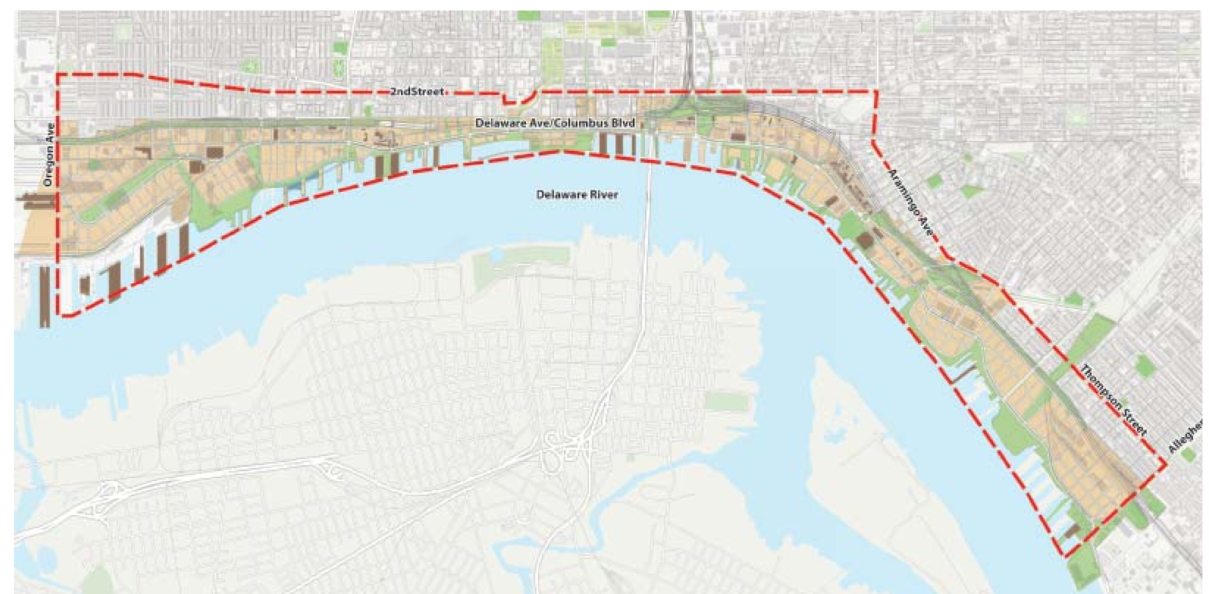

Central Waterfront Redevelopment Traffic Impact Analysis

Case Study Comparison of the Vision and the Trend Scenarios

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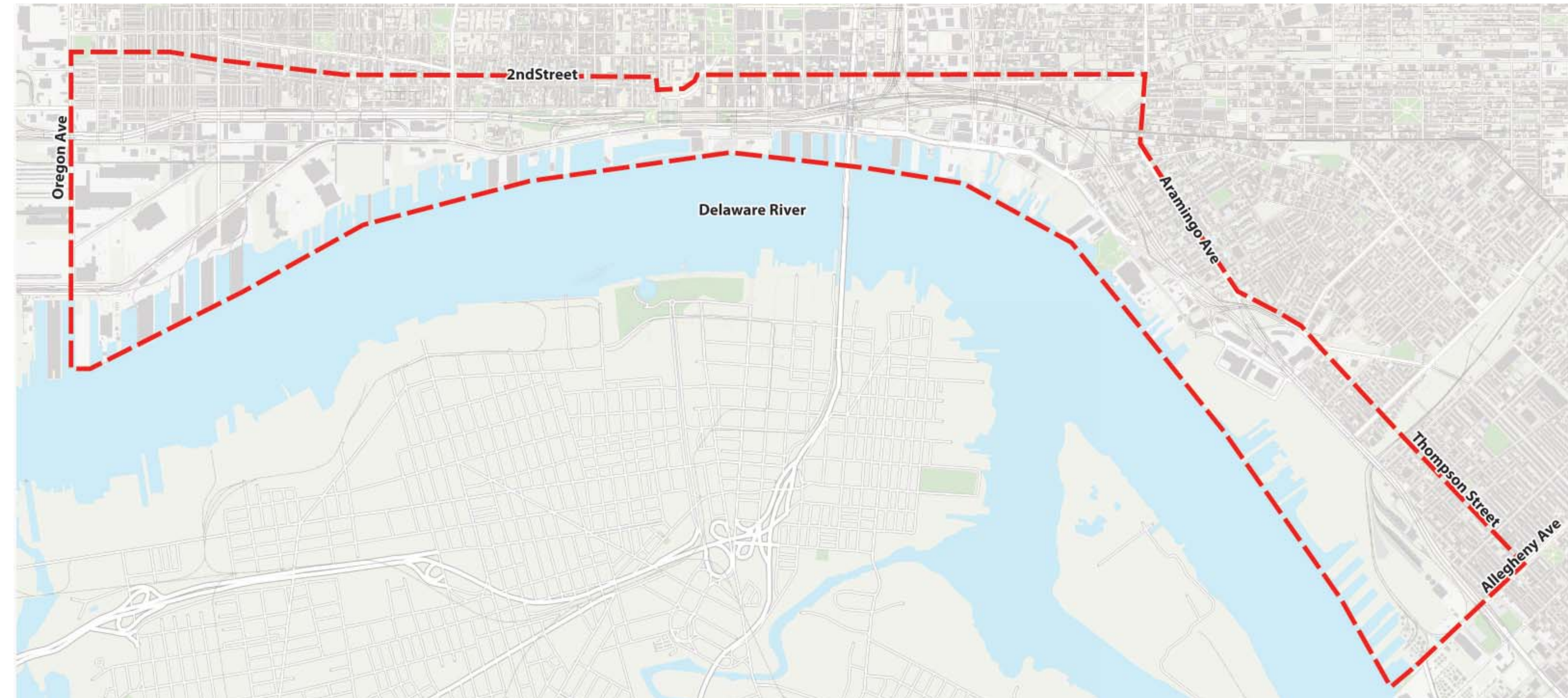
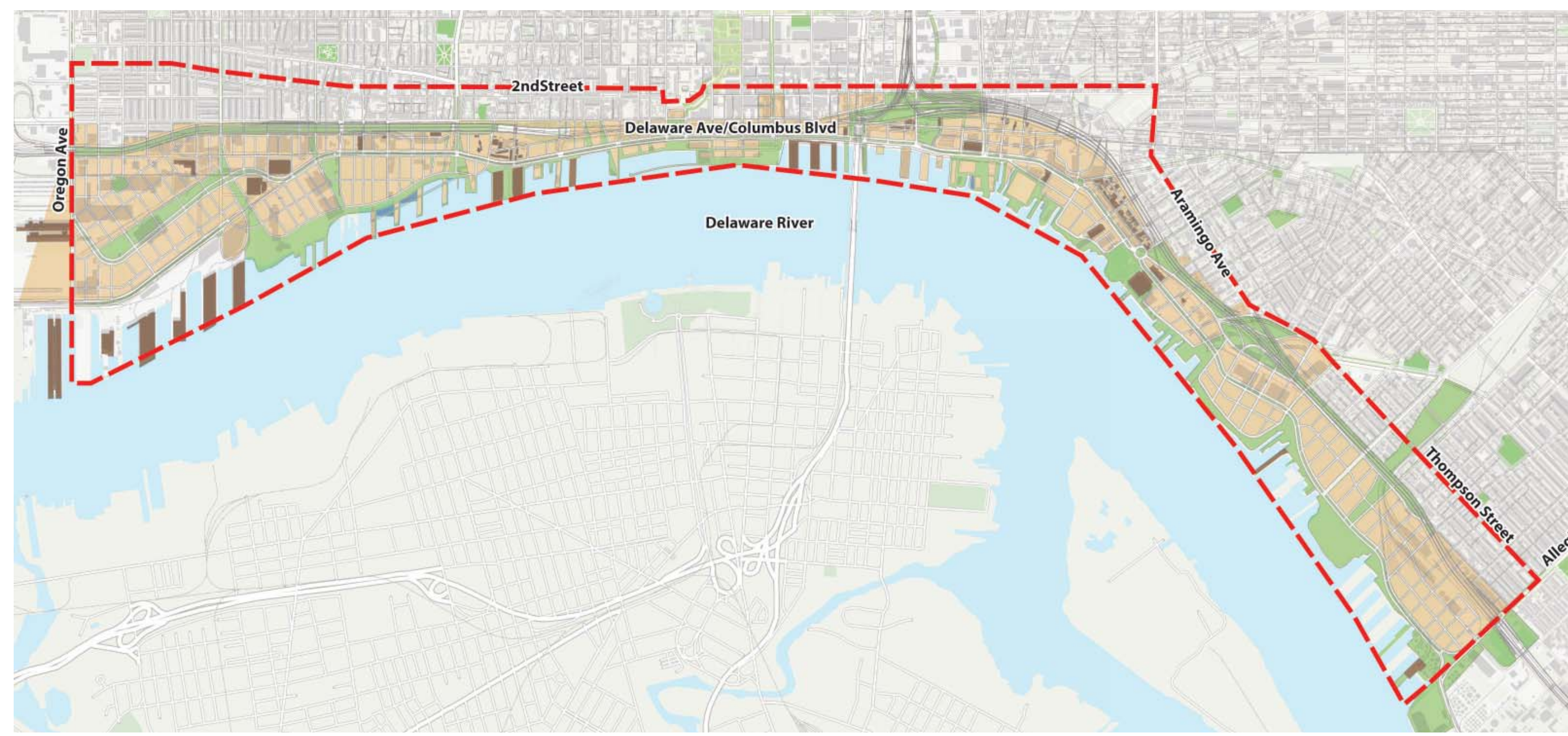
October 30, 2007

Overview

This report provides a case study that compares the effects of the transportation infrastructure changes called for by the vision plan with that of a "trend scenario". The analysis looks into the two scenarios' total trip-making ability, traffic efficiency, and the ability of the transportation infrastructure to support changes in land uses over time.

