Integrating Inland Ports into the Intermodal Goods Movement System for Ports of Los Angeles and Long Beach

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Project 07-01

February 2008

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Abstract

Planners concerned with deep-water port operations are interested in strategies that improve regional truck flows associated with the container trade while also mitigating related problems of highway congestion and air pollution. An inland port or integrated distribution hub is typically located some distance from traditional seaport gateways and is designed to facilitate international trade processing by providing multi-modal transportation assets and value-added services at a single site. Strategically located inland ports could contribute to increasing container flow and solving port-related congestion and pollution problems.

This research identified and analyzed site location methods for inland ports in five counties, including Los Angeles County, and indicated their potential for integration into a more efficient regional intermodal goods movement system served by the Ports of Los Angeles and Long Beach. GIS was used to map the sites where international cargo is processed in the five counties of Los Angeles, Orange, Riverside, San Bernardino, and Ventura. One-hundred transportation zones were determined (from a truck-destination survey), representing density points for distribution/processing centers. First, a single facility location model was used to define the location of a theoretical inland to minimize the total truck-miles traveled. Interestingly, this location seems to coincide with the current location of BNSF's trans-modal facilities in the city of Commerce. Then, we extended this model to a series of location-allocation models with up to six inland port locations included. With no inland port (current system), the total daily VMT was estimated to be 220,100 miles, and the average truck trip length was 11.6 miles. As more inland ports are added to the location-allocation model, the total truck miles traveled is reduced significantly. The new system follows the notion of "satellite inland port," which is based on a hub-and-spoke configuration. In this system, we assume that containers will be delivered to the inland ports via rail and then distributed via trucks. Also, with significant reductions in VMT, congestion relief and air pollution reductions are expected proportionally. The results show that the proposed mathematical approach is a useful platform for initial investigations into inland port site selection.

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Disclosure Statement

This project was funded in its entirety under a contract to California Department of Transportation.

Acknowledgements

The authors wish to thank Jan Green Rebstock (Port of Los Angeles) and Janet Harvey (Meyer, Mohaddes Associates; and the Iteris Company), who provided truck survey data collected in 2004 at the Ports of Los Angeles and Long Beach.

1. Introduction and Background

1.1 Problem statement

The primary objective of this study is to provide a technical framework for integrating inland ports or logistic hubs into the intermodal goods movement system at the ports of Los Angeles and Long Beach (POLA/POLB). The international goods movement system is driven by container movements originating and terminating at the deep-water terminals located within port property. The majority of containers destined for delivery within the state are currently taken by short haul dray trucks to logistics centers where transloading cargo to larger trailers takes place. Concerns are now growing about the economic and social impacts that this system imposes on mobility and the environment in the region. The project focuses on examining the truck vehicle miles of travel (VMT) generated by the logistics centers and estimating the benefits gained from reduced VMT patterns using one or more inland ports. Such benefits are achieved by relocating current logistics activities to a smaller number of hub sites within the Inland Empire. A variety of benefits can be estimated from the reductions in VMT associated with each hub location. This approach could therefore provide a more efficient system of freight distribution at a lower social cost, while retaining the key economic benefits associated with the current system.

1.2 Motivation and historical perspective

Economic globalization means that design, assembly, manufacturing, and consumption sectors are now often geographically disparate and located within long and complex supply chains and value-added networks. This development, coupled with world industrial output, especially in Asia, increasingly impacts the transportation of goods through Californian ports, creating both benefits and challenges to the development of a more sustainable society. California, with the largest state economy in the U.S., accounts for more international trade than any other state in this country. In 2005, the total value of trade using the Southern California trade infrastructure network was $256 billion, creating $28 billion in state and local taxes and 2 million jobs or full-time equivalents in the 48 states (BST Associates, 2007). Growth in both global and domestic freight patterns in the last two decades has placed increased demands on California's ports, highways, and traditional truck/rail intermodal yards. In 2005, over 9 million twenty-foot equivalent units (TEU) moved through the POLA and POLB terminals, representing 24% of U.S. containerized exports and 41% of U.S containerized imports (BST Associates, 2007). All forecasts point to continued growth, notwithstanding the development of alternative transportation corridors in the U.S for international trade.

Seaborne containers are built to International Standard Organization specifications, which were set in the 1960s and form the dimensional platform for the containers' intermodal capability (Tandemloc, 2007). The necessity of vertical stacking, the ability to carry a variety of unbalanced, heavy cargo, and the stresses placed by vessel movement across rolling oceans has resulted in a robust and rather substantial box construction. The drawback is they can at times be somewhat heavy—certainly greater than the aluminum 53-ft semi-trailers used on most U.S. highways. Moreover, they are capacity-constrained compared with that same semi-trailer, because they are limited to 45 ft in length (with the majority being 40 ft) and are 6 inches slimmer in width. Because they both weigh- and cube-out compared to truck trailers, they are simply unsuited to long highway hauls, where they lose competitive advantage.

