformly.
- This analysis is a snapshot in time. The status of parcels and sites are based on the most recent best available data, which ranges from 2019-2025. Given the age of the best available data, the current status may not be reflective of current conditions.
- The data provided indicates that much of the employment land is impacted by one or more environmental constraints, including slope, wetlands, or floodplain. However, the acreage figures in this analysis are the net unconstrained acres. The constrained land has been removed.

Figure 14 and Figure 15 below show the distribution of total *industrial* acres by jurisdiction for vacant, partially vacant, and redevelopable land.

[9] This analysis uses the City of Estacada's BLI, which was completed in 2019. In 2023, approximately 100 acres of Industrial land in the City of Estacada was rezoned to residential and an additional 100 acres of industrial land was redesignated for commercial and mixed-use. Accordingly, 100 acres of Employment land should be subtracted from the total acreage presented in this report.

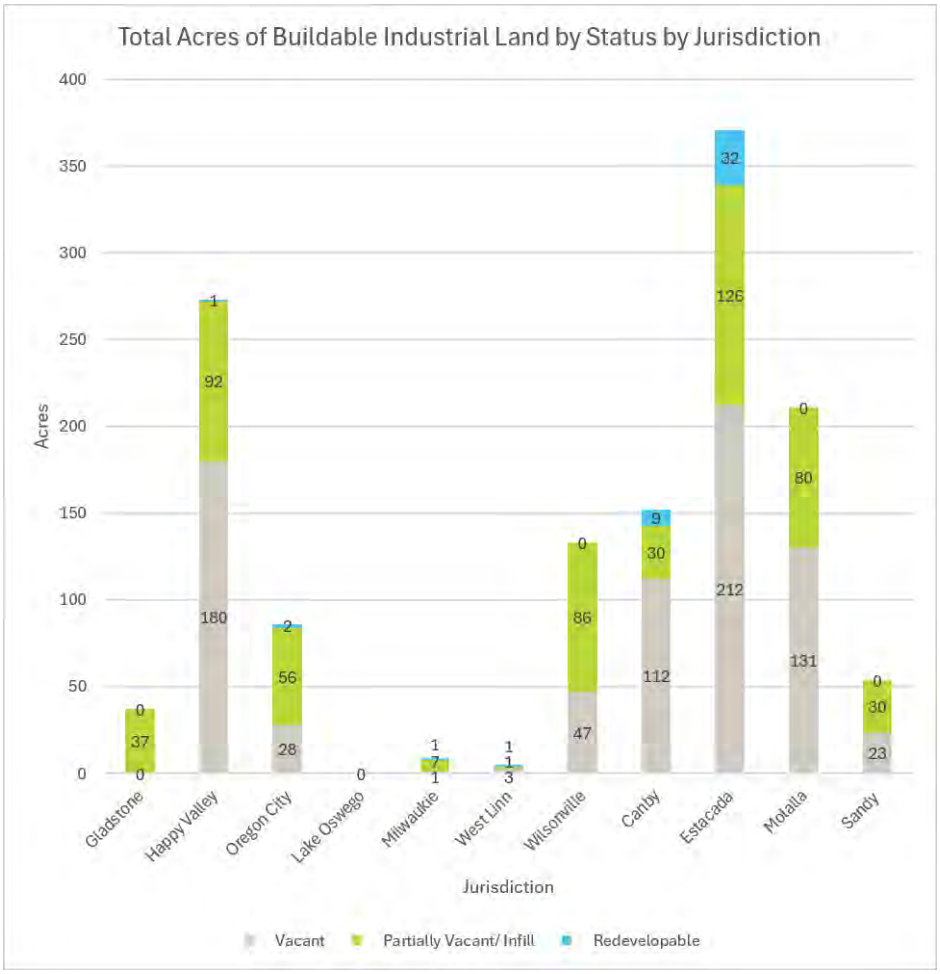


Figure 14. Total Acres of Buildable Industrial Land by Status by Jurisdiction

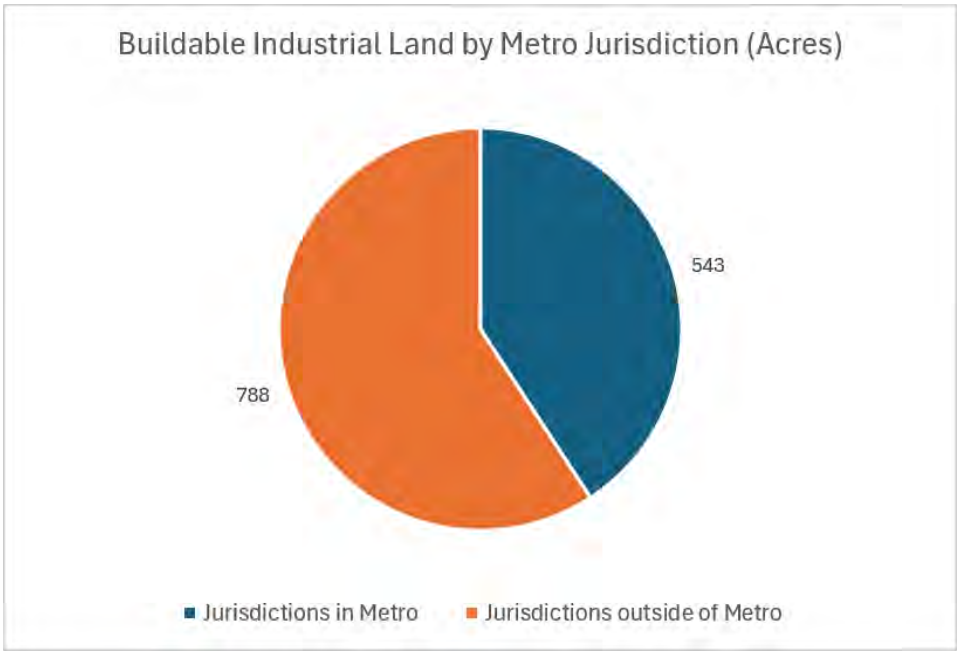


Figure 15. Buildable Industrial Land by Metro Status (Acres)

Figure 16 and Figure 17 below show the distribution of total *commercial* acres by jurisdiction for vacant, partially vacant, and redevelopable land.

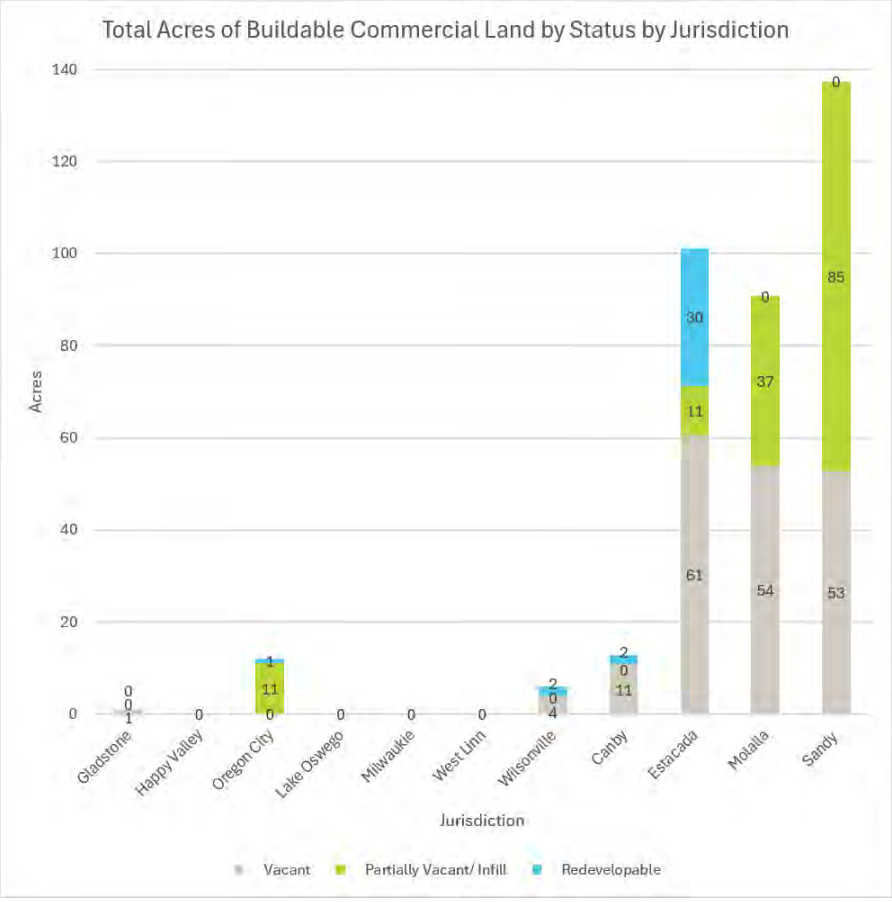


Figure 16. Total Acres of Buildable Commercial Land by Status by Jurisdiction

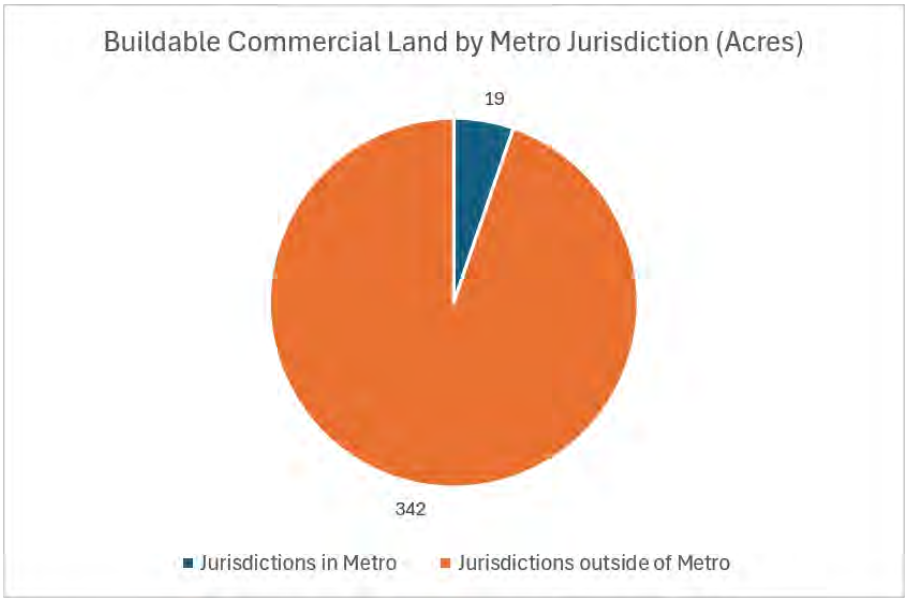


Figure **17***. Buildable Commercial Land by Metro Status (Acres)*

County Wide Maps:

To provide a visualization of this analysis, Mackenzie prepared a series of maps showing the vacant, partially vacant/infill, and redevelopable parcels by zoning classification in the analyzed jurisdictions. These maps are included as Appendix 6. These maps are intended to assist staff and decision makers to understand where employment land acreage is clustered and allow for a more streamlined update process where parcels can be removed by staff as they are developed or conditions change.

Please note that although the entirety of the partially vacant/infill parcels are shown on the map, only a portion of those parcels are considered "buildable" due to existing development. Additionally, though the maps do not show the constraints that were considered in the underlying datasets, the removal of constrained area is accounted in the acreage tabulations presented in this analysis.

Each jurisdiction map in Appendix 6 also contains two (2) tables: Employment Size Distribution and Employment Acreage. The Employment Size Distribution table details the size of parcels and sites within each jurisdiction. The Employment Acreage table tabulates the acreage by development classification (vacant, partially vacant/infill, and redevelopable). These tables show that as parcels are aggregated, there is potential for creation of larger sites.

Recommended Next Steps

The analysis was completed in May 2026 and utilized information from Metro's BLI from June 2024 and individual jurisdiction EOA data, some dating back to 2019. The findings in this report are based on the best available information provided to Mackenzie to use in this report as of May 2026. Since this inventory responds to the commercial real estate market, it is expected to change regularly as properties transact, are rezoned, and/or get developed. Factors impacting this change will include:

- New or better information.
- Site development (resulting in sites coming off of the inventories).
- New properties coming on the market (Resulting in new sites added to the inventories).
- Properties in the inventory coming off the market due to transactions (resulting in parcels/sites coming off of the inventories).
- Other related issues (for example, rezones, annexations, etc.).

Due to this inventory fluctuation, it is recommended that county staff coordinate with jurisdictions to periodically update this inventory to ground truth the data presented in this report for a more accurate real-time inventory and consistent data age.

As a progression of this analysis, the County should consider conducting a study to identify sites for target industries based on the Business Oregon Industrial Competitiveness Matrix, to see how the County's land supply matches up with what industries require for development. As part of that future study, it would be beneficial to investigate infrastructure improvements which could move sites toward development readiness.

Additionally, as a next phase to this project, staff should discuss whether further investigating the identified parcels in this report to analyze how development read the sites are and identify any necessary infrastructure improvements and analyze how the identified parcels match with County economic development goals and target industries.

Staff should also pursue the next phase of extending the Industrial Site Readiness Study already performed (Chapter 1), to add commercial and mixed use properties in unincorporated Clackamas County. This would provide a more holistic view that is more in line with the EOA summary and analysis. Once this analysis is complete, the charts and graphs should be revised to include unincorporated Clackamas County as a jurisdiction in order to analyze and review all buildable employment land in a single report.

Finally, staff should also track Metro's Industrial Land Inventory project, taking place in 2026, and encourage County participation and engagement with Metro staff through the process.

APPENDIX 1

SPREADSHEET SUMMARY OF INVENTORIED UNINCORPORATED PARCELS

Parcel Number	Business if Available	Taxpayer	Address	City	Assessor Parcel Number (APN)	Gross Parcel Acreage	Category	Development Constraints	Development Opportunities	Active Business Use Present	Topography and/or Environmental Constraints Present	"Vacant" in Metro BLI
1 and 2 (see Category 1 Analysis)		CLACKAMAS COUNTY DEVELOPMENT AGENCY	9200 SE MATHER RD	CLACKAMAS	22E09A 00800	7.71	1	Parcel is irregularly segmented and bisected by HWY 224.	Could be consolidated and/or re-grouped with smaller adjacent parcels/parcel segments under shared ownership.			
1 and 2 (see Category 1 Analysis)		CLACKAMAS COUNTY DEVELOPMENT AGENCY	9200 SE LAWNFIELD RD	CLACKAMAS	22E09AB 00100	12.68	1	Parcel is irregularly segmented and bisected by HWY 224.	Could be consolidated and/or re-grouped with smaller adjacent parcels/parcel segments under shared ownership.			
3		CLACKAMAS RIVER WATER DIST	16845 SE ROBERT AVE	CLACKAMAS	22E15B 01103	12.08	3	Partially covered by flood hazard zones and contains a steep slope.			✓	✓
4		CLACKAMAS EDUCATION SERVICE DISTRICT	NO SITUS	CLACKAMAS	22E04 00204	11.55	3	Significantly covered by wetlands.			✓	
5	JOHNSON CREEK PROPERTY	NORTH CLACKAMAS PARKS & REC DIST	8855 SE 76TH DR	PORTLAND	12E29AB 03609	8.3	4	Currently used for walking trails. Partially covered by Flood Hazard zones along Johnson Creek.		✓	✓	
6	MILLER PAINT & 76 GAS STATION	SPITZNAGEL FAMILY LLC	10210 SE HWY 212	CLACKAMAS	22E10C 04400	5.44	4	Partially active use (approximately quarter of parcel).	Mostly vacant.	✓		
7	MT SCOTT FUEL	TYLER FAMILY LIMITED PARTNERSHIP	11851 SE 282ND AVE	BORING	13E36D 00300	13.72	4	Partial active use (approximately half of parcel).	Land for expansion.	✓		
8	FARM/NURSERY	SMITH LARRY D TRUSTEE	NO SITUS	BORING	13E36D 00600	8.59	4	Active use (farm use).		✓		
9	DRAVON MEDICAL & CANNULA COMFORT	MVGD LLC	NO SITUS	CLACKAMAS	22E10DB 00100	5.61	4	Unusually shaped lot surrounding building.		✓		
10		EAGLE FOUNDRY CO	23365 SE EAGLE CREEK RD	EAGLE CREEK	24E31D 00200	7.93	4		Fully vacant. Expansion opportunity for Eagle Foundry from adjacent development.	✓		
11		EAGLE FOUNDRY CO	23003 SE EAGLE CREEK RD	EAGLE CREEK	24E31A 02403	22.81	4		Almost entirely vacant. Expansion opportunity for Eagle Foundry.	✓		
12	CARPENTRY PLUS	MCKEE HOLDINGS II LLC	25845 SE EAGLE CREEK RD	EAGLE CREEK	34E05 04105	6	4	Partially covered in wetland (log pond).	Expansion opportunity for Carpentry Plus.	✓	✓	
13	CARPENTRY PLUS	DAY PORTLAND BUILDING LLC	26175 SE EAGLE CREEK RD	EAGLE CREEK	34E05 04102	7.01	4	Partially covered in wetland (log pond).	Expansion opportunity for Carpentry Plus.	✓	✓	
14	CARPENTRY PLUS	DAY PORTLAND BUILDING LLC	NO SITUS	EAGLE CREEK	34E05 04103	5	4		Fully vacant. Expansion opportunity for Carpentry Plus.	✓		
15	SOUTH COUNTY ASPHALT	GLACIER NORTHWEST INC	24390 S HWY 99E	CANBY	41E05D 00500	17.48	4	Gravel pit requires significant effort and investment to redevelop. Parcel is almost entirely covered by Flood Hazard zones and a pond.		✓	✓	
16	SOUTH COUNTY ASPHALT	GLACIER NORTHWEST INC	NO SITUS	CANBY	41E05D 00400	62.03	4	Gravel pit. Parcel is almost entirely covered by Flood Hazard zones and partially impacted by a pond.		✓	✓	
17	SOUTH COUNTY ASPHALT	B & CO PROPERTIES LLC	24333 S BOBS WAY	CANBY	41E05A 02400	10.17	4	Parcel is partially covered by wetlands and Flood hazard zones along the Molalla River.		✓	✓	
18	CANBY LANDSCAPE SUPPLY	CANBY SAND&GRAVEL CO	NO SITUS	CANBY	41E05BD 01200	15.56	4	Gravel pit. Parcel is impacted by Flood hazard Zones.		✓	✓	
19	ASC SUNSTONE CIRCUITS LLC	FIP MASTER FUNDING XIV LLC	13626 S FREEMAN RD	MULINO	42E17A 00800	15.52	4	Partial active use (approximately third of parcel). Rest of parcel is covered by flood hazard zones along the Milk Creek.	Expansion opportunity for ASC Sunstone Circuits.	✓	✓	
20	RSG FOREST PRODUCTS	SANDERS WOOD PRODUCTS INC	NO SITUS	MOLALLA	42E29 00503	8.11	4	Active use (lumber yard).		✓		
21	RSG FOREST PRODUCTS	SANDERS WOOD PRODUCTS INC	28820 S HWY 213	MOLALLA	42E29D 00500	25.26	4		Fully vacant. Expansion opportunity for RGS.	✓		
22	RSG FOREST PRODUCTS	SANDERS WOOD PRODUCTS INC	28890 S HWY 213	MOLALLA	42E29 00700	152.64	4	Active existing use (approximately half of parcel).	Approximately 50 AC of vacant land. Expansion opportunity for RGS.	✓		
23		PACIFIC FIBRE PRODUCTS INC	NO SITUS	MOLALLA	52E17 02400	16.23	4	Active use (lumber yard).		✓		

APPENDIX 2

MAP PACKAGE OF INVENTORIED UNINCORPORATED PARCELS



AGGREGATED PARCELS #1

Category 1
Taxpayer: CLACKAMAS COUNTY DEVELOPMENT AGENCY

CLACKAMAS, OR

LEGEND

- Tax Lots
- Vacant Industrial Parcel >5 AC

0 50 100 200 Feet

1 inch = 100 feet

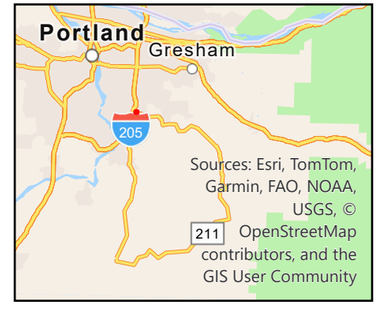
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SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 3/5/2026
File: ClackamasCounty_ISRS

Map Created By: AFLUETSCH
Project No: 2250163.00



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AGGREGATED PARCELS #1

Category 1

Taxpayer: CLACKAMAS COUNTY DEVELOPMENT AGENCY

CLACKAMAS, OR

LEGEND

- Tax Lots
- Vacant Industrial Parcel >5 AC
- 2' Contours

1c
22E09AB 00100
0.78 AC

1b
22E09AB 00100
1.55 AC

1d
22E09A 00101
0.64 AC

1a
22E09A 00800
6.41 AC

Sunrise Expy

224

SE Bordeaux

Microsoft, Vantor, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

0 50 100 200 Feet

1 inch = 100 feet

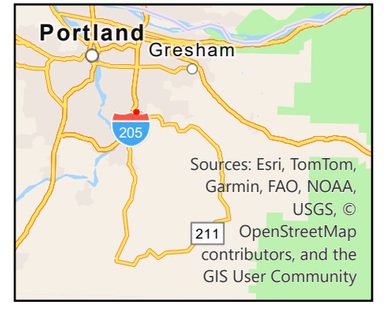
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NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 3/5/2026
File: ClackamasCounty_ISRS