The trend scenario is a continuation of the development pattern that has developed on the waterfront in recent years, where proposed developments tend to serve single land uses and developed with limited transportation infrastructure improvements. The Vision Plan illustrates a future scenario where a new network of roadways, pedestrian trails, and transit improvements occur to serve a mix of land uses.



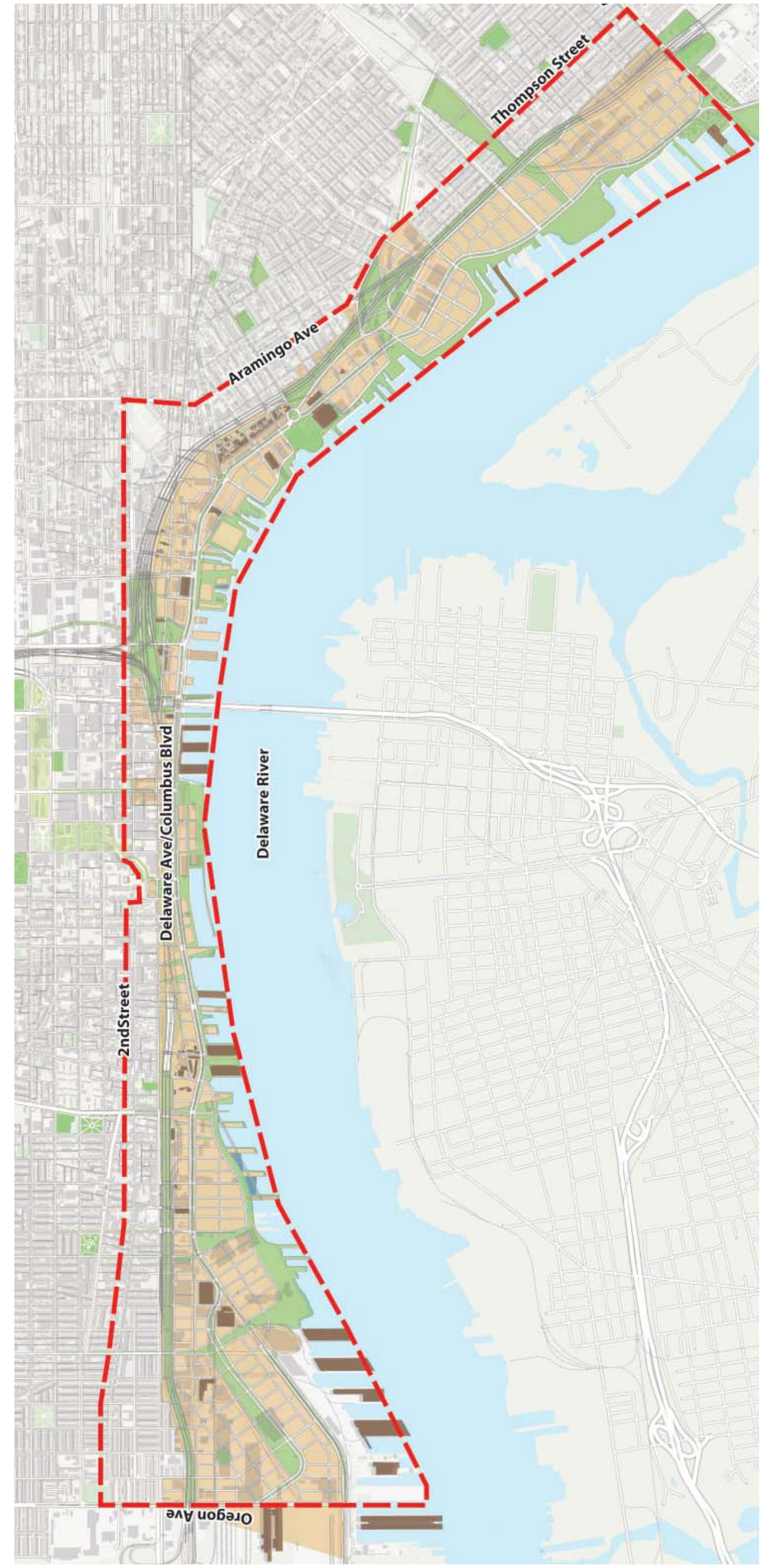


The study area for this case study is generally defined by Oregon Street on the south, 2nd Street and Girard Avenue, Aramingo Avenue, and Thompson Street on the west, Allegheny Avenue to the North, and the Delaware River to the east. The top graphic illustrates the trend scenario and the bottom graphic is the Vision Plan.

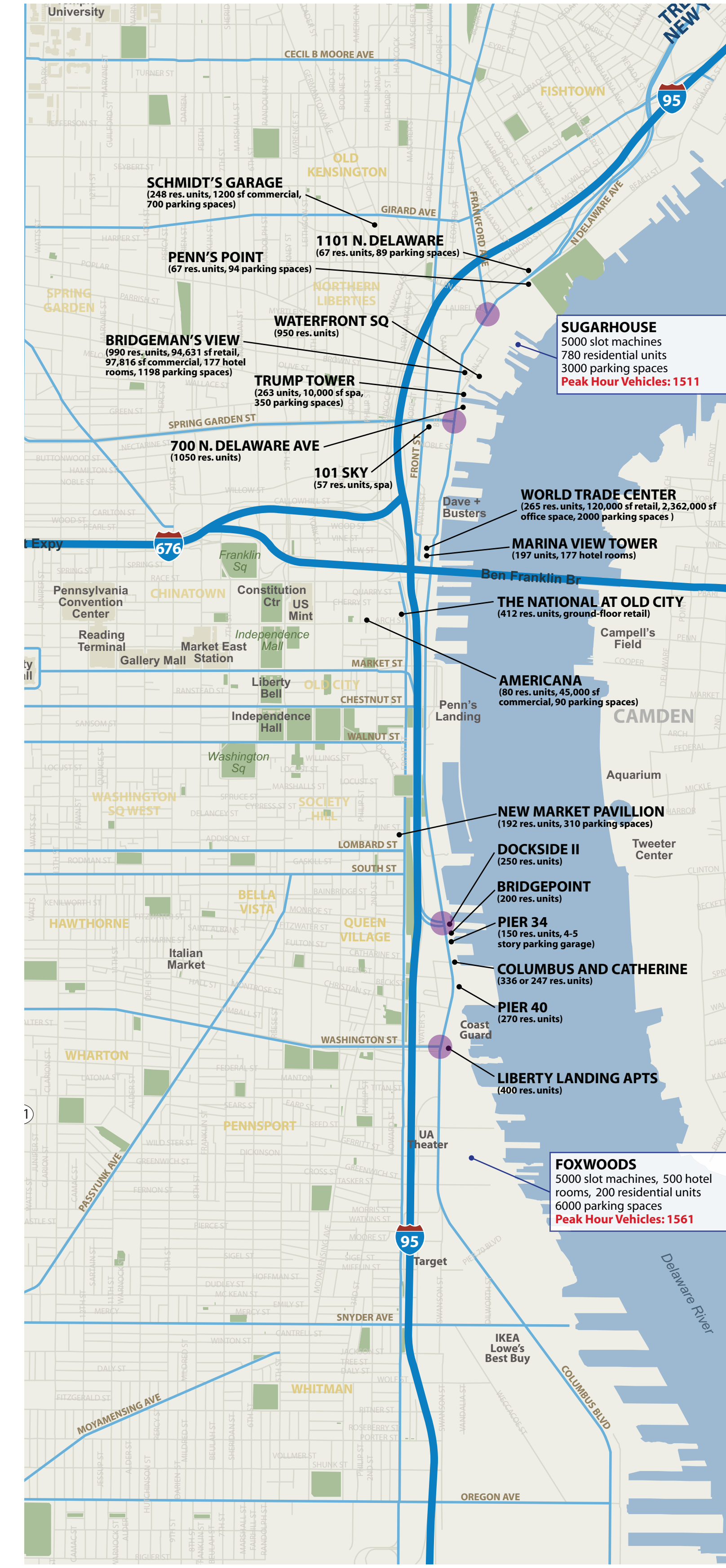
The following table summarizes the characteristics of the trend and vision scenarios.