Containers arriving at POLA and POLB with imported cargo can be grouped into two types: those destined for Californian consumers and the rest for other U.S markets. The former tend to break into two further groups—those that are delivered to the final customer in the original container and those that are transloaded at a location near the port terminal and transferred to a 53-ft highway trailer for the economic advantages specified earlier. Those that are destined for out-of-state destinations are either loaded onto double-stack rail cars at or near the port terminal, or drayed to locations near the port where they are transloaded into 53-ft domestic rail containers and taken to nearby rail yards for onward delivery or, in cases where time is of the essence, they are trucked out (at a higher cost) on interstate highways. These transloading activities take place in a five-county area served by the two ports.

Container forecasts for both POLA and POLB terminals predict double-digit average annual growth with aggregate values that simply cannot be handled by the current landside system. It has been estimated, for example, that container traffic in 2020 could be 28 million TEUs or 15 million containers. Thus, by 2020 the volume of containers moving through the combined POLA/POLB terminals could be over three times current volumes (Mallon and Magaddino, 2001). Regional rail tonnage is likewise expected to increase threefold, from 91 million tons in 1995 to 309 million tons in 2020 (Mallon, Magaddino, 2001), but this still requires substantial increases in truck volumes to move the remainder across the region.

1.3 Needs and characteristics of inland ports

This growth has created planning challenges for both state rail and highway planners and has attracted the attention of impacted local communities. Are there tenable alternatives to the current system if it is unable to meet predicted demand in an efficient and socially responsible manner? This study considers the role that several large intermodal distribution hubs—termed *inland ports*—would make in the impacted counties. An inland port system in Southern California could contribute to a modified state freight network that enables the regional economy to continue competing effectively in both state and national marketplaces in future years. Inland ports, as will be seen in the next section, are becoming well established in the eastern, southwestern and midwestern states and are typically located on the exurban boundaries of metropolitan areas. Though such boundary locations are not a focus of the first phase of this study, the activities undertaken in such logistics centers is relevant.

> *"You just have to plan for this stuff—it can't just happen in sort of a scattered fashion."* Thomas D. Capozzi, Virginia Port Authority

Southern California currently has a wide dispersion of distribution centers serving the POLA and POLB terminals that have grown with little planning, and can be regarded as relatively fragmented. There is now increasing recognition, from non-planners and the private sector alike, that the "free market" approach to logistics channel formation is not going to work efficiently in future, especially in large metropolitan areas. One consequence is the negative impact of the aggregate truck VMT needed to serve such a demanding system, which has resulted in well-documented problems of highway congestion, higher transportation costs, and lower air quality. This study uses 2004 truck VMT patterns—the latest available—and estimates the reduction in VMT associated with various inland port locations in the region, thus providing added benefits to the shippers, modal providers, and adjacent communities alike.

Inland ports have the potential to address a variety of needs if planned and executed in an efficient manner. The benefits are familiar to planners and economic development staff, and include increased property values, jobs creation, reduced transportation costs, and increased tax revenues (Figliozzi and Walton 1999). These impacts are measured through the use of input-output models that are well understood in the planning community and were used in recent POLA and POLB work (BST, 2007). In addition, inland port operations need to mitigate the negative impacts of logistics activities—noise, air quality, congestion, and so forth—while providing the private sector with a more efficient way of moving cargo through the chosen supply chain. This is also now recognized by the private sector as highly desirable and is reflected in BNSF's willingness to upgrade drayage and terminal operations in the Hobart yard area to produce a range of social benefits[1]. This study examines VMT patterns and regards location as the critical element in determining whether the value added to shippers using the inland port justifies the cost of its construction and operation. Location criteria could first include minimizing the impact of inland-port-generated truck flows on existing traffic and mitigating social and environmental degradation, while maintaining effective connectivity with other modes of transportation.

Finally, while California leads other U.S. states in the early adoption of many logistical changes associated with efficient movement of international containerized trade, the issue of inland ports or integrated logistics hubs has been developed in other regions, principally in the East and Southwest. Table 1.1 provides a variety of 2007 inland port projects and demonstrates a link to deep-water container terminals that appears to be growing as port authorities struggle to increase container-handling capacity. Sites need not be large. NRS City, though small, is only 10 miles from Port of Elizabeth, N.J., and is near both CSX and NS rail yards—a perfect location for transloading.

[1] http://www.bnsf.com/media/news/articles/2005/02/2005_02_09a.html

Table 1.1. Selected 2007 Inland Port Projects in the U.S.