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Project No: 2250163.00



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AGGREGATED PARCELS #2

Category 1

Taxpayer: CLACKAMAS COUNTY DEVELOPMENT AGENCY

CLACKAMAS, OR

LEGEND

- Tax Lots
- Vacant Industrial Parcel >5 AC

0 75 150 300 Feet

1 inch = 150 feet

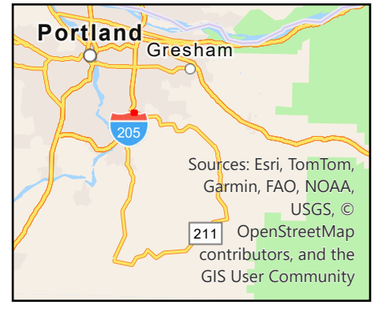
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SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 3/5/2026
File: ClackamasCounty_ISRS

Map Created By: AFLUETSCH
Project No: 2250163.00



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AGGREGATED PARCELS #2

Category 1

Taxpayer: CLACKAMAS COUNTY DEVELOPMENT AGENCY

CLACKAMAS, OR

LEGEND

- Tax Lots
- Vacant Industrial Parcel >5 AC
- 2' Contours

0 75 150 300 Feet

1 inch = 150 feet

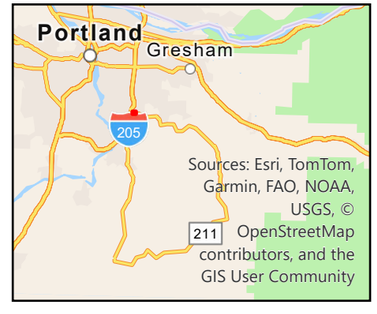
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Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
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Date: 3/5/2026
File: ClackamasCounty_ISRS

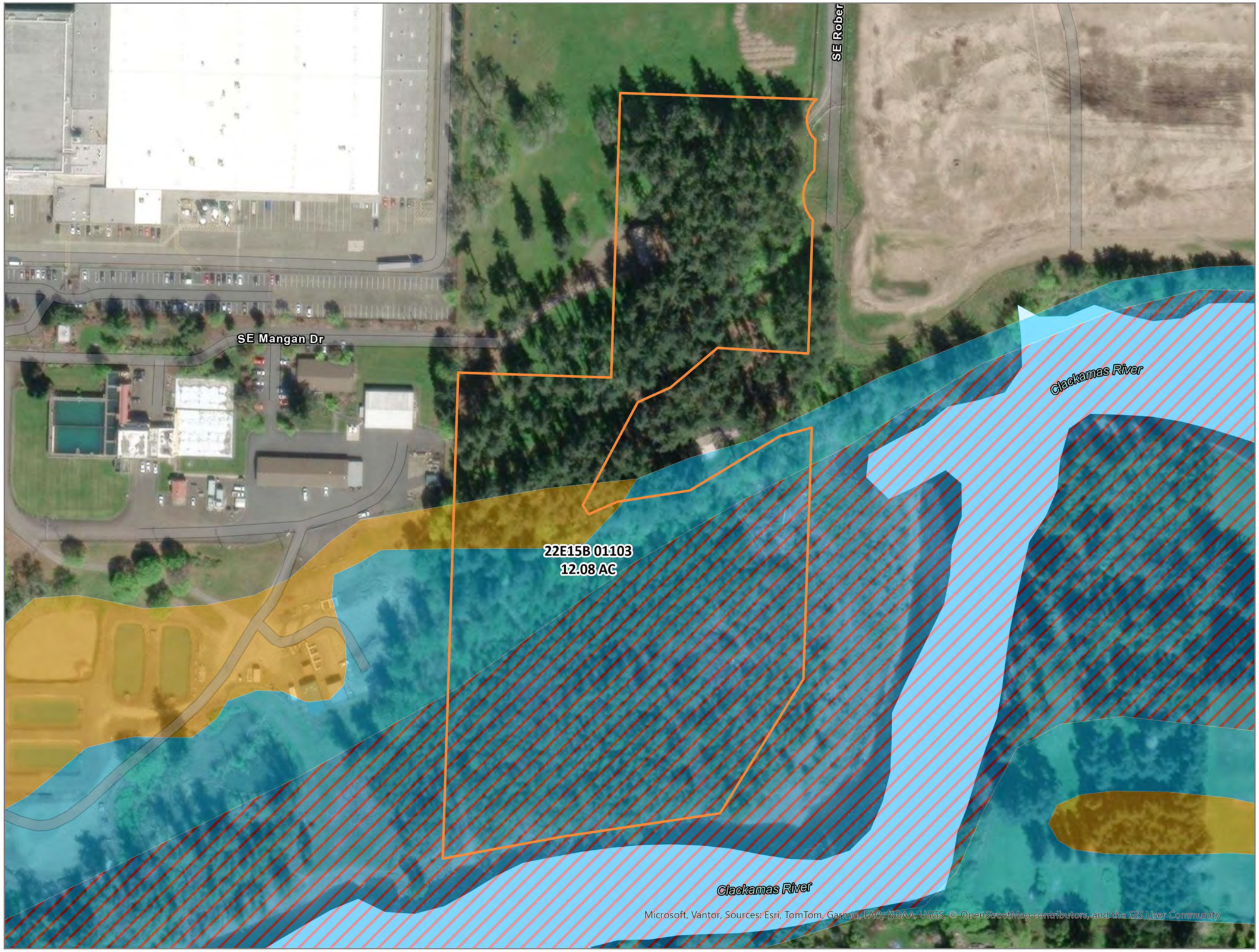
Map Created By: AFLUETSCH
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PARCEL #3

Category 3

Taxpayer: CLACKAMAS RIVER WATER DISTRICT

CLACKAMAS, OR

LEGEND

- Vacant Industrial Parcel >5 AC

Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- Regulatory Flooodway
- 0.2% Annual Chance Flood Hazard
- Streams

0 75 150 300 Feet

1 inch = 150 feet

N

SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

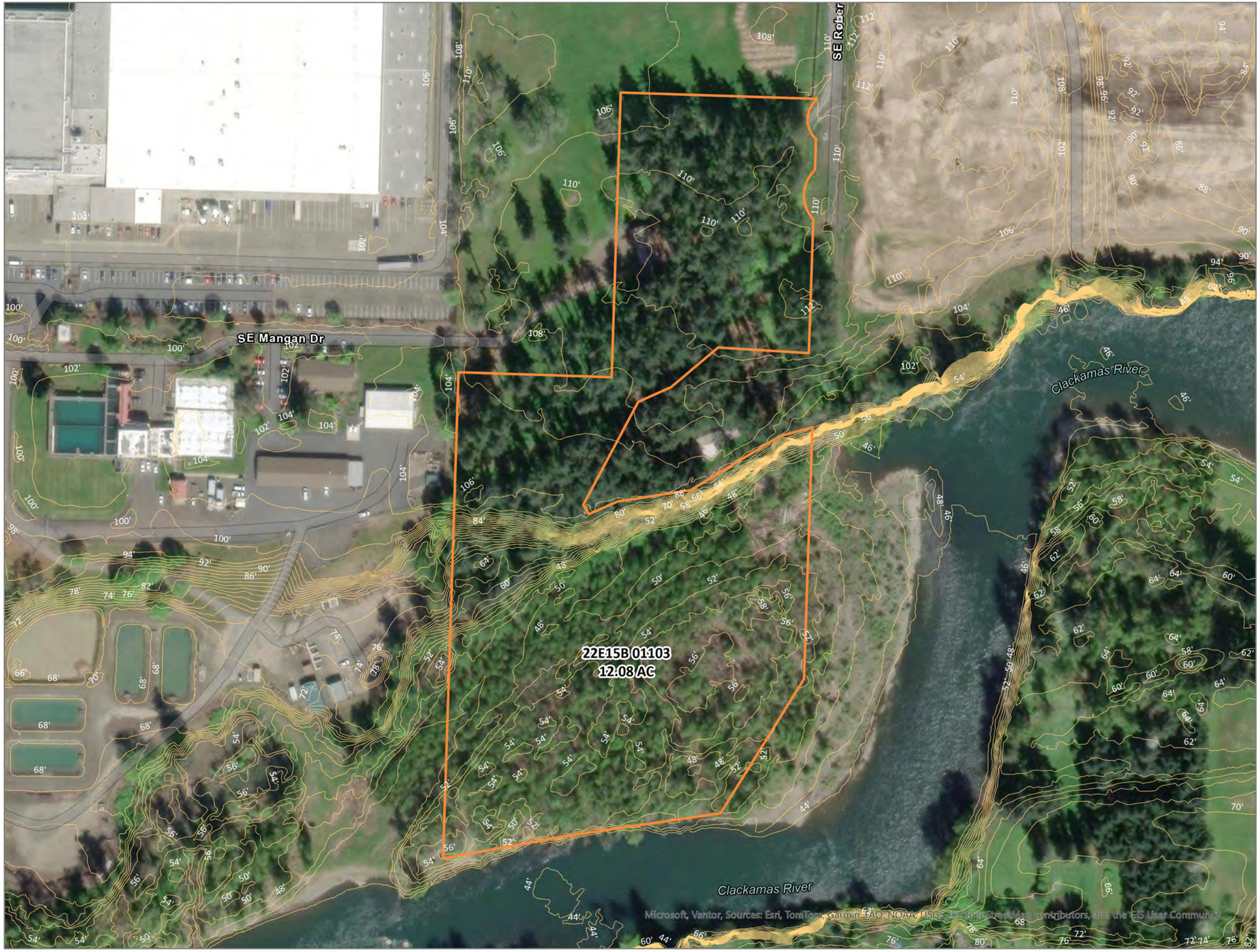
Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00



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PARCEL #3

Category 3

Taxpayer: CLACKAMAS RIVER WATER DISTRICT

CLACKAMAS, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 75 150 300 Feet

1 inch = 150 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00



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PARCEL #4

Category 3

Taxpayer: CLACKAMAS EDUCATION SERVICE DISTRICT

CLACKAMAS, OR

LEGEND

- Vacant Industrial Parcel >5 AC

Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- Regulatory Flooodway
- Wetlands (Locally Corrected)

0 75 150 300 Feet

1 inch = 150 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00



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PARCEL #4

Category 3

Taxpayer: CLACKAMAS EDUCATION SERVICE DISTRICT

CLACKAMAS, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 75 150 300 Feet

1 inch = 150 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

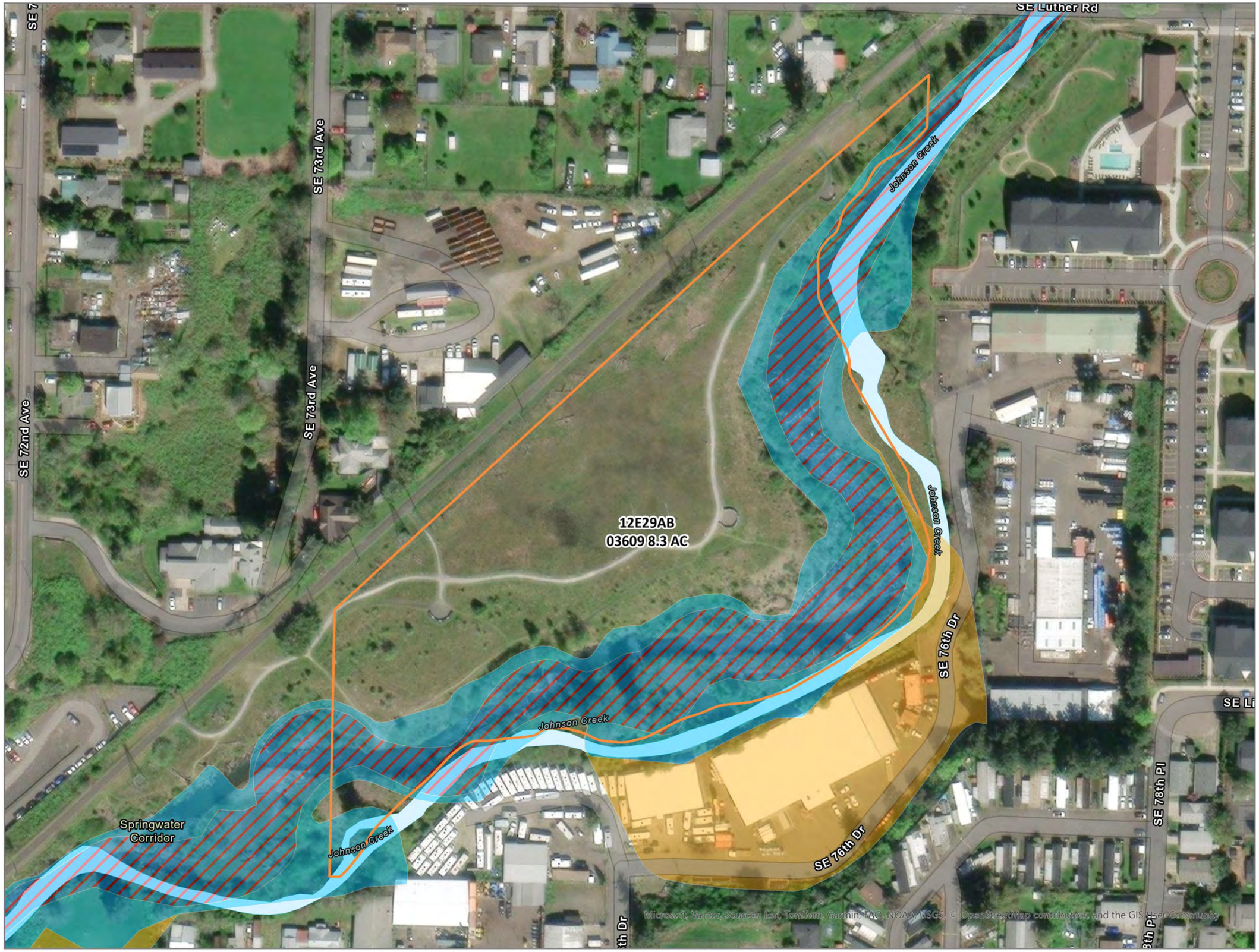
Map Created By: AAF
Project No: 2250163.00



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PARCEL #5

Category 4

JOHNSON CREEK PROPERTY

Taxpayer: NORTH CLACKAMAS PARKS & REC DIST

PORTLAND, OR

LEGEND

- Vacant Industrial Parcel >5 AC

Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- Regulatory Flooodway
- 0.2% Annual Chance Flood Hazard
- Streams

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

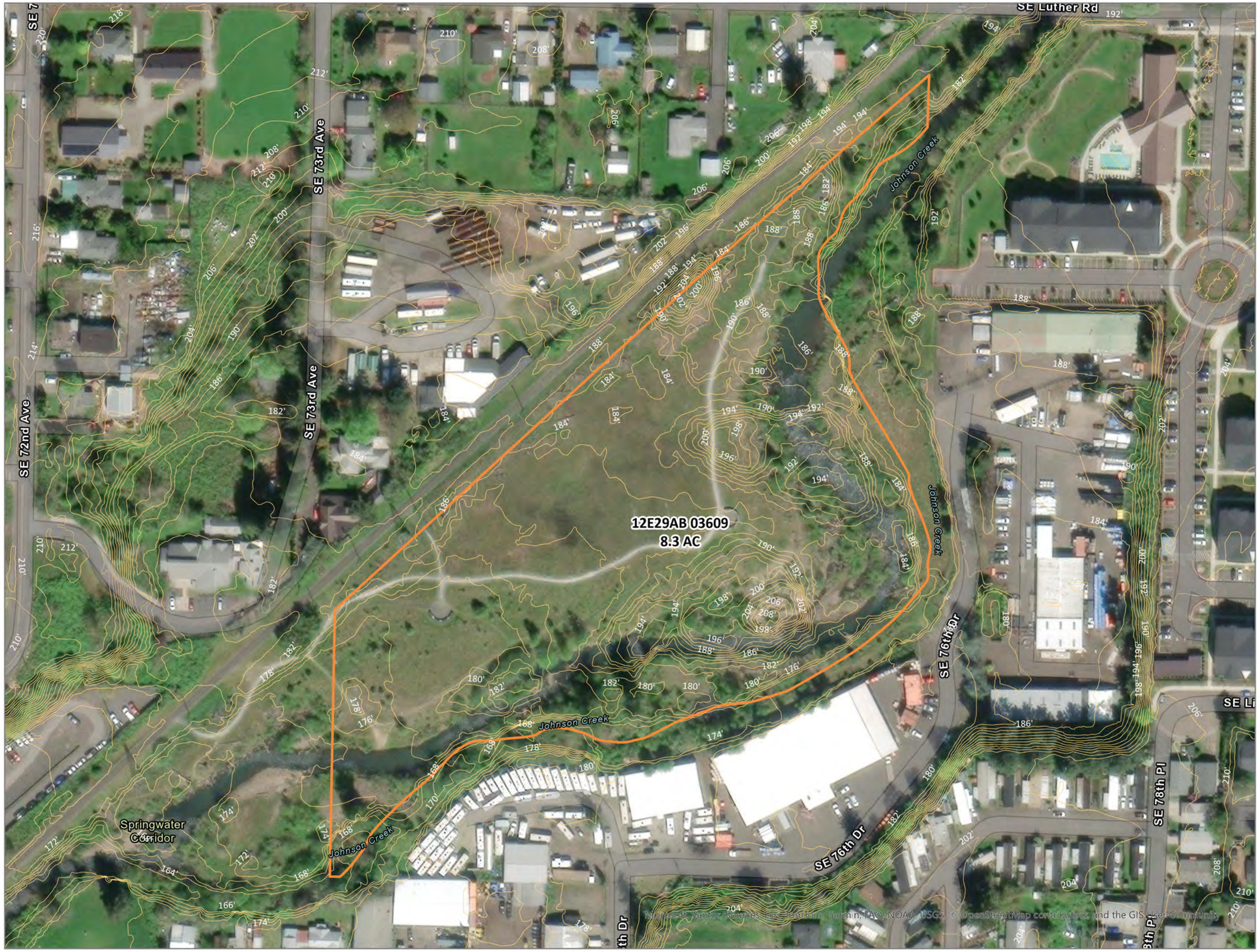
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Map Created By: AAF
Project No: 2250163.00



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PARCEL #5

Category 4

JOHNSON CREEK PROPERTY

Taxpayer: NORTH CLACKAMAS PARKS & REC DIST

PORTLAND, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
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Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00



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PARCEL #6

Category 4

MILLER PAINT & 76 GAS STATION

Taxpayer: SPITZNAGEL FAMILY LLC

CLACKAMAS, OR

LEGEND

Vacant Industrial Parcel >5 AC

0 50 100 200 Feet

1 inch = 100 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00



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PARCEL #6

Category 4

MILLER PAINT & 76 GAS STATION

Taxpayer: SPITZNAGEL FAMILY LLC

CLACKAMAS, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 50 100 Feet

1 inch = 100 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00



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PARCEL #7

Category 4

MT SCOTT FUEL

Taxpayer: TYLER FAMILY LIMITED PARTNERSHIP

BORING, OR

LEGEND

Vacant Industrial Parcel >5 AC

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00



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PARCEL #7

Category 4

MT SCOTT FUEL

Taxpayer: TYLER FAMILY LIMITED PARTNERSHIP

BORING, OR

LEGEND

Vacant Industrial Parcel >5 AC

2' Contours

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00



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PARCEL #8

Category 4

FARM/NURSERY

Taxpayer: SMITH LARRY D TRUSTEE

CLACKAMAS, OR

LEGEND

Vacant Industrial Parcel >5 AC

0 40 80 160 Feet

1 inch = 80 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00



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PARCEL #8

Category 4

FARM/NURSERY

Taxpayer: SMITH LARRY D TRUSTEE

CLACKAMAS, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 40 80 160 Feet

1 inch = 80 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
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PARCEL #9

Category 4

DRAVON MEDICAL & CANNULA COMFORT

Taxpayer: MVGD LLC

CLACKAMAS, OR

LEGEND

Vacant Industrial Parcel >5 AC

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
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PARCEL #9

Category 4

DRAVON MEDICAL & CANNULA COMFORT

Taxpayer: MVGD LLC

CLACKAMAS, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
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PARCEL #10

Category 4

Taxpayer: EAGLE FOUNDRY CO

EAGLE CREEK, OR

LEGEND

Vacant Industrial Parcel >5 AC

0 50 100 200 Feet

1 inch = 100 feet

N

SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
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Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
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PARCEL #10

Category 4

Taxpayer: EAGLE FOUNDRY CO

EAGLE CREEK, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 50 100 200 Feet

1 inch = 100 feet

N

SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

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PARCEL #11

Category 4

Taxpayer: EAGLE FOUNDRY CO

EAGLE CREEK, OR

LEGEND

Vacant Industrial Parcel >5 AC

0 75 150 300 Feet

1 inch = 150 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
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PARCEL #11

Category 4

Taxpayer: EAGLE FOUNDRY CO

EAGLE CREEK, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 75 150 Feet

1 inch = 150 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
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PARCEL #12

Category 4

CARPENTRY PLUS

Taxpayer: MCKEE HOLDINGS II LLC

EAGLE CREEK, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- Wetlands (Locally Corrected)
- Streams

0 50 100 Feet

1 inch = 100 feet

N

SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

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PARCEL #12

Category 4

CARPENTRY PLUS

Taxpayer: MCKEE HOLDINGS II LLC

EAGLE CREEK, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 50 100 Feet

1 inch = 100 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

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PARCEL #13 (04103) &
PARCEL #14 (04103)

Category 4

CARPENTRY PLUS

Taxpayer: DAY PORTLAND BUILDING LLC

EAGLE CREEK, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- Wetlands (Locally Corrected)