Characteristics of Trend and Vision Development Scenarios

Trend: Existing roadway conditions with proposed developments	Vision: Development with mixed land uses and expanded transportation options
Land Use	
• Sugarhouse and Foxwood Casinos with 10,000 slot machines, 980 residential units, and 500 hotel rooms • More than 8,000 residential units, 2.7 million square feet of commercial uses, and 350 hotel rooms • Each development is located in individual blocks.	• Mix of hotels, office, residential, and commercial uses including the current proposed developments in the trend scenario. • High-density developments in core areas transitioning to medium-density developments closer to the neighborhoods • Developments can span multiple urban-sized (smaller) blocks. • Average floor-area-ratio of 4.0
Roadways	
• 6-lane Delaware Boulevard	• 4-lane Delaware Boulevard • Expanded local street network
Pedestrian and Bicycle Network	
• Sidewalks • On-street bicycle lane	• "Complete Streets"—sidewalks, on-street parking, transit • Riverfront trail
Transit	
• Some bus transit • Employee bus shuttle	• Trolley expansion and/or new BRT • LRT expansion • Bus transit



The Vision Plan has a mix of residential, commercial, entertainment, office and open space uses.



The trend scenario includes a number of currently proposed developments.

Comparing the Two Scenarios

1. Vehicular Trip-Making Ability

The two development scenarios offer varying opportunities and capacities for access and mobility for vehicles. In general, each scenario was evaluated based on its through-put capacity, opportunities for waterfront-bound trips, and its ability to accommodate local mobility and access.

Through-put Capacity

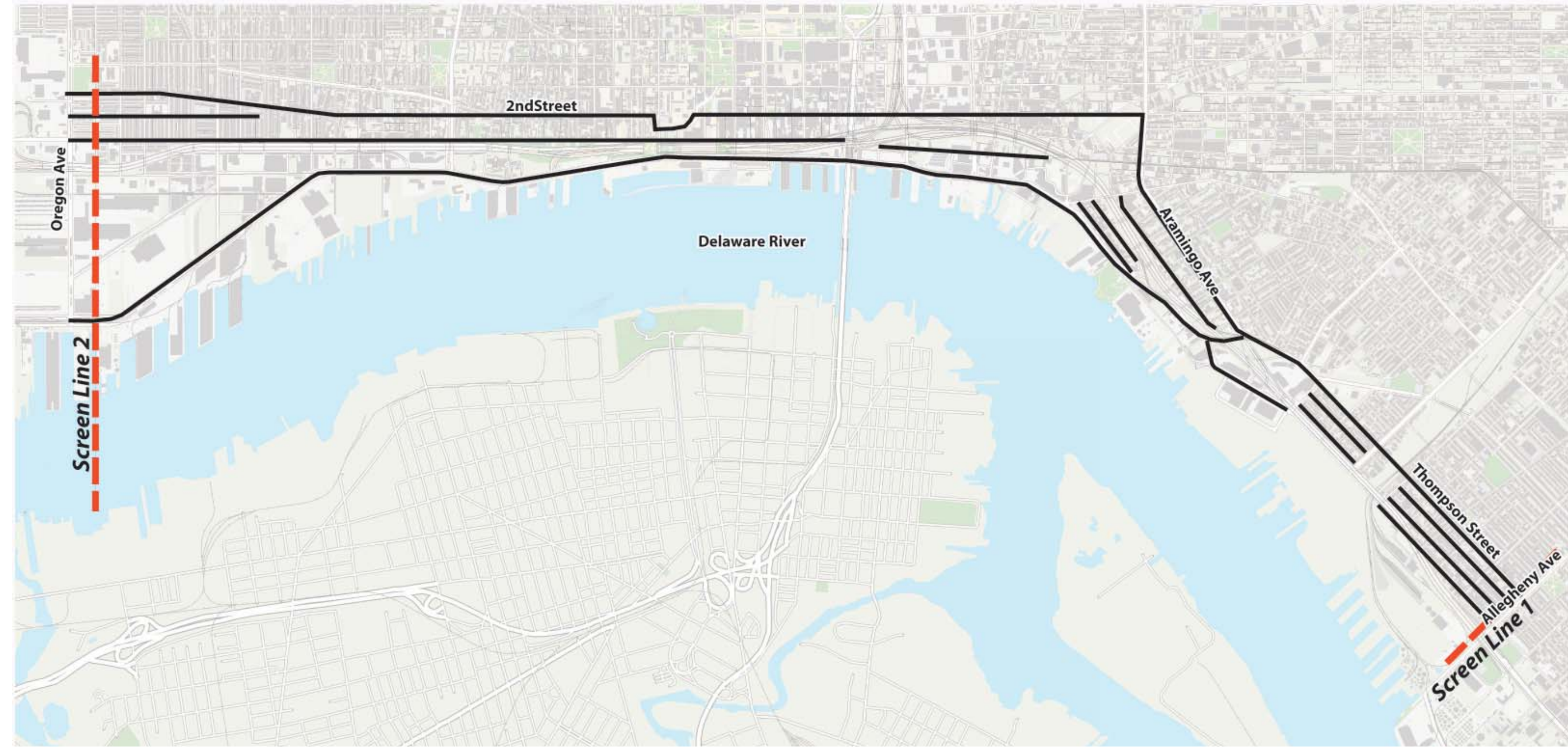
In the trend scenario, a total of 63 lane-miles of roadway will serve the study area. In contrast, the expanded network of streets in the vision plan will have 40% more vehicular capacity at a total of 89 lane-miles of roadway.

In addition to the increased roadway lane miles, the vision plan would also potentially offer a higher north-south through-put capacity for the central waterfront area. Using screen lines at Allegheny Avenue and at Shunk Street, the vision plan demonstrated up to an 80% and 35% increase in traffic capacity, respectively.

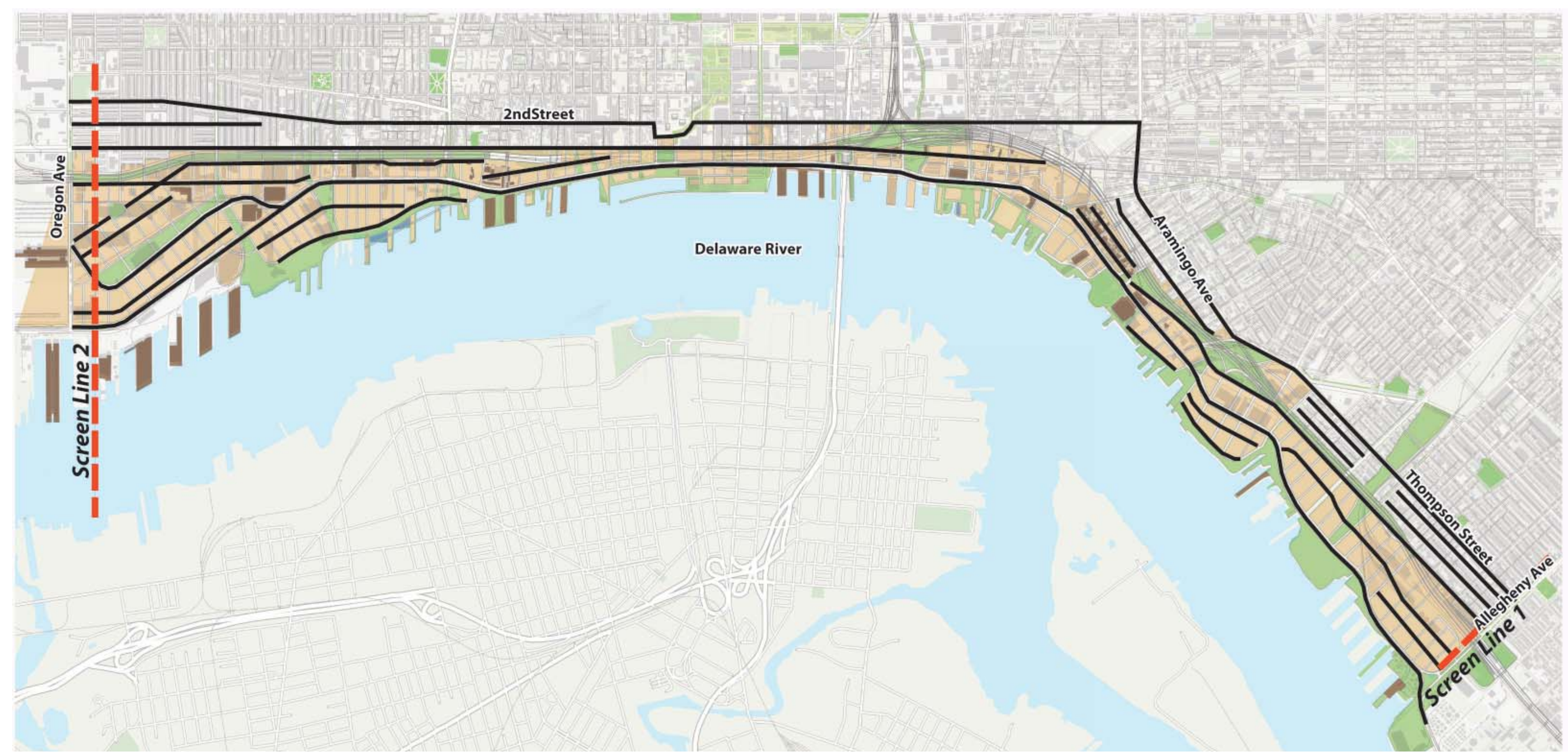
Projected Capacity [Annual Average Daily Traffic (AADT)] for Trend and Vision Scenarios*