Location	Name	Comments
New York City	NRS City	200 acres, 2 x 100 thousand sq. ft transloading facilities, 3,000-container capacity, company operates a similar facility in Los Angeles, opening another in 2008 in Savannah, GA (Progressive Railroading, 2007)
La Porte and Will Counties, Indiana	None at this time	3 intermodal facilities totaling 3,600 acres proposed in Chicago area (Podmolik, 2007)
Dallas, Texas	Dallas Logistics Hub	Allen Group developing a 6000-acre, master-planned distribution hub serving UP RR, IH-20, and IH-35 (Berman, 2007)
Hampton Roads, Virginia	None at this time	Virginia Port Authority planning a 13,000-acre site, long-term goal: 60 million sq. ft of buildings and 26,000 jobs linked to new deep-water terminals by Maersk, APL, and others (Richards, 2007)

Inland ports have the potential to beneficially impact local, regional, and national trade and transportation corridors. Urban and transportation planning already recognize that reduction in congestion on all corridor levels should be integral to the process of supporting international trade and efficient supply chains. Additionally, transportation corridors that utilize multiple modes and serve intermodal facilities may function more effectively for trade than those that do not have centralized inland port connections. Clearly this requires a multi-stage approach that is beyond the scope of this study. However, the key platform for improvement begins with a reduction in VMT and this is both the prime focus of this study and the motivation behind the modeling approach reported in this document.

2. Literature Review

In the early 1990s, the term "inland port" started appearing in supply chain and logistics reports, particularly those published in the trade press. Until that point, it had mainly been associated with inland waterway ports.[2] The new definition of inland ports—as clusters of distribution and logistic centers located on a transportation corridor—indicated a different type of operation, mode, and commodity mix, all carrying profound implications for transportation planners, particularly those in state highway departments. Yet relatively little was known about them and their impacts on the transportation system.

[2] For example, the U.S. Army Corps of Engineers regularly publishes a table ranking inland ports by both tons and trip ton-miles. The 2003 ranking identified Huntingdon–Tristate on the Ohio River as the leading U.S. inland port (USACE, 2005).

Research conducted for the Texas Department of Transportation (TxDOT) in 1997 attempted to relate the emergence of inland ports to state transportation planning and programming activities (Harrison, et al., 2006). The development of single-company retail "big boxes" over the previous decade had resulted in creation of large-scale distribution centers and, increasingly, the Department's exclusion from the planning stages that impacted highways. In extreme cases, TxDOT was excluded from the critical stages of access planning even though the sites, when implemented, comprised large truck generators typically located on metropolitan boundaries where rural roads predominated. TxDOT did not want to have the same problem arising with several inland port proposals being prepared in the state.

This work first examined the reasons for the growth of inland ports in the U.S. and found rather little in the literature. Inland ports were said to enhance company supply chains increasingly associated with successful business operations and the reduction of "transportation-related waste that can add cost but no value" (Morash, 1999). Combinations of modes at inland ports can potentially provide opportunities to reduce inefficiencies, particularly when value-added services are commonly located at an inland port site. An inland port can provide "a shared location for partners" that want to increase the efficiency of their supply chains—an important issue as land prices near U.S. metropolitan areas continue to rise.

An inland port can therefore address inefficiencies by allowing the user to focus on primary activities critical to serving metropolitan markets, many growing at a rate that makes traditional single distribution center "big boxes" expensive and less efficient. At inland ports, elements such as space for expansion, the provision of housing, tax incentives, direct interstate connections, intermodal rail facilities, and air cargo operations can form the building blocks for competitive advantage. When distribution, warehousing, and manufacturing work together at an inland port, uncertainty related to supply chain components and international processing might be reduced (Leitner and Harrison, 2001). However, homogeneity is not a key characteristic of inland ports—they come in a variety of shapes and sizes.

2.1 The first inland ports

All inland ports of any size are multi-modal and led by a single pre-eminent mode. The first group of U.S. inland ports, established by the mid 1990s, appeared to focus on the projected growth in airfreight and had selected air as the main mode. This is interesting because the one key element of air service—provision of runways, taxiways, and parking areas—is expensive and would suggest that substantial investment would have to be undertaken before a revenue flow could be expected. Why then was air popular? The trend was, for the most part, a consequence of the U.S. Base Realignment and Closure (BRAC) commission, set up to periodically assess the continuing need of all military bases throughout the world. In reviewing the assets of the U.S. Department of Defense, five sets of closures were recommended by the commission in the years 1989, 1991, 1993, 1995, and 2005, resulting in the closure of over 350 bases—many operated by the U.S. Air Force.

Base closure generally resulted in the facility being offered to the local authorities for a nominal sum, although the condition of the facilities varied and substantial investment was often needed before commercial activities could be undertaken. Nevertheless, the bases generally appeared to be a bargain. This intrinsic asset value spurred the authorities—city or county—to consider how best to use a base for economic development, principally to compensate for the loss of employment and taxes associated with the base closure. The opportunity for economic development through the creation of an inland port gained strength, and by 1995, several sites were being promoted—with varying degrees of success—as inland ports. These included sites at San Antonio, Texas (Kelly Air Force Base [AFB]), Columbus, Ohio (Rickenbacker AFB), Kansas City, Missouri (Richards-Gebaur AFB), and Riverside, California (March AFB), while other inland ports were linked to existing airport facilities, as at Huntsville, Alabama. An exception was the site developed at Alliance, Fort Worth, where the Perot family had purchased over 16,000 acres of ranchland to pursue a planned multi-facility development—in effect, a new city built around transportation services (Leitner and Harrison, 2001).

