# Traditional Warehouse Developments vs. Modern E-commerce Facilities

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# Executive Summary

Warehousing, broadly described as the storage of bulk inventory in large facilities, has undergone substantial evolution, from the introduction of forklifts and pallets in the 1920s to automation and cloud computing today. As a result of advances in technology and proliferation of trucking, warehouses are a critical intermediate step between supplier and consumer. Additionally, trends like e-commerce and online shopping, near-shoring and reshoring[1] of manufacturing have increased global demand for industrial warehousing, resulting in unprecedented warehouse development in recent years. These factors have been accelerated by the COVID-19 global pandemic.

Given Vancouver's location near a major airport, seaport, and population center, warehousing demand in the Vancouver/Portland region is particularly robust. Over the past year, the City of Vancouver received five applications to develop large industrial warehouses (>250,000 square feet), which are expected to store and repackage e-commerce goods intended for various purposes including retail home delivery. In response to this regional trend, the City seeks to better understand key characteristics of these larger, typically e-commerce-oriented facilities in comparison to smaller-sized, more traditional warehouses, and how these differences might impact the local economy, street capacity, the environment, and overall quality of life for Vancouver residents.

This report details physical, operational, and economic differences between traditional and modern industrial warehouses, including e-commerce facilities. The report includes strategies for the City of Vancouver to consider in ensuring that future warehouse developments support the City's economic vision, have adequate transportation infrastructure, and align with climate goals and priorities. Given the relevant newness of the e-commerce sector, data about its impacts are evolving and incomplete. This report summarizes insights from a high-level analysis of available literature, data from the US Census Bureau and the Bureau of Economic Analysis, previously collected empirical warehouse traffic data from California[2], correspondence with developers, and a review of peer cities. This serves as an initial step towards understanding the how Vancouver might respond to the growth of e-commerce-oriented facilities.

## Warehousing Trends

The size, design, function, level of automation, and siting of warehouses has evolved considerably over the years in response to market changes and in support of supply chain efficiencies. There has been a

[1] Reshoring describes the process of returning domestic product manufacturing from a foreign country back to the home country of where a business' products are sold. Near-shoring focuses on moving manufacturing operations to nearby countries or close to the point of use.

[2] The previously collected empirical warehouse traffic data from California is assumed to provide general insights of the differences in traffic impacts between traditional warehouses and e-commerce facilities. An in-depth review of local warehouse developments sites in the Vancouver/Portland region would help inform more representative trends that are context sensitive.

recent trend toward high-tech warehousing that supports e-commerce and Just-in-Time (JIT)[3] inventory practices aimed at businesses saving costs by using less space to hold both consumer goods and inputs to production. These are the top three factors influencing warehousing demand in Vancouver today:

- **E-commerce** (electronic commerce), defined as the process of buying and selling goods or services via the internet, has garnered popularity over the past years, particularly due to the COVID-19 pandemic. Growth in e-commerce has impacted supply chain management and increased the demand for industrial property development.
- **Just-in-Time (JIT) versus Just-in-Case (JIC) inventory management**[3] played a significant role in the shortages for basic household goods, such as toilet paper and cleaning supplies, over the past years. JIT offers cost savings because less space is needed for storage, but JIC is trending back due to the hardships the lack of inventory created for many companies. Both practices are anticipated to continue, and more warehousing space is needed to support this.
- **Market Need** – warehouse sites near logistics hubs, such as intermodal rail yards, airports and seaports are in high demand. As a City surrounded a major airport and seaport, and population center, there is a market need for warehouse developments in Vancouver to support e-commerce and online shopping. Due to the absence of e-commerce facilities within City limits, households and businesses currently rely on facilities/warehouses in Portland.

## Warehouse Characteristics

Various warehouse types support retail, commercial, and industrial supply chains. Virtually all industries rely directly or indirectly on warehousing services. Directly related to e-commerce, distribution and fulfillment centers typically provide value-added logistics services, allowing operators to efficiently meet varying customer demands streamlining supply chains. These facilities differ from traditional warehouses from a physical, operational, and economic standpoint.

### *Key Physical Differences*

Physical characteristics of warehouses include warehousing design (building size, lot coverage, loading bays, and parking spaces) and siting. Key physical differences that distinguish e-commerce facilities from traditional warehouses include:

- **More varied building sizes/footprints.** While traditional warehouses are typically less than 100,000 square feet, e-commerce facilities range from about 100,000 square feet to over 1 million square feet.
- **E-commerce warehouses tend to be taller.** Building clear height, defined as the height of a building from the floor to the bottom of the lowest hanging item on the ceiling, is typically less than 32 feet for traditional warehouses, but often greater than 36 feet for e-commerce facilities.
- **More loading dock doors.** Operations at e-commerce facilities require more loading docks.

[3] JIT inventory practices are strategies in which commerce companies receive the exact amount of inventory they need, right when they need it. A contrasting approach is Just-in-Case (JIC) inventory management which centered around keeping a lot of stock/ inventory on hand to reduce the risk of stock-out.

- **Different siting locations.** Traditional warehouses are typically situated close to other industrial uses, whereas e-commerce facilities tend to be proposed near population centers and ports.

### *Key Operational Differences*

Recent technological improvements have resulted in increasingly efficient use of warehouse space and consolidation of facilities. Modern warehouses operate differently than traditional warehouses, particularly regarding hours of operation and the flow of goods:

- **24-7 operations.** Typical hours of operation for e-commerce facilities span 24 hours a day, seven days per week. The non-stop activity in modern warehouses is made possible by shift workers and automation. In contrast, traditional warehouses with slower inventory turnover are typically limited to normal business hours, i.e., 8-hour shifts, five days per week.
- **More constant flow of goods.** E-commerce facilities typically focus less on long-term storage and more on the flow of goods and services. Modern industrial warehouse facilities are often driven by demand, compared to traditional warehouses, where operations are related to storing the largest amount of goods possible.

### *Traffic Impacts*

Warehouses generate some level of traffic (passenger cars and trucks), but this varies significantly based on the operations of the facilities. In addition, the type of trucks (medium- vs. heavy-duty trucks[4]) also varies. Traffic impacts differ between e-commerce and traditional warehouses in the following ways:

- **Much higher vehicle activity.** Based on data from the Institute of Transportation Engineers (ITE) Trip Generation Manual, e-commerce facilities generate up to four times more daily vehicle trips than traditional warehouses, particularly for fulfillment centers that require extensive sorting.
- **Smaller delivery vehicles are more common.** Whereas traditional warehouses generate mostly medium-duty and heavy-duty truck trips, light-duty trucks and vans play a substantial role in the transport of goods from today's e-commerce facilities.

### *Key Economic Differences*

Industrial warehouses generate jobs and tax revenue (property, sales and use, and utility taxes). Warehousing jobs provide two important community benefits: 1) pay rates that start above minimum wage, and 2) on-the-job-training for career advancement. Warehouses also generate indirect jobs[5] that benefit local and regional economies. Regionally, the U.S. Bureau of Economic Analysis (BEA) estimates that 10 new warehouse jobs create about 14 jobs in other industries.[6] For every $1.00 of earnings paid to

[4] Trucks are placed into classifications based on the gross vehicle weight rating (GWVR). The Federal Highway Administration (FHWA) categorizes medium duty trucks as classes 3-6, with GWVR range of 10,001- 26,000 lbs. and heavy-duty trucks as classes 6-7, with GWVR greater than 26,001 lbs.

[5] Indirect jobs are jobs generated in supporting industries; these include repair and maintenance jobs, service jobs and third-party vendors.

the new warehouse workers, an additional $1.50 in earnings is generated throughout the economy.[6] Key distinctions in the economic impact of e-commerce versus traditional warehouses include:

- **Higher-skilled labor.** While traditional warehouses rely on unskilled labor and managerial jobs, highly automated e-commerce facilities offer high-paying jobs such as automation engineers with average salaries over $100,000 annually. With companies such as Amazon investing more in warehouse automation and on-the-job training for skilled labor, the prominence of these high-paying jobs is likely to grow.
- **More ripple effects on the local economy.** Based on building size/footprint and warehouse jobs created, e-commerce facilities typically entail more local and regional economic impacts (tax revenue, indirect jobs, and new dollars circulating in the economy) than traditional warehouses.

## Key Takeaways

From a physical, operational, and economic standpoint, there are pronounced differences between traditional warehouses and e-commerce facilities. With the evolving warehousing industry and a market need for e-commerce facilities in Vancouver, the City may benefit from new warehouse developments targeted to store and repackage e-commerce goods intended for various purposes, including retail home delivery. The development of e-commerce facilities will support the growth of the local economy in Vancouver through job creation and tax revenue. Regulatory amendments are needed to ensure that any new development supports the City's economic growth, has adequate transportation infrastructure, and aligns with climate goals and priorities.

## Regulatory Recommendations

Recent best practices focus on understanding the operations of industrial warehousing and taking a performance-based zoning approach directly addresses the potential impacts of modern warehouse facilities. The following provides some potential conditions of approval for the City's consideration:

### *General*

- **Update conditional use permitting (CUP) requirements** to make applicants describe their proposed operations, such as hours of operation, number of employees per shift, number of shifts, daily and AM/PM peak hour trips by vehicle type, number of dock doors, number of parking spaces for employees, trailers, tractor-trailers, and/or tractors, and anticipated water/sewer usage in volume, and power requirements in megawatts.
- **Address impacts early in the entitlement process.** There are several measures that the City can take to mitigate impacts related to traffic congestion, air and noise pollution, such as identifying

[6] The region discussed is the Portland-Vancouver-Hillsboro Metropolitan Statistical Area. The provided estimates are based on U.S. Bureau of Economic Analysis (BEA) RIMS II multipliers: 1.408 for each new job and 1.508 for earnings in the Portland/Vancouver/Hillsboro MSA. The multipliers estimate the impact from changes in final demand on one or more regional industries in terms of output, employment, and labor earnings. These multipliers are based on estimates of local area personal income and on the national input-output (I-O) accounts.

truck routes and access, right sizing the employee, truck and trailer parking requirements, and requiring sustainable development standards specific to each facility's anticipated impacts.

*Traffic Impacts*

- **Develop a traffic impact assessment/analysis (TIA) template** to guide the assumptions to use in preparing TIAs.
- **Update the City's parking and circulation regulations** to address parking and queueing concerns that often arise with warehouse developments. Specifications of truck parking for long duration or overnight parking, trailer storage, and dock spaces in length and width, should accommodate the largest commercial motor vehicle that is anticipated to utilize a facility. The number of spaces offered and their dimensions should be consistent with the proposed use and potential future re-uses of the site.
- **Consider trails, sidewalks, and access to transit facilities** when planning for the location of freight-based operations. This infrastructure serves both drivers and employees accessing the site.
- **Require tenants to establish and promote rideshare programs** that discourage single-occupancy vehicle trips and provide financial incentives for modes like carpooling, public transit, and biking.

*Adaptive Reuse*

- **Require design features that support broader uses** to accommodate potential future adaptive reuse of warehousing sites. Warehouses have been converted to "ghost" kitchens, segmented artist studios, start-up office space, and production or testing facilities for industries like biotech.

*Environment and Climate*

- **Further the City's Climate Action Plan** to reduce greenhouse gas emissions and build resiliency to climate change impacts by providing incentives or codifying sustainable design features or business practices, where applicable. Example features include bicycle, hybrid/electric, and carpool vehicle parking for employees, auxiliary power/electric truck charging, alternative energy sources like solar, water conservation measures, dedicated area for onsite recycling, and environmentally friendly building materials.