Screen Line Location	Trend Scenario	Vision Scenario
At Allegheny Avenue	54,800	98,800
At Oregon Shunk Street	111,560	150,860

** The projected AADT was estimated using the Generalized AADT volumes for Florida's Urbanized Areas with a level of service standard of "D".*



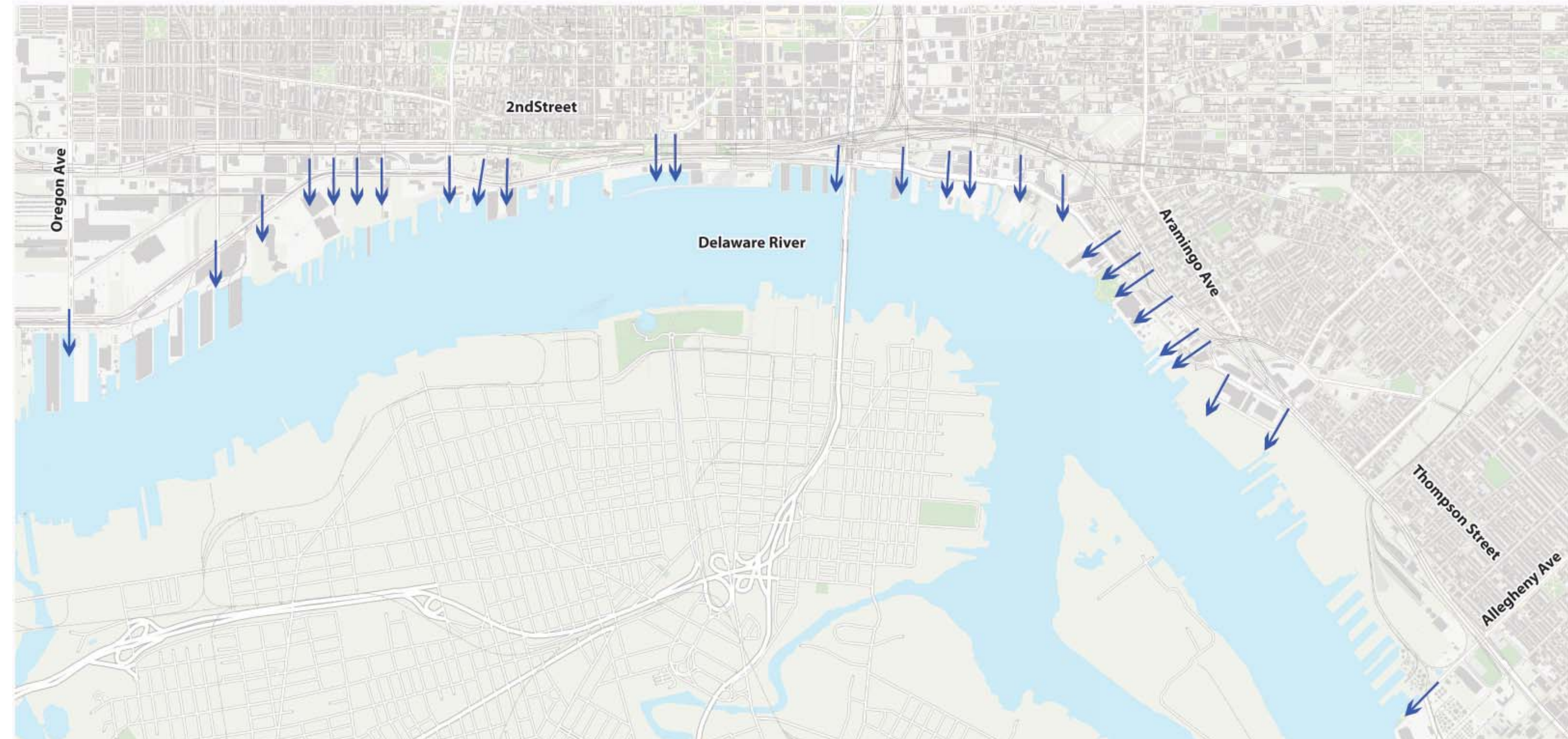
Trend Scenario North-South Roadways



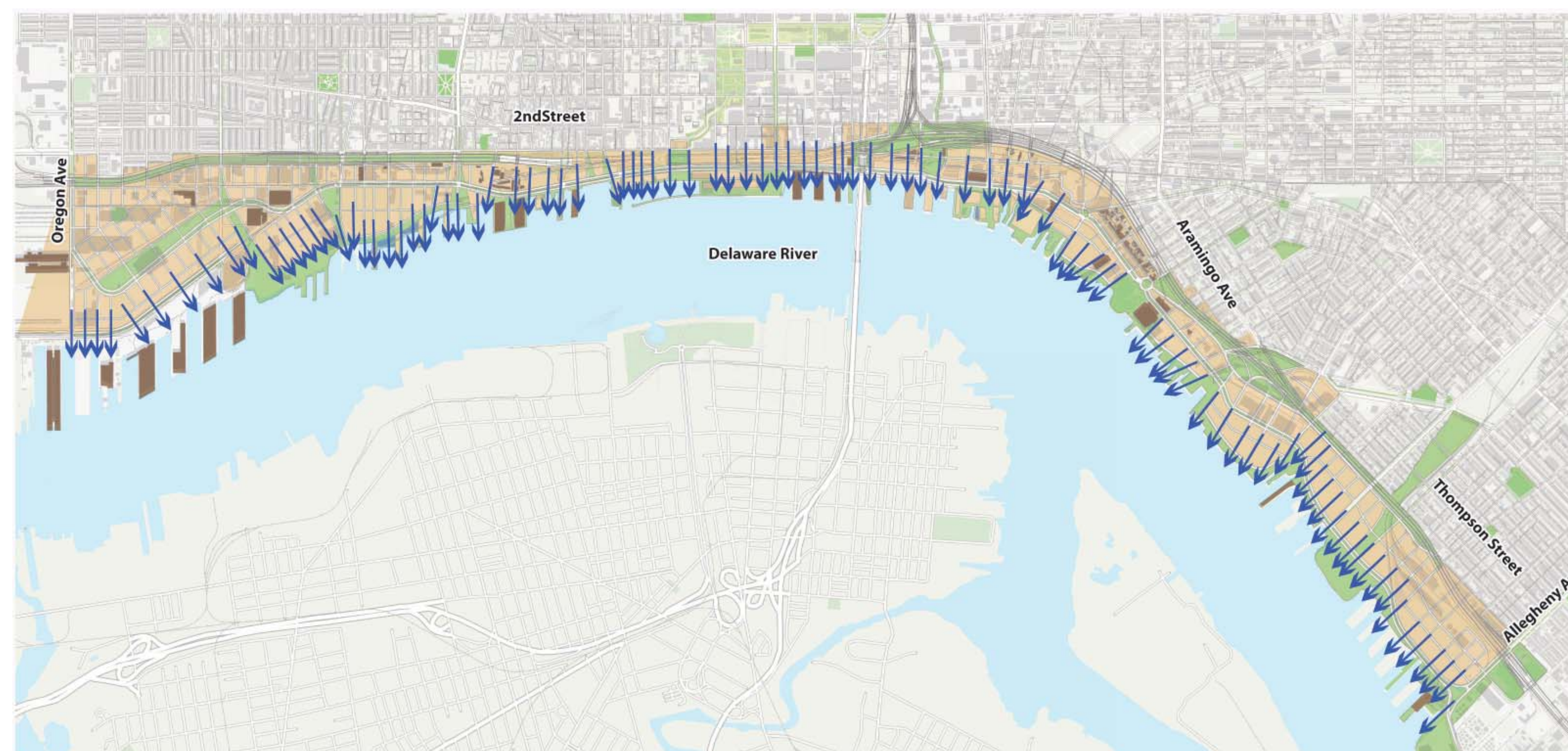
Vision Plan North-South Roadways

Access to the Waterfront

The number of roadways leading directly to the Delaware/Columbus Avenue determines the permeability of the Central Waterfront area. Again, using this measure, the vision plan outperforms the trend scenario. Within the study area, the trend scenario provides 27 roadway access points to the Waterfront, while the vision plan offers 95 roadway access points to the waterfront.