A change from airfreight as the main inland port mode occurred in the mid-1990s as the impacts of Asian—particularly Chinese—containerized imports were felt on U.S. transportation corridors in general and rail corridors in particular. The cost advantage of double-stacked container rail systems over trucking were so profound that rail intermodal demand grew greatly, especially on the east-west (for distances over 700 miles) systems servicing the ports of Los Angeles-Long Beach. This "land bridge" became the preferred way to move Asian goods to central and eastern U.S. population centers from the west coast and, in turn, increased the need for distribution centers located near rail intermodal terminals. Alliance, for example, attracted a new BNSF Railway intermodal terminal for such trade in 1994 and rail soon became the dominant mode at the site, reaching 700,000 TEU lifts within a decade. This heralded the creation of a series of inland port sites that now had intermodal rail as the dominant mode and international trade as the main commodity source. Inland ports with rail as the central mode have been started at two locations near Chicago—Joliet (Logistics Park, BNSF) and Rochelle (Global III, UP)—Memphis (BNSF), Dallas (Wilmer, UP), and several other sites served by the Class One railroad companies.

The definition and role of inland ports continue to expand, as inland ports are being considered as extensions of deep-water marine port terminals where expansion is limited by cost, environmental issues, and congestion. The Port of New York–New Jersey has for some time planned an inland port network where a central hub terminal is served by barges taking containers to smaller regional terminals served by rail, which then transports the boxes to inland ports closer to the various population centers in the port hinterland (Ellis, 2001). More recently, container terminals at the Port of Virginia will be able to use a shorter Norfolk Southern route termed the Heartland Corridor, which serves Chicago 24 hours earlier than do current routes. It will also service the inland port of Columbus, which will allow boxes to be lifted and drayed to nearby metro markets such as Philadelphia.

The term "inland port" is now sufficiently mature to refer to a site at which several combinations of mode and types of operation are offered. However, the variety of activities of ports, rail, inland ports, and truckers are rarely the deciding factor for the successful implementation and operation of inland ports on the supply chain. BNSF, no doubt impressed with the success at Alliance, coined the phrase "logistics park" for other versions of Alliance-type terminals, and calculated there were approximately five to seven similarly sized sites on its network. However, BNSF intended to operate only the rail terminal—the overall inland port site containing the facility would be given to commercial developers with the drive, ability, and financial backing to manage the port successfully. In almost all cases, new inland ports are now promoted, financed, and managed by a commercial developer such as Hillwood (at Alliance) or the Allen Group (at Wilmer).

2.2 Inland port characteristics

The expanded "inland port" concept incorporates the idea that some facilities at traditional maritime ports could be duplicated or complemented at inland locations, thus promoting economic development and logistics integration while reducing the demands on limited capacity (land and access) at the seaport. This concept is clearly appealing as it is being promoted by a number of port authorities, no doubt influenced by the increase in port-area land values, the limited size of adjacent warehousing and distribution facilities, and the opportunity for their shippers to link with larger, out-of-state modern distribution locations providing a variety of value-added services.

In addition to international trade processing, a crucial role of an inland port is to relieve congestion at borders and traditional maritime ports. Many services can be provided at this location, which promotes regional development. Once goods are received at the inland port, further inspection can occur or the goods can be transferred to a different transportation mode, stored for future distribution, or assembled into other products. This consolidation of services provides value-adding activities, allowing for less congestion and fewer delays at border points of entry. A complete range of services can be provided at an inland port, typically in one location. These services can range from all modes of transportation (highways, rail, air, water, and pipelines), distribution, warehousing, manufacturing, and logistics-management services (Gooley, 1997). Providing consolidated services at one location makes an inland port more attractive to shippers and logistics managers concerned with promoting efficient supply chains.

An inland port also has the ability to promote local and regional development, which is a key factor in gathering community support for an inland port. Local employment opportunities are vast, especially when a wide range of value-added services are provided. Regional economics can be improved by a shift in trade from the traditional maritime port to the inland port. This is accomplished by providing jobs in the direct processing of international trade and attracting distribution and manufacturing industries to the region.

Additional user benefits related to an inland port include the reduction of vehicle miles traveled (VMT) or emissions when multiple modes of transportation are supported. This is particularly attractive to transportation planners concerned with system efficiency and environmental health. A rail shuttle connecting the seaports with an inland port facility could have the potential to simultaneously reduce truck traffic and congestion and promote jobs and economic growth inland. This benefit specifically attracted the attention of the study team, who decided to model the impacts of VMT reduction as a central element in this phase of the work.