# Introduction

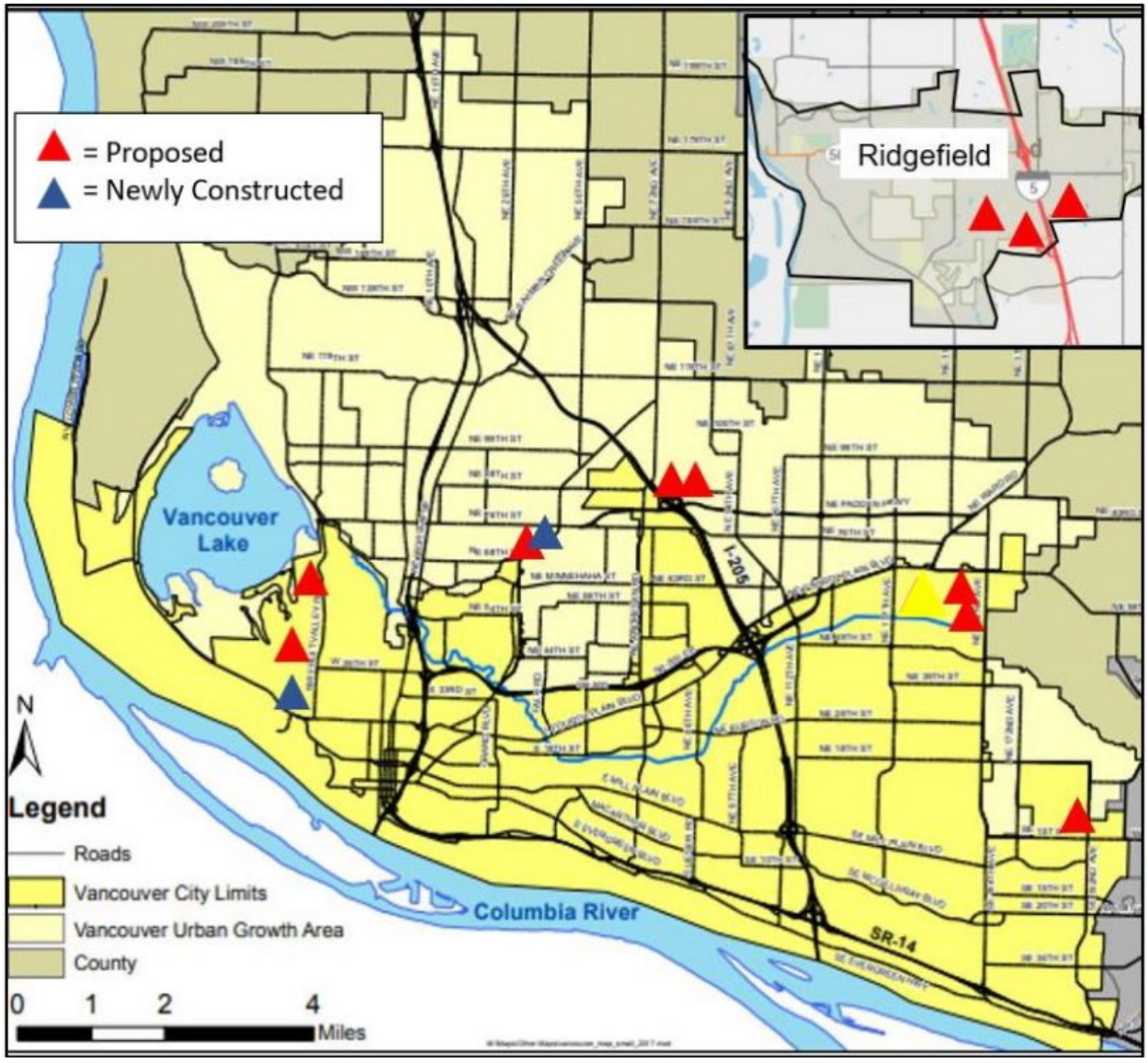
In recent years, the rapid growth in e-commerce and online shopping, near-shoring and reshoring of manufacturing, demand for industrial warehousing, and aging warehouse inventory, has resulted in unprecedented warehouse development.[7,8] Between March 2020 and November 2021, warehouse space purchases were up 300 percent among the five biggest retailers (Amazon, Walmart, Costco, Target, and TJX companies) compared to the 2019 to 2020 period.[7] This was largely accelerated by the COVID-19 global pandemic. The nearly two-year boom in warehouse development is being followed by a slow-down in new development as economic factors including inflation and increases in borrowing rates have resulted in a pivot to optimization of available space. In the first part of 2023, only 6,700 warehouses were added to the global building stock, a decline of 35 percent compared to the same time period in 2022.[8] With warehouse vacancy rates at three percent, a 30-year low, this slowdown in development appears to be more of a reflection of capitalization than decreasing demand.

Despite the indication that demand for new warehousing space is slowing at the global level, warehousing demand in the Vancouver/Portland region remains strong. Over the past year, the City of Vancouver received five applications for the development of new industrial warehouses with gross floor areas greater than 250,000 square feet, shown in **Figure 1**. While the intended use or expected tenants for the proposed warehouses are not known, these developments are expected to be operated as high-tech industrial warehousing facilities, which are likely to include e-commerce operators. This use, along with the size of these proposed developments compared to the size of existing warehouse uses in Vancouver has resulted in a desire to better understand several key characteristics of these larger, frequently e-commerce-oriented facilities. This report will explore:

- The typical number of employees per acre compared to more traditional warehouses, as the City has limited buildable land remaining that is zoned for industrial uses
- Anticipated local and regional economic impacts and tax revenue generation associated with these facilities
- How travel associated with these warehouses, specifically by trucks, may impact roadway maintenance costs
- How these warehouses result in increases in heavy truck traffic that adversely impacts air quality, noise, congestion and safety, which are noted community concerns
- If development of these warehouses would conflict with the City's newly adopted Climate Action Plan based on their travel patterns or other factors[9]

[7] Bloomberg. Covid E-commerce Boom Sees US Retailers Hunt for Warehouses. 2022
[8] Freight Waves. Global Warehouse, Fulfillment Construction Seen Waning. 2023
[9] City of Vancouver. Climate Action Framework. 2022

**Figure 1: Proposed Warehouse Developments with GFA greater than 100 KSF**




Source: City of Vancouver. 2023

On December 12, 2023, Vancouver City Council enacted a six-month moratorium on new applications for the development of warehouses and distribution facilities totaling more than 100,000 square feet (100 KSF) in the Light Industrial (IL) and Heavy Industrial (IH) zoning districts, as defined in Vancouver Municipal Code Title 20.[10] This is consistent with Washington State law (RCW 36.70A.390 and RCW 35.63.200), which allows for a six-month maximum moratorium on land uses, with one six-month extension, if necessary. The moratorium has since been amended to increase the threshold to only include developments that exceed 250 KSF. The City's moratorium exempts warehouses supplying storage for

[10] City of Vancouver. Six-month Moratorium. 2022

traded sector goods, as defined in the Clark County Comprehensive Economic Development Plan, and a bulk storage exemption for the Port of Vancouver on property owned by the Port in Vancouver.

The moratorium was put in place to provide the City with the necessary time to closely study the emerging trend of applications for warehouse and distribution facilities, understand how those trends may impact the City's economy and transportation system, and develop appropriate land use regulations. This report documents the physical, operational, economic, and environmental/quality of life differences between traditional warehouses that store goods for delivery to businesses and larger, modern industrial warehouses that support today's just-in-time (JIT) inventory practices by storing and repackaging goods intended for retail home delivery or business to business delivery (including e-commerce facilities, grocers, and high-pace manufacturing/assembly).

This report is split into two sections. The first section, **Warehouse Characteristics**, describes the differences in physical, operational, and economic characteristics between traditional warehouses and modern, high-tech industrial warehouse facilities. This section also discusses sustainable warehousing practices which touch on environmental sustainability and adaptive re-use feasibility of warehouses. The second section, **Recommendations,** includes key takeaways from the comparison and strategies the City could consider to ensure that these developments support the City's economic, transportation, and climate goals and priorities. A summary table of the differences between traditional warehouses and e-commerce facilities is provided in **Appendix A**. Additional supporting documentation that informed report findings is included in **Appendix B**.

# Warehouse Characteristics

Having space available in a large building, often referred to as a warehouse, where physical goods or inventory can be stored prior to selling has long been a critical piece of the supply chain. Traditionally, warehouses have been used for the prolonged storage of bulk inventory or business-to-business (B2B) orders. In recent years, changing consumer habits have led to the emergence of high-tech warehousing that support e-commerce and Just-in-Time (JIT) inventory practices aimed at saving costs by using less space to hold both consumer goods and inputs to production.

Directly related to e-commerce, distribution centers (DCs) and fulfillment centers (FCs) are designed to provide value-added logistics services, which allow operators to efficiently meet varying customer demand using technology and processes to streamline the supply chain. Even though FCs and DCs have become a prevalent use of warehousing space, modern high-tech facilities are still being utilized for other uses. The subsequent section describes the different types of warehouses which serve different parts of the supply chain process.

## Facility Types

There are various warehouse types and functions that support retail, commercial, and industrial supply chains. Virtually all industries rely directly or indirectly on warehousing services.

Traditional warehouses receive goods, store them for prolonged periods, and then send them out again. In contrast, distribution centers (DCs) take in different bulk goods from a variety of vendors, store those products in ways that allow for quickly filling orders, then repack the products to meet multiple customer orders.[11] This includes labeling the orders accurately, packing orders together for shipment out of the center, then loading trucks that take orders on the next leg of their journey or to their final destination.

Modern distribution centers are not traditional warehouses. They are high-tech distribution hubs that require significant investment, including building design and construction, as well as advanced technological, safety, and logistical equipment.

The main role of a DC is to store products in bulk and shipped in bulk to a retailer, whereas the main role of a fulfillment center (FC) is to pick, pack and ship the products directly to the consumer.[12] While DC and FC are frequently used interchangeably, they are quite different in design and operation. The main difference in fulfillment centers versus distribution centers is that DCs rarely offer small parcel order fulfillment. Instead, warehouse space for DCs moves large quantities of items in and out quickly. Fulfillment center operations typically work best for e-commerce companies who need small parcel order processing.

[11] ShipBob. Distribution Center Benefits and Key Processes Explained. 2021
[12] ShipBob. Fulfillment Center: What Is It, Why It's Important, & How Does It Compare to Warehousing. 2018

A distinguishing feature of a DC is that it acts as a hub for shipments. These businesses may take large volumes and redistribute the products into smaller shipments that will be sent to various destinations, including warehouses and fulfillment companies. Another key factor is how products are transported. A DC will often handle multiple modes of transportation when receiving and shipping inventory. A product may arrive by rail but leave the facility by air transport to a fulfillment center. DC Services are as follows:

- **Receiving Inventory:** Materials come on pallets or floor loaded in containers. The distribution center's job is to document and categorize all inbound materials. This way they can be sent to their proper destination such as a fulfillment center or big box retail store.
- **Replenishing Retailers:** One major service that distribution centers provide is restocking or replenishment of inventory for retailers. Considering a store like Target or Walmart as an example, there are thousands of individual SKUs in any given store and thus need a process that ensures inventory replenishes to the store before it runs out of stock.
- **Just-in-Time Materials:** A useful service that distribution centers provide is just-in-time inventory replenishment. Manufacturers use a lot of parts to assemble and build their various products. These parts require storage space. But manufacturers only need a limited number of parts for their output in a particular period. A distribution center can send materials on a regular basis to the manufacturer so they can maintain production. At the same time, the manufacturer can dedicate their warehouse space to their manufacturing activities.
- **Wholesale Marketing:** Wholesale distributors usually operate within a single industry like plumbing, construction, or electronics and offer their own marketing, sales, and product fulfillment. These distributors sell to resellers (and sometimes the general public) at discounted prices. Manufacturers choose to work with them at a lower price point because they come with a larger customer base.

FCs usually rely on a third-party logistics provider (3PL) to handle the storage, packaging, and shipping of products to be sent directly to the consumer (business-to-consumer or B2C) or directly to a business (business-to-business or B2B). Typically, an FC stores all of the products from a web site that are to be individually picked and packaged to be sent out to the consumer. Fulfillment centers are typically used by industries that require fast inventory turnaround and order fulfillment, such as e-commerce businesses. FCs may be used for time-critical and time-sensitive products — including food and pharmaceutical commodities — to fill orders quickly for businesses and consumers. A fulfillment center has three important functions in the supply process. These include:

1. Receiving and storing inventory
2. Fulfilling orders for customers
3. Packing and shipping goods to their final destination

Fulfillment centers are ideal for e-commerce businesses because their warehouse locations are closer to their customers. Fulfillment center services may include:

- **Pick and pack fulfillment services**, which are typically the core component of every fulfillment center. When customers place orders, the fulfillment center generates pick lists for all the items. A warehouse employee collects the items on the list and places the item(s) in shipping packages.
- **Kitting and Assembly**: A kit is a collection of items that your customers order together like a bundle. Fulfillment center services may prepackage and bundle these items beforehand. This assigns each group of merchandise a new stock keeping unit (SKU). Kitting is critical for a business offering products like subscription boxes.
- **Freight Shipping:** Some warehouse fulfillment services include shipping goods in bulk. An example is B2B orders going to big box stores, or retailers. A fulfillment warehouse may also transport oversized goods with less-than-truckload (LTL) service.
- **Cross-docking** is useful in the supply chain when a business needs to transfer cargo from 40-foot marine shipping containers into larger 53-foot over-the-road shipping containers. Not only does this reduce the number of trucks on the road and overall shipping costs, but this is also an efficient means for combining multiple goods that are destined for the same location, such as a local big box retail store. Both distribution centers and fulfillment centers perform this service.

The following sections summarize the differences between traditional warehouses and modern e-commerce facilities[13] with respect to physical, operational, and economic characteristics.

## Physical Characteristics

For the purpose of this comparison, physical characteristics include warehousing siting and design (building size, lot coverage, loading bays, and parking spaces).

### City of Vancouver - Code Requirements

Within City limits, warehouse developments are required to adhere to Vancouver's Municipal Code (VMC). Warehouses are only permitted in the IL (Light Industrial) and IH (Heavy Industrial) zones. The siting of warehouses in the IL zone requires that all activities, except outdoor storage of materials, are completely contained within building(s). The IH zone is exempt from this condition. For both zones, setbacks determined by adjacent zone as follows:[14]

- When IL and IH zones are adjacent to nonresidential districts, buffering and screening standards are contained in VMC Tables 20.925.030-1 and 20.925.030-2.
- When adjacent to residential districts, buffering and screening standards are also pursuant to standards in VMC Tables 20.925.030-1 and 20.925.030-2, plus an additional 1/2 foot for each foot the building exceeds 20 feet in height to a maximum setback requirement of 40 feet. Buildings in excess of 20 feet may be stepped.

[13] This report focuses on comparisons between traditional warehouses and e-commerce facilities. However, it should be noted that e-commerce is not the only freight sector that relies on modern industrial warehouse design and operations.

[14] City of Vancouver. Municipal Codes: Minimum Landscaping and Buffer Setback Standards

Lot coverage, defined as the footprint of a building in relation to the development site, is set to the following requirements for warehouse developments:

- IL: maximum lot coverage of 75%; maximum height of 45 feet
- IH: maximum lot coverage of 100%; no maximum height

VMC 20.945.080 outlines the off-street loading requirements based on the gross floor area of a building. The minimum number of loading berths or off-street loading spaces based on varying floor area thresholds are provided in **Table 1**.