Trend Scenario Waterfront Access Points

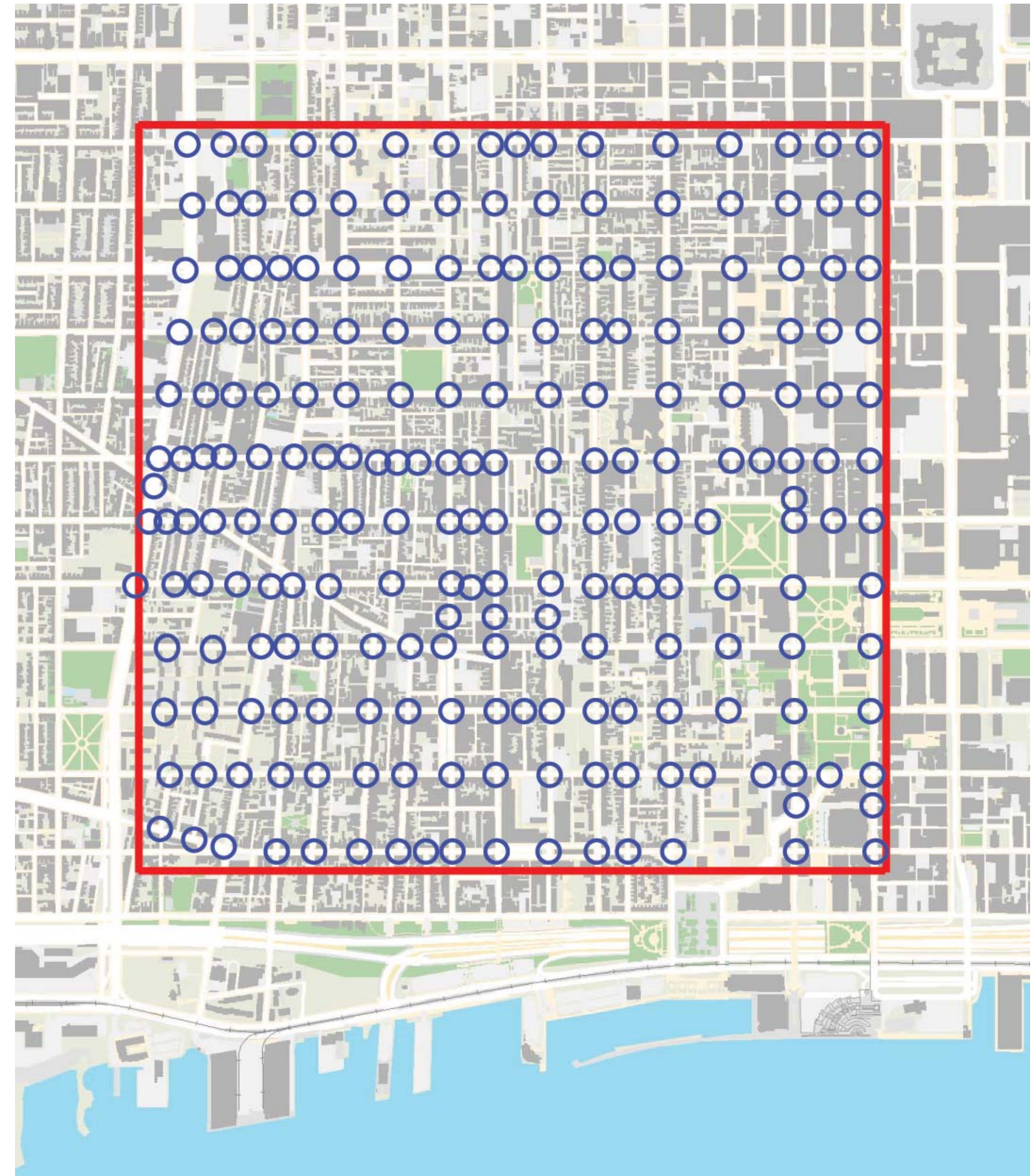


Vision Plan Waterfront Access Points

Circulation and Local Access

The level of local access was evaluated using the density of intersections within the study boundary. Within a well-connected street network, there are redundant paths that vehicles can use to access the same destination. This increase in path choice can be measured by the number of intersections within a certain area. Areas with higher concentrations of intersections are areas with higher potentials for accessibility. The following series of images visualizes this characterization of accessibility.

Using this metric, the vision plan clearly shows a higher level of local access than the trend scenario. The trend scenario has 407 at-grade intersections (186 intersections per square mile) while the vision plan has 688 at-grade intersections (or 315 intersections per square mile). In contrast, Old City Philadelphia has an average of 220 intersections per acre.

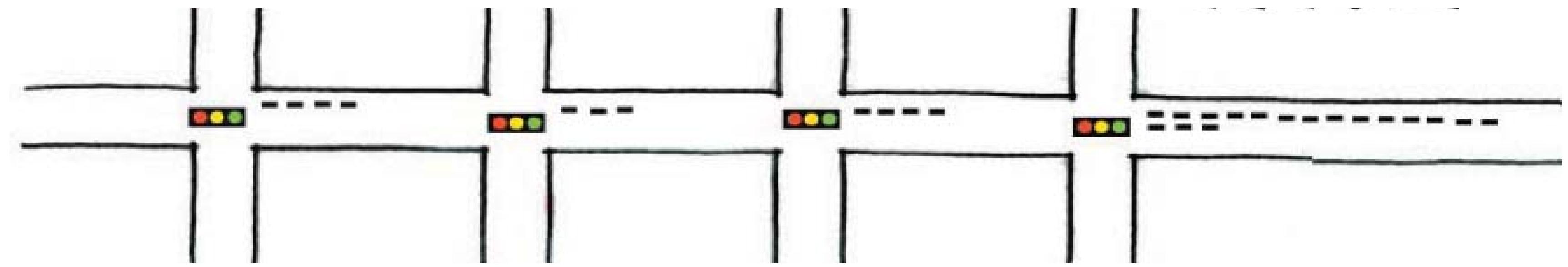


The well connected street network in Old City has an intersection density of 220 intersections per acre.

Traffic Efficiency
One of the great benefits to the actual system of traffic movement within a connected network of streets that is offered by the Vision Plan is multiple, frequent opportunities for left turns. This allows traffic signals to avoid high volumes of left-turning traffic to be channeled to a few signal locations creating longer left-turn green time needed and less efficient signal cycles. When left-turning traffic is distributed throughout the network, smaller and even non-signalized intersections operate in the 'shadow' of the thru-phase green time, resulting in shorter delays. Left-turning traffic channeled through fewer intersections can have a tendency to create problematically long queues that block driveways and can require lengthened or multiple auxiliary lanes (e.g. for left turns).

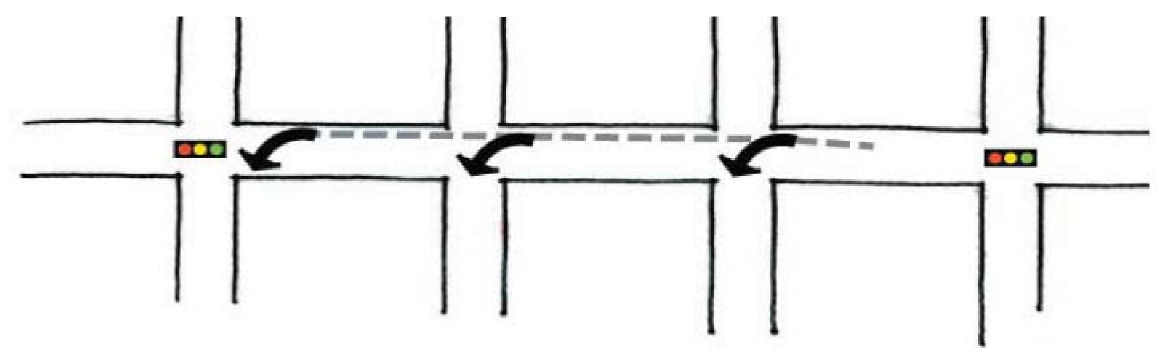
Also, because of its denser network, the roadways in the Vision Plan will provide more "resilience" by increasing route options for motorists and fewer potential problems when a particular street or link is closed or congested.

Lastly, when compared to the trend scenario, the Vision Plan will also provide more direct routing and access to more properties in the central waterfront, avoiding inefficient routing that involves "double-backing" for services such as emergency response, garbage collection, postal service, street sweeping, etc., and resulting in lower municipal costs.



Longer blocks generate longer, more problematic queues; they require longer auxiliary lanes and the queues block driveways and curb cuts, complicating access from the street.

Frequent intersections tend to "chop" queues into smaller, more manageable groups; with coordinated signals, there is actually less signal delay in the system, even with more signals.