0 50 100 Feet

1 inch = 100 feet

N

SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
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Date: 11/14/2025
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PARCEL #13 (04103) & PARCEL #14 (04103)

Category 4

CARPENTRY PLUS

Taxpayer: DAY PORTLAND BUILDING LLC

EAGLE CREEK, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 50 100 Feet

1 inch = 100 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

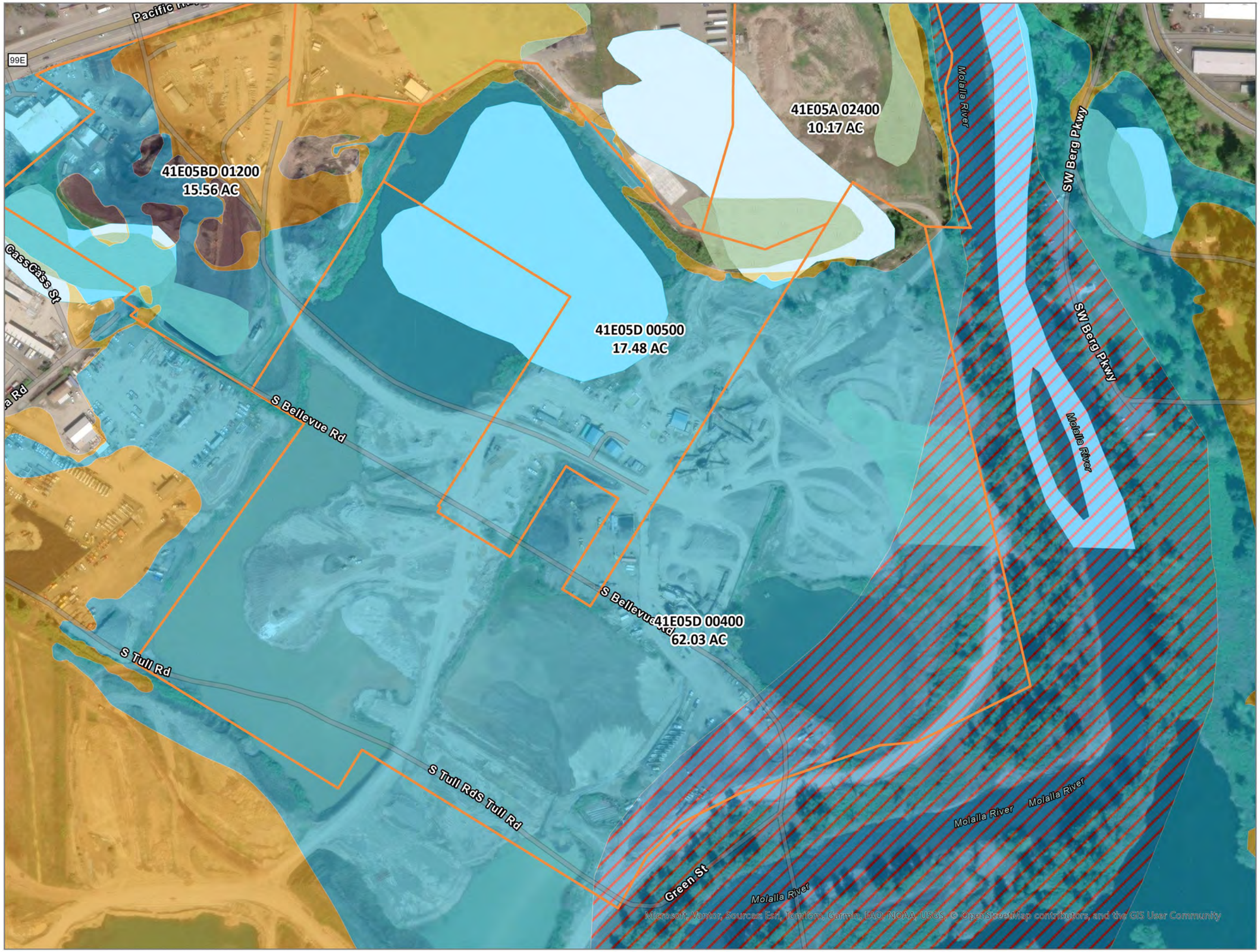
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PARCEL #15 (00400) & **PARCEL #16** (00500)

Category 4

SOUTH COUNTY ASPHALT

Taxpayer: GLACIER NORTHWEST INC

CANBY, OR

LEGEND

- Vacant Industrial Parcel >5 AC

Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- Regulatory Flooodway
- 0.2% Annual Chance Flood Hazard
- Wetlands (Locally Corrected)
- Streams

0 125 250 500 Feet

1 inch = 250 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

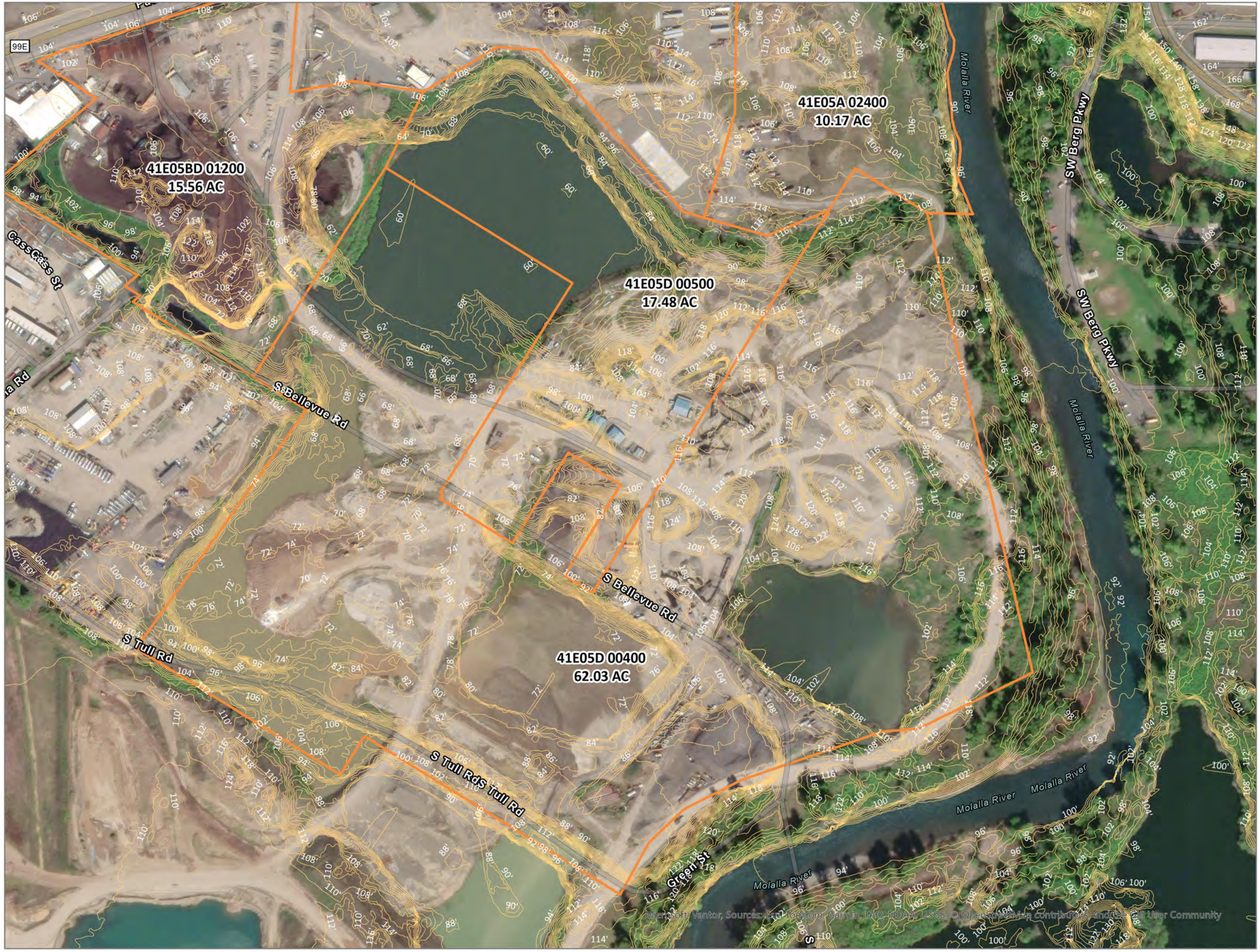
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PARCEL #15 (00400) & PARCEL #16 (00500)

Category 4

SOUTH COUNTY ASPHALT

Taxpayer: GLACIER NORTHWEST INC

CANBY, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 125 250 Feet

1 inch = 250 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00

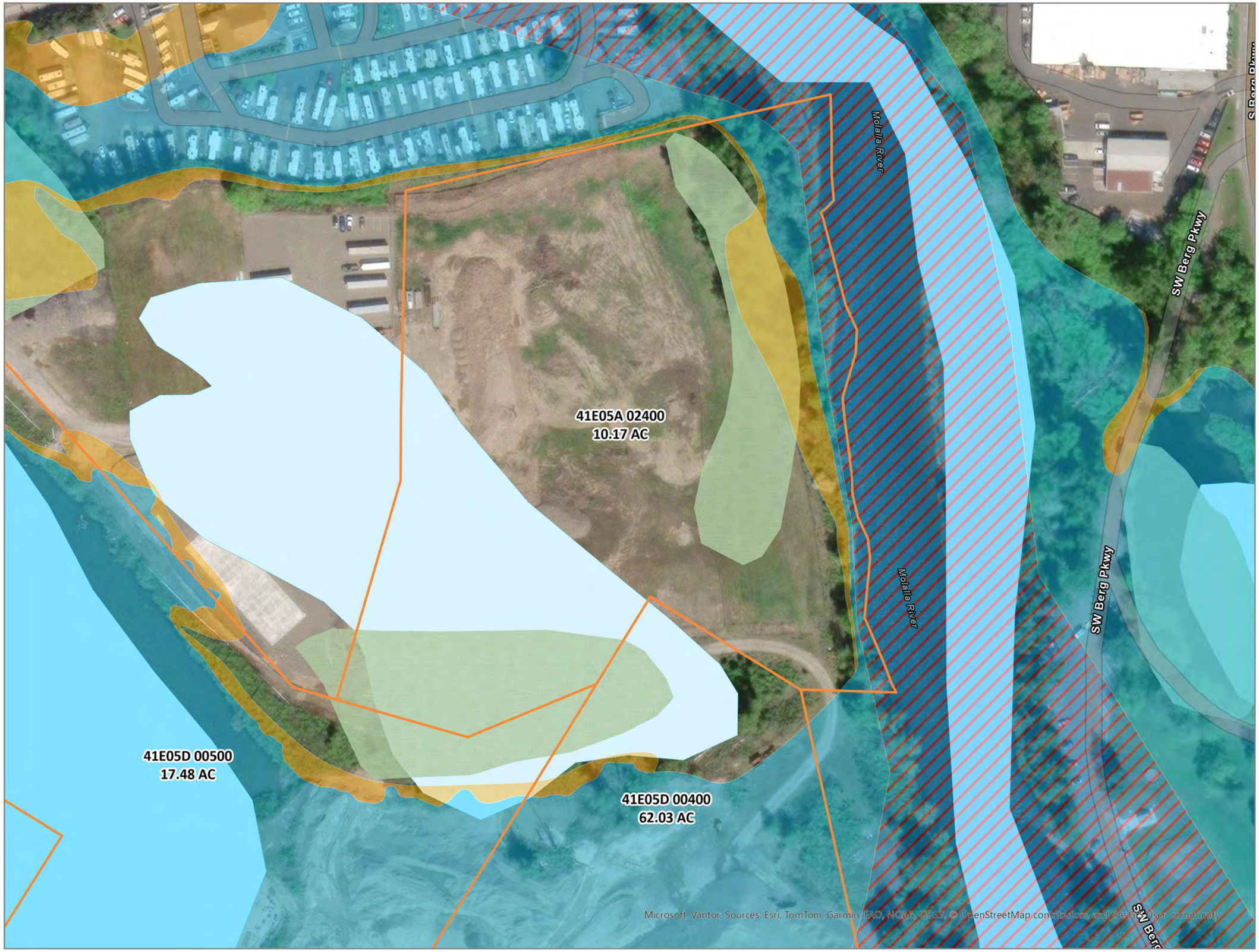


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PARCEL #17

Category 4

SOUTH COUNTY ASPHALT

Taxpayer: B & CO PROPERTIES LLC

CANBY, OR

LEGEND

- Vacant Industrial Parcel >5 AC

Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- Regulatory Flooodway
- 0.2% Annual Chance Flood Hazard
- Wetlands (Locally Corrected)
- Streams

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
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PARCEL #17

Category 4

SOUTH COUNTY ASPHALT

Taxpayer: B & CO PROPERTIES LLC

CANBY, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

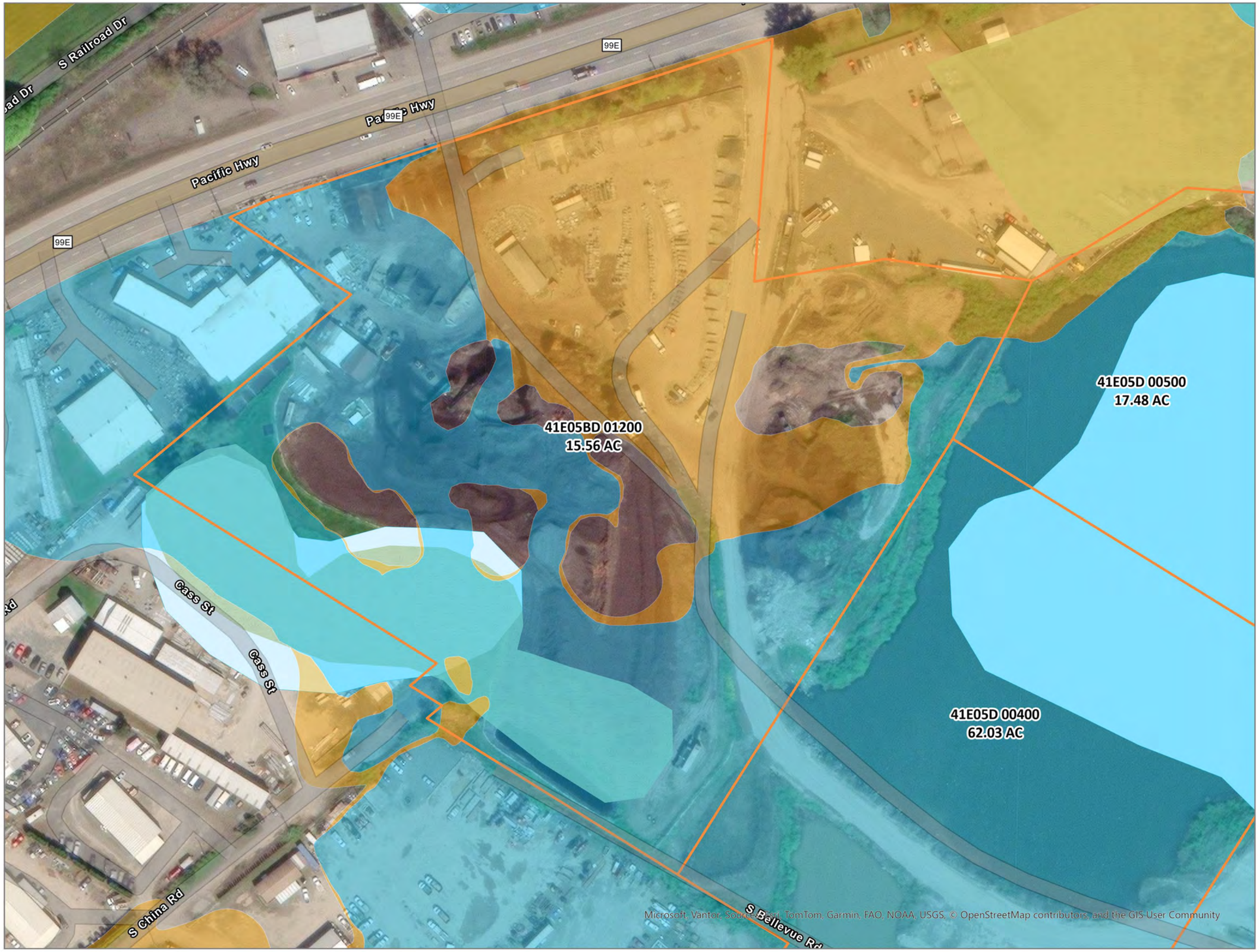
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PARCEL #18

Category 4

CANBY LANDSCAPE SUPPLY

Taxpayer: CANBY SAND&GRAVEL CO

CANBY, OR

LEGEND

- Vacant Industrial Parcel >5 AC

Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- 0.2% Annual Chance Flood Hazard
- Wetlands (Locally Corrected)
- Streams

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County,
Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
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PARCEL #18

Category 4

CANBY LANDSCAPE SUPPLY

Taxpayer: CANBY SAND&GRAVEL CO

CANBY, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 60 120 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

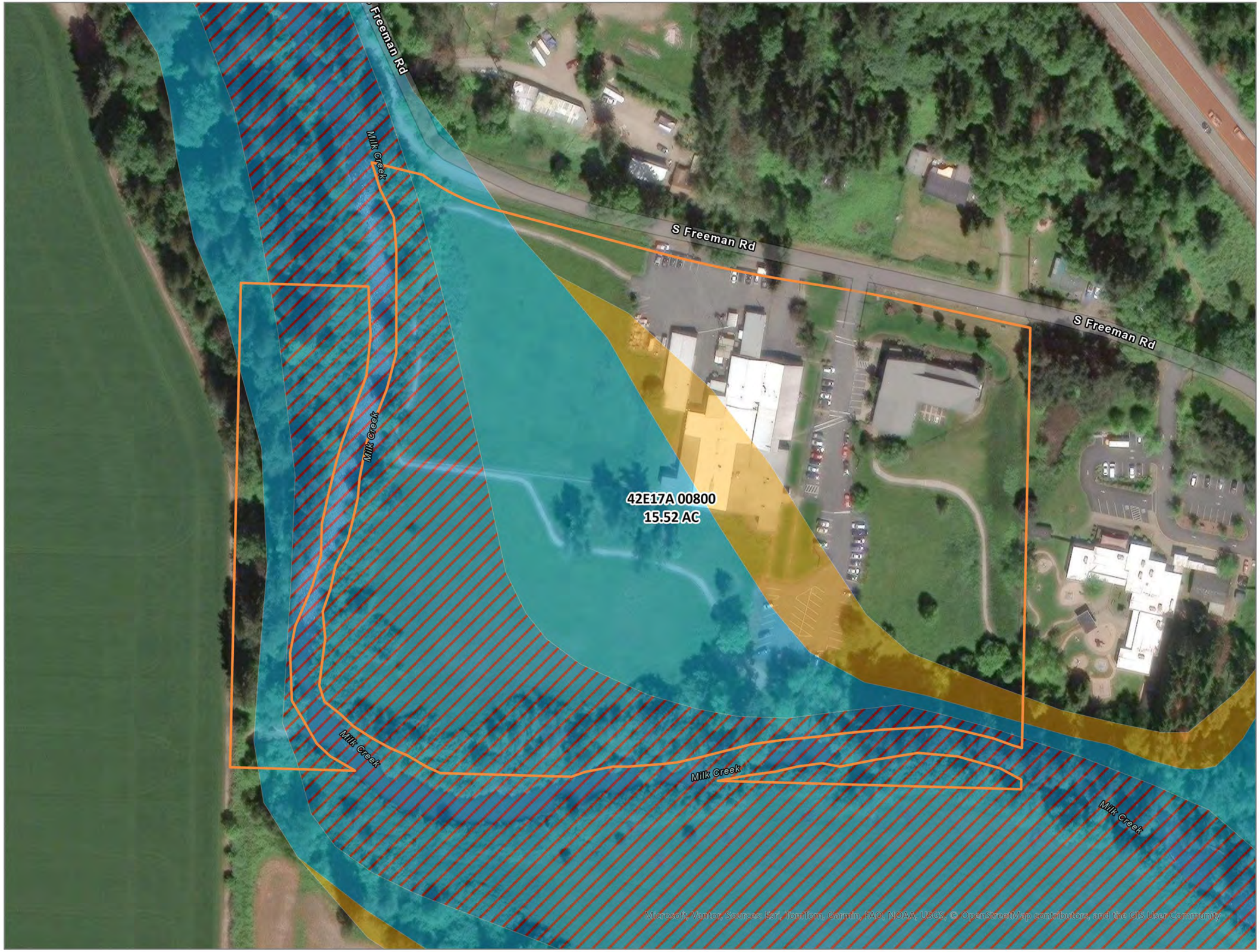
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PARCEL #19

Category 4

ASC SUNSTONE CIRCUITS LLC

Taxpayer: FIP MASTER FUNDING XIV LLC

MULINO, OR

LEGEND

- Vacant Industrial Parcel >5 AC

Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- Regulatory Flooodway
- 0.2% Annual Chance Flood Hazard