**Table 1: Loading Dock Requirements**

| Gross Floor Area | Required Number of Loading Docks |
|---|---|
| 5,000 sq. ft. up to 25,000 sq. ft. | 1 |
| 25,000 sq. ft. up to 50,000 sq. ft. | 2 |
| 50,000 sq. ft. up to 100,000 sq. ft. | 3 |
| Each 50,000 sq. ft. in excess of 100,000 sq. ft. | 1 |

Source: City of Vancouver. Municipal Codes: Off-street Loading Requirements.

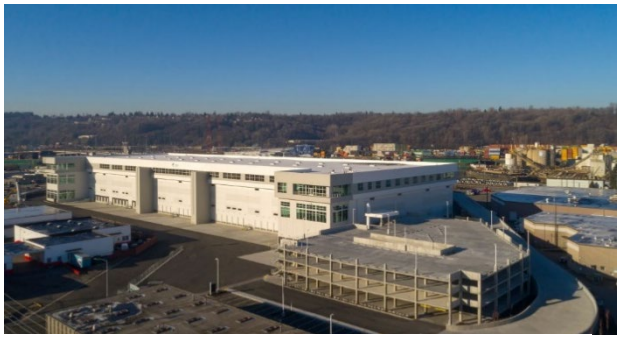
## Physical Differences between Traditional Warehouses and E-commerce Facilities

Based on the 250 KSF threshold outlined in the City's amended warehouse moratorium, only a subset of the proposed warehouse developments that exceed this threshold were selected for this study. The building footprints for these selected developments range from 280 KSF to about 570 KSF, while traditional warehouses within City limits are typically under 100 KSF. This variation in size and footprint is depicted in the images below. While size and footprint are typically reliable indicators of the type of warehousing that is occurring, in urban in-fill locations with higher land values and therefore, higher barriers to entry, e-commerce facilities may be closer in size to traditional warehouses.

*Example of Existing Warehouse in Vancouver, WA (70 KSF)*

Source: LoopNet Commercial Property. 2023

*Example of Prologis Georgetown Crossroads Facility in Seattle, WA (590 KSF)*

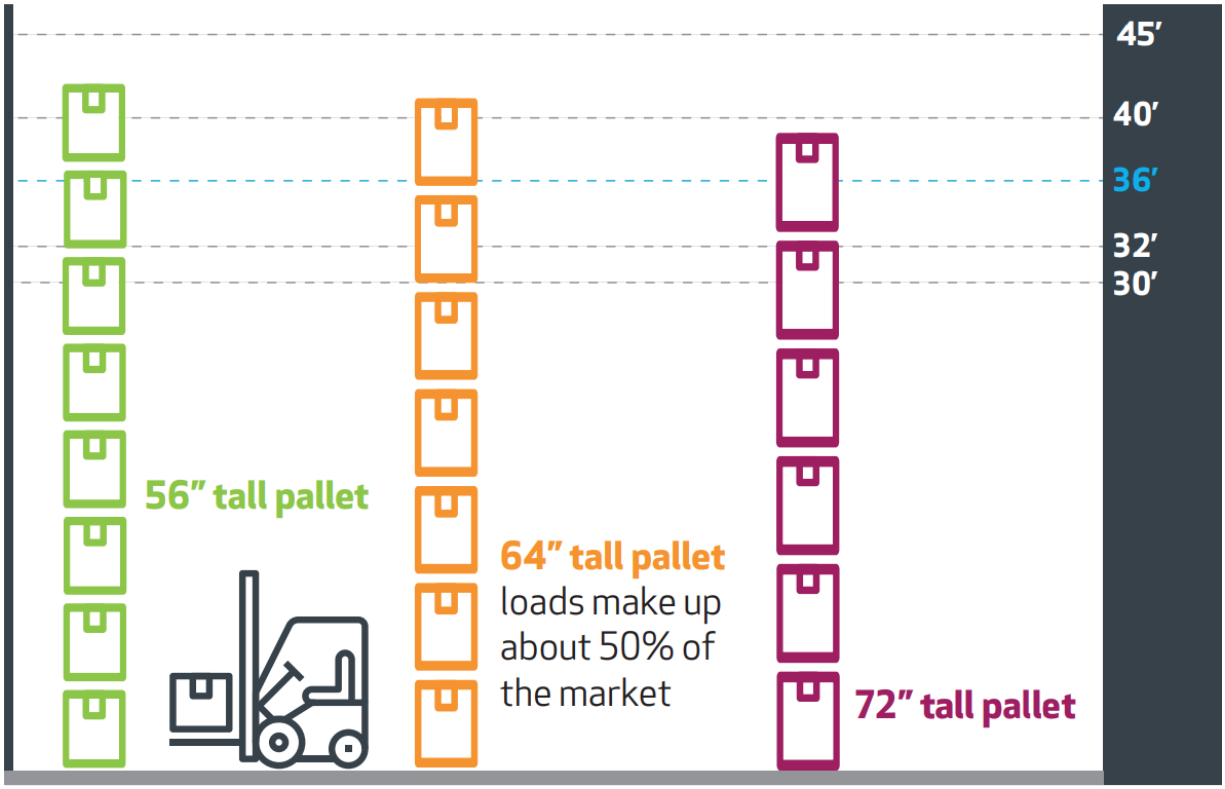


Source: NELSON Worldwide. 2023.

Another notable physical difference between traditional warehouses and modern e-commerce facilities is building clear height. In industrial real estate, building clear height is defined as the height of a building from the floor to the bottom of the lowest hanging item on the ceiling (i.e., sprinklers, lights, etc.). Building clear height dictates the height to which inventory can be safely stored. CBRE Group, Inc, one of the world's largest commercial real estate services and investment firms, noted that e-commerce trends have resulted in an ongoing shift towards increased building clear heights for warehouses and distribution centers. Between 2010 and 2016, the average clear height for all warehouses built by CBRE rose from 30.19 feet to 32.95 feet.[15] Other research indicates that at the national level, the industrial market is moving toward a 36-feet clear height standard for new developments. In comparison, traditional warehouses often have a clear height well under 30 feet. As illustrated in **Figure 2**, taller clear heights allow tenants to store more palletized product, which translates to lower occupancy costs per square foot[16].

In addition to higher clear height, e-commerce facilities have more space for staging and queuing as a result of the operational characteristics, which will be discussed in the subsequent section.

**Figure 2: Warehousing Capacity Based on Clear Height**



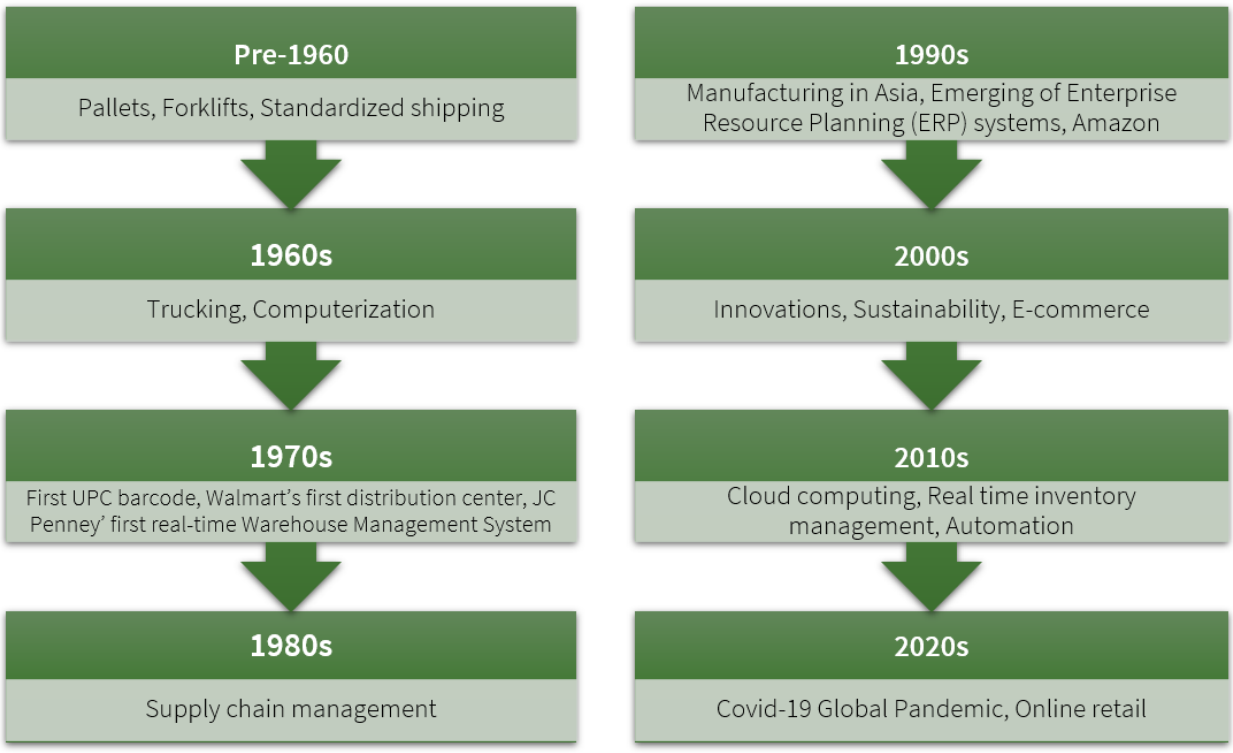

Source: Modern Architecture. 2020.

[15] RoofLifters. As e-commerce grows, so does the clear height of warehouses. 2020
[16] Method Architecture. 36 is the new 32: Increasing Clear Height for Maximum Efficiency. 2020

## Operational Characteristics

Warehousing has undergone operational evolution over the past decades, leveraging technology and adapting to trends as depicted in **Figure 3**. Recent improvements in technology have resulted in increasingly efficient use of warehouse space resulting in an increased consolidation of facilities. Technology, such as barcoding and radio-frequency identification (RFID), coupled with automated warehouse inventory and sortation practices, has resulted in significant efficiency gains and cost savings. In addition to better managing inventory, these systems make it possible to store more goods under one roof, improve safety, and reduce the number of automobile trips and parking demand. As a result of warehouse automation, these new facilities require fewer unskilled workers to drive forklifts and manage inventory and create high-tech jobs to operate and maintain the automated systems, as well as value-added services that are occurring in some facilities.

**Figure 3: Evolution of Warehousing**



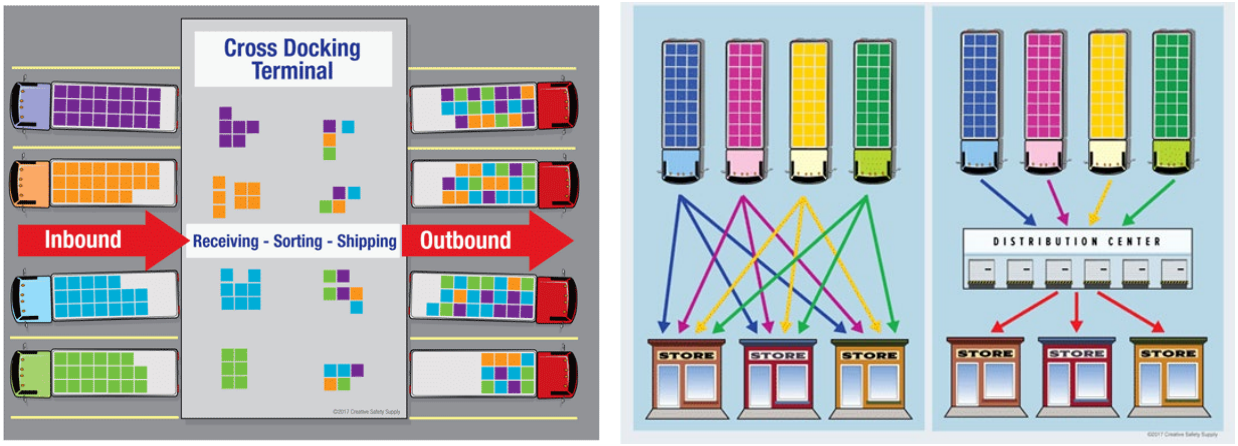

As a result of the advances in logistics operations to support e-commerce and advances in business-to-business supply chains, modern warehouses operate differently than traditional warehouses, particularly regarding hours of operation, the flow of goods, types of vehicles utilized, vehicle trips generated, and related traffic operations.

E-commerce facilities are intended for streamlined and efficient logistics services with typical hours of operation spanning 24 hours a day, seven days per week. The non-stop activity in modern warehouses is made possible by shift workers and automation. Automation has replaced outdated processes, such as

digital bills of lading versus handwritten, use of RFID versus manual paperwork by gate attendants, automated stacking, and retrieval systems instead of forklifts. These modern innovations benefit all industrial and retail sectors because they allow beneficial cargo owners to meet customer (both consumers and businesses) expectations for quick delivery of goods either purchased online, purchased by a retail store, or required as an input to production. To meet those demands, warehouses must operate around the clock.[17] In contrast, hours of operation at traditional warehouses with slower turnover of inventory are typically limited to normal business hours, i.e., 8-hour shifts, five days per week. The noted differences are directly linked to the flow of goods and storage duration.