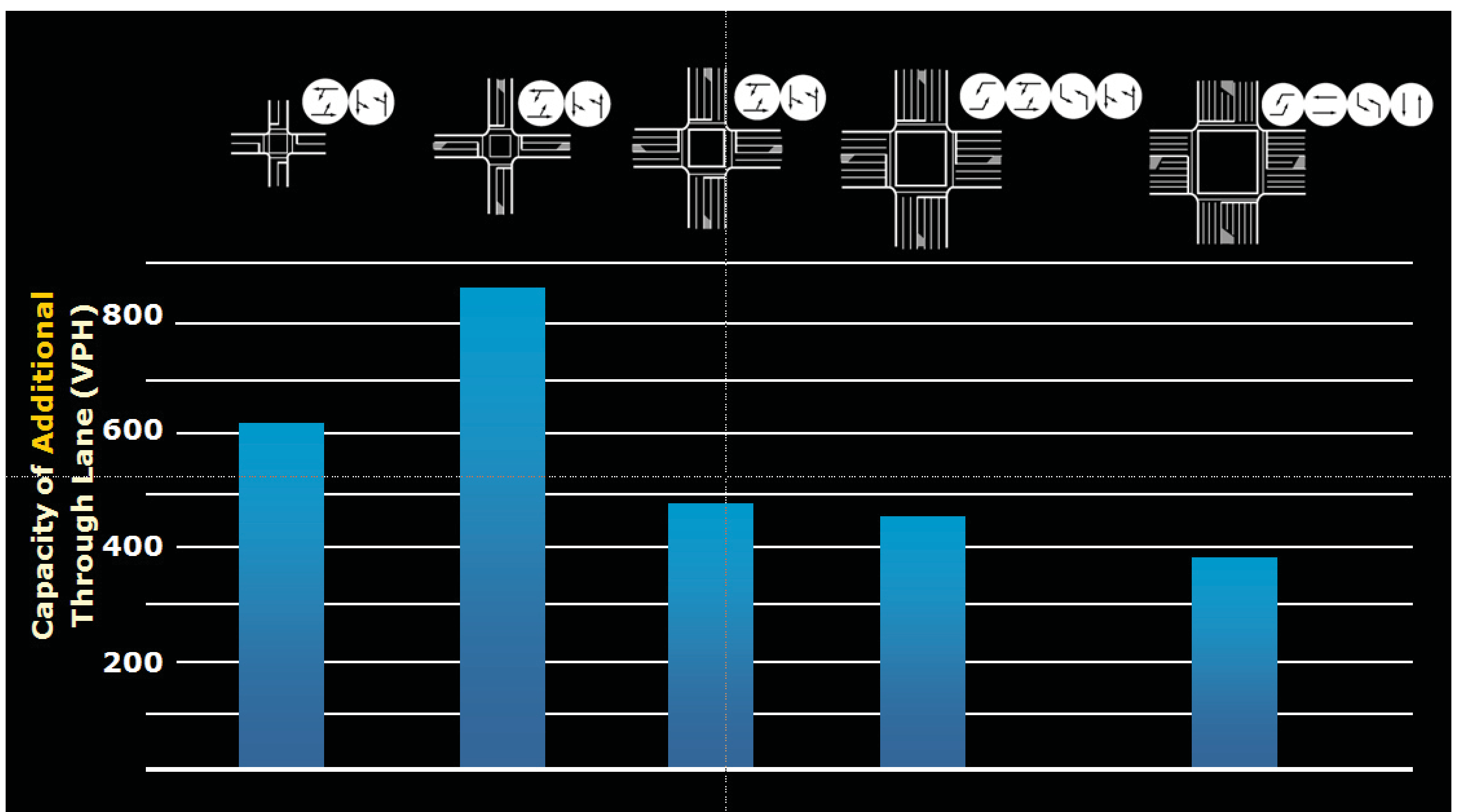


Multiple left turns lessen reliance on three-phase signals that actually reduce signal capacity. Left turns at intersections that are not signalized operate in the 'shadow' of the signal: the signal controls oncoming and turning cross traffic, which allows motorists at the non-signalized intersections to make turns and not rely on the signal. This greatly improves signal capacity and efficiency.

The benefits of a connected street network is illustrated by the two scenarios--the right graphic shows multiple routing options for different trips. The graphic on the left shows all trips "channeled" to a single roadway because of limited connectivity.

Intersection Operations
Except for the four-lane boulevard that generally follows the existing alignment of Delaware Avenue, all new streets proposed as part of the Vision Plan are two-lane roadways, with left-turn lanes at some intersections. In the trend scenario, Delaware Avenue would remain six lanes through most of the study area. The wider roadways and therefore larger intersections in the trend scenario are inherently less efficient in terms of processing traffic.

As an intersection grows in size, adding additional turn lanes and through lanes yields lower capacity in terms of number of vehicles per lane that each signal leg can process. The most efficient intersection design includes a single lane in each direction with an exclusive left turn lane to remove those vehicles from the traffic stream. When the intersection grows from that size, the need for protected left turn phases increases, reducing the capacity of that lane group and increasing the need for dual left turn lanes. This results in a less efficient intersection operation because of increased yellow and all-red time necessary to clear the intersection, longer distances for left-turning vehicles to cover, and the inability to have permissive left turn phases.



2. Transit Trip Making Ability

The potential for travel by transit within the study area is dictated by the availability of transit as well as the availability of transit-supportive land use pattern, urban design and transportation infrastructure. To evaluate the transit trip-making ability, we looked at the capacity of the two development scenarios to accommodate various modes of transit as well as census data and literature research on variations of transit use in different physical environments that are characteristic of the trend and vision scenarios.

Flexibility to Accommodate Various Transit Modes
The land use and infrastructure pattern of the trend scenario limits the central waterfront area's ability to accommodate various types of transit. This analysis assumes that in the trend scenario, the existing Market-Frankford Line and SEPTA Route 15 Trolley (Girard Avenue Trolley) would remain in the trend scenario. Bus service could be expanded to serve new developments and the two casino developments and possibly other developments would provide employee shuttle service to and from the transit stops.

In the vision plan scenario, a variety of transit technologies can function well within the new network of streets. The following are the most applicable transit technologies that could serve future development in the central waterfront area. (See additional information on transit options memo.)

Expanded Bus Service: Both the trend and vision plan scenarios have the potential for expanded bus service. Standard transit buses are useful in areas of moderate to high-volume, short-to-medium distance travel. With vehicle costs of $200,000 to $300,000, standard transit buses have a capacity of up to 68 passengers per bus.

Expanded Trolley: There is potential to expand the existing Girard Avenue trolley line to serve the southern study area. As it is today, the trolley line would have electrically-powered rail cars with an overhead electric wire (catenary) as the power source and would have a single vehicle. With an average cost of $5 to $40 million per mile, the expanded trolley service can have a capacity of up to 100 passengers per car (including standees).

Dedicated Lane Bus Rapid Transit (BRT): The vision plan recommends transit provision along Delaware Avenue. One option is to provide BRT that would run along the Avenue's median. BRT utilizes buses to perform premium services usually on dedicated rights-of-way. BRT lines are projected to cost between $4 and $40 Million per mile and transports an average of 4,000 to 12,000 passengers per hour.

Light Rail Transit (LRT): Another transit option along the future Delaware Avenue is LRT. As with the historic trolley, LRT also uses electrically-propelled rail cars using an overhead electric wire (catenary) as the power source. A typical LRT system would cost between $20 million to $40 million per mile and would be able to transport between 6,000 to 20,000 passengers per hour.

Modern Streetcar: Another transit option for the Vision Plan is the Modern Streetcar. The modern streetcar is considered the more traditional version of LRT and more updated than the historic trolley. Unlike LRT which runs mostly in exclusive lanes. the modern streetcar tracks and trains run along the streets and share space with road traffic. Stops tend to be very frequent, but little effort is made to set up special stations. Because space is shared, the tracks are usually visually unobtrusive. Modern streetcars are estimated to carry between 1,400 to 4,000 passengers per hour.