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

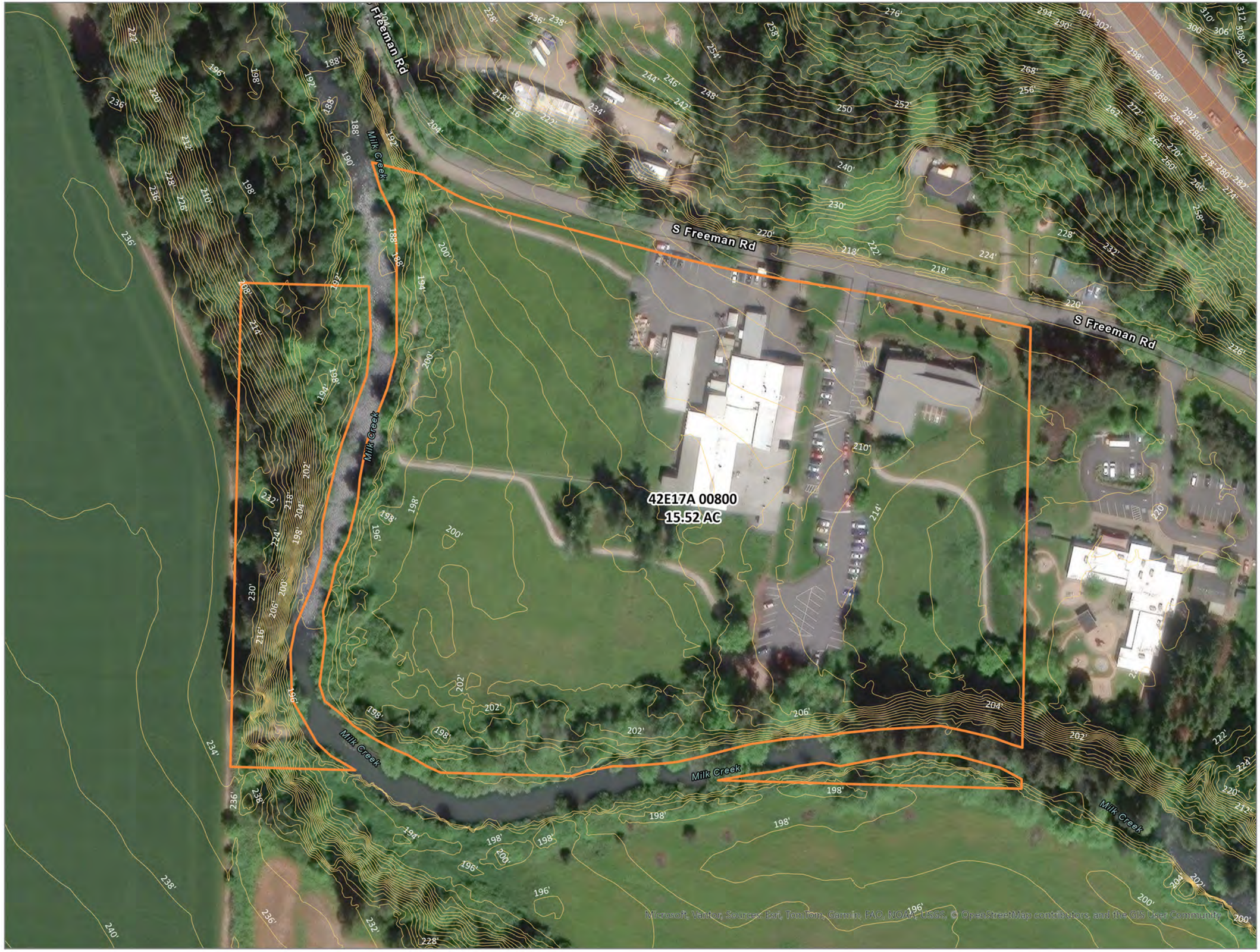
Map Created By: AAF
Project No: 2250163.00



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PARCEL #19

Category 4

ASC SUNSTONE CIRCUITS LLC

Taxpayer: FIP MASTER FUNDING XIV LLC

MULINO, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 2' Contours

0 60 120 240 Feet

1 inch = 120 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/9/2025
File: ClackamasCounty_ISRS

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PARCEL #20 (00503)
PARCEL #21 (00500)
PARCEL #22 (00700)
Category 4
RSG
Taxpayer: SANDERS WOOD PRODUCTS INC
MOLALLA, OR

LEGEND

- Vacant Industrial Parcel >5 AC

Flood Hazard Zones

- 1% Annual Chance Flood Hazard
- Regulatory Flooodway
- 0.2% Annual Chance Flood Hazard

0 250 500 Feet 1,000

1 inch = 500 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
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PARCEL #20 (00503)
PARCEL #21 (00500)
PARCEL #22 (00700)
Category 4
RSG
Taxpayer: SANDERS WOOD PRODUCTS INC
MOLALLA, OR

LEGEND

Vacant Industrial Parcel >5 AC

10' Contours

Note: the contours are 10 ft.

0 250 500 Feet 1,000

1 inch = 500 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/10/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
Project No: 2250163.00



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PARCEL #23

Category 4

Taxpayer: PACIFIC FIBRE PRODUCTS INC

MOLALLA, OR

LEGEND

Vacant Industrial Parcel >5 AC

0 75 150 300 Feet

1 inch = 150 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 11/14/2025
File: ClackamasCounty_ISRS

Map Created By: AAF
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PARCEL #23

Category 4

Taxpayer: PACIFIC FIBRE PRODUCTS INC

MOLALLA, OR

LEGEND

- Vacant Industrial Parcel >5 AC
- 10' Contours

Note: the contours are 10 ft.

0 75 150 300 Feet

1 inch = 150 feet

N

SOURCE DATA:
Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 12/10/2025
File: ClackamasCounty_ISRS

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APPENDIX 3

COUNTY WIDE MAP OF INVENTORIED UNINCORPORATED PARCELS

County Wide Map: 23 Inventoried Sites by Category

Clackamas County, OR

LEGEND

- Clackamas County Boundary

Site Categorization

- Category 1. Development-ready
- Category 2. Developable with constraints
- Category 3. Unlikely to develop due to constraints
- Category 4. Active business use present

Miles
0 1.12 2.25 4.5

1 inch = 2.25 miles

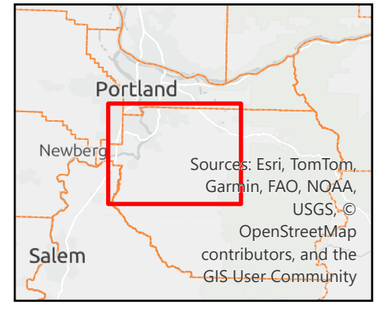
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Clackamas County, Oct 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 3/5/2026
File: ClackamasCounty_ISRS

Map Created By: AFLUETSCH
Project No: 2250163.00



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APPENDIX 4

EOA SUMMARY AND ANALYSIS MATRIX

City	Year EOA Completed	Forecast Year	Top Level Findings	Industrial Supply, Buildable Land Available in Acres (AC): Total AC of Buildable Land	Industrial Supply, Buildable Land Available in Acres (AC): Total AC of Buildable Land by share of City's land mass within Clack. Co.	Industrial Supply, Buildable Land Available in Acres (AC): AC of *Vacant* Land	Industrial Supply, Buildable Land Available in Acres (AC): AC of *Redevelopable* Land	Industrial Land Demand in Acres (AC): *Scenarios vary by city*			Reconciliation: Industrial Land Surplus or Deficit (-) in Acres ((AC): *Scenarios vary by city*			Commercial Supply, Buildable Land Available in Acres (AC): Total AC of Buildable Land	Commercial Supply, Buildable Land Available in Acres (AC): Total AC of Buildable Land by share of City's land mass within Clack. Co.	Commercial Supply, Buildable Land Available in Acres (AC): AC of *Vacant* Land	Commercial Supply, Buildable Land Available in Acres (AC): AC of *Redevelopable* Land	Commercial Land Demand in Acres (AC): *Scenarios vary by city*			Reconciliation: Commercial Land Surplus or Deficit (-) in Acres (AC): *Scenarios vary by city*			Urban Growth Boundary (UGB): Independent or Metro
								Industry Trend Extrapolated	*Growth Rate Extrapolated**	*Metro Rural Cities*	*Industry Trend Extrapolated*	*Growth Rate Extrapolated**	*Metro Rural Cities*					*Industry Trend Extrapolated*	*Growth Rate Extrapolated**	*Metro Rural Cities*	*Industry Trend Extrapolated*	*Growth Rate Extrapolated**	*Metro Rural Cities*	
Estacada	2019	2038	Estacada is experiencing significant growth in population, annual employment, and earnings, which can be attributed to increase in residential construction and an increase in economic activity in the business park. Despite this reality, Estacada still has ample supply of employment land, even assuming greater than expected employment growth and market realities that make some available employment land very unlikely to develop. Employment land demand (including commercial and industrial) is projected to be between 26 and 50 AC. The BLI indicates a total of 470 AC of available employment land, but given market reality, the effective employment land supply is estimated to be 216 AC.	369.28	369.28	337.39	31.89	39.50	18.2	33.73	329.78	351.08	335.55	101.07	101.07	71.32	29.75	-1.40	7.8	16.55	102.47	93.27	84.52	Independent
Lake Oswego	2013	2035	*95% of Lake Oswego's land mass is located within Clackamas County (the rest is located within Multnomah County). These figures reflect the city as a whole, except for column F and column Q which share the total buildable land by share of City's land mass within Clackamas County.* Lake Oswego is forecasted to have a surplus in both industrial and commercial/mixed-use land in all growth forecasts except for the high growth scenario. Much of this land in the redevelopable category. For industrial lands, the forecast of land demand is low (1-2 acres) to flat in most scenarios, except for the high growth scenario forecasts a need for 70 AC. There is a supply of 39 AC of industrial land (38 AC of this is redevelopable, with only 1 AC vacant). For commercial and mixed-use needs, Lake Oswego is forecasted to have a demand of between 19 and 187 AC, and a total supply of 119 AC, again creating a surplus in all scenarios except for the high growth scenario.	38.5	36.61	1	37.5	*Low Growth Scenario* 1	*Medium Growth Scenario** 2	*High Growth Scenario* 70.4	*Low Growth Scenario* 37.5	*Medium Growth Scenario** 36.5	*High Growth Scenario* -31.9	119	113.17	12.3	106.7	*Low Growth Scenario* 18.7	*Medium Growth Scenario** 41.8	*High Growth Scenario* 186.7	*Low Growth Scenario* 100.3	*Medium Growth Scenario** 77.2	*High Growth Scenario* -67.7	Metro
Milwaukie (2017)	2017	2035	Milwaukie is seeing significant deficits for both industrial and commercial land needs. Forecasted industrial land needs in 2035 range from 588 to 605 AC and vacant and developable acreage within the City and Urgban Growth Management Area (UGMA) is insufficient to accommodate this projected growth. Therefore, Milwaukie's capacity for future industrial growth will be heavily reliant on redevelopment and intensification of uses. This limited inventory of vacant and developable sites is Milwaukie's primary challenge in attracting and retaining new growth. Commercial land needs range from 172 to 253 AC, and Milwaukie has a supply of 0.6 AC of commercial land which creates a significant deficit.	32.5		21.3	11.2	*Safe Harbor Forecast** 588	*Alternative Forecast* 605		*Safe Harbor Forecast** -555.5	*Alternative Forecast* -572.5		0.6		0.5	0.1	*Safe Harbor Forecast** 172	*Alternative Forecast* 253		*Safe Harbor Forecast** -171.4	*Alternative Forecast* -252.4		Metro
Milwaukie (2026)*	2026	2035	Re-running the methodology using the same forecasted needs with updated 2026 data on the buildable land available showed that nearly one-third of the industrial land from 2017 is still available, creating an even larger deficit. While there was slightly more commercial land available, there was still a significant deficit of between 157 to 238 AC.	11.95	11.95	2.91	9.04	588	605		-576.05	-593.05		14.26	14.26	0.37	13.89	172	253		-157.74	-238.74		
Canby	2023	2043	Canby is seeing deficits for both industrial and commercial land needs. The City has 163 AC of industrial land available, creating a deficit of between 81 AC to 474 AC. For commercial land, the city has a smaller deficit, with 16 AC of buildable land, leading to a deficit of between 4 and 8 AC.	163	163	163	n/a	*Low Growth Scenario* 244.4	*Medium Growth Scenario** 601.5	*High Growth Scenario* 637.8	*Low Growth Scenario* -81.4	*Medium Growth Scenario** -438.5	*High Growth Scenario* -474.8	16.4	16.4	16.4	n/a	*Low Growth Scenario* 20.5	*Medium Growth Scenario** 24.7	*High Growth Scenario* 33.9	*Low Growth Scenario* -4.1	*Medium Growth Scenario** -8.3	*High Growth Scenario* -17.5	Independent (Currently under evaluation for UGB expansion)
Happy Valley	2011	2035	Happy Valley has ample supply of industrial lands, with a 207 AC of buildable land and a need of only between 91 to 152 AC, creating a surplus in every forecasted scenario. The city has 76 AC of buildable land for commercial uses, with a need ranging from 55 to 91 AC. This creates a surplus in the low growth and medium growth scenarios, but a deficit of 16 AC in the high growth scenario.	207	207	207	n/a	*Low Growth Scenario* 92	*Medium Growth Scenario** 122	*High Growth Scenario* 152	*Low Growth Scenario* 115	*Medium Growth Scenario** 85	*High Growth Scenario* 54	76	76	76	n/a	*Low Growth Scenario* 55	*Medium Growth Scenario** 73	*High Growth Scenario* 91	*Low Growth Scenario* 21	*Medium Growth Scenario** 3	*High Growth Scenario* -16	Metro
Molalla	2025	2045	Molalla has a sufficient supply of industrial land, but an insufficient supply of commercial land. The industrial land need for the City is 78 AC and the City has a supply of 175 AC. The commercial land need is 70.2 AC and the city only has a supply of 55 AC, creating a deficit of 15 AC.	174.6	174.6	174.6	n/a	*Adjusted Employment Forecast** 78.1			*Adjusted Employment Forecast** 96.5			54.7	54.7	54.7	n/a	*Adjusted Employment Forecast** 70.2			*Adjusted Employment Forecast** -15.5			Independent (Currently under evaluation for UGB expansion)
Sandy	2024	2044	Sandy is forecasted to have insufficient land supply for industrial development, with a supply of 54 AC and a forecasted need of 63 AC, creating a 9 AC deficit. Sandy has ample supply of commercial lands, with a supply of 142 AC, and a forecasted need of 91 AC, creating a surplus of 52 AC. The EOA notes that some of this commercial land may be used for development of affordable housing as allowed by Senate Bill 8.	54	54	54	n/a	*Safe Harbor Forecast** 63			*Safe Harbor Forecast** -9			142	142	142	n/a	*Safe Harbor Forecast** 91			*Safe Harbor Forecast** 52			Independent
Tualatin	2019	2040	*Only 9% of Tualatin's land mass is located within Clackamas County (the rest is located within Washington County). These figures reflect the city as a whole, except for column F and column Q which share the total buildable land by share of City's land mass within Clackamas County.* Tualatin is forecasted to have a surplus of industrial land of 220 AC, though this takes into consideration 294 AC of redevelopable land. Additionally, 120 AC of industrial land is within the Basalt Creek Planning Area. Tualatin is forecasted to have a deficit of commercial lands of 171 AC.	668	60.97	374	294	*Metro's Emp Growth Rate Scenario** 448			*Metro's Emp Growth Rate Scenario** 220			15	1.37	11	4	*Metro's Emp Growth Rate Scenario** 186			*Metro's Emp Growth Rate Scenario** -171			Metro
West Linn	2016	2036	West Linn is projected to have just enough industrial and commercial lands for its needs. There is forecasted to be between 0.5 and 8.5 AC of surplus industrial land, and between 5 and 7 AC of surplus commercial lands.	11.52	11.52	4.72	6.8	*Scenario A: Existing trends* 11	*Scenario B: Trends toward retail & office** 3		*Scenario A: Existing trends* 0.52	*Scenario B: Trends toward retail & office** 8.52		31.89	31.89	13.36	18.53	*Scenario A: Existing trends* 25	*Scenario B: Trends toward retail & office** 27		*Scenario A: Existing trends* 6.89	*Scenario B: Trends toward retail & office** 4.89		Metro
Wilsonville	2025	2046	*89% of Wilsonville's land mass is located in Clackamas County (the rest is located within Washington County). These figures reflect the city as a whole, except for column F and column Q which share the total buildable land by share of City's land mass within Clackamas County.* Wilsonville is projected to have a sufficient supply of industrial land, but a deficit in commercial land. The industrial land need is 321 AC, and the supply is 353 AC, creating a surplus of 32 AC. The commercial land need is 110 AC and the supply is only 63 AC (50 AC of which is redevelopable), creating a deficit of 47 AC.	353	315.20	353	n/a	*Safe Harbor Forecast** 321			*Safe Harbor Forecast** 32			63	56.25	13	50	*Safe Harbor Forecast** 110			*Safe Harbor Forecast** -47			Metro
TOTALS				**2050.85**	***1404.12***	**1671.62**	**379.23**	**2244.80**			**-193.95**			**633.32**	***607.11***	**410.45**	**222.87**	**803.50**			**-169.18**			

* used for totals in countywide analysis in executive summary. Description of scenarios and approach to selecting which scenario to choose in summarization is detailed in Section 3 of the memo.

Total deficit after accounting for share of city land mass within Clackamas County: ***-840.68***

Total deficit after accounting for share of city land mass within Clackamas County: ***-196.39***

APPENDIX 5

EOA SUMMARY METHODOLOGY AND ASSUMPTIONS

APPENDIX 5 – EOA SUMMARY METHODOLOGY AND ASSUMPTIONS

Approach to Variation Across Cities

Scenario Forecasting

Statewide Planning Goal 9, which requires cities to consider future land needs for economic activities, does not have a required method for forecasting employment change and land demand. As such, each city has different approaches to developing forecast scenarios. This means it is difficult to accurately project countywide land demand and the resulting countywide land surpluses or deficits because each city has a different methodology for forecasting these needs, so the analysis is not comparing apples to apples. However, if this countywide projection is taken with this caveat, it can still act as a useful reference.

In order to aggregate the land demand projections from each city, the following process was undertaken to select which forecast scenario was used in this EOA Summary and Analysis:

- Some cities' EOAs only provide land demand figures for one scenario forecast. These cities are Molalla, Sandy, Tualatin, and Wilsonville. In the case of these cities, this forecast was chosen for the EOA Summary and Analysis due to no other data being available.
- For cities' EOAs that provide land demand figures for multiple forecasts, the scenario that was most similar to meeting the following characteristics was chosen:
    - Uses employment growth rate and projections provided by the Oregon Employment Department (OED)
    - Considers industry trends

See Table 1 for the scenario that was selected for this EOA Summary and Analysis.

Though this process was imperfect, it allows for comparison across cities and allows for the cities' land demand and resulting land surplus or deficit to be aggregated for a countywide view of approximate needs.

Redevelopable Assumptions

Like forecast scenarios, there is not a standard required methodology for how BLI's should consider redevelopment potential or how they define land as "redevelopable." As such, each city approaches redevelopment potential differently.

Some cities do not provide separate acreage figures for redevelopable, and instead only provide a total "Vacant" land acreage figure. These cities include Canby, Happy Valley, Molalla and Sandy. Some of the EOAs explain that some degree of redevelopment potential is already included in their Vacant land category (like Molalla).

Other cities separate redevelopable and vacant land and use a variety of methodologies for determining redevelopable land, including improvement to land value ratio or Real Market Value per square foot.

See Table 1 for how each city defines and calculates redevelopable.

Multi-County Cities

Three cities in Clackamas County also fall within another county: Lake Oswego (Multnomah County), Tualatin (Washington County) and Wilsonville (Washington County).

The EOA's for these three cities are city-wide, meaning they include buildable land across the entire city, which could include land in other counties. Including these cities' entire buildable land could distort the countywide summary and projections because it could include land that is not within Clackamas County's jurisdiction.

In order to account for this, the percentage share of area (land mass) within Clackamas County was calculated for these three cities:

- Lake Oswego: 95% of City's area is within Clackamas County.
- Tualatin: 9% of City's area is within Clackamas County.
- Wilsonville: 89% of City's area is within Clackamas County.

An additional layer of analysis summarized and analyzed the buildable land in all the cities by share of area within Clackamas County. This alters the cumulative buildable land countywide, particularly for industrial land, given that the city of Tualatin had over 650 AC of buildable industrial land, but only 9% of Tualatin's area is within Clackamas County.

Though this is an imperfect method for accounting for buildable land in multi-county cities, it takes into consideration that these cities' BLI's are not accurately representative of Countywide land.

EOA Completion Year and Forecast Year

There is also variation across the cities for when the Economic Opportunity Analysis was completed, ranging from 2011 (Happy Valley) to 2025 (Wilsonville and Molalla). (Milwaukie's EOA was completed in 2017 but re-ran their BLI methodology to produce updated data in 2026.) As a result, the forecast year for each of these cities varied and the employment forecast scenarios vary based on different economic conditions in those time periods. For example, EOAs completed before the COVID-19 pandemic consider different economic conditions than those completed after.

This EOA Summary and Analysis did not account for these temporal differences.