2.3 Reducing truck VMT and emissions using rail

For the purposes of this study, the primary goal of inland port development would be the net reductions in truck VMT and total emissions for port traffic. The idea of an intermodal rail shuttle between the ports and the inland port is an integral part of the concept. As proposed in the Virginia Inland Port, the concept calls for a rail shuttle link with the seaport and an inland terminal functioning as a satellite. As trade has continued to increase, the ports of Los Angeles and Long Beach have worked to support and accommodate the development of rail facilities to expedite the movement of containerized cargo and other freight through the ports, including development of the Alameda Corridor and four on-dock rail facilities. The inland port concept attempts to go one step further.

A transportation study sponsored by the POLA and POLB estimates that a maximum of 30–35% of all containers that move through the ports will be transported by rail to inland destinations via on-dock or off-dock rail yards by the year 2020. Inland ports and related initiatives have been proposed as solutions to freight mobility issues at POLA/POLB. However, the ability of an inland port/rail shuttle combination to reduce net truck VMT and regional emissions depends primarily on its capacity and the ability to divert container flows from trucking.

The geographic configuration of the combined port complex is such that all fourteen terminals are served by only two major freeways: IH-710, or the alternate IH-110. Other ports' terminals located landward of Terminal Island are served by Alameda Street. The potential for net VMT and emissions reductions depends on the proximity of the inland port location to shipment origins and destinations and its ability to reduce congestion on these major freeways. The net emissions reduction also depends on the tradeoff between reductions in truck miles and additional rail mile. Emissions impacts can be calculated by using standard emissions factors and the total emissions are directly correlated with VMT for each type of criteria pollutant (carbon monoxide, organic gasses, oxides of nitrogen, and particulate).

The goods movement system is now defined in greater detail to determine the appropriate analysis approach for this study.

3. Inland Port Characteristics

The team examined a wide variety of inland ports, as reported in the literature, to derive the characteristics of the type of inland ports most likely to support deep-water terminals in Southern California. The range of salient characteristics were then grouped into three areas that impact locational analysis: (a) site selection, (b) elements required if the site was to function as an intermodal hub, and finally (c) activities that add value to traditional distribution functions in the supply chain.

The following review details critical elements necessary for successful port operations, needs that have been explored in published articles and identified by individuals involved in port operations. These needs have been used to identify successful development strategies, location strategies for shippers, and site selection criteria.

3.1. Inland port site selection

In developing strategies for new intermodal terminals, Harder (1999) provided insight to communities about the factors the private sector uses to locate new intermodal terminals and how sites are selected. Harder indicates that the private sector is investing in large metropolitan areas because of an expected higher financial return. For smaller communities, strong public promotion is needed to successfully draw private-sector development. Before beginning the steps to market in a small community, Harder suggests that four objectives be investigated. These four objectives could also represent the critical needs of small communities considering inland port developments. The four objectives or critical needs are:

- Sufficient demand for intermodal freight transportation
- Local supply of competitive carrier service
- Practical basis for successful community relationships
- Adequate public/private-sector capital to fund development

Harder also stated that metropolitan planning organizations (MPOs) can influence terminal locations by direct action partnerships with shippers, state and local governments, or by indirect action in improving highways, changing zoning and land use, and creating economic development agencies. He states that the "challenge for MPOs and other public agencies is to understand these factors well enough to optimize use of direct and indirect influences in accomplishing public sector goals." Gooley (1998b) looks at the critical needs from a company's need for strategic positioning. Companies locate where they can derive the most benefits and operational efficiencies. The factors Gooley outlines are for companies to consider when locating manufacturing and distribution facilities. These factors directly apply to inland port critical needs because an integral part of a developed inland port are value-added services like manufacturing and distribution. Gooley's site selection factors are:

- Physical infrastructure
- Proximity to suppliers and customers
- Political and tax considerations
- International trade considerations

Gooley (1998b, p. 65) states that "(w)ith site selection, perhaps the most important thing is to think in terms of a supply chain, recognizing that an entire, organic system is involved." This directly connects these critical needs to inland port development because one focus at inland ports is to integrate all supply chain components to create a more efficient system. In Richardson's (1999) article, a checklist is provided to shippers so that the best port based on particular needs can be selected. Fifteen items are included in the checklist; all combined, the list provides the shipper with the total picture when selecting a port. The following list briefly describes each item in the checklist provided in Richardson's article.

- Location: Closest port geographically or by transit time
- Cost: Actual cost, time, insurance, other legs

- Service: shipping lines, railroads, carriers servicing the port
- Reliability: Consistent transit time
- Time: Time cargo takes to move through the actual port facility
- Security: Protection from theft, proper handling
- Labor: Stable environment
- Infrastructure: Highway, rail, other modal access
- Market: Large or small consumer base
- EDI: Paperwork handled electronically
- Customs: Available and adequate
- Equipment: Specialized needs considered
- Facility: Handling volume
- Environmental Issues: Problems with dredging, air/water quality, species
- Foreign-Trade Zone: Whether the site has Foreign-Trade Zone designation

This list is very comprehensive and easily identifies a wide range of critical needs. However, this checklist requires modifications, i.e., inland ports may not need dredging but there may be other environmental issues.