Portland Modern Streetcar


Historic Route 15 Trolley along Girard Avenue


LRT Line through Downtown Houston


LRT in San Jose, CA

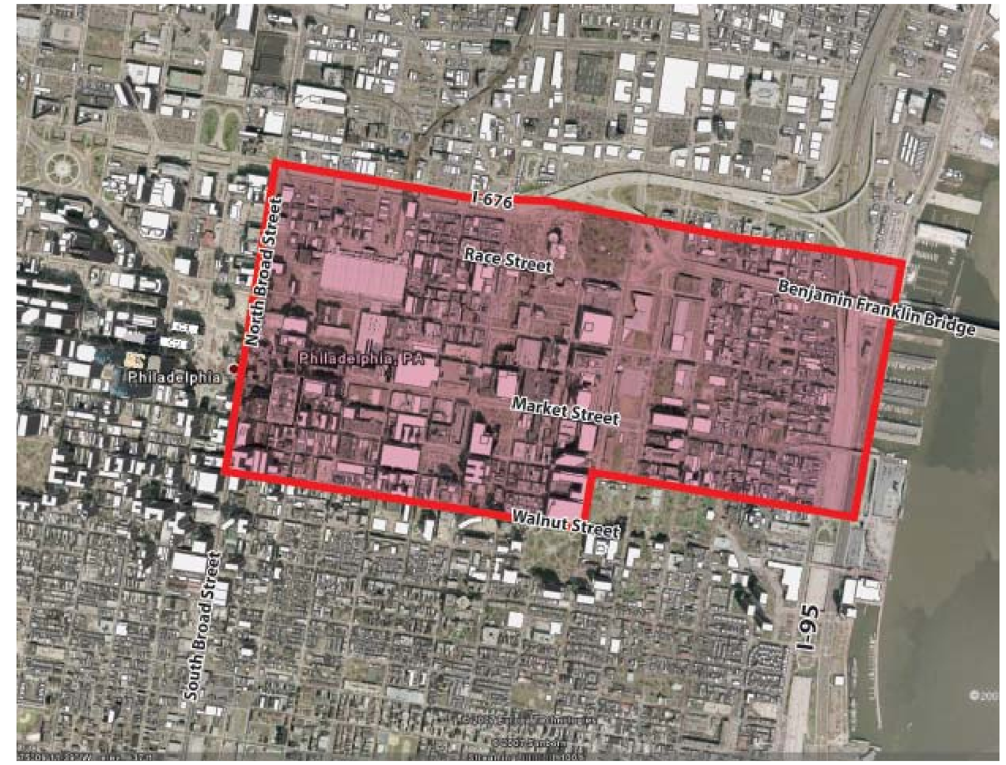

Light rail vehicle in Lyon, France

Propensity of Transit Use in Various Environments

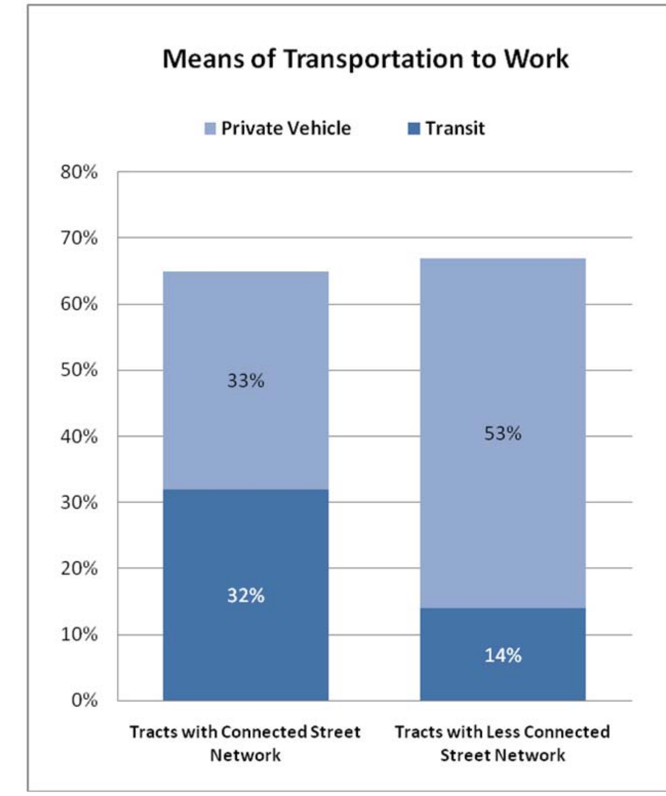
The amount of transit use is dependent on the uses around which transit stations and stops are located. Higher density and mixed-use environments have a tendency to encourage more transit usage than single-use low-density developments around stations. Also, beyond just the nature of land uses, the patterns of these land uses also impact the success of transit. Because every transit trip starts and ends with a walking trip, transit usage goes up if station areas have well-connected streets and sidewalks. [Reilly and Landis (2003) analyzed a 1996 travel survey of 14,400 San Francisco Bay Area residents. They found that a 25% increase in intersection density, representing the difference between suburban Concord, CA and central Palo Alto, CA, increased the probability of using transit by 62%.]

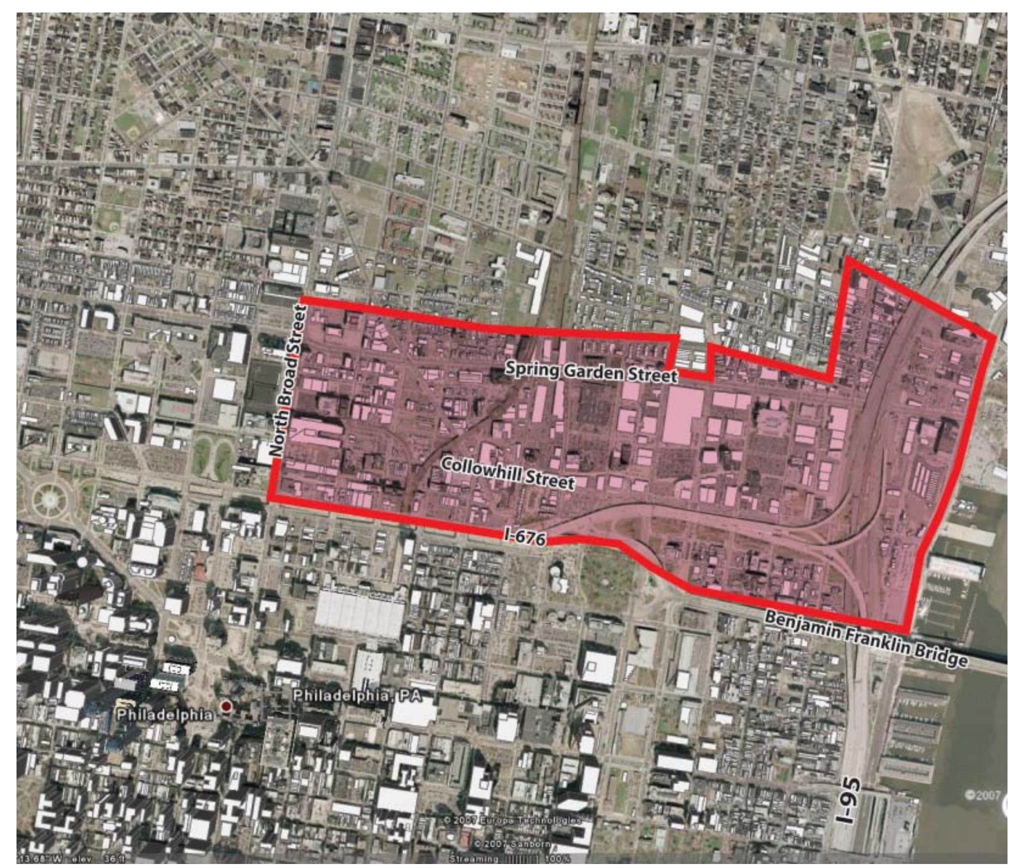
To demonstrate the potential success of transit use, we analyzed information from the 2000 Census Journey to Work survey on various areas that have similar characteristics as the two development scenarios. Both sets of census tracts were adjacent to the study area. Census Tracts 1, 2 and 5 are located just south of the Ben Franklin Bridge on the west side of the study area. These tracts represent a smaller block pattern and connected roadway network similar to the vision plan. Census Tracts 127, 128 and 129, located just north of the Ben Franklin Bridge approximate the large-block, limited network connectivity environment that the trend scenario would have.

The census data shows that in the area where the street network is connected, the share of transit use is almost similar to that of private vehicle use in home to work trips. On the other hand, for the tracts with less connected street network, the share of trips using transit is less than one third of trips using private vehicles.



Tracts with Connected Street Network





Tracts with Disconnected Street Network

3. Walking and Bicycle-Trip Making Ability

The ability to move around using bicycles and as a pedestrian within the two development scenarios were measured by determining the presence of the necessary infrastructure (sidewalks, trails, and bicycle lanes) as well as by determining if the urban design and the transportation pattern encourage walking and bicycling.

Sidewalks and Bicycling Infrastructure
The trend scenario has 41 miles of roadway, while the Vision Plan has 64.5 miles of roadway. Because the vision plan has 23.5 more miles of roadway, it would logically have the potential to have 45 more miles of sidewalks. The vision plan will have the opportunity for a multi-use trail along the river as well as a system of bicycle and pedestrian-friendly two-lane streets while the trend scenario will also have the opportunity for a multi-use trail along portions of Delaware Boulevard and on-street bicycle lanes along the Columbus Boulevard corridor.