Variation in Assumptions Across Cities' EOAs

TABLE 1. VARIATION IN ASSUMPTIONS ACROSS CITIES' ECONOMIC OPPORTUNITY ANALYSES

(Page numbers denote reference in respective EOA)

City	Forecasted Scenario Selected for EOA Summary and Analysis	Redevelopable Definition
Estacada (2019)	Scenario 2, Growth Rate Extrapolated applies the total annual growth rate between 2010 and 2017 and distributes the growth to industry sectors based on share of	Developed parcels that fall within the lowest 25% of parcels in terms of value per square foot are considered redevelopable (page 22).

	employment in 2017. This forecast aligns with Oregon Employment Department's employment forecast (page 26).	
Lake Oswego (2013)	Medium Growth Scenario utilizes the most current trend and forecast data available from the Oregon Employment Department (page 31).	Parcels with an improvement value of 150% or less of the land value are considered redevelopable, using 2010 Clackamas County Assessor data (page 30).
Milwaukie (2017 and 2026)	Scenario 1, Safe Harbor Forecast relies on the most recent regional forecast by the Oregon Employment department, applying industry specific growth rates. This scenario is the recommended forecast (page 44).	Properties with a Real Market Value (RMV) per sq. ft. below the threshold value are designated as redevelopable. Thresholds were determined by baseline strike prices that reflect the generalized view of current market conditions. RMV values were provided by the Assessor's office (page 59).
Canby (2023)	Medium Growth Forecast Scenario reflects the level of job growth anticipated based on actual historic job growth rates, using Oregon Employment Department estimates (page 16).	*Does not include separate redevelopable acres in land demand figures.* Instead, incorporates redevelopable assumptions into employment forecasts separately, noting a projected number of jobs not requiring vacant land (page 17 and Appendix D on page 43).
Happy Valley (2011)	Scenario B, Medium Growth Scenario assumes consistency with the current employment forecast adopted by Metro. (Low Growth assumes growth is 25% below, and High Growth assumes 25% higher) (page 7).	*Does not include separate redevelopable acres in land demand figures.* Land needs already account for the level of expected redevelopment activity (page 13).
Molalla (2025)	*Land demand and reconciliation figures were only provided for one scenario.* Scenario 2: Adjusted Employment Forecast formulates an employment growth trajectory based on identified trends, an increased growth outlook for targeted industries, and input from a project advisory group (page 35).	*Does not include separate redevelopable acres in land demand figures.* "Vacant" land includes parcels that may be redevelopable: have an improvement value that is less than $5,000 or less than 5% of the property's land value. Vacant also includes "partially vacant" which is land that has an improvement value of between 5% and 40% of the land value or is greater than one acre in size with at least ½ acre not improved. Each partially vacant parcel is assigned a vacant area based on aerial photos. (Appendix B, page 9).
Sandy (2024)	*Land demand and reconciliation figures were only provided for one scenario.* Population Growth Forecast for the City forecasts employment growing at the rate of the PSU population growth rate (page 28-29).	*Does not include separate redevelopable acres in land demand figures.* Lands with an improvement value of $0 are considered vacant. Also includes "partially vacant" land, which are lax lots between one and five acres occupied by a use that could be further developed based on zoning.

Tualatin (2019)	*Land demand and reconciliation figures were only provided for one scenario.* Metro's Employment Growth Rate for Tualatin is based on Metro's employment forecast for Tualatin for the 2015-2040 period (page 38).	Redevelopable lots are identified if they meet size and price thresholds based on location, using property value thresholds where it is economically viable for the lot to redevelop. These thresholds vary based on location, for example, in a central commercial Plan Designation, a lot that is larger than 0.249 AC and has a RMV per square foot of below $12 is considered redevelopable (page 55).
West Linn (2016)	Scenario B assumes that the Metro 20-year employment forecast for West Linn is realized using an employment mix that trends less towards industrial and government/education job growth and more towards retail and office jobs. This scenario is the preferred forecast (page 44).	Redevelopable land is identified based on the ratio of assessed improvement value to land value. Lots with an improvement to land value ratio of less than 0.5 had "high" redevelopment potential, and lots with an improvement to land value ratio of between 0.5 and 1 had a "moderate" redevelopment potential. Lots in both high and moderate categories were included in the redevelopable acreage figures (page 23-24).
Wilsonville (2025)	*Land demand and reconciliation figures were only provided for one scenario.* Oregon Employment Department's (OED) regional growth rate assumes the current number of jobs in Wilsonville will grow at the same rate as the regional employment growth rate from the most recent OED forecast (page 82-83).	Redevelopment potential was not modeled for industrial sites because there was a surplus of industrial land. Redevelopable acres for commercial land reflected known near-term opportunities (for example, in Town Center and reuse of large vacant sites like the former Rite Aid, Albertsons, and Regal Cinema).

TABLE 2. REFERENCES FOR EOA ANALYSIS

City	Reference:
Estacada (2019)	Figure 28, page 29
Lake Oswego (2013)	Table 14, page 35
Milwaukie (2017 and 2026)	*Re-ran methodology with 2026 data, provided by City of Milwaukie
Canby (2023)	Exhibit 28, page 23
Happy Valley (2011)	Industrial: Table 7, pg. 14 Commercial: Table 9, page 15
Molalla (2025)	Figure 7.4, page 43
Sandy (2024)	Exhibit 21, page 46
Tualatin (2019)	Exhibit 31, page 57
West Linn (2016)	Buildable Land: Exhibit 27, page 23 (Vacant) and Exhibit 29, page 24 (Redevelopable) Land Demand: Exhibit 26, page 22.
Wilsonville (2025)	Exhibit 41, page 107

APPENDIX 6

MAP PACKAGE OF BLI BY JURISDICTION

Employment Buildable Land

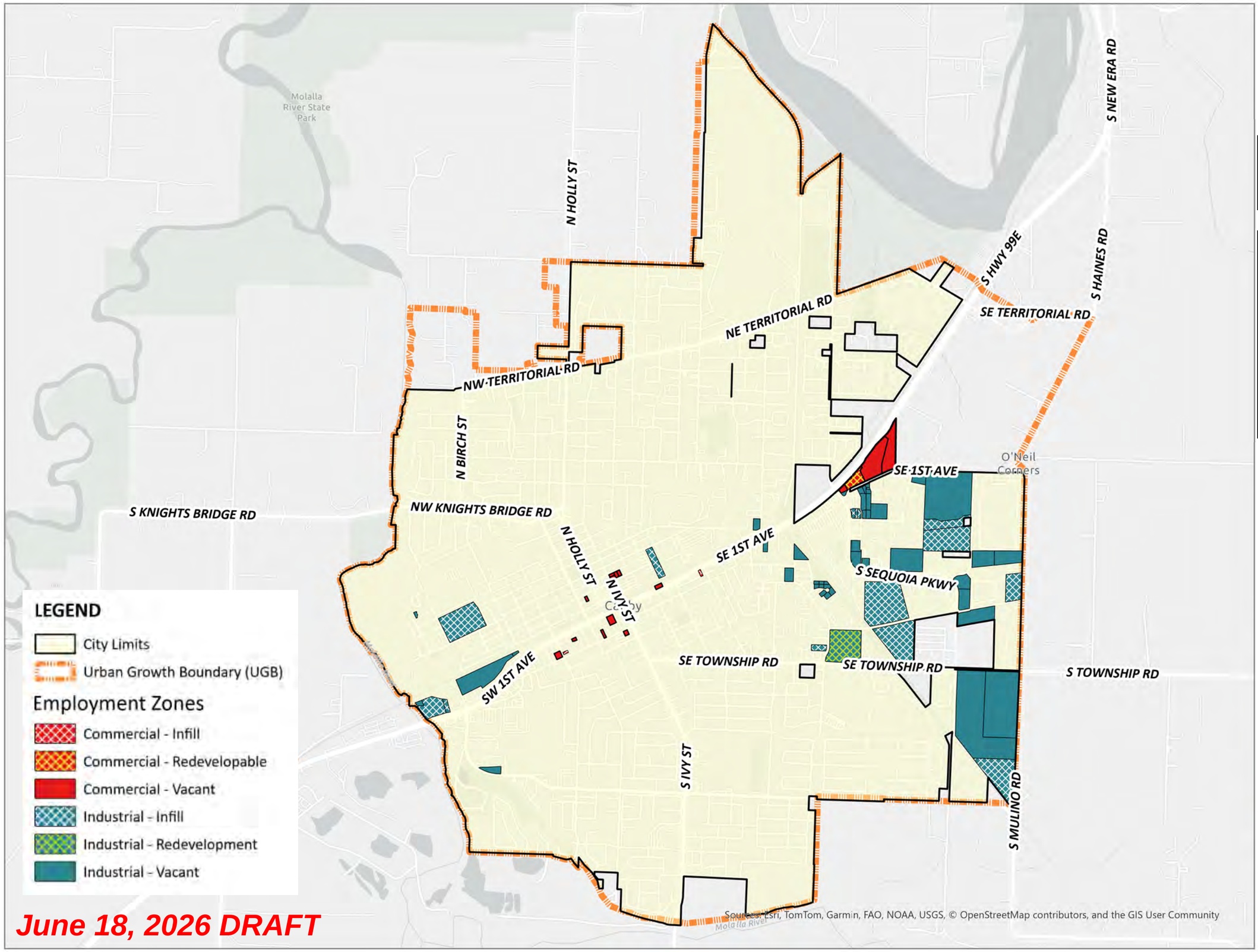
Canby, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	47	18
1 - 4.99	22	13
5 - 9.99	4	5
10 - 19.99	0	1
>20	3	2

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	**Acres**
Commercial	**13**
Vacant	11
Partially Vacant/ Infill	0
Redevelopable	2
Industrial	**152**
Vacant	112
Partially Vacant/ Infill	30
Redevelopable	9
Mixed Use	**n/a**
Vacant	n/a
Partially Vacant/ Infill	n/a
Redevelopable	n/a
Total	**165**

Data from City of Canby EOA (2023). Data may not be reflective of current conditions.



June 18, 2026 DRAFT

0 900 1,800 3,600 Feet

1 inch = 1,800 feet

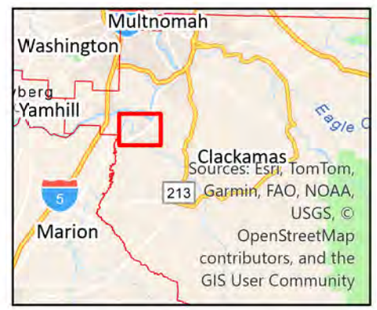
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SOURCE DATA:
Metro RLIS, March 2026
City of Canby, 2023 EOA dataset
Clackamas County May, 2026

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 6/18/2026
File: Clackamas County EOA Analysis

Map Created By: AFLUETSCH
Project No: 2250163.00



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Employment Buildable Land

Estacada, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	89	26
1 - 4.99	42	9
5 - 9.99	16	2
10 - 19.99	4	1
>20	6	6

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	Acres
Commercial	**101**
Vacant	61
Partially Vacant/ Infill	11
Redevelopable	30
Industrial	**371**
Vacant	212
Partially Vacant/ Infill	126
Redevelopable	32
Mixed Use	**n/a**
Vacant	n/a
Partially Vacant/ Infill	n/a
Redevelopable	n/a
Total	**472**

Data from City of Estacada EOA (2019). Data may not be reflective of current conditions.

0 650 1,300 2,600 Feet

1 inch = 1,300 feet

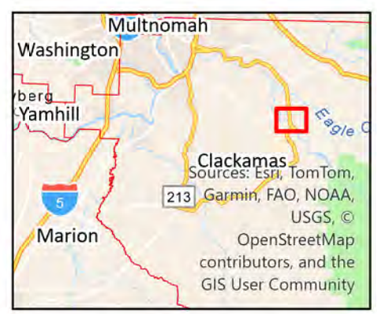
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SOURCE DATA:
Metro RLIS, March 2026
City of Estacada, 2019 EOA dataset
Clackamas County May, 2026

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North Lambert Conformal Conic

Date: 6/16/2026
File: Clackamas County EOA Analysis

Map Created By: AFLUETSCH
Project No: 2250163.00



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LEGEND

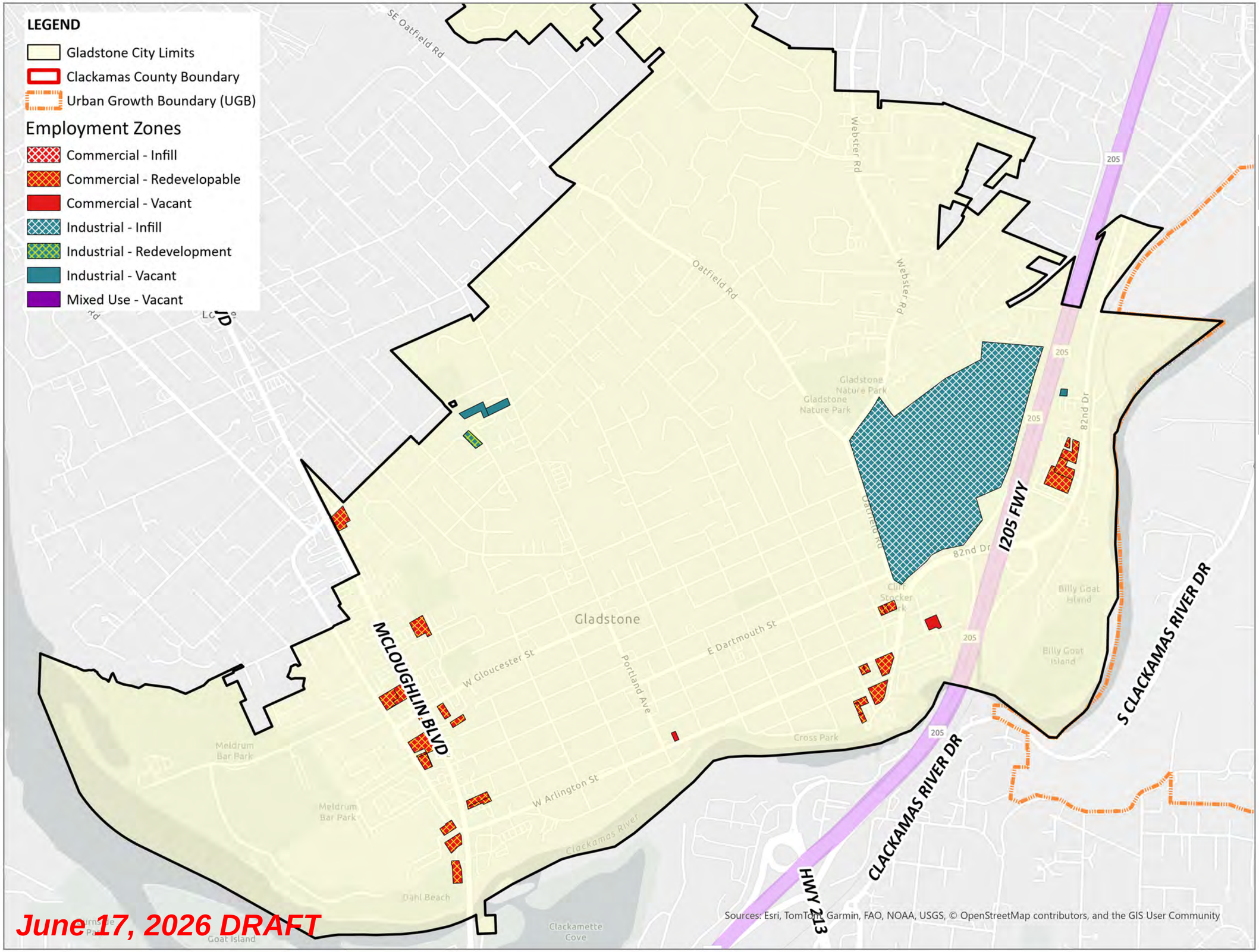
- City Limits
- Urban Growth Boundary (UGB)

Employment Zones

- Commercial - Infill
- Commercial - Redevelopable
- Commercial - Vacant
- Industrial - Infill
- Industrial - Redevelopment
- Industrial - Vacant

Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

June 17, 2026 DRAFT



June 17, 2026 DRAFT

Employment Buildable Land

Gladstone, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	31	24
1 - 4.99	0	0
5 - 9.99	0	0
10 - 19.99	0	0
>20	1	1

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	Acres
Commercial	**1**
Vacant	1
Partially Vacant/ Infill	0
Redevelopable	0
Industrial	**37**
Vacant	0
Partially Vacant/ Infill	37
Redevelopable	0
Mixed Use	**0**
Vacant	0
Partially Vacant/ Infill	0
Redevelopable	0
Total	**38**

Data from Metro Urban Growth Report (2024). Data may not be reflective of current conditions.

0 500 1,000 2,000 Feet

1 inch = 1,000 feet

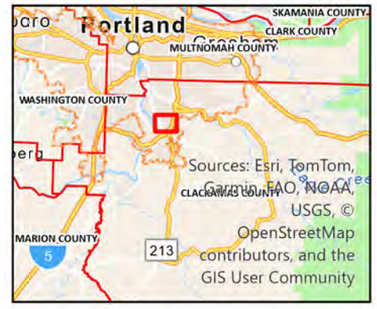
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SOURCE DATA:
Metro RLIS, March 2026
Metro, 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 6/2/2026
File: Basemap

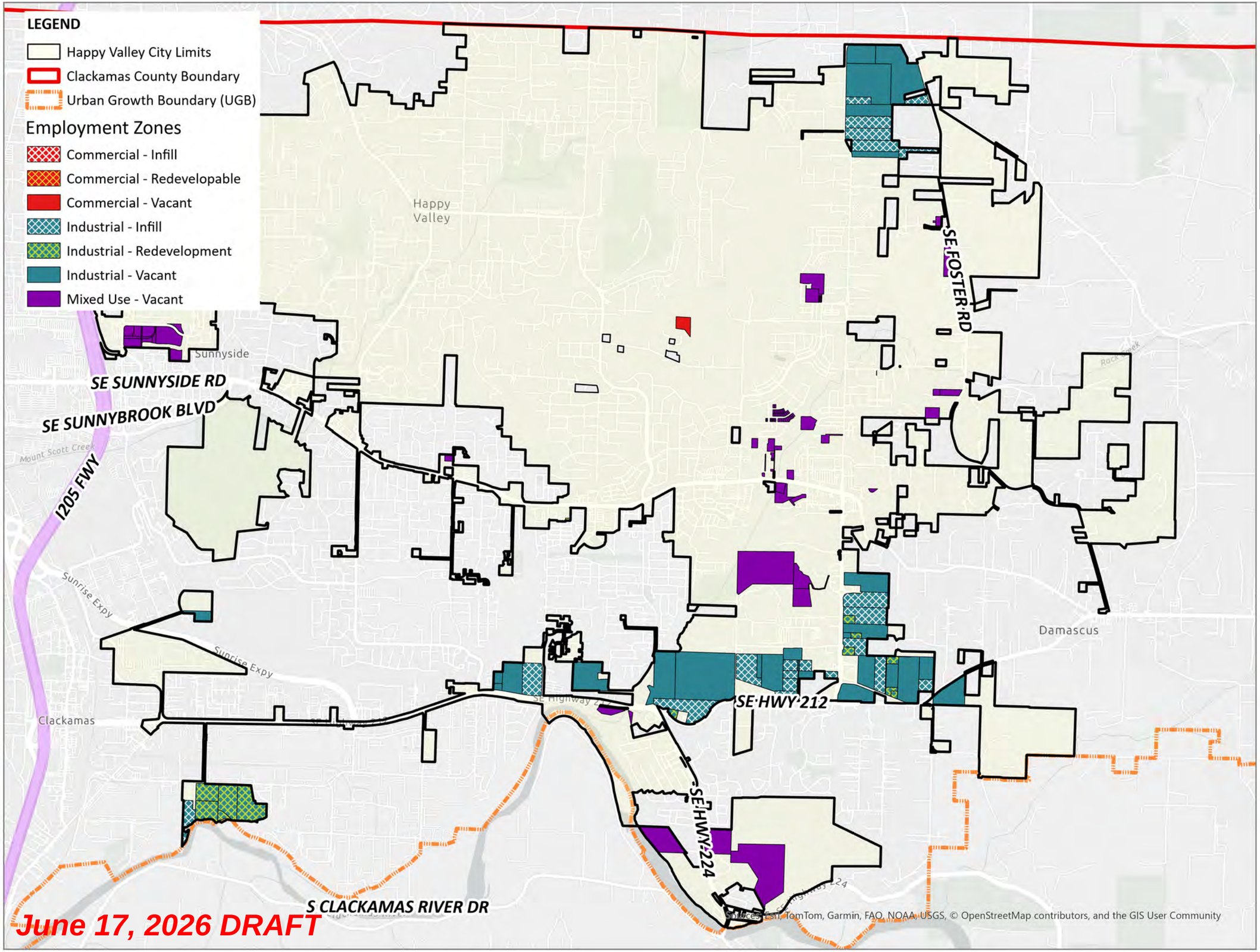
Map Created By: SHARIHARANGODT
Project No: 2250163.00



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Employment Buildable Land

Happy Valley, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	112	77
1 - 4.99	28	7
5 - 9.99	13	2
10 - 19.99	3	0
>20	3	4

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	**Acres**
Commercial	**0**
Vacant	0
Partially Vacant/ Infill	0
Redevelopable	0
Industrial	**273**
Vacant	180
Partially Vacant/ Infill	92
Redevelopable	1
Mixed Use	**16**
Vacant	16
Partially Vacant/ Infill	0
Redevelopable	0
Total	**289**

Data from Metro Urban Growth Report (2024). Data may not be reflective of current conditions.