As described in previous sections, there are several industrial warehouse typologies including distribution centers and fulfilment centers among others. These facilities typically focus less on long-term storage and more on flow of goods and services compared to traditional warehouses. Another key difference is that operations at modern industrial warehouse facilities are often driven by demand, compared to traditional warehouses, where operations are related to storing the largest amount of goods possible. Typical operations at a distribution center, including the combination of similar sized goods with similar destinations, are depicted in **Figure 4**. While the figure depicts distribution to stores, e-commerce has altered supply chains whereby goods flow to fulfillment centers by truck to be moved into a delivery van and delivered directly to the consumer. Transload facilities and distribution centers often both participate in the sorting and combining of truckloads of goods to reduce travel time, vehicle miles of travel, and fuel consumption.

**Figure 4: Visual Depiction of Cross Docking at a Fulfilment Center and Operations at a Distribution Center**




Source: Creative Safety Supply.

[17] Multibriefs. Do warehouses still need 8-hour work shifts? 2014

## Traffic Impacts

Efficient logistics in warehousing facilities entail higher vehicle activity than traditional warehouses. The Institute of Transportation Engineers (ITE) Trip Generation Manual offers trip generation estimates associated with land use developments and the database includes a breakdown of vehicle types. **Table 2** presents trips generation estimates for warehouse developments per 1,000 square foot of gross floor area. In practice, traditional warehouse developments are assumed to be ITE land use code 150 and e-commerce facilities range from ITE land use codes 154 to 155 and 130 is used for industrial parks. As shown in **Table 2**, e-commerce facilities generate more daily vehicles particularly for fulfillment centers that require extensive sorting (ITE land use code 155). These are estimated to generate almost four times the number of vehicle trips than traditional warehouses.

Because ITE trip generation data is limited regarding the breakdown between vehicle types, the project team relied on an assessment of recently collected data to provide insight into this[18]. As highlighted in **Table 3** and **Table** 4, e-commerce facilities such as Amazon generate more medium-duty and heavy-duty truck trips as compared to passenger cars, but these trends are not universal. Notably, the magnitude of trips at an Amazon facility is substantially higher than those at a UPS facility. This illustrates the variation in trip generation at e-commerce facilities. It is also important to note that while the collected data provides general insights, the data are from sites in California. Therefore, reviewing local warehouse developments sites in the Vancouver/Portland region may help inform more representative trends.

[18] Based on extensive comparisons between ITE trip generation estimates and observed traffic data, ITE is limited in capturing the breakdown in vehicle types. Because of this, the team opted for previously collected empirical warehouse traffic data from California which is assumed to provide general insights. Local data would need to be collected to provide context sensitive insights.

**Table 2: Warehousing Trip Rate Comparison (Trips per 1,000 square feet of GFA)**

| Warehouse Type | Daily Average Rate | | AM Peak Hour Average Rate | | PM Peak Hour Average Rate | |
|---|---|---|---|---|---|---|
| | Truck | Total Vehicles | Truck | Total Vehicles | Truck | Total Vehicles |
| ITE Land Use: 130 Industrial Park | 0.57 | 3.37 | 0.03 | 0.41 | 0.05 | 0.40 |
| ITE Land Use: 150 Warehousing | 0.60 | 1.71 | 0.02 | 0.17 | 0.03 | 0.18 |
| ITE Land Use: 154 High-Cube Transload and Short-Term Storage Warehouse | 0.22 | 1.40 | 0.02 | 0.08 | 0.01 | 0.10 |
| ITE Land Use: 155 High-Cube Transload and Short-Term Storage Warehouse (Non-sort Facility) | 0.23 | 1.81 | 0.02 | 0.15 | 0.01 | 0.16 |
| ITE Land Use: 155 High-Cube Transload and Short-Term Storage Warehouse (Sort Facility) | 0.19 | 6.44 | 0.02 | 0.87 | 0.02 | 1.20 |
| ITE Land Use: 156 High-Cube Parcel Hub Warehouse | 0.58 | 4.63 | 0.09 | 0.70 | 0.06 | 0.64 |
| ITE Land Use: 157 High-Cube Cold Storage Warehouse | 0.75 | 2.12 | 0.03 | 0.11 | 0.03 | 0.12 |

Source: ITE Trip Generation Manual, 11th Edition.
Notes:
ITE Trip Generation provides the following definitions for the tabulated warehouse types:

- An industrial park contains several individual industrial or related facilities. It is characterized by a mix of manufacturing, service, and warehouse facilities with a wide variation in the proportion of each type of use from one location to another. Many industrial parks contain highly diversified facilities.
- A warehouse is primarily devoted to the storage of materials, but it may also include office and maintenance areas.
- A high-cube warehouse (HCW) is a building that typically has at least 200,000 gross square feet of floor area, has a ceiling height of 24 feet or more, and is used primarily for the storage and/or consolidation of manufactured goods (and to a lesser extent, raw materials) prior to their distribution to retail locations or other warehouses.
- A high-cube fulfillment center warehouse is subcategorized into sort or non-sort. A sort facility is a fulfillment center that ships out smaller items, requiring extensive sorting, typically by manual means. A non-sort facility is a fulfillment center that ships large box items that are processed primarily with automation rather than through manual means.
- A high-cube parcel hub warehouse typically serves as a regional and local freight-forwarder facility for time sensitive shipments via airfreight and ground carriers. A site can also include truck maintenance, wash, or fueling facilities. Some limited assembly and repackaging may occur within the facility.
- A high-cube cold store warehouse has substantial temperature-controlled environments for frozen food and other perishable products.

**Table 3: Observed Trip Activity at Comparable Sites in California (Distribution by Vehicle Type per Time Period)**

| Customer | Building Size (sf) | Daily | | | AM Peak Hour | | | PM Peak Hour | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Passenger Car | Medium-duty Trucks | Heavy-duty Trucks | Passenger Car | Medium-duty Trucks | Heavy-duty Trucks | Passenger Car | Medium-duty Trucks | Heavy-duty Trucks |
| Pratt Corrugated Holdings | 350,892 | 309 | 13 | 216 | 21 | 1 | 15 | 47 | 2 | 21 |
| **HJ Heinz** | **500,199** | **208** | **13** | **155** | **25** | **0** | **2** | **48** | **1** | **13** |
| Prism Team Services, Inc. | 443,640 | 113 | 15 | 142 | 4 | 2 | 15 | 14 | 3 | 12 |
| Orchard Supply Company | 346,524 | 113 | 54 | 22 | 13 | 2 | 1 | 9 | 1 | 1 |
| Fox Head, Inc. | 388,000 | 183 | 19 | 15 | 34 | 0 | 0 | 49 | 2 | 0 |
| **Amazon.com Services, Inc.** | **388,183** | **69** | **214** | **241** | **9** | **5** | **12** | **12** | **5** | **11** |
| Niagara Bottling, LLC | 512,000 | 59 | 5 | 153 | 7 | 0 | 5 | 18 | 0 | 7 |
| Kraft Foods Group, Inc. | 351,788 | 117 | 7 | 169 | 4 | 2 | 11 | 32 | 1 | 13 |
| **Coastal Pacific Food** | **500,004** | **581** | **37** | **283** | **66** | **1** | **21** | **76** | **1** | **7** |
| Restoration Hardware | 283,712 | 540 | 16 | 42 | 47 | 1 | 6 | 60 | 1 | 2 |
| Dart Container | 340,000 | 200 | 13 | 50 | 21 | 2 | 4 | 30 | 1 | 2 |
| Lowes | 570,000 | 277 | 11 | 164 | 36 | 0 | 6 | 78 | 0 | 16 |
| **UPS** | **560,000** | **70** | **10** | **11** | **8** | **2** | **1** | **9** | **0** | **0** |
| Cargill Food | 350,000 | 457 | 19 | 311 | 39 | 0 | 17 | 44 | 2 | 19 |
| International Paper | 375,000 | 312 | 16 | 133 | 70 | 0 | 10 | 75 | 0 | 5 |
| IPC Smucker's | 403,560 | 205 | 12 | 149 | 25 | 0 | 10 | 39 | 4 | 10 |

Source: Fehr & Peers. 2022.
Notes: Sites with bold text inform the trip activity comparison discussion.

**Table 4: Observed Trip Activity at Comparable Sites in California (% Distribution by Vehicle Type per Time Period)**

| Customer | Building Size (sf) | Daily | | | AM Peak Hour | | | PM Peak Hour | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Passenger Car | Medium-duty Trucks | Heavy-duty Trucks | Passenger Car | Medium-duty Trucks | Heavy-duty Trucks | Passenger Car | Medium-duty Trucks | Heavy-duty Trucks |
| Pratt Corrugated Holdings | 350,892 | 57% | 3% | 40% | 58% | 2% | 40% | 68% | 2% | 30% |
| **HJ Heinz** | **500,199** | **55%** | **3%** | **41%** | **92%** | **0%** | **8%** | **78%** | **2%** | **20%** |
| Prism Team Services, Inc. | 443,640 | 42% | 5% | 53% | 21% | 8% | 71% | 49% | 9% | 41% |
| Orchard Supply Company | 346,524 | 60% | 29% | 12% | 81% | 15% | 4% | 82% | 6% | 12% |
| Fox Head, Inc. | 388,000 | 84% | 9% | 7% | 98% | 1% | 1% | 97% | 3% | 0% |
| **Amazon.com Services, Inc.** | **388,183** | **13%** | **41%** | **46%** | **35%** | **18%** | **47%** | **43%** | **18%** | **39%** |
| Niagara Bottling, LLC | 512,000 | 27% | 2% | 70% | 58% | 0% | 42% | 71% | 0% | 29% |
| Kraft Foods Group, Inc. | 351,788 | 40% | 2% | 58% | 24% | 10% | 65% | 69% | 3% | 28% |
| **Coastal Pacific Food** | **500,004** | **65%** | **4%** | **31%** | **76%** | **1%** | **24%** | **91%** | **1%** | **8%** |
| Restoration Hardware | 283,712 | 90% | 3% | 7% | 87% | 1% | 12% | 95% | 2% | 3% |
| Dart Container | 340,000 | 76% | 5% | 19% | 78% | 9% | 13% | 89% | 4% | 7% |
| Lowes | 570,000 | 61% | 2% | 36% | 85% | 0% | 15% | 83% | 0% | 17% |
| **UPS** | **560,000** | **77%** | **11%** | **12%** | **73%** | **15%** | **12%** | **97%** | **0%** | **3%** |
| Cargill Food | 350,000 | 58% | 2% | 40% | 69% | 0% | 31% | 68% | 3% | 30% |
| International Paper | 375,000 | 68% | 3% | 29% | 87% | 0% | 13% | 94% | 0% | 6% |
| IPC Smucker's | 403,560 | 56% | 3% | 41% | 71% | 0% | 29% | 74% | 8% | 18% |

Source: Fehr & Peers. 2022.
Notes: Sites with bold text inform the trip activity comparison discussion.

On a vehicle-type basis, medium-duty and heavy-duty trucks tend to be the main mode of transportation for goods in and out of traditional warehouses. Whereas, in today's logistics operations, light-duty trucks and vans play a substantial role in goods transportation via e-commerce facilities. Based on the collected data from warehouse sites in California tabulated in **Table 4**, peak activity of these trucks is generally observed between 4 am to 7 am and around 12 pm to 1 pm. This is also indicated by the magnitude of peak hour trips in comparison to daily trips reported in **Table 4**.

*Summary of Proposed Development Traffic Impact Analyses*

One of the most challenging issues associated with analyzing impacts of industrial land uses is understanding their operations. The National Academies of Science's Transportation Research Board and the Institute of Transportation Engineers have attempted to standardize trip generation rates (**Table 2**) associated with a variety of land uses, including industrial uses, for over 50 years. Unlike many land uses, such as residential and retail uses, the big box design of industrial warehouses makes them flexible, meaning the trip generation is difficult to estimate. For example, two common reuses are mega-churches and indoor trampoline parks. For this reason, many cities are using the conditional use permit (CUP) mechanism for requiring operational data, dictating assumptions for use in traffic impact analysis, and identifying conditions of approval to mitigate potential impacts. In the 11th Edition of the ITE Trip Generation Manual, there are currently ten categories that an industrial warehouse could fit into, and the categories most closely related to the proposed facilities in Vancouver are defined in the industrial trip generation assumptions section. A cursory review of the intersections that have been analyzed in the traffic studies for four of the proposed projects is described herein, as well.

In reviewing the ITE industrial trip generation rates, the variance in size and footprints do not easily translate to the amount of auto, van, and truck traffic that is generated by these facilities. What is needed is more information about the intended operations of the facilities. This can be challenging to obtain, especially when buildings are constructed without knowledge of who the future tenant may be (e.g., spec buildings). In the absence of the necessary information to discern operations of the proposed development, assuming the highest trip generation (ITE land use code 550) presents a conservative approach to address potential traffic impacts.

**Table 5** contains data that was abstracted from the traffic studies associated with the proposed projects, as well as trip generation estimates calculated using the ITE Trip Generation web-based app (based on the 11th Edition). ITE provides both average rates and fitted curve rates. And for AM and PM peak rates, analysts are provided with two more options: peak of the site or peak of the adjacent street. It is common to perform impact analysis using data for the peak of the adjacent street, but in the case of major industrial facilities that generate large volumes of trips and could overwhelm the local system, considering peak trip generation of the site may be the more appropriate rate to use. In addition to the effects of these two assumptions on trip generation rates, the validity of the rates in 2023 is questionable considering the small sample of sites that this data is based on and the old age of some of the surveys. More recent, empirical data should be used when available and feasible.