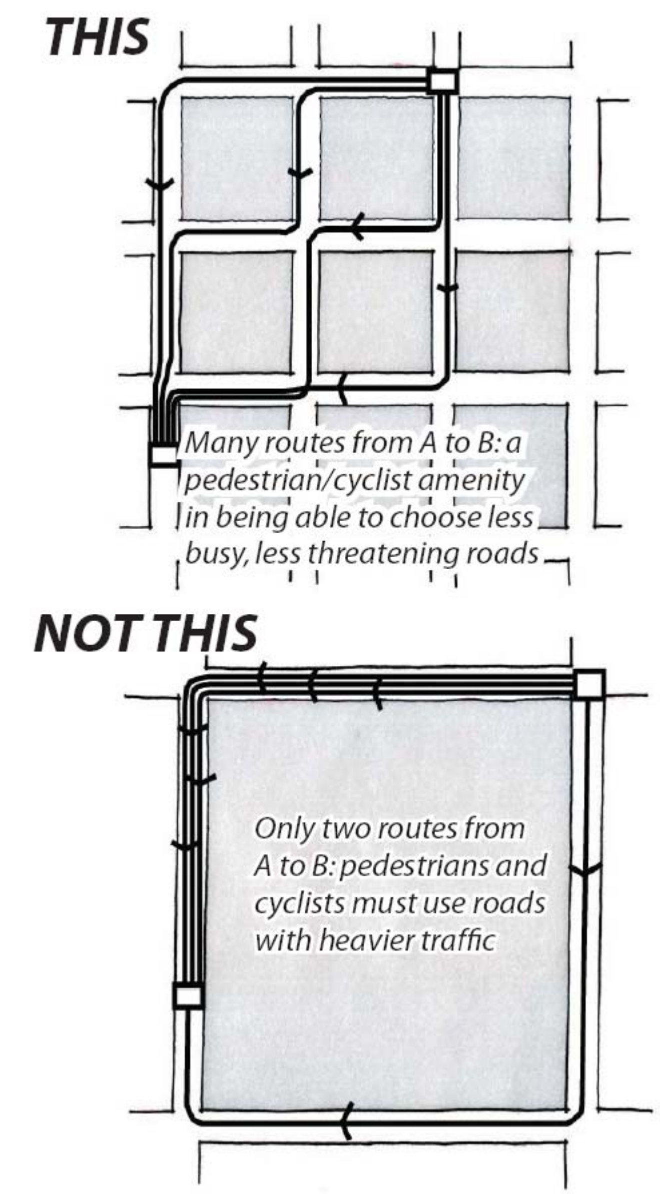
Connected Street Networks and their Effects on Walking and Bicycling
The nature of the connected street networks in the vision plan inherently encourages more walking and bicycling trips while disconnected street networks similar to the trend scenario encourages more driving trips. Indeed, among the greatest beneficiaries of a well-connected street system are pedestrians and bicyclists. As with vehicles, the connected network of streets in the vision plan allows pedestrians and cyclists a greater variety of routes between destinations. This especially helps a pedestrian or bicyclist in events where there are obstructions to the intended travel path such as closed sidewalks, busy traffic, dangerous mixed traffic, etc. without retracing steps. Fewer but wider roadways in the trend scenario will also tend to have more traffic in a single roadway, exposing more pedestrians and cyclists to greater vehicle traffic, which can produce a less friendly walking and cycling environment.

The vision plan's denser street network inherently requires a motorist to cross more intersections. With block lengths of 300 to 500 feet, a motorist traveling at 30 miles per hour will cross an intersecting street every 7 to 12 seconds, which approximates the 8- to 10-second "attention span" that is needed to sustain a driver's attention. Each intersection is an event that demands attention, directly encouraging speeds and driving behavior more conducive to walking and bicycling.

Just as the relatively frequent spacing of intersection encourages safer driving behavior, smaller blocks give the pedestrian a sense of progress and rhythm. In general, a desirable pedestrian environment will have functional block perimeters of between 1,500 and 2,100 feet. This guideline yields walkable block sizes of between 250 to 350 feet by 500 to 700 feet, and block faces that are no more than 400 to 450 feet for square block sides. Within this smaller block size, pedestrian interest is easier to achieve with building massing and architectural articulation.

Studies have shown that because of all the above reasons, less driving trips occur while walking trips occur more often in a connected street environment (similar to the Vision Plan) than one that is not well-connected (similar to the trend scenario). Reilly and Landis' 2003 survey of the Bay Area residents found that a 25% increase in intersection density increased the probability of walking by 45%. Frank (2005) in a Study of Land Use, Transportation, Air Quality, and Health (LUTAQH), examined the relationships between street connectivity and driving in the Puget Sound area. With controls on the influences of demographics, vehicle ownership and transit availability, the greatest differences in vehicle miles traveled (VMT) were observed across levels of intersection density (street connectivity). Their study showed that there was 26% fewer vehicle miles of travel for residents who live in communities that have the most interconnected street networks.

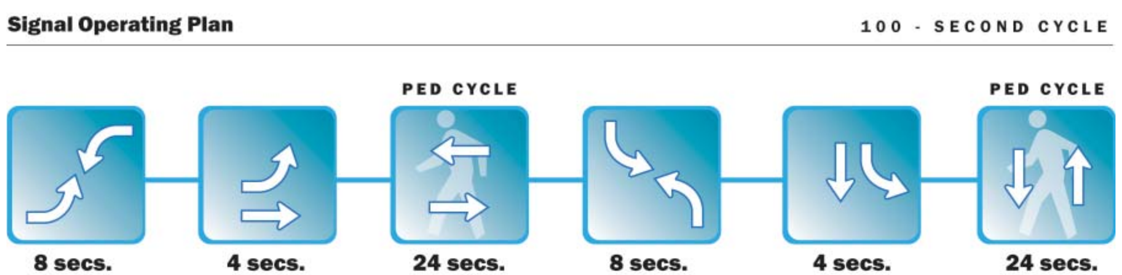
The Synergy of Connected Networks, Mixed Land Uses, and Healthy Densities
When combined with other factors such as mixed-use, residential density, availability of high quality transit, and other urban design factors, the reduction of driving trips because of a connected street network is even more significant. In 2004, the SMARTRAQ study surveyed 8,000 households in Atlanta and determined that the people who live in neighborhoods with the lowest walkability drive an average of 30% to 40% percent more than those who live in areas with the highest walkability. The study defined walkability as a combination of residential density, land use mix, and street connectivity.

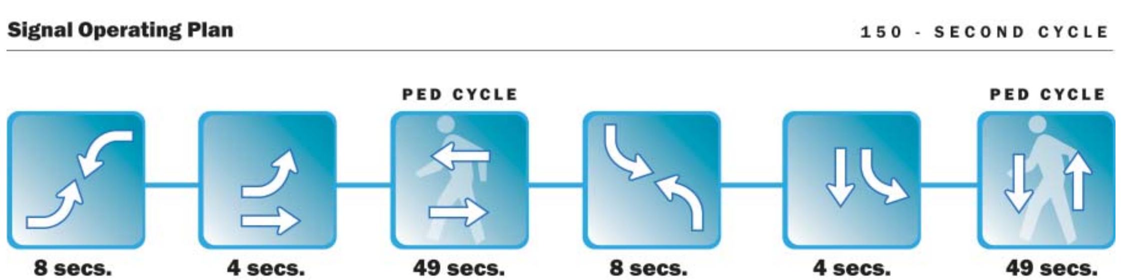


Walkability, Roadway Widths, and Intersection Sizes

As mentioned earlier, except for the four-lane boulevard, all new streets proposed as part of the Vision Plan are two-lane roadways while the trend scenario will have intersections having six and four lanes of intersection traffic. The wider roadways and therefore larger intersections in the trend scenario inherently impact the ability of pedestrians to cross at intersections.

Smaller intersections also encourage more comfortable pedestrian movement, where the streets aren't seen as insurmountable barriers. The following series of graphics illustrates the amount of green time allotted on each phase of two six-phase signal cycles typical for urban intersections. When the minimum allowed green time was assigned to the left-turn phases, the pedestrian phases will have a maximum of 24 seconds of green time for a 100-second signal cycle.





A pedestrian requires eight seconds to cross a 2-lane street (28 feet / 3.5 feet per second). As the intersection grows, the length of time it takes for a pedestrian to cross increases. For an intersection with dual left turns, three through lanes and a right turn lane, the time it takes for a pedestrian to cross safely is approximately 33 seconds. This is counter-productive in an urban environment, as the larger intersections require greater green times for the main streets, leaving less green time for the side street and pedestrians to cross the greater distances. Even with a 150-second signal cycle which is more common for larger intersections with roadways of four or more lanes of intersecting traffic where the pedestrian phase cycle will have 49 seconds of green time which leaves only a 16 second "steady walk" signal (with 33 seconds of "blinking walk").

Pedestrian crossing time at various sized-intersections.

6. Ability of Infrastructure to support changes in land uses over time

The Vision Plan's connected network of streets form urban blocks that can be adopted to serve different uses, as land economics change over time. A network of streets, with its accompanying infrastructure for utilities (sewer, water, power, etc.) offers a ready palette for any new type of development to occur. Larger blocks created to specifically fit a particular use have roadways, access drives, and infrastructure are hard-wired to suit one specific use. These larger blocks do not offer the same flexibility if their intended use becomes obsolete. The adjacency, visibility, and access that a small block pattern affords make the environment that the blocks create far more attractive a business environment.