0 1,250 2,500 5,000 Feet

1 inch = 2,500 feet

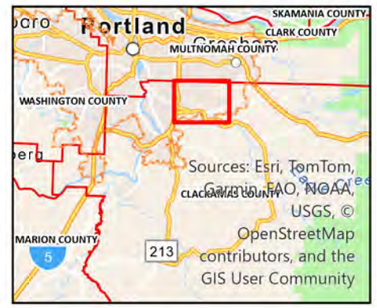
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SOURCE DATA:
Metro RLIS, March 2026
Metro, 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 6/2/2026
File: Basemap

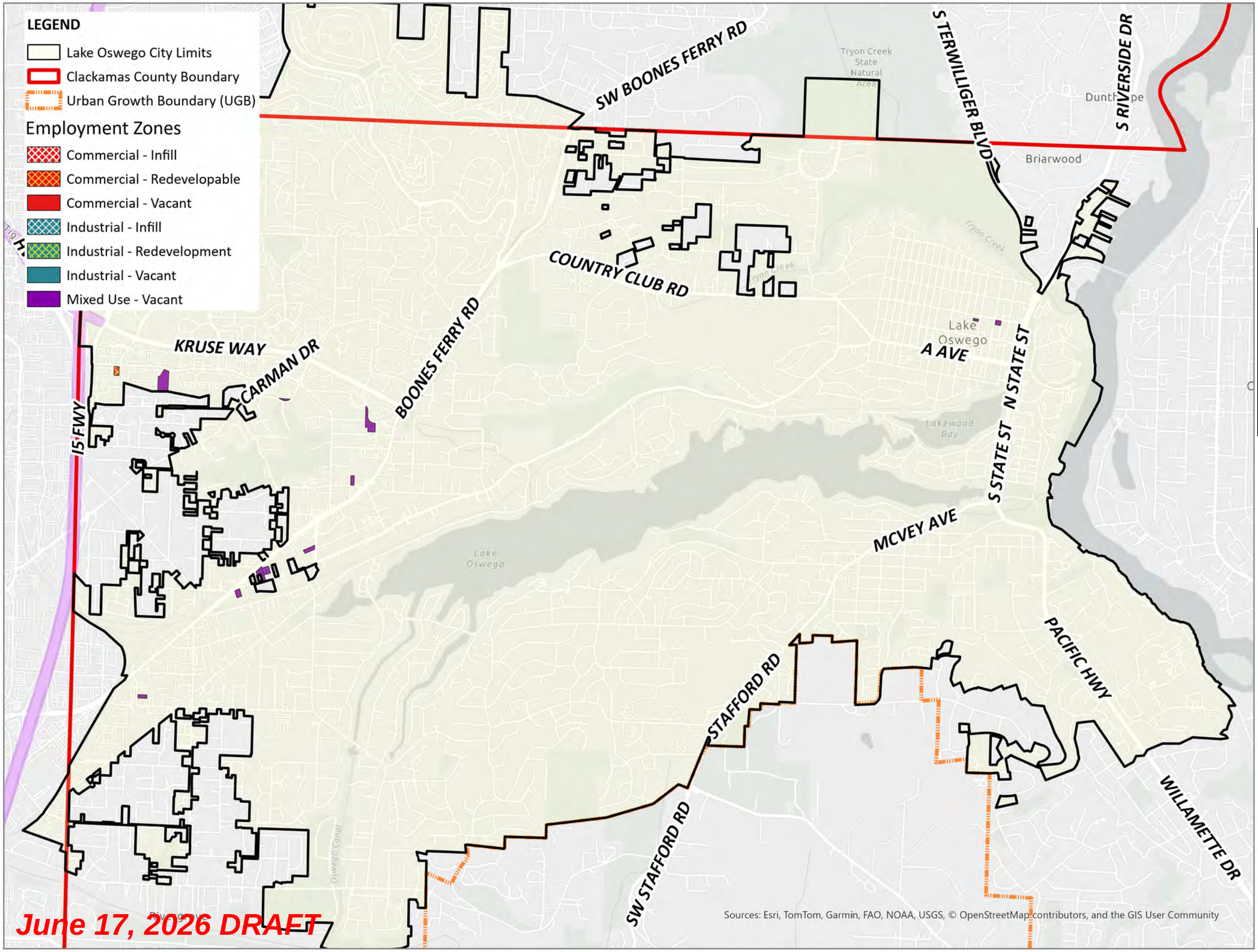
Map Created By: SHARIHARANGODT
Project No: 2250163.00



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Employment Buildable Land

Lake Oswego, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	14	12
1 - 4.99	0	0
5 - 9.99	0	0
10 - 19.99	0	0
>20	0	0

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	Acres
Commercial	**0**
Vacant	0
Partially Vacant/ Infill	0
Redevelopable	0
Industrial	**0**
Vacant	0
Partially Vacant/ Infill	0
Redevelopable	0
Mixed Use	**1**
Vacant	1
Partially Vacant/ Infill	0
Redevelopable	0
Total	**1**

Data from Metro Urban Growth Report (2024). Data may not be reflective of current conditions.

Note, this analysis is limited to the parcels within Clackamas County

0 1,000 2,000 4,000 Feet

1 inch = 2,000 feet

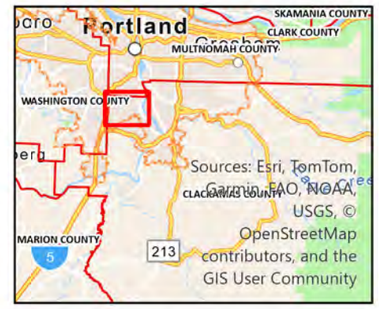
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SOURCE DATA:
Metro RLIS, March 2026
Metro, 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

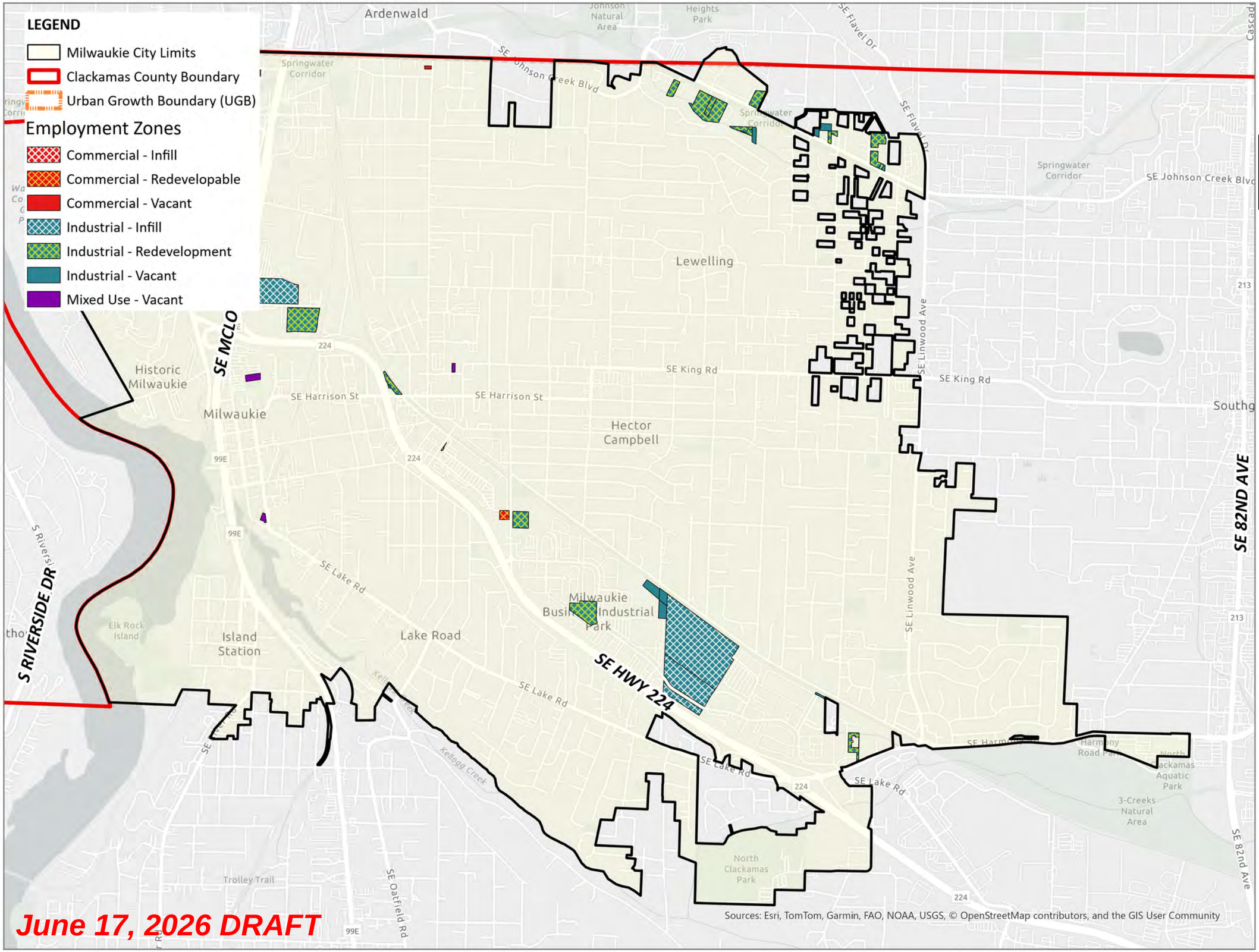
Date: 6/2/2026
File: Basemap

Map Created By: SHARIHARANGODT
Project No: 2250163.00



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June 17, 2026 DRAFT

Employment Buildable Land

Milwaukie, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	34	27
1 - 4.99	3	2
5 - 9.99	0	0
10 - 19.99	0	0
>20	0	0

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	Acres
Commercial	**0**
Vacant	0
Partially Vacant/ Infill	0
Redevelopable	0
Industrial	**8**
Vacant	1
Partially Vacant/ Infill	7
Redevelopable	1
Mixed Use	**0**
Vacant	0
Partially Vacant/ Infill	0
Redevelopable	0
Total	**9**

Data from Metro Urban Growth Report (2024). Data may not be reflective of current conditions.

Note, this analysis is limited to the parcels within Clackamas County

0 1,500 3,000 Feet

1 inch = 1,500 feet

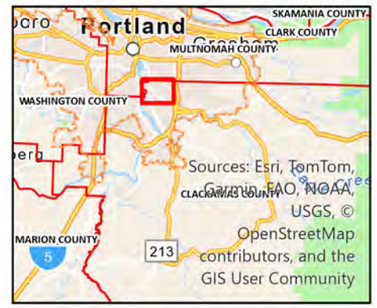
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SOURCE DATA:
Metro RLIS, March 2026
Metro, 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 6/2/2026
File: Basemap

Map Created By: SHARIHARANGODT
Project No: 2250163.00



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Employment Buildable Land

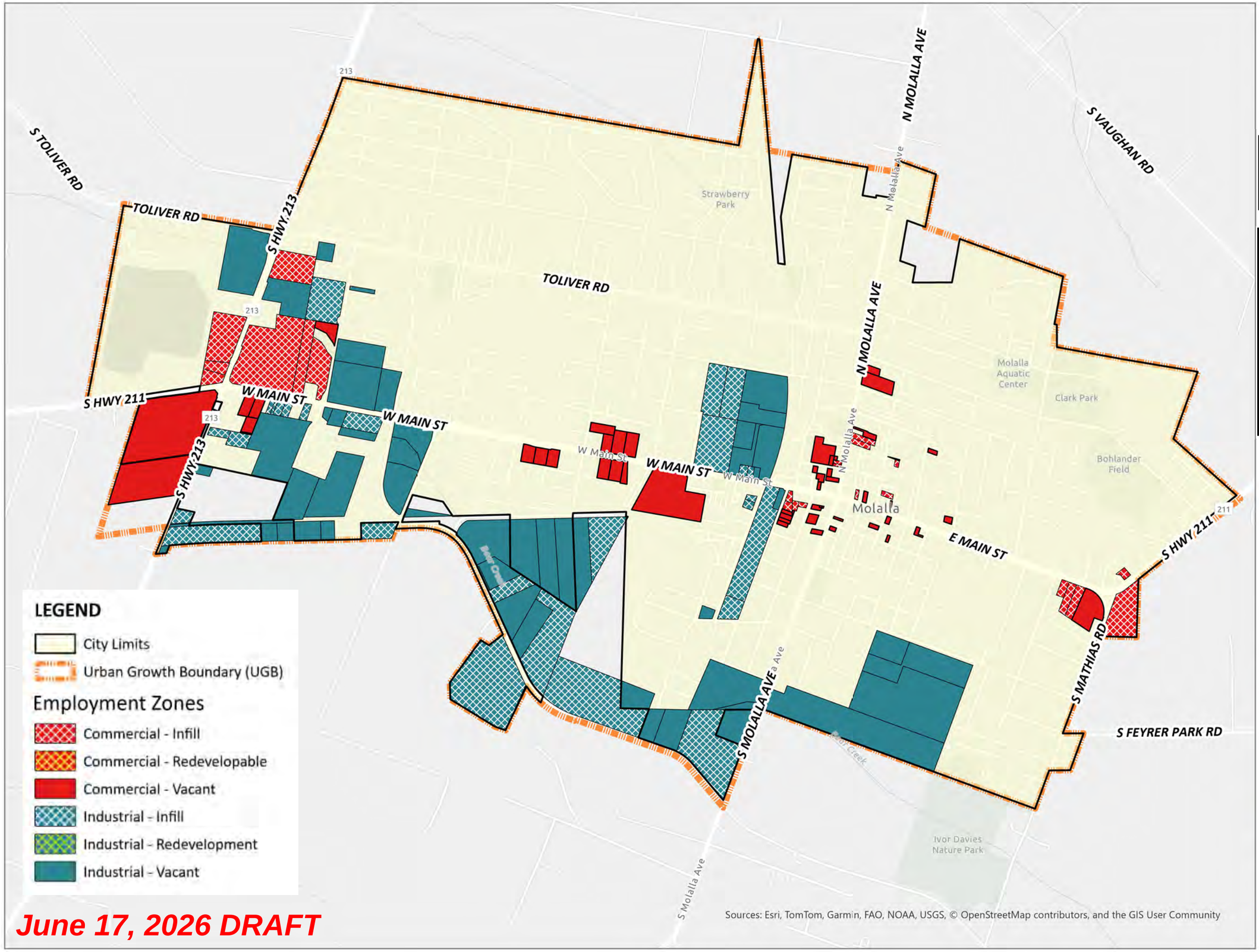
Molalla, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	88	27
1 - 4.99	50	12
5 - 9.99	12	5
10 - 19.99	3	3
>20	0	5

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	**Acres**
Commercial	**91**
Vacant	54
Partially Vacant/ Infill	37
Redevelopable	n/a
Industrial	**211**
Vacant	131
Partially Vacant/ Infill	80
Redevelopable	n/a
Mixed Use	**n/a**
Vacant	n/a
Partially Vacant/ Infill	n/a
Redevelopable	n/a
Total	**302**

Data from City of Molalla EOA (2025). Data may not be reflective of current conditions.



June 17, 2026 DRAFT

0 550 1,100 2,200 Feet

1 inch = 1,100 feet

N

SOURCE DATA:
Metro RLIS, March 2026
City of Molalla, 2025 EOA dataset
Clackamas County May, 2026

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 6/16/2026
File: Clackamas County EOA Analysis

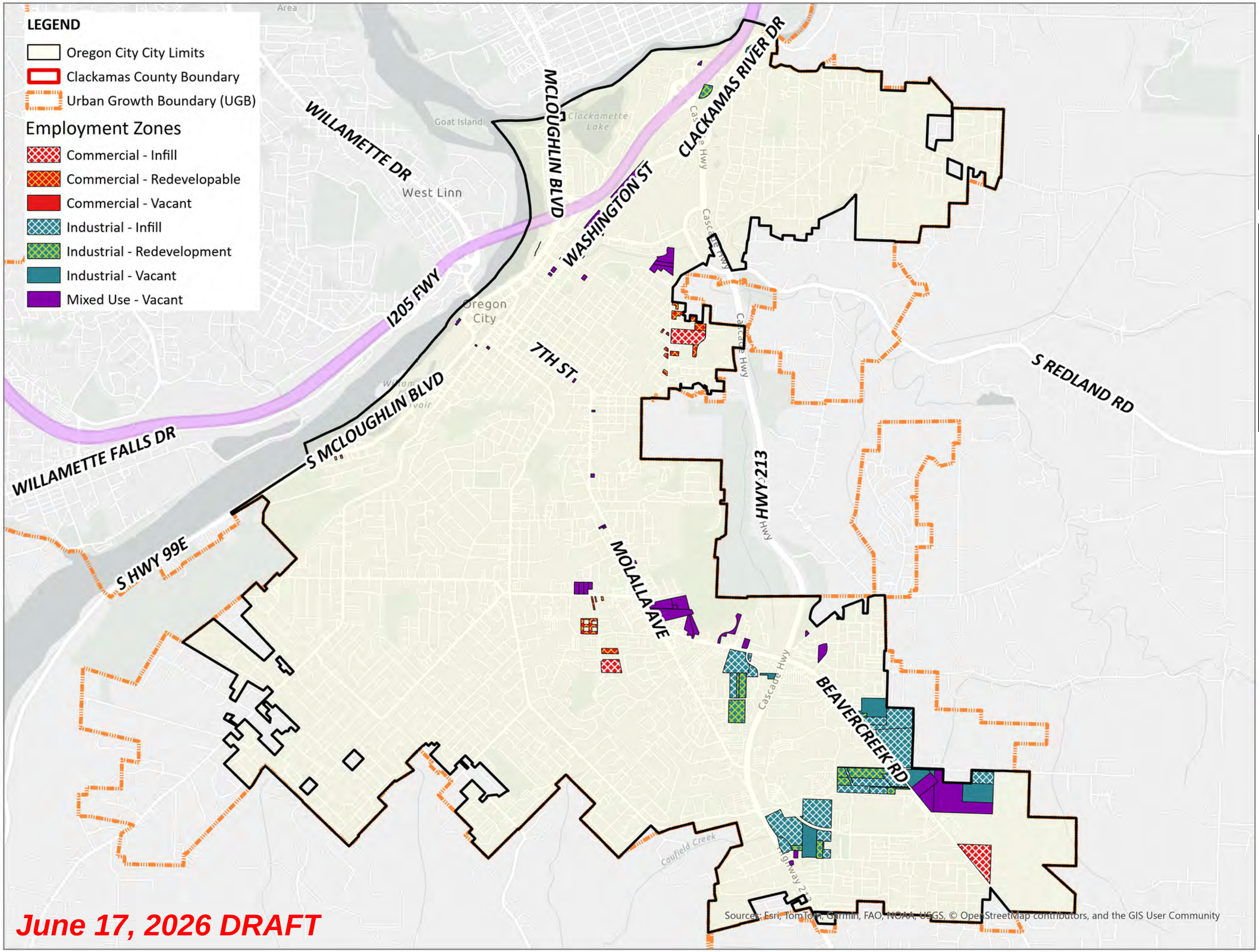
Map Created By: AFLUETSCH
Project No: 2250163.00



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June 17, 2026 DRAFT

Employment Buildable Land

Oregon City, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	81	57
1 - 4.99	17	4
5 - 9.99	7	1
10 - 19.99	1	2
>20	0	2

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	Acres
Commercial	**12**
Vacant	0
Partially Vacant/ Infill	11
Redevelopable	1
Industrial	**86**
Vacant	28
Partially Vacant/ Infill	56
Redevelopable	2
Mixed Use	**10**
Vacant	10
Partially Vacant/ Infill	0
Redevelopable	0
Total	**108**

Data from Metro Urban Growth Report (2024). Data may not be reflective of current conditions.

0 1,250 2,500 5,000 Feet

1 inch = 2,500 feet

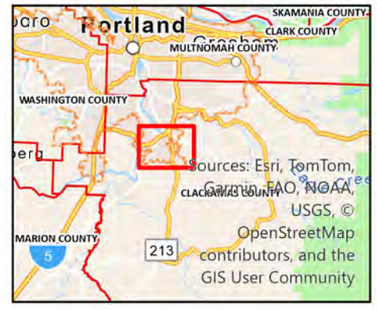
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SOURCE DATA:
Metro RLIS, March 2026
Metro, 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 6/2/2026
File: Basemap

Map Created By: SHARIHARANGODT
Project No: 2250163.00



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Employment Buildable Land

Sandy, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	36	16
1 - 4.99	25	8
5 - 9.99	7	1
10 - 19.99	2	2
>20	1	2

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	Acres
Commercial	**137**
Vacant	53
Partially Vacant/ Infill	85
Redevelopable	n/a
Industrial	**54**
Vacant	23
Partially Vacant/ Infill	30
Redevelopable	n/a
Mixed Use	**n/a**
Vacant	n/a
Partially Vacant/ Infill	n/a
Redevelopable	n/a
Total	**191**

Data from City of Sandy EOA (2024). Data may not be reflective of current conditions.