Private developers interested in creating inland ports have assembled critical needs that they feel are necessary for the creation of a successful site. The Lynxs Group, developers of the March GlobalPort and other air cargo operations in the United States, consider existing supply the most critical need of a location. Before investing in a new air cargo operation, the Lynxs Group examines the SIC codes of frequently shipped items in the selected region. The top twenty codes shipped by air are examined to determine if supply exists in the region and if potential for increase in supply is evident. If the supply exists, the Lynxs Group will consider locating an air cargo facility in the examined region (Brimble 2001). Hillwood, developers of Alliance Texas, has a list of seven critical needs for an inland port development of Alliance's size and content, shown in Box 1. Strong financial backing should be added to the list, as Hillwood's substantial resources have allowed its multi-year promotional strategies.

Hillwood believes that inland ports on a scale with Alliance can succeed only in four or five areas of the country. This is shown by the large-scale needs, especially because not many metropolitan areas have populations that are large enough or have enough available acreage. *The research team believes that the Los Angeles basin is one that meets most if not all of these criteria.*

Box 1: Inland Port Recipe—Alliance Style

1. Base population 3 million
2. Multiple modes
3. 5,000–10,000 acres
4. Tax and other incentives
5. Strong employment base
6. Telecommunications
7. Foreign-Trade Zone status

Source: Leitner and Harrison, 2001.

Robinson (1999) provided a list of assets necessary for a community to become an inland port (originally derived from a list created by Trade Point USA). This asset list comprehensively describes what a community can concentrate on to develop into an inland port. These assets can be considered the critical needs of an inland port. The following list is the nine assets and a description of each.

- Intermodal transportation capacity: Air, rail, highway, deep-water access
- Demographic advantage: Close to large population center
- Geographic advantage: Access to markets
- Presence of shippers: Existing demand
- Information technology infrastructure: Existing logistics IT
- Public/private cooperation: Established working relationship
- Councils: Address concerns of interested parties
- Aggressive marketing: Obtains community support and attracts business
- Capable program management: Leadership to move the inland port forward

Because inland ports are generally linked to a network of intermodal rail hubs, Harder (1999) also suggested strategies for locating railroad intermodal terminals. In determining new intermodal terminal sites, railroads consider market factors (customer clusters, specific customer requirements), physical factors (proper size and shape, low-cost development, expandability, highway and rail access), and local community considerations. In a recent study of the inland ports, The Tioga Group, et al. (2003 and 2006) has also developed a list of physical considerations to evaluate a site. These include:

- Proper size: to handle the anticipated customers and volume
- Proper shape: very long (more than a mile in length), relatively narrow, and parallel to the railroad's main line
- Low-cost development: massive funds needed
- Expandability: modular to include future expansion
- Highway access: close to key trans-shipment links
- Rail access: including intermodal hubs
- Local community considerations

3.2. Inland ports as intermodal hubs

Freight gateways were defined by Gooley (1997) as regional hubs that offer shippers "a complete range of domestic and international transportation and distribution services...[that] bring together in one location all the modes of transportation, along with warehousing, freight forwarding and customs brokers, and logistics-management services."

Similarly, Trade Point USA (is-Trade, 1999) defines an inland port as "a combination of assets which make a region an attractive distribution hub, consolidation point, or destination for imported and exported goods." These assets may include the following:

- Transportation infrastructure: air cargo capacity, rail links with intermodal ramps, and an accessible highway system.
- Demographic advantage in the form of proximity to a significant percentage of the nation's manufacturing capacity and/or to the buying public.
- Geographic advantage in the form of accessibility to coastal ports, and a lack of barriers to efficient transportation.
- Presence of large shippers seeking to leverage the benefits of an inland port community.
- Presence of an information technology infrastructure that supports leading-edge information technologies required to facilitate the efficient movement of goods into and out of the area.
- Cooperation among public and private entities, focused on the improvement of transportation and logistics services, for the benefit of the whole community.
- The creation of councils to expand public and private involvement through groups of related participants that meet to address concerns shared by various entities in the international trade community: shippers, transportation providers, and service providers.
- The willingness to aggressively market the inland port concept locally, nationally, and internationally, to gain community support, and attract potential relocation prospects.

In a departure from the traditional inland port needs assessment, LaLonde (1997) described the inland port concept in terms of a hub for information flow: "Traditionally, a port is located on navigable waters. Now, it is information, used to coordinate transportation and distribution, instead of water, that allows an inland area to operate as a port."

3.3. Value-added functions

A successful inland port or logistics park designs its facilities and attracts tenants who can create value for their customers. The Inland Port Feasibility Study (The Tioga Group, 2006) defines a value-added function as a processing, consolidation, or distribution activity. Most facilities host a combination of these basic value-added steps.