**Table 5: Estimated Trip Activity related to Proposed Industrial Warehouse Developments**

| Development | Building Size (sf) | ITE Trip Generation Code | Daily Truck Trips | Daily Total Trips | AM Peak Hour Truck Trips | AM Peak Total Trips | PM Peak Hour Truck Trips | PM Peak Total Trips |
|---|---|---|---|---|---|---|---|---|
| Panattoni Fruit Valley Rd<br>PDC Seattle LPIV BB/TH, LLC | 60,050 | 150 | 36*<br>40** | 103*<br>**134**** | 4*<br>5** | 13*<br>**35**** | 2 | 34 |
| Harmony<br>Industrial project | 460,000 | 150 | **787***<br>765** | 787*<br>**765**** | 28*<br>29** | 97*<br>**79**** | 28*<br>24** | 106*<br>**89**** |
| Vancouver Wellons<br>Prologis, Inc. | 566,527 | 130 | 323* | 1909*<br>2134** | 17* | 232* | 28* | 227* |
| Vancouver Innovation Center<br>Building North | 200,700 | 110 | 50* | 977*<br>805** | 6* | 183*<br>153** | 10* | 161*<br>137** |

* Average Rate
** Fitted Curve Rate
Notes:
Tabulated rates are based on the ITE Trip Generation data on AM/PM peak of adjacent streets
Numbers in bold are assumed rates provided in the traffic studies. None of the traffic impact studies used Passenger Car Equivalents (PCE) factors to assess the potential impacts of trucks at intersections. In general, trucks are assumed to equal 1.5 to 3 passenger cars for the purposes of intersection analysis due to their lengths and slower starting and stopping abilities. None of the four studies appeared to consider this in their analysis. The following section identifies the intersections analyzed by each of the studies.



### Intersection Analysis

A list of the analyzed intersections for each of the proposed industrial developments is provided in this section. There is only one identified intersection that is shared by two of the proposed developments, the intersection of Fruit Valley Road and W. 39th Street. Both studies indicate that this intersection will operate at Level of Service (LOS) C in the future. It is unclear if the projects assumed each other as related projects in the analysis, however, the City does have a preproposal process that it could use to collect additional data about the proposed facilities, confirm trip generation rates to use, and identify related projects to consider.

Panattoni Fruit Valley Project

1. NW Lakeshore Ave/NW 78th Street
2. NW Whitney Rd/NW 61st Street
3. Fruit Valley Rd/NW 61st Street
4. **Fruit Valley Rd/W 39th Street**

Vancouver Innovation Center

1. SR-14/SE 192nd Avenue
2. SE 176th Avenue/SE 20th Street
3. SE 34th Street/SE 192nd Avenue

Harmony

1. 137th Ave – 49th St to Fourth Plain Blvd
2. 192nd Ave & SR 14 Ramps
3. Fourth Plain Blvd & 152nd Ave
4. Lieser/St. Helens/MacArthur
5. 192nd Ave & NE 13th Street
6. 192nd Ave & SE 34th Street
7. 176th Ave & SE 20th Street
8. Grove St/Columbia House Blvd/SR-14 WB Off-Ramp
9. NE 172nd Ave/NE 18th Street
10. NE 179th Place/NE 18th Street
11. NE 187th Ave/NE 18th Street
12. NE 172nd Ave/NE 9th Street
13. NE 9th Street/NE 162nd Ave
14. NE 192nd Ave/NE 9th Street
15. NE 187th Ave/SE 1st Street
16. SE 192nd Ave/Mill Plain Blvd

Prologis

1. 32nd Avenue/La Frambois Road

2. 32nd Avenue/Lower River Road
3. **Fruit Valley Road/39th Street**
4. Fruit Valley Road/Firestone Lane

As discussed in the subsequent sections, warehouse facilities generate truck and passenger car traffic which results in wear and tear of roads, noise pollution, light pollution, and safety concerns. Examples of measures to mitigate the resulting impacts are summarized in **Table 6**.

**Table 6: Potential Mitigation Measures**[19]

| Impact | Measure |
|---|---|
| Truck traffic impacts | • Design, construct, and clearly mark truck routes that provide direct access to freight-served facilities and avoid residential neighborhoods and other sensitive receptors (schools, hospitals, etc.). |
| Truck parking demand | • Review and update zoning that is consistent with the state of industry operations, such as performance zoning that customizes loading, parking, curb returns, on-site recycling, etc., based on the intended operations of the facility.<br>• Require the provision of adequate areas for on-site parking, on-site queuing or staging, and truck check-in to avoid trucks queuing in travel lanes or parking in undesignated areas. |
| Truck emissions | • Promote fleet electrification by requiring electric charging stations at each warehouse development, so trucks can get recharged while loading/unloading and incentivizing zero-emission vehicles in business operations.<br>• Encourage tenants to enroll in the US Environmental Protection Agency's SmartWay[20] program to help companies advance supply chain sustainability by measuring, benchmarking, and improving freight transportation efficiency. |
| Congestion management | • Nexus impact fee to support funding for capacity expansion projects.<br>• Incentives for off-peak delivery; an example is the Off-Hour Deliveries program in New York City that offers participants financial incentives.[21]<br>• Right-size on-site employee parking and encourage alternative modes of transportation for employees (e.g., bicycle parking, transit passes, carpool spaces). |

[19] Department of Justice, State of California. Warehouse Projects: Best Practices and Mitigation Measures to Comply with the California Environmental Quality Act. 2022

[20] SmartWay is an EPA program that helps the freight transportation sector improve supply chain efficiency. SmartWay reduces transportation-related emissions by accelerating the use of advanced fuel-saving technologies.

[21] New York City. Off-Hour Deliveries.

| Impact | Measure |
|---|---|
| Noise pollution | • Face dock doors and trash receptacles away from residential uses and sensitive receptors.<br>• Limit hours of operations if a facility is within one-quarter mile of a sensitive receptor.<br>• Require all combustion-powered construction equipment to be surrounded by a noise protection barrier.<br>• Paving roads where high truck traffic is anticipated with low-noise asphalt. |
| Roadway wear and tear | • Require the siting of warehouse developments to be within a mile of the City's designated freight routes. These routes are typically well designed to accommodate truck traffic. |
| Safety | • Provide off-street or buffered bikeways on shared truck routes to ensure employees working in the industrial areas can safely bike to work.<br>• Provide adequate curb return radii at intersections and driveways into freight generators to avoid trucks overtaking the curb/sidewalk.<br>• Review truck routes designation periodically and modify as needed. Ideally, truck routes should not conflict with major transit and bicycle and pedestrian corridors unless properly designed to serve employees working at freight generators. |
| Visual impacts | • Require buildings to be dark colored<br>• Provide vegetative buffers |

Source: Department of Justice, State of California. 2022.

# Economic Characteristics

## Warehousing Trends

*Global and National Supply Chain System Trends*

A range of supply chain logistics system factors influence changes that we are experiencing today. These factors are important to understand as they impact local economics, such as tax revenue and employment rates, and worker salaries. Below is a summarized list of global supply chain trends that are contributing to industrial warehouse development demand in Vancouver:

- **E-commerce:** The emergence of the e-commerce sector from its inception in the 1990s to a major factor in global supply chain management and industrial property development. The e-commerce supply chain requires up to three times more warehouse space than a traditional brick and mortar retail facility. For example, for every $1 billion in incremental e-commerce growth, 1.2 million square feet of facility demand is generated. Based on this, the U.S. will need up to 330 million square feet of additional space to support e-commerce growth through 2025.
- **Market need:** Sites near logistics hubs, such as intermodal rail yards, airports and seaports are in high-demand. As a City surrounded a major airport and seaport, and population center, there is a market need for warehouse developments in Vancouver to support e-commerce and online shopping. Due to the absence of e-commerce facilities within City limits, households and businesses currently rely on facilities/warehouses in surrounding jurisdictions such as Portland.
- **Just-in-Time (JIT) versus Just-in-Case (JIC) inventory management** played a significant role in the shortages for basic household goods, such as toilet paper and cleaning supplies. JIT offered cost savings because less space was needed for storage, but JIC is trending back due to the hardships the lack of inventory created for many companies.
- **Trucking and equipment shortages** have resulted in more food product production moving nearer to consumption markets.
- **Sector-specific competitive factors**, such as the Apparel sector's focus on fast fashion (e.g., Shein).
- **Highly developed integrated technologies** in support of supply chain efficiencies allow for more products to be stored, retrieved, and sold expeditiously. Large advances like in-building automation, yard automation and expected point-to-point location automation improve storage and retrieval reducing time to market. Integrated inventory tracking systems connecting in-warehouse robotic cargo handling/inventory management equipment, warehouse staff, trucking services, terminal operators, ocean carriers and shippers support same-day shipping to e-commerce consumers, as well as other customers, such as manufacturers. More recent and expected advances in zero emission vehicle and equipment powertrains; in some cases, requiring new distance intervals between inventory and shipment points.

- **Facility Trends**: The size, design, and function of warehouses has evolved considerably in past two decades – so much so that the Institute of Transportation Engineers (ITE) embarked on a study of warehouse trip generation characteristics to add to its Trip Generation Handbook (as shown in **Table 2**). Not only have the size and design of warehouses changed, but the locations for developing new facilities has also changed. In general, warehouse operators need sites closer to consumers, such as in some high-value markets like Seattle. In high-cost urban areas, these facilities are going vertical when land becomes expensive and scarce requiring more sophistication and a smaller footprint on multiple floors. In markets like Vancouver and Portland, region-specific sites may be required. These include small- to mid-sized facilities within the urban areas and larger facilities on the outskirts to serve primary markets.

## Warehousing Jobs

Industrial warehouses typically generate both jobs and tax revenue. Warehousing jobs, while often perceived as inferior to manufacturing jobs, provide two important community benefits: 1) pay rates that start above minimum wage, 2) and on-the-job-training that provide opportunities for employees with no college education to make over $80,000 a year. The salary for automation engineers (a job associated with highly automated warehouses) starts in the high $80,000s and pay on average over $100,000 a year with experienced engineers earning closer to $140,000 annually. US Census County Business Patterns (CBP) provides subnational economic data by industry, including the number of establishments, employment, and annual payroll. This provides insight into the average wage and employees per establishment for "Warehousing and Storage" sector in Clark County and other surrounding or comparable counties in the region (**Table 8** through **Table 13)** [22]:

- At a high-level, Clark County's industrial sector average number of jobs per establishment is up by 50% and average annual wage has increased by 10% over the past six years. This is considerably higher than comparable counties, where jobs per establishment increased by only 17%.
- As of 2021, in Clark County, there are more employees per establishment (approx. 42) for "Warehousing and Storage" than other industrial types of employment: "Manufacturing" (approx. 31) and "Scientific Research and Development Services" (approx. 21). At a high-level this is also consistent with other comparable counties in the region. The limitation of this dataset is that it doesn't provide establishment acreage, however, at a high-level, warehouses generate more jobs per establishment than competing uses (**Table 8**, **Table 9,** and **Table 10**). From conversations with warehouse developers, jobs per acre vary depending on the specific use, i.e., distribution center versus sorting, or consolidation versus fulfillment center.
- The average annual wages per employee in 2021 for "Warehousing and Storage" is less than those for "Manufacturing" and both are outpaced by "Scientific Research and Development

[22] Data from US Census County Business Patterns (CBP) reports aggregated and averaged data for all warehouse and storage types. Therefore, the warehousing and storage jobs and salaries reported will not highlight any specific warehouse facilities with high employment or high paying jobs.

Services". It is worth noting that this average bundle up management and non-management staff (**Table 11**, **Table 12**, and **Table 13**).

*Types of Warehouse Jobs*

**Safety Manager**: This person's responsibilities include oversight of a safety-minded culture in the warehouse through OSHA training and education, investigating onsite accidents to determine the cause and recommend preventative measures, managing the employee health and safety guidelines set forth by both the company and local/state/federal laws, and implementing and creating programs that promote safety and security of warehouse employees.

**Warehouse Supervisors**: This role supervises, organizes, and monitors inventory receiving, storage, and distribution. They oversee the facility workforce, with management of performance metrics and train new employees.

**Operations/Warehouse Manager**: The warehouse manager position monitors all day-to-day warehouse activities, including receiving, order filling, shipping, and inventory control. Their responsibilities involve scheduling tasks for personnel, helping negotiate rates with carriers, creating daily work logs, collecting actionable data related to labor, shrinkage, fill rate, etc., planning more efficient operations, and supervising and training warehouse employees and their supervisors.

**Inventory Clerk**: The inventory clerk is responsible for various clerical duties for warehousing, receiving, and shipping materials. In most cases, this person handles relationships with vendors and/or suppliers and is responsible for monitoring inventory performance and assists in creating purchase orders to replenish stock before it runs out. They are also heavily involved with keeping inventory counts in check.

**Material Handlers**: Depending on the size of the operation and operator, a fulfillment center may have employees who do only one job or are cross-trained for multiple jobs, as follows:

- Pickers – this role receives orders that drop to the warehouse floor, then collect the item(s) for each order to prepare for shipment.
- Packers – this role takes the picked orders, scan them in as 'ordered', then pack them into appropriate packaging for shipment. They also include any package inserts, custom packaging, and the packing slip in the order.
- Receivers – this role unloads inbound freight from carrier trucks, processing it into inventory.
- Stockers (replenishment) – this role takes inventoried items from receiving and move them to either a storage area or to the warehouse floor. They are also responsible for replenishing products that are out or low.
- Assemblers or value-adders – this role pieces kits of items together, wrap gifts, and personalize orders.