0 800 1,600 3,200 Feet

1 inch = 1,600 feet

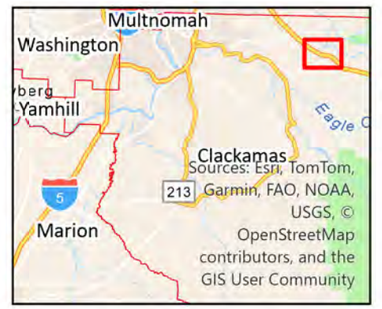
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SOURCE DATA:
Metro RLIS, March 2026
City of Sandy, 2024 EOA dataset
Clackamas County May, 2026

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 6/16/2026
File: Clackamas County EOA Analysis

Map Created By: AFLUETSCH
Project No: 2250163.00



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Kelso
SE KELSO RD
KELSO RD
SE ORIENT DR
BLUFF RD
SE HWY 26
Highway 26
362ND AVE
HWY 26
SE 362ND DR
BLUFF RD
PROCTOR BLVD
PIONEER BLVD
TEN EYCK RD
HWY 26
SE TEN EYCK RD
HWY 211
LANGENSAND RD
HWY 26
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SE LANGENSAND RD
SE HWY 26
SE 362ND DR
SE HWY 211

LEGEND

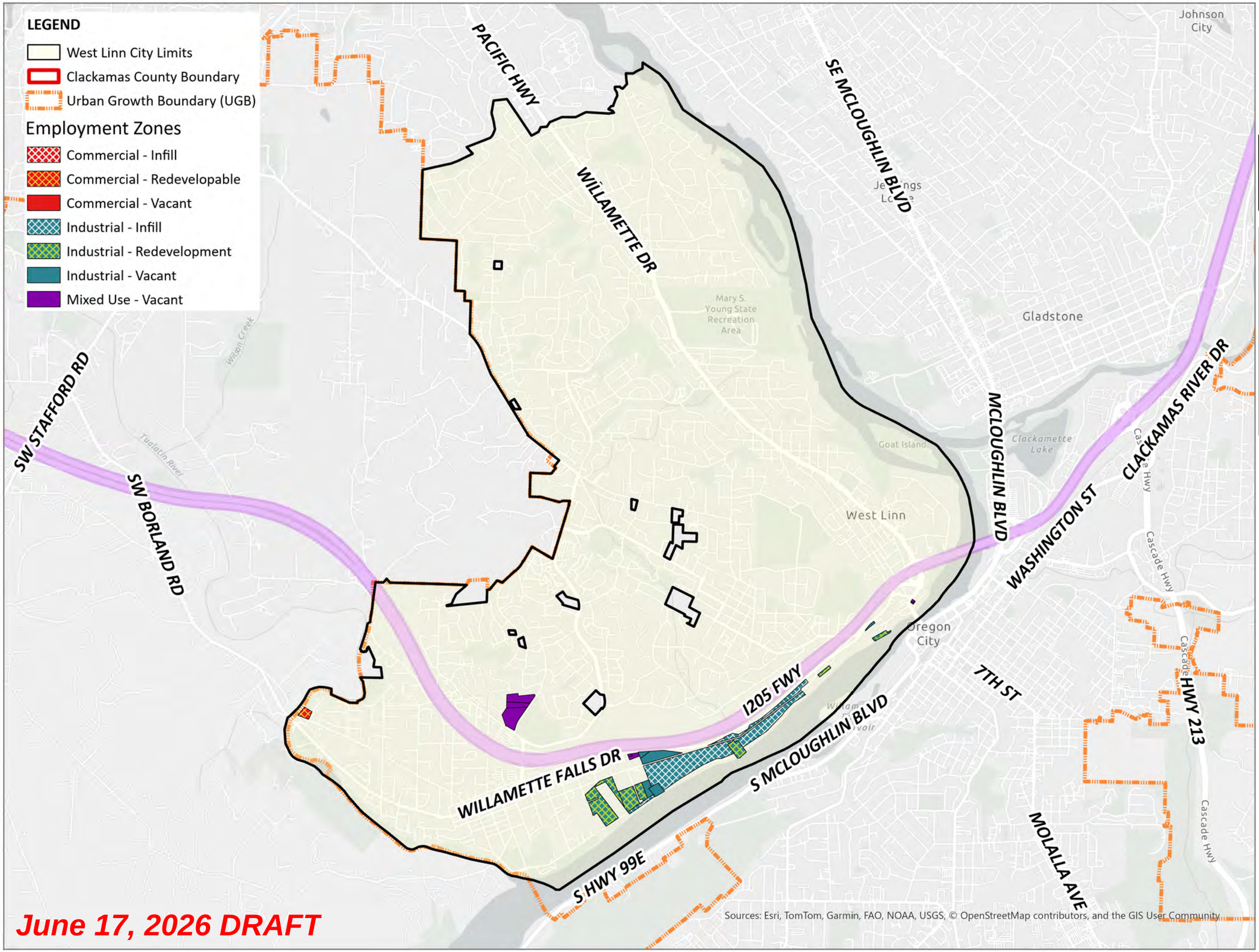
- City Limits
- Urban Growth Boundary (UGB)

Employment Zones

- Commercial - Infill
- Commercial - Redevelopable
- Commercial - Vacant
- Industrial - Infill
- Industrial - Redevelopment
- Industrial - Vacant

Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

June 17, 2026 DRAFT



June 17, 2026 DRAFT

Employment Buildable Land

West Linn, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	17	11
1 - 4.99	3	0
5 - 9.99	0	1
10 - 19.99	0	0
>20	0	0

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	Acres
Commercial	**0**
Vacant	0
Partially Vacant/ Infill	0
Redevelopable	0
Industrial	**6**
Vacant	3
Partially Vacant/ Infill	1
Redevelopable	1
Mixed Use	**0**
Vacant	0
Partially Vacant/ Infill	0
Redevelopable	0
Total	**6**

Data from Metro Urban Growth Report (2024). Data may not be reflective of current conditions.

0 1,250 2,500 5,000 Feet

1 inch = 2,500 feet

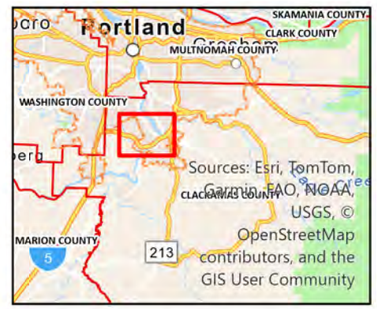
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SOURCE DATA:
Metro RLIS, March 2026
Metro, 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 6/2/2026
File: Basemap

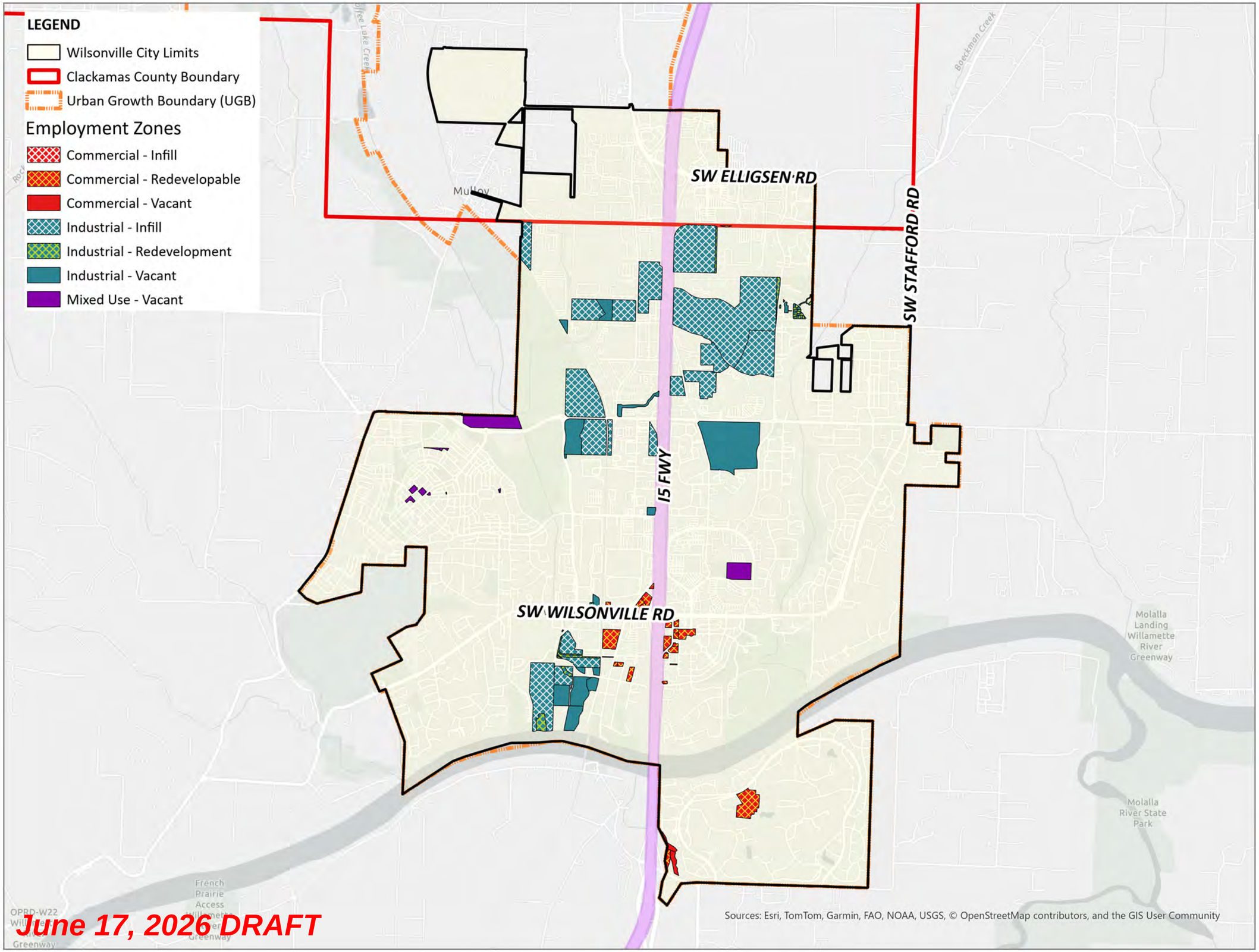
Map Created By: SHARIHARANGODT
Project No: 2250163.00



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June 17, 2026 DRAFT

Employment Buildable Land

Wilsonville, Oregon

Employment Size Distribution		
Acres	Number of Parcels	Number of Sites
1<	83	70
1 - 4.99	19	8
5 - 9.99	3	5
10 - 19.99	0	0
>20	3	3

Note, Sites consist of aggregated parcels which have a shared property line.

Employment Acreage	
Employment Zone	Acres
Commercial	**6**
Vacant	4
Partially Vacant/ Infill	0
Redevelopable	2
Industrial	**133**
Vacant	47
Partially Vacant/ Infill	86
Redevelopable	0
Mixed Use	**0**
Vacant	0
Partially Vacant/ Infill	0
Redevelopable	0
Total	**139**

Data from Metro Urban Growth Report (2024). Data may not be reflective of current conditions.

Note, this analysis is limited to the parcels within Clackamas County

0 1,250 2,500 5,000 Feet

1 inch = 2,500 feet

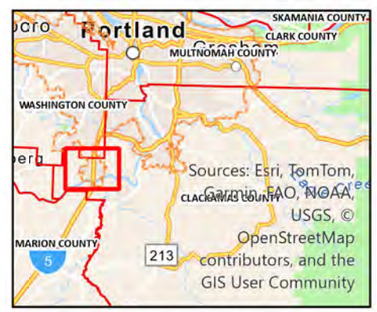
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SOURCE DATA:
Metro RLIS, March 2026
Metro, 2025

GEOGRAPHIC PROJECTION:
NAD 83 HARN, Oregon North
Lambert Conformal Conic

Date: 6/2/2026
File: Basemap

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APPENDIX 7

BLI MAPPING METHODOLOGY AND ASSUMPTIONS

APPENDIX 7 – BLI MAPPING METHODOLOGY AND ASSUMPTIONS

To support the economic development activities of Clackamas County, Mackenzie conducted a systematic review of the 2024 Metro Buildable Lands Inventory (BLI) and publicly available Economic Opportunity Analysis (EOA) reports from incorporated cities within Clackamas County. This section provides explanations of the methodology utilized in this project and the nuances and differences and similarities between the datasets used in this report.

Metro Jurisdictions

For incorporated jurisdictions within the Metro Urban Growth Boundary (UGB), this analysis used the Buildable Lands Inventory (BLI) from the 2024 Metro Urban Growth Report, provided by Metro. These jurisdictions are Gladstone, Happy Valley, Johnson City, Lake Oswego, Milwaukie, Oregon City, Tualatin, West Linn, and Wilsonville. Metro classified parcels as Vacant, Partially Vacant/Infill, Redevelopable. Refer to the Metro Urban Growth Report, Appendix 2, for further details of Metro's BLI methodology.

Once the GIS BLI dataset from Metro was obtained, the study area was isolated to the area of the above listed jurisdictions within Clackamas County. Then, the GIS data was filtered to identify parcels designated as Industrial, Commercial, and Mixed Use Residential per Metro's land use classification. The identified Industrial, Commercial, and Mixed-Use parcels were sorted by their classification of vacant, partially vacant/infill, and redevelopable per the Metro dataset. From this filtering, Mackenzie prepared tables showing the employment area by jurisdiction (acres) and parcel size distribution.

Non-Metro Jurisdictions

For incorporated jurisdictions outside of the Metro UGB, this analysis used BLI data provided by each City from the respective EOA reports. These jurisdictions are Canby (2023), Estacada (2019), Molalla (2025), and Sandy (2024). The datasets provided by each City were developed when the City completed its Economic Opportunity Analysis. As such, these datasets are from different years, noted parenthetically above. The status of parcels may be outdated and not reflective of current parcel status at the time of this report.

The most notable example of outdated data is in the City of Estacada. The BLI data for Estacada is from 2019, but the City has since updated its Comprehensive Plan Zoning Map in 2023, rezoning some Industrial land in northern parts of the City to residential (North City Residential), and some Industrial land throughout the City to commercial and mixed Use (Outdoor Commercial, Commercial Mixed Use, Mill Area Mixed Use, and Highway Commercial). As a result, there is currently approximately 200 acres less industrial land (approximately 100 acres have been rezoned to residential and 100 acres rezoned to commercial and mixed use) than what is shown in the 2019 EOA and what is included in this report's analysis, due to this rezoning.

Additionally, the methodologies for each BLI are slightly different. Each city has its own definitions for the classifications of status: vacant, partially vacant, and redevelopable. For example, Estacada defines "vacant" as land with less than $10,000 in improvements or no functional improvements, whereas Canby defines vacant as lands with no structures or with improvement value less than $5,000 and the improvement value is 5% or less than the land value, and the Canby EOA also explains they made some

determinations based on aerial imagery. Sandy and Molalla have their own unique definitions too. These differing definitions are further described in Table 1, below.

Furthermore, the BLI methodology for Molalla and Sandy did not include “Redevelopable” as a separate status classification, whereas Canby and Estacada do include redevelopable. The non-Metro jurisdictions also did not include mixed-use as a separate employment zone. See each jurisdiction’s EOA for further details on their BLI methodology.

After data was obtained from each jurisdiction via Clackamas County staff, the GIS data was filtered to identify parcels designated Industrial and Commercial per their Comprehensive Plan Designation. Next, each data set was filtered by status, retaining parcels identified as vacant, partially vacant, and redevelopable. From this filtering, Mackenzie prepared tables summarizing the employment area (unconstrained acres) by jurisdiction, status, zone, and parcel size distribution.

Site Aggregation

As part of this analysis, Mackenzie was asked to identify parcels that may be suitable for aggregation to create a larger development site. In the event parcels identified as Vacant, Partially Vacant/Infill, and Redevelopable had a common property line extending at least 100', these parcels were categorized as a site. In some cases, this would lead to two (2) parcels becoming a site, and in other situations, up to 22 parcels becoming a site. Parcel aggregation did not take into consideration ownership, access, status classification, or infrastructure. This parcel aggregation process also treated the filtered employment-zoned parcels as one, meaning some sites could be composed of parcels within different zones – Industrial, Commercial, and/or Mixed-Use – and different status – vacant, partially vacant/infill, and/or redevelopable.

Table 1: Status Classification Definitions			
City	**Vacant**	**Partially Vacant/ Infill**	**Redevelopable**
Metro Jurisdictions (2024): Gladstone, Happy Valley, Johnson City, Lake Oswego, Milwaukie, Oregon City, Tualatin, West Linn, Wilsonville	▪ Any tax lot that is fully vacant (Metro aerial photo). ▪ Tax lots that are 95% or more "vacant" from the GIS vacant land inventory. ▪ Tax lot with less than 2,000 square feet (SF) developed AND developed portion is under 10% of entire tax lot.	▪ Tax lots with at least ½ an acre undeveloped.	▪ "Pro forma" model known as the "developer supply preprocessed model" to predict which tax lots with existing development are likely to redevelop within the 20-year time frame. Please see the Metro Urban Growth Report, Appendix 2 for further details.
Canby (2023)	Properties with no structures or that have buildings with very little value. For purpose of the BLI, employment lands with improvement value less than $5,000 are considered vacant and the improvement value is 5% or less than the land value. These lands were also subjected to review using satellite imagery via Google Earth; and if the land is in a committed use such as a parking lot, an assessment has been made to determine if it is to be classified as vacant, part vacant, or developed.	Properties that are occupied by a use (e.g., a home or building structure with value over $5,000) but have enough land to be subdivided without the need for rezoning. This determination is made using tax assessor records and satellite imagery. For lots with structures that are in value 40% below their land value, it is assumed that half the lot is developed and the other half is vacant. Commercial inventory for partially-vacant land includes lots of at least one acre in size and one half-acre of unimproved land. The partially-vacant industrial land inventory includes lots that have at least five acres of unimproved land.	Occupied properties with a higher land value than the on-site structure. Properties must be at least 20,000 SF to be considered of interest for redevelopment. Commercial inventory for redevelopment land includes lots of at least one acre in size and one half-acre of unimproved land. The redevelopable industrial land inventory includes lots that have at least five acres of unimproved land.
Estacada (2019)	Land with less than $10,000 in improvements or no functional improvements.	Land that is at least 1 acre in size with greater than $10,000 in improvements but less than 50% developed.	Developed parcels that fall within the lowest 25% of parcels in terms of assessed value per square foot are considered redevelopable.
Molalla (2025)	Land that meets one or more of the following criteria: ▪ Equal to or larger than ½ acre and not currently containing permanent improvements. ▪ Equal to or larger than 5 acres where less than ½ acre is occupied by permanent buildings or improvements. ▪ Improvement value is less than $5,000 or less than 5% of the property's land value.	Land with an improvement value of between 5% and 40% of the land value, or is greater than 1 acre in size with at least ½ acre not improved (based on aerial photos). Each Partially Vacant parcel is assigned a vacant area based on review of aerial photos with the assumption that existing uses will remain on site.	N/A (does not include separate redevelopable land classification).
Sandy (2024)	A tax lot: (a) Equal to or larger than ½ acre not currently containing permanent buildings or improvements; or (b) Equal to or larger than five acres where less than one-half acre is occupied by permanent buildings or improvements. For the purpose of criterion (a) above, lands with improvement values of $0 are considered vacant.	Tax lots between 1 and 5 acres occupied by a use that could still be further developed based on the zoning. This determination was based on a visual assessment and City staff verification.	N/A (does not include separate redevelopable land classification).


Photo Credit: Dave Killen/Oregonian



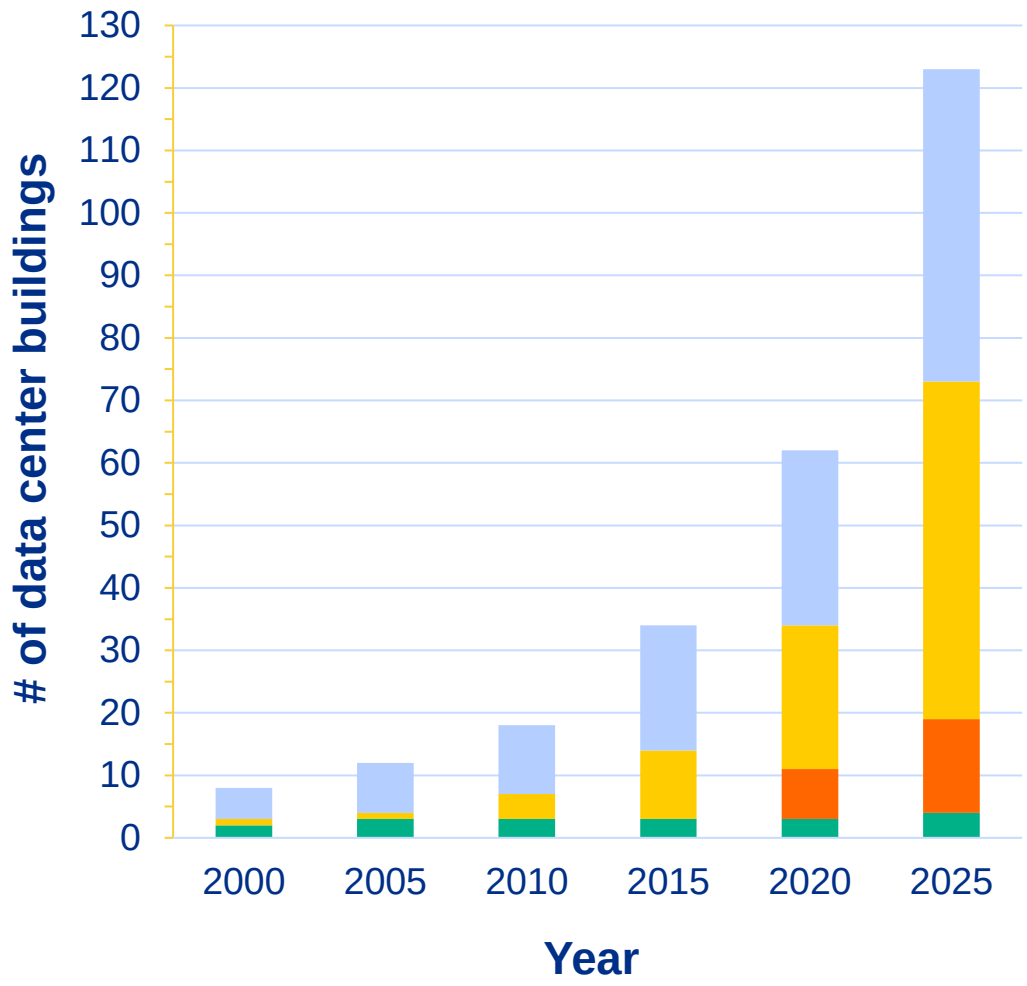
Data Centers & Land Use in Oregon

Land Conservation and Development Commission
June 25, 2026

Leigh McIlvaine, Economic Development Specialist, Department of Land Conservation & Development