- <u>Process the goods to increase their value</u>: "Processing" in the broadest sense could include refining, sorting, packaging, testing, assembling, or any other operation that increases the value of the goods to the customer.
- <u>Consolidation</u>: Consolidation is a second means of adding value. Consolidation can include the consolidation of multiple small shipments into a single, more efficient large shipment; or consolidation of multiple items into a single delivered product.
- <u>Distribution</u>: Distribution in its simplest sense is the act of splitting large shipments into smaller shipments for local delivery. Typical examples include wholesale-to-retail distribution centers (DCs), inbound rail/truck transloading for local delivery, inbound airfreight forwarding; inbound LTL trucking, and import container freight stations.

The Inland Port Feasibility Study also details a number of other possible ways in which value could be created in an inland port. These include:

- Cargo-handling functions: This function for containerized freight includes consolidation, deconsolidation, and transloading. "Transloading" is the practice of transferring cargo between international and domestic transportation equipment, typically to take advantage of the large cubic capacity of U.S. trucks.
- Customs inspections: Only a small percentage of all import containers are opened or otherwise inspected by Customs and Border Protection (CBP) at the ports. A number of safety/security considerations need to be taken into account, if this operation is to be performed at inland port locations.
- In-bond transport: Any portion of a split shipment that arrives at a different port must be transported in-bond to the port of destination where entry will be made; such in-bond transportation to the port of destination must occur before the transported merchandise may be released by Customs.
- Customs bonded warehouse: Once "bonded" a shipment can also be moved to a Customs Bonded Warehouse to await final clearance.
- Foreign-Trade Zones: A Foreign-Trade Zone (FTZ), also known as a Free-Trade Zone, is a federally sanctioned site where foreign and domestic goods are considered to be outside of the U.S. customs territory.
- Container Depots: These depots handle both carrier-owned containers and leasing company containers, and have the capability of accepting containers from one trucker and releasing them to another. Container depots have three major functions: storing containers that are currently surplus, acting as a supply point for empty containers, and servicing/repairing containers under contract.
- Heavy Commodities and "Overweights": A major reason for transloading or consolidation is the opportunity to load an international container with more net weight than can be legally handled over the highway.
- Empty Container Supply: Most export loads require draying in an empty container, and each import load generates an empty to be returned to a port. If the need for empty movements can be reduced or rationalized, total cost can be reduced. The rationalization for using empty container flows include using rail shuttle service to position empties at inland port depots and reusing import empties for export loads.
- LTL Terminals: Terminals for less-than-truckload (LTL) motor carriers are sometimes considered as candidates for inclusion in an inland port/logistics park development. LTL terminal location choices reflect market demand, operational needs, and labor rules.

Notteboom and Rodrigue (2005) also reiterate these important value-adding functions. The authors state that inland terminals have become crucial cargo consolidation and deconsolidation centers. A large number of inland ports have become broader logistics zones, as they not only have assumed a significant number of traditional port functions and services, but also have attracted many related logistical services. The authors also provide a differentiation between two types of value-adding logistical services (VAL): low-end (e.g., labeling, insertion of manuals, etc.), and high-end (e.g., distribution, container handling, etc.).

Walter and Poist (2003) developed a list of inland port characteristics, based on focus group interviews, field interviews, and literature reviews. Twelve attributes have been identified as those that make a region an attractive distribution hub, consolidation point, or destination for imported and exported goods. These attributes include:

- Transportation center: licensing and compliance activities
- Multi-purpose business center: temporary office space, seminar and trade show facilities
- Port of entry for customs clearance and inspection
- Public warehouse services: general and special commodities
- Bonded warehouse services: tariff and tax postponement
- Intermodal transfer facility for containers
- Foreign-Trade Zone: tariff shelter, light assembly, and distribution
- Travel plaza: food service, fueling, and rest areas
- Single source for federal and state transportation agencies: US DOT, IA DOT
- Single source for federal and state trade support agencies: Departments of Commerce, Treasury, Agriculture
- Information clearinghouse or library for transportation and trade publications
- Internet Web site(s): transportation and trade information

The literature clearly shows that while inland ports—defined as large-scale logistics hubs—are growing across the global supply chains, they remain extraordinarily diverse in their design, operations and impacts. Their advantage to the planning agency faced with high demand for container processing sites is essentially one of scale. Reducing the number of sites allows for targeted investment in highway segments and connections, and may even stimulate different modes (like rail) within the system. The creation of large inland ports could justify shuttles from the port terminals to feed the containers and bundled transportation systems to move the goods out along the supply chain (Nottenboom and Rodrigue, 2005). In all cases, location is a critical input to the success of any inland port and this supported the decision of the research team to concentrate on defining location in terms of aggregate truck vehicle miles of travel and adopting it as the main focus of the study.