- Returns – this role processes inbound returned orders, removes items from packaging, and conducts visual inspections. They document returns, then refurbish or return it to replenishment for restocking or work with the retailer/manufacturer to have the product returned to them.

**Emerging Tech-elated Positions**: Highly automated warehousing facilities require skilled labor such as automation engineers to monitor and repair control systems and sensors within a building to ensure efficient handling of goods. These jobs entail average salaries over $100,000 annually.

Based upon the manner in which the US Bureau of Labor Statistics compiles their data, there are four kinds of employees that work in warehouse/storage positions. In the Portland-Vancouver-Hillsboro MSA there are 47,480 people employed in these positions with 97% of them being in categories A and D, as listed below.

A. Laborers and freight, stock, and material movers – manually move freight, stock, luggage, or other materials, or perform other general labor. There are 16,960 people employed in this position in the MSA, with an average mean wage of $41,260.
B. Machine feeders and off bearers – feed materials into or remove materials from machines or equipment that is automatic or tended by other workers. There are 640 people employed in this position in the MSA with an average mean wage of $41,890.
C. Packers and packagers – pack or package by hand a wide variety of products and materials. There are 330 people employed in this position in the MSA with an average mean salary of $37,120.
D. Stock and order fillers – receive, store, and issue merchandise, materials, equipment, and other items from stockroom, warehouse, or storage yard to fill shelves, racks, tables, or customers' orders. May operate power equipment to fill orders. May mark prices on merchandise and set up sales displays. There are 29,880 people employed in this position with an average mean salary of $38,710.

## Warehousing Regional Economic Impacts

The modern distribution centers discussed herein generate more than direct jobs. These facilities also generate and support a number of other industries in a region, such as food and supplies for restaurants and grocery stores, retail goods for brick-and-mortar retail stores, third-party vendors (e.g., Etsy producers), and inputs to local manufacturing and service providers (e.g., auto repair, beauty salons, etc.).

For the purposes of comparison, the following provides detailed employment figures, salary information, cost of new construction (another indirect economic benefit), tax revenue, and the indirect benefits of various existing Amazon facility types and a food redistribution warehouse which is assumed to be representative of traditional warehouses.[23] The comparison highlights that e-commerce facilities typically entail more local and regional economic impacts (tax revenue, indirect jobs, and new dollars circulating in the economy) than traditional warehouses.

*Sortable fulfillment centers*

These facilities are approximately 800,000 square-feet in size and employ about 1,500 full-time associates. In these buildings, employees pick, pack, and ship customer orders. Depending on the location, facilities are partly automated, with workers and robots working alongside each other. Facilities employ approximately one employee per 1,000 square feet over a multi-shift workday.

- 800,000 sq ft
- 1500 full time employees at an average wage of $39,980 annually = annual payroll of $59,970,000
- Average cost per sq ft of new construction: $175/ sq ft
- Estimated valuation of development = $140,000,000
- Property tax in the MSA at $2.06 per $1000 of valuation = $288,400 annually
- Multiplier for the total change in number of jobs in all industries within the MSA for each additional job in the warehouse/storage industry = 1.4082. 1,500 x 1.4082 = 2,112 new jobs will be created in the regional economy
- Multiplier for the total dollar change in earnings of all households in the MSA for each additional dollar of earnings paid directly to households employed by the warehouse/storage industry = 1.5080. $39,980 x 1.5080 =$60,290. Each new job in the MSA created by the warehouse/storage sector creates $60,290 in the regional economy for a total of $90,434,760 annually (1,500 x $60,290)

*Non-sortable fulfillment centers*

With sizes ranging from 600,000 to 1 million SF, these facilities employ more than 1,000 full-time workers. In these centers, associates pick, pack, and ship bulky or larger-sized customer items such as patio

[23] The analysis was conducted using U.S. Bureau of Economic Analysis (BEA) RIMS II multipliers. The multipliers estimate the impact from changes in final demand on one or more regional industries in terms of output, employment, and labor earnings. These multipliers are based on estimates of local area personal income and on the national input-output (I-O) accounts.

furniture, outdoor equipment, or rugs.  Approximately 1500/sq ft per employee over a multi-shift workday.

- 1,000,000 sq ft
- 675 fulltime employees at an average wage of $39,980 annually = $26,986,500 annual payroll
- Average cost per sq ft of new construction: $175/sq ft
- Estimated valuation of development = $175,000,000
- Property tax at $2.06 per $1000 of valuation = $360,500 annually
- Multiplier for new job creation creates 951 new jobs
- Each new job in the MSA created by the warehouse/storage sector adds $60,290 to the regional economy for a total of $40,695,642 annually

*Receive centers*

Amazon's receive centers support customer fulfillment by taking in large orders of the types of inventories that are expected to quickly sell and allocating it to fulfillment centers within the network. They also receive and consolidate items from vendors. These buildings are about 600,000 square feet in size. Approximately 1500 SF/employee

- 600,000 sq ft
- 400 full time employees at an average wage of $39,980 annually = $15,992,000 annual payroll
- Average cost per sq ft: $175/sq ft
- Estimated valuation of development = $105,000,000
- Property tax at $2.06 per $1000 of valuation = $216,300 annually
- Multiplier for new job creation creates 563 new jobs
- Each new job in the MSA created by the warehouse/storage sector adds $60,290 to the regional economy for a total of $24,115,936

*Last mile delivery centers*

These facilities operate 24/7. Tractor trailers arrive from fulfillment centers; orders are processed and loaded onto delivery vans. The vans leave the warehouses outside of peak hours with the departure times scheduled in waves. If demand is especially high third-party partners/drivers can make deliveries in their personal vehicles. These facilities generate a large amount of new traffic activity.

- 100,000 sq ft
- 100 full time employees at an average wage of $39,980 annually = $3,998,000 annual payroll
- Average cost per sq ft: $92/sq ft
- Estimated valuation of development = $9,200,000
- Property tax at $2.06 per $1000 of valuation = $18,952 annually
- Multiplier for new job creation creates 141 new jobs
- Each new job in the MSA created by the warehouse/storage sector adds $60,290 to the regional economy for a total of $6,028,984 annually

*Food service redistribution warehouse*

A food service redistribution company, which offers over 112,000 products from over 800 food industry manufacturers built a new distribution center to serve Southern California, Arizona, New Mexico, Southern Nevada, and Utah. The company consolidates these products and delivers them in less than truckload quantities to distributors on a weekly basis. They have 11 distribution centers nationally.

- 165,000 sq ft distribution center space which includes 20,000 sq ft of refrigerated space
- 126 full time employees at an average of $39,980 annually = $5,037,480 payroll
- $45,000,000 of project costs which includes refrigerated and dry storage areas, installation of new equipment and infrastructure improvements
- City property tax of $2.06 per $1,000 valuation = $92,700 annually
- With a multiplier of 1.4082, the 126 jobs will create 177 new jobs in the MSA
- With a multiplier of 1.5080, each new job in the MSA created by the warehouse/storage sector adds $60,290 to the regional economy for a total of $7,596,519 annually

## Background Economic Data Specific to Vancouver

The Portland/Vancouver/Hillsboro Metropolitan Statistical Area (MSA) saw an increase of 4.8 percent in Warehouse/Storage employment from September 2021 to 2022. The average weekly wage in that period was $1,315, which ranked 66th in MSAs in the nation out of 395 MSAs. During the same period of time, Washington State was second in the nation for weekly wages paid to the Warehousing/Storage sector at $1,657 while Oregon's was $1,301. This difference is in part due to the higher cost of living in the Seattle region, which requires higher wages to attract and retain warehouse workers. The top five states for highest warehousing job wages include District of Columbia, Washington, Massachusetts, New York, and California. The cost of living in these states ranks equally high.

Based upon 2022 year-end employment numbers in the Warehousing/Storage sector in the MSA:

- 47,830 employees in the Portland, Vancouver, Hillsboro MSA
- 121,950 employees in Washington State
- 80,610 employees in Oregon

In 2022, overall statewide employment growth was 1.1 percent in Oregon (lowest nationally) and 4.4 percent in Washington. Applicable taxes in Vancouver consist of property tax, sales and use tax, and utility taxes. Vancouver property tax levy rate is $2.06 per $1,000 assessed value. Washington State law requires that county assessors appraise all property at its true market value in dollars, according to the highest and best use of the property. Washington State sales and use tax is 6.5 percent, whereas Vancouver's sales and use tax is 2.2 percent. Washington State uses a Destination Sales Tax system which means that the sales tax is applied at the destination. A Washington State Department of Revenue exemption is available for warehouses of 200,000 or more square feet. Sales tax on the construction costs for new warehouses (or an expansion of an existing warehouse that meets the 200,000 square feet requirement) qualify for 100 percent exemption. Material-handling equipment and racking equipment in warehouses are eligible for a 50 percent exemption. This applies to the state portion of the tax.

## Sustainable Practices

With the significant post-pandemic increase in e-commerce and recent near-shoring and reshoring of manufacturing, the demand for industrial warehousing has grown significantly and shows little signs of waning despite capitalization concerns related to interest rate hikes. This creates both challenges and opportunities for Vancouver to ensure that the development is sustainable – both from an environmental perspective, as well as long-term economic perspective. This section discusses opportunities for applying sustainable building and operations practices to the freight industry to reduce energy and water consumption, as well as emissions, landfill waste, and urban stormwater runoff.[24] This section will also discuss flexible re-use designs that support long-term, productive use of large industrial structures.

### Environmental Sustainability

As part of the trend toward greener warehouses, businesses are seeking not only energy savings but also more efficient materials handling. Automated storage and retrieval systems (AS/RS), the robotic handling system, and warehouse management systems (WMS), help achieve significant efficiencies by maximizing storage space while reducing operating costs. The WMS has the added benefit of increasing the speed of delivery and deployment of goods, which reduces truck queues and idling, particularly during peak seasons or immediately following a supply chain disruption. Flexible, hybrid AS/RS designs use one or more cranes in an aisle that only need to be as wide as the largest commodities – a substantial space saving in comparison with forklift-operated facilities. Automated racking systems can store products single-deep, double-deep, or up to 12 loads deep in the rack structure. AS/RS systems can be customized based on the warehouse's inventory mix of high, intermediate, and slow-moving products to minimize the cubic space required for storage and handling. Unmanned rack entry vehicles quickly, smoothly, and accurately transport pallets and containers in and out of the storage rack, resulting in faster throughput. These systems benefit small and large warehouses alike. Although the following example focuses on a very large-scale warehouse, it demonstrates the ability of systems like this to perform a vast amount of work in a very small space – a potential opportunity for Vancouver.

Automated systems also deliver the following environmental benefits:

1. Less land usage: A warehouse with an AS/RS uses up to 40 percent less space than a conventional warehouse to store the same number of products.

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[24] Green building is the practice of creating structures and using processes that are environmentally responsible and resource- efficient throughout a building's life cycle from siting to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high-performance building. http://www.epa.gov/greenbuilding/

2. Less energy consumption: Automated warehouses require less lighting and cooling; regenerative braking on storage/ retrieval machines produce energy for assisting with powering the system; the warehouse maintenance system controls all product flows and optimizes product movements.
3. Less product waste: Automated warehouses reduce product damage caused by human error; require less shrink wrapping to secure pallets; improve accuracy of fulfillment through technology like RFID.
4. Reduced maintenance: Maintenance costs for AS/RS are lower than for forklift operations; automated facilities require less space resulting in facility leasing savings.
5. Safety benefits: Automated facilities have fewer workers moving goods, thus resulting in fewer injuries that are typically inherent in warehouses, such as back and neck injuries and forklift accidents.
6. Result in fewer employees on site and therefore require fewer parking spaces (typically 40 percent less employee parking demand than a typical warehouse).

One of the challenges with AS/RS is the cost and return on investment. AS/RS is most commonly used by tenants who intend to operate a facility for a minimum of ten years. AS/RS also requires minimum ceiling height of 40 feet and perfectly level floors.

## Adaptive Re-use Feasibility

The growth rate for warehousing space is flattening due to changing economic trends and optimization of available space (e.g., automation). Therefore, it is important that warehousing properties are adaptive to reuse for different tenants with varying purposes. Over the years, warehouses in several parts of the country have been successfully reused for the following:

- Commercial kitchens to support local food trucks, segmented artist studios, or start-up office space for entrepreneurs or small businesses. Properties with high ceilings and abundant natural light can be converted into attractive office space.
- Production or testing facilities for a range of technology, such as biotech industries, automobile parts, aviation, and 3D printing.
- Gyms and indoor sports spaces.

As an example, St. Ann's warehouse in New York which was initially utilized for tobacco processing was repurposed into a theater for live performances in 2015.[25]

[25] BIM Smith. Functional and Creative: 5 Inspiring Adaptive Reuse Projects. 2022

The feasibility of reuse or multi-use of warehouses is highly dependent on the design nature of a development:

- Warehouse developments that typically work for both warehousing and manufacturing include flexible, dock-high, high-clear height buildings with provisions to expand power in the future, including under slab conduits so that power can be delivered to different ends of a building.
- To accommodate a use that may have more trucking, 185 ft truck courts may be necessary to accommodate trailer storage or truck courts that are 135 ft deep if no trailer storage is anticipated.

The multi-story warehouse concept, centered on building vertically rather than horizontally, is garnering traction. Building vertically helps overcome the limits of property lot sizes. Small trucks are able to easily navigate ramps to upper floors, while the main loading dock accommodates the conventional 53-foot trailers typically used in the US. This concept offers developers and property owners the ability to maximize profit potential. However, multi-story warehouses can be substantially more expensive to build than a standard warehouse.[26] An example warehouse is the 590 KSF multi-story warehouse in the Georgetown Crossroads district of south Seattle near the Port of Seattle.