Photo Credit: Jenny Kane/AP

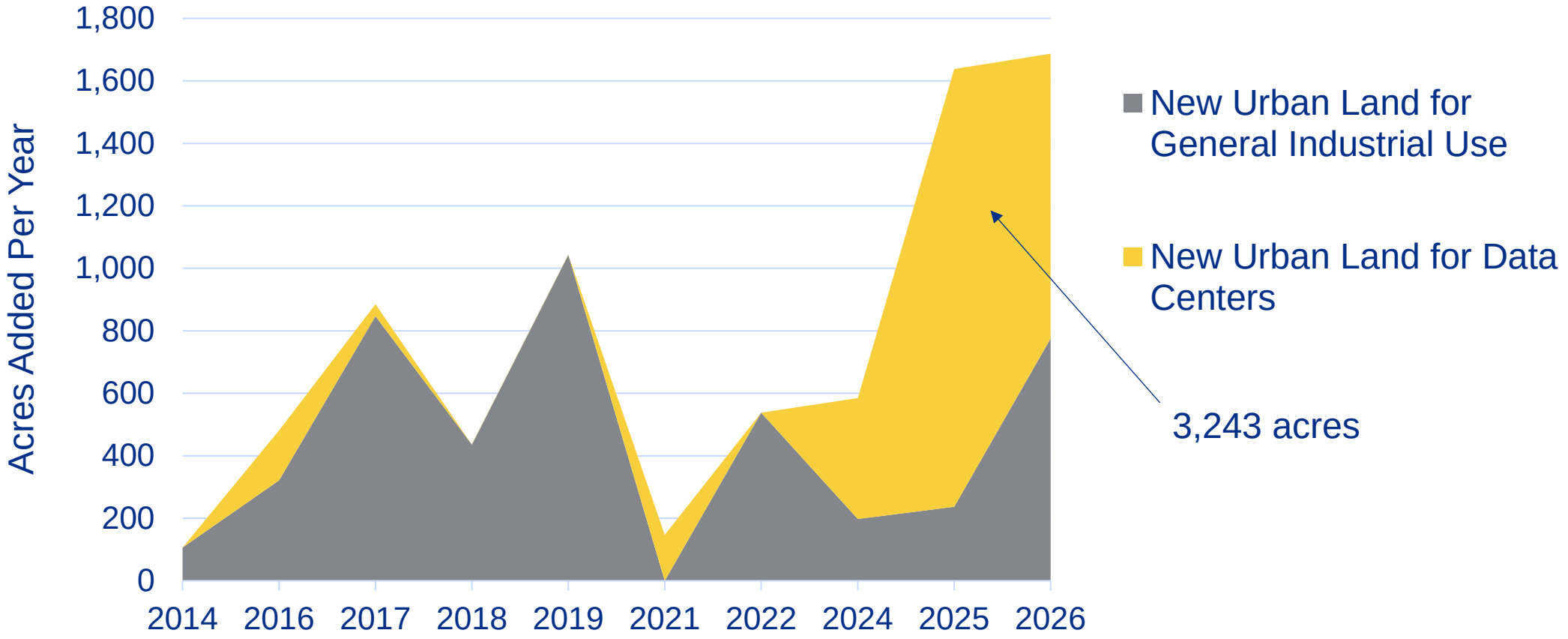
Data Center Growth in Oregon, 2000-2025



Data Center Buildings by Region

- Other Regions
- Central Oregon Region
- Umatilla Basin (incl. The Dalles)
- Metro Region

Cumulative Statewide UGB Expansions* for Industrial Lands, 2014-2026



*Including Recently Adopted EOAs

Governor’s Data Center Advisory Committee

- Convened by Governor Kotek in January 2026
- Develop policy and regulatory framework recommendations
- Report due to Governor in October 2026
- Six monthly public meetings
- Addressing energy, water, land use, economic development
- Supported by state agencies

Where are existing data centers sited in Oregon?

Three primary regional markets in Oregon:

- Umatilla Basin
- Central Oregon (Prineville)
- Washington County (Hillsboro)

Cities, inside Urban Growth Boundaries:

- ~80% of all data centers
- Available water supply

Outside UGBs, on “rural” lands:

- ~20% of all data centers
- No new industrial water rights
- Existing rural industrial lands

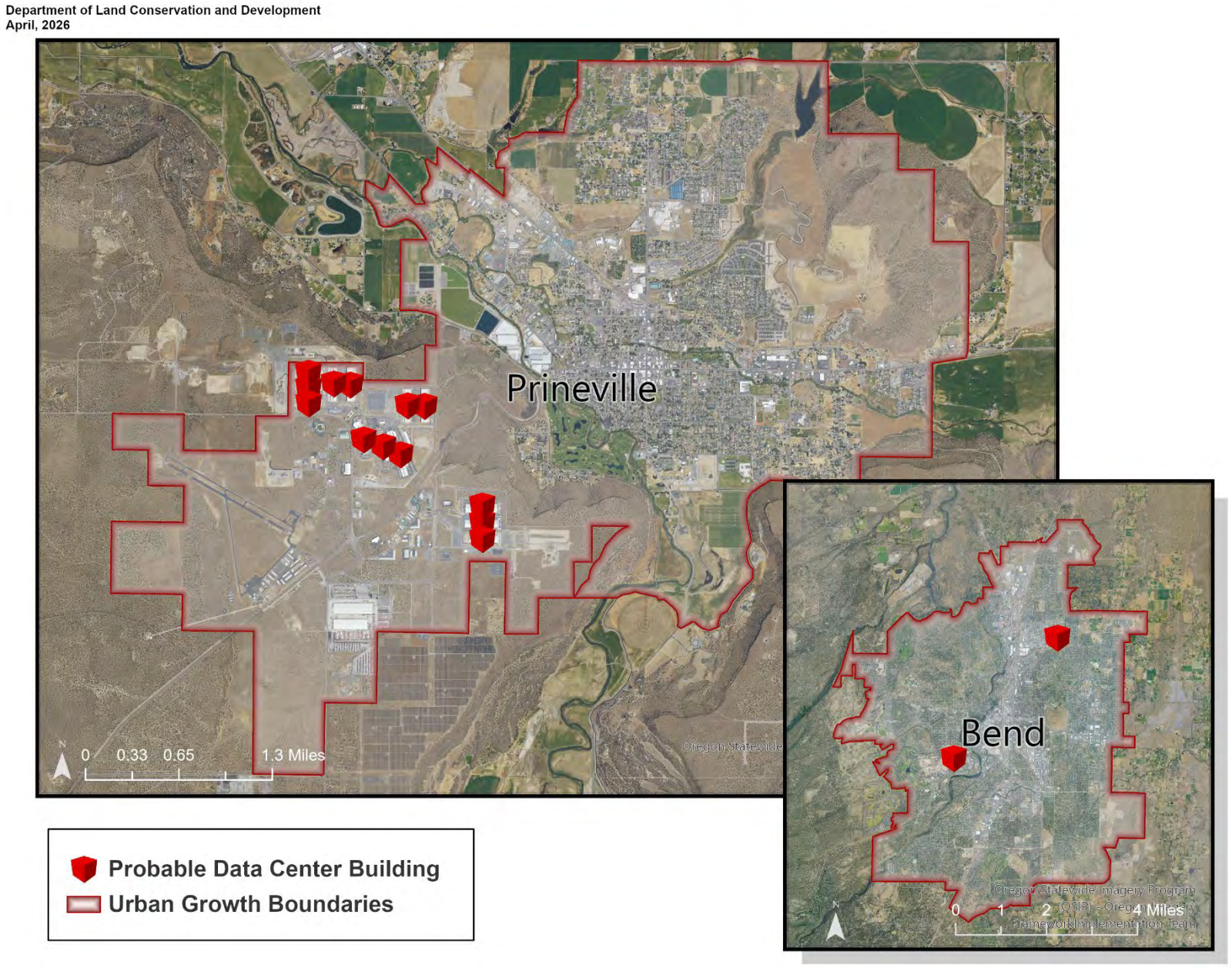
What are the determinant site needs?

What are the site requirements?

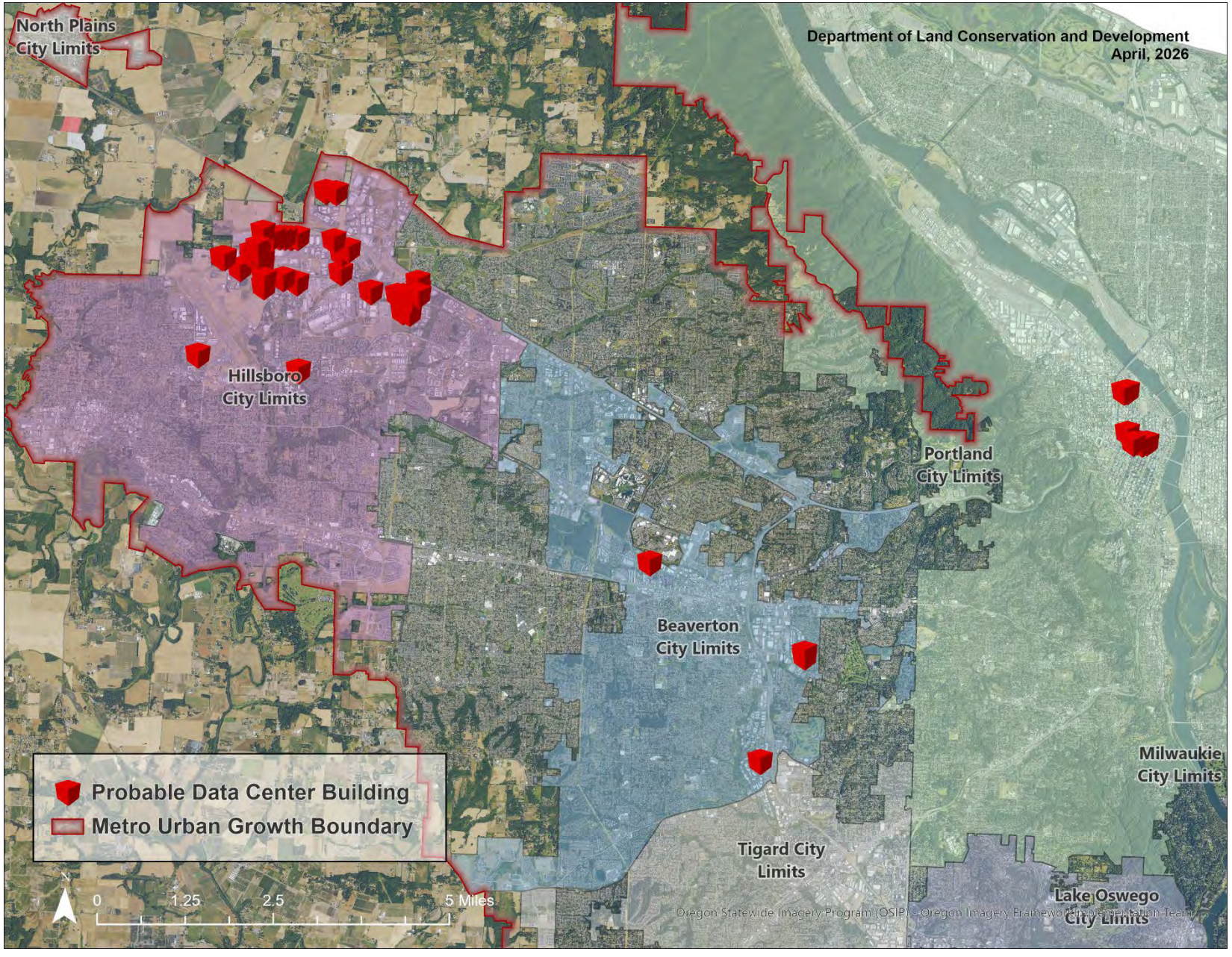
- Large, flat sites (50-200+ acres)
- Available water
- High-capacity electrical transmission lines
- Light industrial zoning (current or future)

- Other land use siting factors:
  - Supportive/permissive local gov’t
  - Property tax subsidies
  - Inexpensive, available land

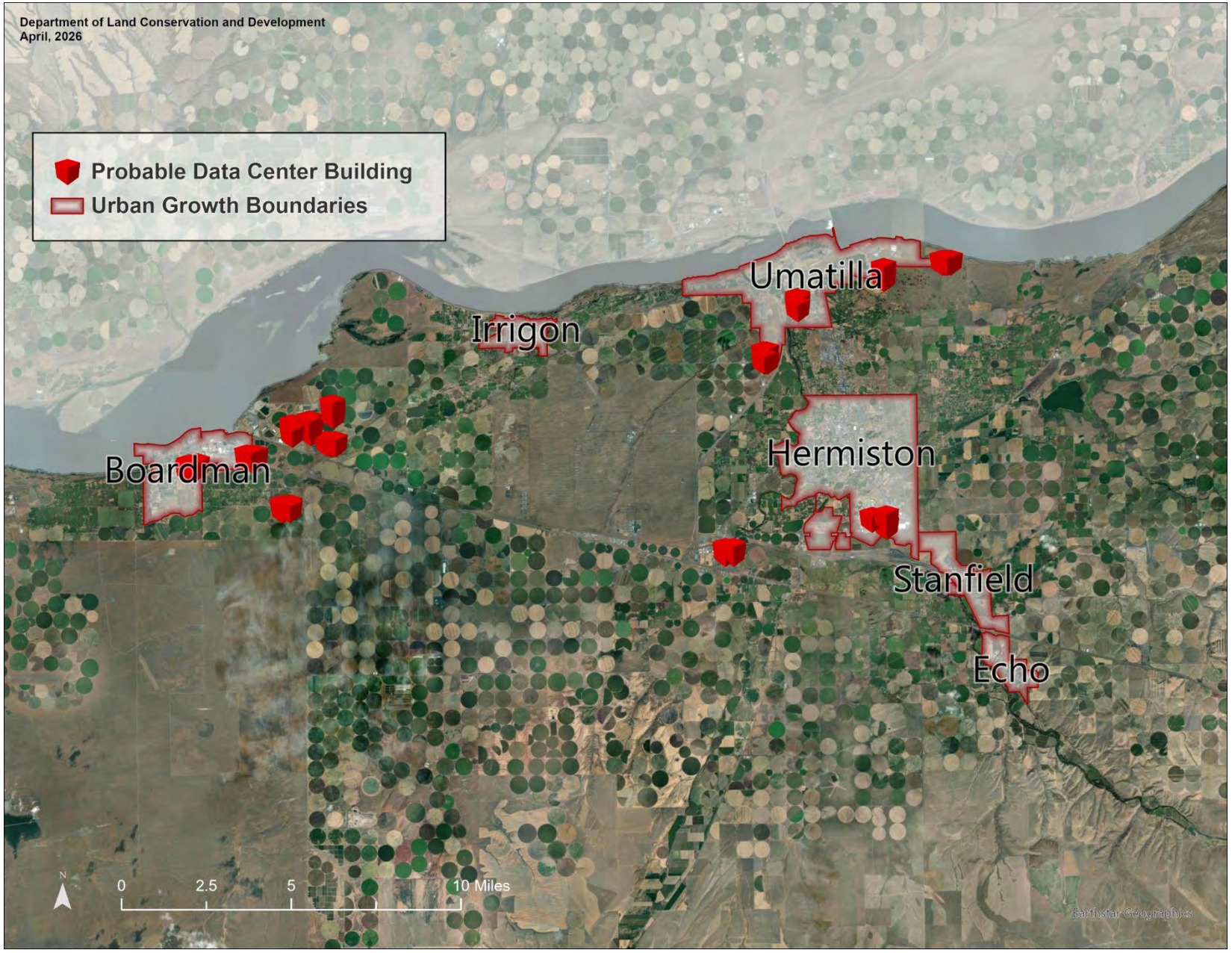
Central Oregon Data Centers, 2026



Metro Region Data Centers, 2026



Umatilla Basin Data Centers, 2026



Rural Industrial Zones & Data Centers (Umatilla Basin)

Unique local land use strategy - key ingredients:

- Rural industrial lands
- Port of Morrow – industrial development capabilities
- Significant land holdings in common ownership

DLCD perspective:

- Data centers have urban & rural characteristics
- Defer to local governments
- Prioritize no net loss of EFU

Should data centers be sited exclusively inside UGBs?

Future Data Center Land Demand by Region (2026)

Land demand identified by local governments in key data center markets, 2021-2026

	Total land demand	To be satisfied by UGB expansion or rural upzoning
Eastern Oregon/ Umatilla Basin	7,073	5,972
Central Oregon	2,020	500
Total acres	**9,093**	**6,472**

Existing and planned data center development in Hillsboro (February 2026)

	Existing/ operational	Planned/ under construction	Total acres
Washington County/ Hillsboro	436	50	486

- Local preference & community character
- Land use compatibility issues
- Resource allocation opportunity costs (water, industrial lands)
- Expense of planning and UGB expansion
- Water, sewer, transportation requirements
- Local political concerns

Community Land Use Considerations

Regional & State Considerations

- Need for regional coordination regarding resource allocation
- Impact to agricultural economy
- Wildlife habitats
- Land is a non-renewable resource; opportunity cost of development
- Speculative real estate development dynamics
- Rural capacity
- Intra-regional competition

Envisioning Best Land Use Outcomes of Smart Data Center Siting

- Mitigation of potential land use conflicts
- Conservation of highest quality resource lands and wildlife habitats
- Integrated land use strategy with clean energy (and land coverage)
- Systems capacity-based approvals process that considers opportunity costs
- Enhanced local government resources and capacity
- Increased certainty for community members and developers
- Increased confidence and trust in local government planning and approval processes



DLCD

Department of Land Conservation & Development

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Thank you!

DLCD's Ace Crew on Data Centers (AC/DC):

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Karen Grosulak-McCord

Jon Jinings

Dawn Hert

Alyssa Bonini

Public hearings on potential data center moratorium

Wednesday, Oct. 21, 6 p.m.

Thursday, Oct. 22, 10 a.m.

CLACKAMAS COUNTY

Overview

- ORS 197.520 allows local governments to adopt moratoria on certain land uses.
  - Requires a public hearing.
    - We are holding two public hearings.
  - Requires 45 days' advance notice to DLCD.
    - Notice was provided on August 13, 2026.
  - Requires findings.
    - Proposed findings are included in the packet.
- Initial moratorium may not exceed 120 days.
  - May be extended for six months.

Proposed Resolution

- Would prohibit the development of new or the expansion of existing data centers as primary uses in unincorporated areas for 120 days.
- Defines “data center” as a facility for the storage, management, processing, and/or transmission of digital data.
  - Includes facilities used for cloud computing services, artificial intelligence training or inference services, etc.
  - Excludes telecommunications facilities.
- Defines “primary use” as a principal activity on a site.

Proposed Findings

- ORS 197.520(3): “A moratorium * * * may be justified only by a demonstration of compelling need. Such a demonstration * * * shall include * * * findings:”
  - ORS 197.520(3)(a)(A): “That application of existing development ordinances or regulations and other applicable law is inadequate to prevent irrevocable public harm from development in affected geographical areas;”
    - Noise, heat, and air impacts.
    - Water and electricity demands.
    - Employment density.

Proposed Findings

- ORS 197.520(3): “A moratorium * * * may be justified only by a demonstration of compelling need. Such a demonstration * * * shall include * * * findings:”
  - ORS 197.520(3)(a)(B): “That the moratorium is sufficiently limited to ensure that a needed supply of affected housing types and the supply of commercial and industrial facilities * * * are not unreasonably restricted * * *;”
    - Applies to only one type of industrial facility.

Proposed Findings

- ORS 197.520(3): “A moratorium * * * may be justified only by a demonstration of compelling need. Such a demonstration * * * shall include * * * findings:”
  - ORS 197.520(3)(a)(C): “Stating the reasons alternative methods of achieving the objectives of the moratorium are unsatisfactory;”
    - Objective is to give the County time to develop and adopt ZDO amendments.
    - Only alternative is developing and adopting ZDO amendments without moratorium.
    - Would allow data centers to develop before amendments are adopted.

Proposed Findings

- ORS 197.520(3): “A moratorium * * * may be justified only by a demonstration of compelling need. Such a demonstration * * * shall include * * * findings:”
  - ORS 197.520(3)(a)(D): “That * * * the public harm which would be caused by failure to impose a moratorium outweighs the adverse effects * * *, including shifts in demand for housing or economic development, public facilities and services and buildable lands, and the overall impact * * * on population distribution; and”
    - Unlikely to result in surge of data center development in other jurisdictions.

Proposed Findings

- ORS 197.520(3): “A moratorium * * * may be justified only by a demonstration of compelling need. Such a demonstration * * * shall include * * * findings:”
  - ORS 197.520(3)(a)(E): “That * * * sufficient resources are available to complete the development of needed interim or permanent changes in plans, regulations or procedures within the period of effectiveness of the moratorium.”
    - Amending the ZDO takes approximately 114 days.
    - County will need to amend its 2025-27 Long-Range Planning Work Program to accommodate the development and adoption of ZDO amendments during the moratorium period.

Proposed Findings

- ORS 197.520(3)(a) requires the foregoing findings for moratoria on urban and urbanizable land.
- ORS 197.520(3)(b) requires findings for moratoria on rural land.
  - The required findings for rural land are similar to the required findings for urban and urbanizable land.
  - The full text of each provision is set out in the packet.

Public Comment

- As of October 11, 2026, the County had received comments from nine individuals.
  - Four supported the proposed moratorium.
  - Two proposed ZDO amendments.
  - Three opposed data center development in general.
  - None opposed the proposed moratorium.