[26] Prologis. The Future is Multistory. 2021

# Recommendations

As demonstrated in this report, industrial warehouses can vary significantly based on the types of activities occurring within them. Recent best practices that our team has identified focus on understanding the operations of industrial warehousing and taking a performance-based zoning approach. This type of zoning fosters the creation of a set of conditions of approval that best address the potential impacts of their operations. The following provides some potential conditions of approval for the City's consideration.

## Potential Conditional Use Permit (CUP) Requirements

The City could consider updating CUP requirements to require applications for new warehouses or distribution centers to describe the proposed operations, such as hours of operation, number of employees per shift, number of shifts, hours of shifts, daily and AM/PM peak hour medium- and heavy-duty truck volumes, number of dock doors, number of parking spaces for employees, trailers, tractor-trailers, and/or tractors, and anticipated water/sewer usage in volume, and power requirements in megawatts.

### Transportation and Parking Analysis

*Traffic Impact Review Guidelines and Process*

The City may want to consider developing a traffic impact assessment/analysis (TIA) template to guide the assumptions to use in preparing TIAs. As a starting point, the City could request that the following information be submitted by the applicant and approved by the City prior to collecting traffic data and initiating the TIA:

- Trip generation rate (ITE-based rates for both peak hour generator and peak hour of adjacent streets, or other based on empirical evidence)
- Trip distribution
- Parking demand (ITE or other based on empirical evidence)
- Study intersections
- Annual ambient traffic growth rate
- Related projects

*Off-Street Parking and Site Access*

The City's parking and circulation regulations were adopted before the advent of modern warehouses and distribution centers, which are now serviced by larger trucks. Specifications and design of truck parking for long duration or overnight parking, trailer storage, as well as dock spaces in length and width, should accommodate the largest commercial motor vehicle. In addition, sufficient truck parking spaces or designated areas for staging may be needed to prevent queuing onto public streets. The number of spaces and dimensions should be consistent with the proposed use and potential future re-uses of the

site. Today's standard over-the-road heavy-duty trucks carry 53-foot trailers with a total length (tractor and trailer) of 65 feet. These trucks are typically 8.5 feet wide and 13.5 feet tall. Below are some examples of off-street truck parking provisions developed to reflect the increase in truck sizes and changing parking uses:

- **Staging Spaces:** Two 12-foot-by-75-foot truck staging spaces for each loading dock. A minimum of five percent of required truck staging spaces shall be reserved for outbound trucks which are required to layover or rest due to hours-of-service regulations. Such spaces must be accessible during and after the facility's operating hours as necessary.
- **Loading Spaces:** One 12-foot-by-75-foot truck loading space for each loading dock.
- **Loading Docks:** The minimum number of loading docks shall be determined using the following calculation: *Number of trucks per hour* (at the peak hour of the use) multiplied by the *turnaround time per truck* (in hours). The number of docks determined by the above formula shall be rounded up to the next whole number. For example: 17 trucks are required to be serviced during the peak hour of use, each requiring 45 minutes (0.75 hours) to service. This equates to 17 trucks per hour multiplied 0.75 hours per truck, resulting in the need for 12.75 docks, which would be rounded up to 13 docks. If a particular tenant has not been identified for the facility, a minimum of one loading dock shall be provided per 5,000 square feet of building gross floor area.
- **Reserved Spaces:** Reserve a minimum of 5% of the proposed total tractor-trailer parking spaces for trucks that are required to arrive early or to layover or rest due to hours-of-service regulations. Such spaces must be made available to tractor-trailers 24 hours a day, seven days a week.

### *Dimensional Requirements and Emergency Response*

Industrial warehouses are often characterized by their substantial size relative to other buildings in a community. Today, regional freight facilities typically range between 400 KSF and 1 million square feet. These facilities are often greater than four stories tall, to provide as much space as possible to store goods prior to movement. The combination of square footage and building height can pose visual impacts and potential challenges to emergency responders. Examples of codes from other jurisdictions to address height and building coverage and emergency access:

- Structures higher than a certain height may be permitted as a conditional use, provided that fire protection measures above and beyond those normally required would be provided as the Supervisors determine are necessary, after providing the Township Fire Commissioner with an opportunity for a review.
- Total Impervious Coverage — 50% (At least 30% of the total lot area shall be lawns and/ or vegetation land cover).
- An exterior access stair tower shall be provided to allow public safety personnel direct emergency access to the roof of the building from the ground level. Steps, guiderails, handrails, brackets, gates, and other components shall meet or exceed applicable Uniform Construction Code and Occupational Safety and Health Administration (OSHA) standards. The final location and

specifications for the exterior access stair tower shall be subject to review and approval by the Emergency Services Coordinator and/or Fire Marshall.

- Commercial Knox Boxes[27] are required to provide public safety personnel access to any secured areas of the site, the principal building structure, and any accessory structures. The final location(s) and specifications for Knox Boxes shall be subject to review and approval by the Emergency Services Coordinator and/or Fire Marshall.
- Plans that accompany special exception or conditional use applications, or subdivision or land development applications, should clearly identify the location, design, and capacity of water storage facilities intended for fire suppression.
- Municipalities should require requests for special exceptions and conditional uses, as well as all subdivision and land development applications for freight-based development, be submitted to emergency service providers for their comment and review. Thresholds for review, such as a minimum square footage of principal building and trip generation rate, can be used to determine which applications should be reviewed.

*Driver and Facility Amenities*

Land development plans for freight centric or freight movement dependent operations need to provide accommodations at their facilities to enable the truck drivers essential to their operations to comply with federal laws regulating the hours a driver may operate a commercial vehicle. At federal level, the Federal Motor Carrier Safety Administration (FMCSA) regulates the maximum amount of time drivers are permitted to be on duty including driving time, and specifies number and length of rest periods, to help ensure that drivers stay awake and alert.[28] Freight land uses and facilities should incorporate onsite parking for the commercial vehicles that are essential to the operations of the building or use.

It should be noted that drivers of a commercial motor vehicle (CMV) or commercial trucks that fall under the hours of service (HOS) regulations are defined as being used as part of a business, is involved in interstate commerce, and fits any of the following descriptions:

- Weighs 10,001 pounds or more
- Has a gross vehicle weight rating or gross combination weight rating of 10,001 pounds or more
- Is designed or used to transport 16 or more passengers (including the driver) not for compensation
- Is designed or used to transport nine or more passengers (including the driver) for compensation
- Is transporting hazardous materials in a quantity requiring placards. There are special exemptions from these HOS requirements such as:
    - Short-Haul: Driving within 150 miles of the origin and destination and must start and end within 14 hours at the same starting location.

[27] Knox Emergency Boxes provide onsite, high security storage for pre-fire plans, key storage, elevator drop keys, Haz-Mat data and other emergency items.
[28] Code of Federal Regulations (CFR). Title 49 – CFR 395.3

- Adverse Driving Conditions: Drivers can extend their duty day and driving time by up to two hours when adverse driving conditions are encountered. Adverse driving conditions include snow, ice, sleet, fog, or other weather conditions or unusual road or traffic conditions that were not known, or could not reasonably be known, to:
    - A driver immediately beginning the duty day or immediately before driving after a qualifying rest break or sleeper berth period, or:
    - A motor carrier immediately before dispatching a driver

Long-term or overnight truck parking amenities should provide or enable trucks to:

- Have easy access to trash receptacles
- Adequate lighting to provide security for drivers while sleeping or resting
- Directional signage to major interstates or common freight destinations

Additionally, it is important that the freight-based land use also provide amenities for the driver to utilize while restricted from driving. These amenities may include:

- Driver Lounges with vending machines
- Rest Rooms
- Showers
- Wi-Fi Internet access
- Dog walking
- Multimodal trails

### *Multimodal Access*

Municipalities should plan for the availability of trails, sidewalks, and access to transit facilities when planning for the location of freight-based operations. This infrastructure serves both drivers accessing the site as well as providing employees options for commute trips. The subdivision and land development approval process should require consultation with transit providers on the optimal location for transit stops. Sidewalks and trails should also be required to connect with existing and proposed trail and sidewalk systems.

Dedicated parking spaces for alternative modes of transportation encourage choices that support the City's greenhouse gas (GHG) reduction goals and promote health and well-being. In addition, the City may require tenants to establish and promote a rideshare program that discourages single-occupancy vehicle trips and provides financial incentives for alternate modes of transportation, including carpooling, public transit, and biking.

# Possible Project Conditions or Standards to Address Climate Action Goals

Warehouse developments offer opportunities to further the City's Climate Action Plan by providing incentives or codifying sustainable design features or business practices, where applicable. Generally, there are industry efforts to address climate change. From fleet owners to policymakers, various stakeholders are taking the initiative to reduce the impact of e-commerce on GHG emissions. Examples of e-commerce platforms and shippers with climate-related commitments to ensure zero emission deliveries include Amazon, IKEA, Nestle, and Walmart.[29] Additionally, developers are also incorporating sustainable design features in their warehouse developments. **Figure 5** illustrates how Prologis developers are incorporating sustainable practices in warehouse developments. The design features the City can incorporate to address climate action goals include the following[30]:

## Energy Provisions & Conservation

**Power Requirements:** The City should consider requiring the installation of adequate electric infrastructure for charging electric vehicles, charging trucks at loading docks, powering refrigeration units of temperature-controlled trailers, and providing auxiliary power for diesel trucks to allow climate control and use of in-cab electronics without idling.

**Auxiliary power/ electric truck charging**: Locate plug-ins at dock doors.[31]

**Solar, storage, and wind power**: Warehouses are viable candidates for alternative energy systems, including photovoltaic solar cells and battery storage. In particular, warehouses have huge, flat, unobstructed roofs that are ideal for solar arrays capable of pumping out torrents of clean, renewable energy. The City should consider requiring warehouse developers and tenants to install alternative energy systems.

As an example, the City of Seattle regulates renewable energy and solar-ready roofs for commercial buildings as outlined in the 2018 Seattle Energy Code (Section C411 and Section C412).[32, 33] The regulatory requirements centered around solar readiness are based on roof area and electrical service as indicated below. As a general requirement for on-site renewable energy systems, each new building larger than 5,000 sf of gross conditioned floor area is required to include a renewable energy generation system consisting of not less than 0.25 watts rated peak photovoltaic energy production per square foot of conditioned space.[33]

[29] Nowlan, A., and Usmani, S. Accelerating Zero-Emissions Delivery: An innovative approach to transforming the last mile. Environmental Defense Fund, 2021
[30] Prologis. Sustainable Design Features & Benefits. 2023
[31] SafeConnect. Docking Stations.
[32] City of Seattle. Renewable Energy and Solar-Ready Roofs for Commercial Buildings. 2021
[33] City of Seattle. 2018 Seattle Energy Code. 2021

*Solar Readiness Example*

**Example:** A building with a 10,000 SF total roof area, 1,000 SF skylight area, and a 400 Amp, 240-volt single phase electrical service is required to provide a solar zone area of the smaller of the following:

1. [40% x (10,000 SF roof area – 1,000 SF skylights)] = 3,600 SF; or
2. [400 Amp x 240 Volts x 20% / 10 watts per SF] = 1,920 SF

Therefore, a *solar zone* of 1,920 square feet is required.

Source: 2018 Seattle Energy Code (Section C411)

**Motion sensors:** Use of motion sensors to turn on lights for workers when natural light is not sufficient.

**Skylights and clerestory windows:** Utilize natural light to lower electricity use and associated greenhouse gas emissions and improve indoor environmental quality for warehouse personnel.

**High-reflectance roof membranes**: Traditionally, warehouse roofing has black ethylene propylene diene terpolymer (EPDM) rubber membranes that absorb heat from sunlight. White thermoplastic polyolefin (TPO) roofing, also known as "cool roofs," offers equal performance at similar costs while comparatively reducing heat absorption and often providing a more comfortable work environment. This design feature can also lower operating costs by reducing energy use in air-conditioned spaces.

**Climate control:** Ventilation system that utilizes outside air drawn through louvers facing the prevailing winds, supplemented by energy efficient heating and cooling systems.

## Water Conservation & Waste Management

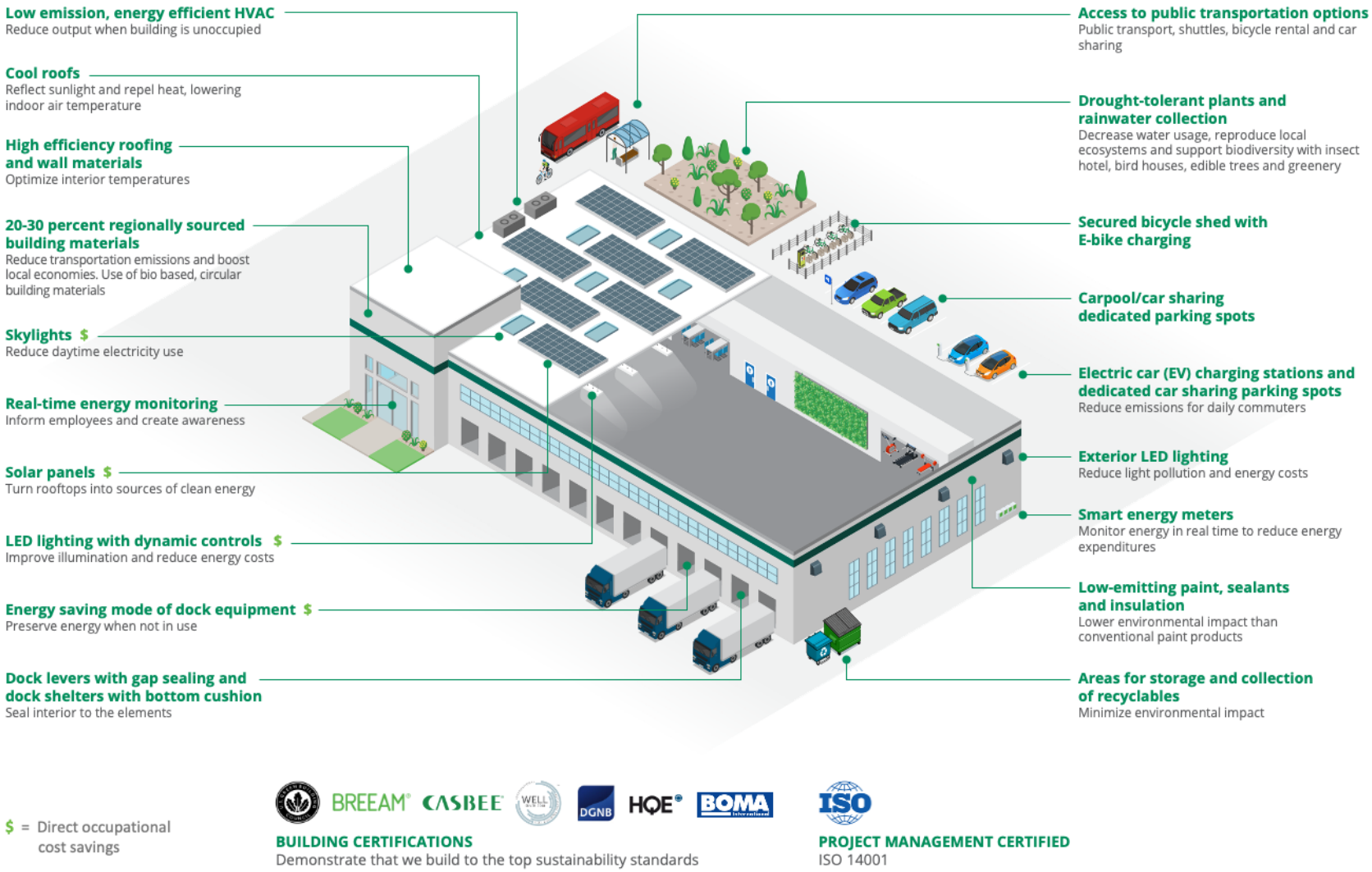
**Water conservation measures**: Exterior landscaping, motion-activated faucets, low-flow toilets, waterless urinals, and captured rainwater for irrigation all reduce the use of fresh water. Use native plant species and drip irrigation.

**Dedicated area for onsite recycling**: Support water and waste recycling efforts, such as onsite shredding and compaction of recyclable cardboard and other materials on site.

**Physical, structural, and/or vegetative buffers** that adequately prevent or substantially reduce pollutant dispersal between warehouses and any areas such as homes, schools, daycare centers, hospitals, community centers, and parks.

**Environmentally Friendly Building Materials:** Use low emitting VOC materials, such as glues, adhesives, paints etc.; use recycled construction materials to construct buildings.

## Figure 5: An Example Warehouse Development that Advances Sustainability




Source: Prologis, Prologis Buildings, A Story of Sustainability. 2023.

# Appendix A

**Table 7: Differences between Traditional Warehouses and E-commerce Facilities**

| Characteristics | Traditional Warehouse | E-commerce Facilities |
|---|---|---|
| Physical | • Smaller building footprint<br>• Lower clear heights[34] under 30 feet<br>• Fewer dock doors<br>• Typically located close to other industrial uses (targeted clients) | • Variation in building footprint; emphasis is on space utilization<br>• Higher clear heights (over 36 feet) to allow for storing multiple stock keeping unit (SKUs)<br>• More dock doors, especially at transload facilities<br>• Near population centers, ports, and/or intermodal railyards with easy freeway access to serve consumers (front porch) |
| Operational | • Slower turnover of stored goods<br>• Goods are stored in bulk for usually more than a day then distributed<br>• Operations are typically limited to normal business hours, i.e., 8-hour day shifts, five days per week<br>• Fewer employees, primarily unskilled labor<br>• Fewer daily vehicle trips, (includes medium- and heavy-duty truck trips) - limited to less than two total vehicles per 1,000 square feet of building gross floor area | • High turnover of goods<br>• Goods may be sorted, consolidated, and repackaged in less than a day before distribution<br>• More likely to have automation, such as Radio Frequency Identification (RFID) to manage inventory and fully automated sortation, stocking and retrieval<br>• Around-the-clock operations<br>• Fewer unskilled workers; creates high-tech jobs<br>• More daily vehicle trips (ranges from 1.40 to 6.44 total vehicles per 1,000 square feet of building gross floor area)<br>• More van trips for first/last mile deliveries |
| Economic | • Limited to unskilled labor and managerial jobs with lesser earnings than in high-tech warehouses<br>• Generates less indirect jobs<br>• Less local and regional economic impacts | • May entail some high paying jobs such as automation engineers with average salaries over $100,000 a year<br>• Generates more indirect jobs as these facilities support several other industries<br>• More local and regional economic impacts |

Source: Fehr & Peers. 2023

[34] In industrial real estate, building clear height dictates the height to which inventory can be safely stored.

# Appendix B

## County Business Patterns Data

**Table 8: Average Employees per Establishment for Warehousing and Storage**

| Counties | Employees per Establishment | | | | | | Change 2016-2021 |
|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | |
| Clark County, Washington | 28 | 24 | 27 | 33 | 38 | 42 | 50% |
| Yakima County, Washington | 91 | 89 | 86 | 81 | 80 | 82 | -10% |
| Lewis County, Washington | 97 | 100 | 107 | 108 | 105 | 109 | 12% |
| Multnomah County, Oregon | 34 | 37 | 35 | 36 | 46 | 43 | 26% |
| Washington County, Oregon | 13 | 36 | 31 | 35 | 59 | 66 | 408% |
| Clackamas County, Oregon | 36 | 41 | 22 | 16 | 16 | 43 | 19% |
| Spokane County, Washington | 24 | 26 | 29 | 25 | 24 | 25 | 4% |
| Pierce County, Washington | 75 | 50 | 49 | 50 | 57 | 49 | -35% |
| King County, Washington | 35 | 41 | 42 | 43 | 50 | 49 | 40% |
| Average | 48 | 49 | 48 | 47 | 53 | 56 | 17% |

Source: US Census Bureau, 2016 – 2021. Fehr & Peers, 2023.

**Table 9: Average Employees per Establishment for Manufacturing**

| Counties | Employees per Establishment | | | | | | Change 2016-2021 |
|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | |
| Clark County, Washington | 33 | 33 | 32 | 34 | 33 | 31 | -6% |
| Yakima County, Washington | 39 | 41 | 42 | 39 | 37 | 36 | -8% |
| Lewis County, Washington | 28 | 30 | 31 | 34 | 34 | 32 | 14% |
| Multnomah County, Oregon | 29 | 28 | 30 | 31 | 31 | 27 | -7% |
| Washington County, Oregon | 40 | 55 | 54 | 58 | 59 | 55 | 38% |
| Clackamas County, Oregon | 33 | 30 | 29 | 29 | 30 | 30 | -9% |
| Spokane County, Washington | 29 | 28 | 29 | 30 | 31 | 29 | 0% |
| Pierce County, Washington | 32 | 32 | 33 | 33 | 35 | 33 | 3% |
| King County, Washington | 39 | 39 | 39 | 41 | 41 | 38 | -3% |
| Average | 34 | 35 | 35 | 37 | 37 | 35 | 3% |

Source: US Census Bureau, 2016 – 2021. Fehr & Peers, 2023.

**Table 10: Employees per Establishment for Scientific Research and Development Services**

| Counties | Employees per Establishment | | | | | | Change 2016-2021 |
|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | |
| Clark County, Washington | 14 | 17 | 20 | 20 | 17 | 21 | 50% |
| Yakima County, Washington | - | - | - | - | - | - | - |
| Lewis County, Washington | - | - | - | - | - | - | - |
| Multnomah County, Oregon | 14 | 10 | 12 | 13 | 13 | 15 | 7% |
| Washington County, Oregon | 140 | -* | 162 | 165 | 143 | 138 | -1% |
| Clackamas County, Oregon | 6 | 3 | 4 | 3 | 3 | 3 | -50% |
| Spokane County, Washington | 4 | 5 | 5 | 6 | 7 | 7 | 75% |
| Pierce County, Washington | 30 | 39 | 38 | 28 | 30 | 37 | 23% |
| King County, Washington | 32 | 33 | 37 | 37 | 37 | 38 | 19% |
| Average | 34 | 18 | 40 | 39 | 36 | 37 | 8% |

Source: US Census Bureau, 2016 – 2021. Fehr & Peers, 2023.
Notes:
"-"No available data

**Table 11: Average Annual Wage for Warehousing and Storage**

| Counties | Average Annual Wage | | | | | | Change 2016-2021 |
|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | |
| Clark County, Washington | $52,774 | $42,494 | $50,093 | $55,299 | $58,491 | $58,146 | 10% |
| Yakima County, Washington | $40,470 | $40,167 | $42,877 | $46,486 | $45,682 | $47,851 | 18% |
| Lewis County, Washington | $43,390 | $37,655 | $38,493 | $40,248 | $42,177 | $43,615 | 1% |
| Multnomah County, Oregon | $59,454 | $56,566 | $58,630 | $56,863 | $53,792 | $55,249 | -7% |
| Washington County, Oregon | $50,743 | $35,884 | $44,432 | $35,778 | $22,358 | $24,441 | -52% |
| Clackamas County, Oregon | $49,618 | $48,033 | $37,162 | $42,837 | $46,170 | $55,070 | 11% |
| Spokane County, Washington | $47,417 | $49,716 | $56,143 | $51,159 | $49,452 | $52,692 | 11% |
| Pierce County, Washington | $47,458 | $46,965 | $50,019 | $55,488 | $52,580 | $48,903 | 3% |
| King County, Washington | $60,198 | $54,053 | $54,934 | $58,092 | $55,381 | $59,708 | -1% |
| Average (excluding Washington, Oregon) | $ 50,097 | $ 46,956 | $ 48,544 | $ 50,809 | $ 50,466 | $52,654 | 5% |

Source: US Census Bureau, 2016 – 2021. Fehr & Peers, 2023.

**Table 12: Average Annual Wage for Manufacturing**

| Counties | Average Annual Wage | | | | | | Change 2016-2021 |
|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | |
| Clark County, Washington | $57,339 | $58,211 | $60,167 | $59,664 | $62,305 | $67,683 | 18% |
| Yakima County, Washington | $46,421 | $45,401 | $46,602 | $52,751 | $56,223 | $52,461 | 13% |
| Lewis County, Washington | $47,506 | $51,955 | $53,442 | $55,593 | $55,101 | $61,710 | 30% |
| Multnomah County, Oregon | $52,737 | $56,749 | $61,720 | $61,337 | $57,421 | $64,269 | 22% |
| Washington County, Oregon | $67,890 | $93,612 | $95,915 | $100,181 | $98,181 | $112,930 | 66% |
| Clackamas County, Oregon | $60,528 | $60,813 | $61,615 | $63,875 | $63,122 | $70,637 | 17% |
| Spokane County, Washington | $51,858 | $51,936 | $52,285 | $54,265 | $53,598 | $57,287 | 10% |
| Pierce County, Washington | $54,729 | $55,551 | $57,429 | $59,635 | $56,289 | $62,867 | 15% |
| King County, Washington | $70,054 | $74,031 | $75,578 | $81,671 | $77,961 | $84,535 | 21% |
| Average | $56,562 | $60,918 | $62,750 | $65,441 | $64,467 | $70,487 | 25% |

Source: US Census Bureau, 2016 – 2021. Fehr & Peers, 2023.

**Table 13: Average Annual Wage for Scientific Research and Development Services**

| Counties | Average Annual Wage | | | | | | Change 2016-2021 |
|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | |
| Clark County, Washington | $99,175 | $88,833 | $85,088 | $100,811 | $262,809 | $154,401 | 56% |
| Yakima County, Washington | - | - | - | - | - | - | |
| Lewis County, Washington | - | - | - | - | - | - | |
| Multnomah County, Oregon | $80,865 | $79,689 | $83,813 | $88,613 | $94,260 | $96,140 | 19% |
| Washington County, Oregon | $156,485 | - | $172,566 | $185,406 | $187,757 | $184,753 | 18% |
| Clackamas County, Oregon | $107,356 | $62,833 | $44,300 | $61,452 | $98,972 | $103,028 | -4% |
| Spokane County, Washington | $82,134 | $71,500 | $87,275 | $80,366 | $89,741 | $91,474 | 11% |
| Pierce County, Washington | $64,474 | $69,053 | $70,543 | $72,708 | $78,525 | $69,384 | 8% |
| King County, Washington | $107,026 | $110,600 | $114,221 | $132,973 | $142,585 | $154,854 | 45% |
| Average | $99,645 | $80,418 | $93,972 | $103,190 | $136,378 | $122,005 | 22% |

Source: US Census Bureau, 2016 – 2021. Fehr & Peers, 2023.
Notes:
"-"No available data