4. Container Movement and Transportation Nodes

4.1. Loaded and empty container movement

International trade plays a significant role in the state's economy. Logistics firms employ over 500 thousand workers in Southern California alone and account for one in every seven jobs in the state. The average wages for these jobs are close to $50,000, making it an attractive source of income for workers.

Containerized waterborne commerce through California's ports accounted for 40% of the national total port terminal throughput in 2006. The combined value of exports and imports at the Los Angeles, San Francisco, and San Diego Ports has been estimated at $513 billion for 2006. The ports of Los Angeles and Long Beach together handle one-third of all U.S. container traffic, and over 65% of all west coast container traffic. The 19 million residents of the region defined by five counties represent the final market for about a quarter of all the imports coming through the ports. Another 25% is handled in this region and then moved elsewhere through various supply chains. The lockout of West Coast ports in September and October of 2002 dramatically illustrated the importance of maritime commerce to the region and its vulnerability. Shippers are currently experimenting with competing transportation corridors which would divert business away from Southern Californian terminals. Failure to invest in goods movement infrastructure could mean significant losses of future state tax revenues.

Table 4.1 shows the volume of operations of the top 12 containerized ports in U.S. and the rest of the world in 2006. It shows the pre-eminence of Californian ports, although East Coast ports, particularly Virginia (Hampton Roads), Savannah, Charleston and Houston are all growing strongly. Houston, Charleston and Savannah are served by new liner services using the Panama Canal while Virginia is positioned to receive containers from both Panama and Suez Canals, the latter served by large port-Panamax container vessels. Much of the Panama Canal container traffic is diverted business from Southern Californian terminals. The table also shows the scale of foreign terminals, and shows that U.S. locations do not dominate the global transportation corridors. Los Angeles (10), Long Beach (12), New York/New Jersey (18) and Oakland (42), in world rankings, compare with Hong Kong (2), Shanghai (3) and Shenzhen (4) from China. Clearly, it is unreasonable to expect that West Coast U.S port terminals can process the Asian trade alone—other North American ports terminals are needed. The Southern Californian terminals will continue to play the major role in serving Asian trade but the distribution and processing sites in the five counties served by the terminals need substantial changes if efficiency and social equity targets are to be reached.

Table 4.1. TEU throughput for top 12 U.S. and world ports, 2006 (10^3 units).

USA			World		
Rank	Port	TEUs	Rank	Port	TEUs
1	Los Angeles	8,470	1	Singapore	24,792
2	Long Beach	7,289	2	Hong Kong	23,359
3	NY/NJ	5,093	3	Shanghai	21,710
4	Oakland	2,390	4	Shenzhen	18,469
5	Savannah	2,160	5	Busan	12,030
6	Tacoma	2,067	6	Kaohsiung	9,775
7	Virginia	2,046	7	Rotterdam	9,603
8	Seattle	1,987	8	Dubai	8,923
9	Charleston	1,968	9	Hamburg	8,862
10	San Juan	1,750	10	Qingdao	7,702
11	Houston	1,606	11	Ningbo-Zhousan	7,068
12	Honolulu	1,114	12	Antwerp	7,019

Source: Container Management, 2006.

Improvements in the following dimensions are among the most important strategic and operational decisions to be made in a port complex such as San Pedro Bay (SPB) Port.

- Capacity (loading/unloading, in-port road and rail road, landside accessibility, and highways and railways network)
- Utilization (actual throughput divided by the theoretical capacity)
- Efficiency (actual throughput divided by the effective capacity)
- Lead times and reliability in lead times
- Environmental impacts (emissions into air, water, and soil)

However, the essence of all of these dimensions can be represented by the concept of flow time reduction; that is, smooth, straight, and fast flow from origin to destination. By the virtue of Little's Law, flow time is linked with throughput and average inventory (I=TR where I is the average inventory, and T and R are flow time and throughput, respectively). In addition, lessons from lean system operations have shown that smooth flow also reveals and resolves quality problems. Therefore, a smooth flow also means a substantially lower probability of error in transporting the right container to the right place at the right time. Furthermore, the less time a container spends in the following stages, the less likely it is to require additional handling, generate pollution, and absorb costs.

- Loading and unloading
- In-terminal transportation via hostlers
- On-terminal storage
- From-terminal transportation (landside accessibility to highway and railway network)
- Transportation from the port to an intermediate processing stage inland

Southern California benefits from a large and extensive intermodal transportation infrastructure for its goods movement. Given this infrastructure, planners are striving to bring this system into full utilization. Currently, some sections of this system are underutilized. For example, the Alameda Corridor has not met its capacity targets and is working at about a third capacity. The most significant reasons mentioned in the literature are:

- Less total cost for truck travel compared to rail
- More flexibility for trucks, faster deliver time, and increased reliance on just-in-time delivery
- Building of large truck-friendly logistic hubs (e.g., distribution centers) in the region (e.g., Mira Loma and Colton)

As mentioned before, the traditional view of moving cargo in the region no longer seems viable. This classic view follows the current modal split of about two-thirds movements using trucks. Instead, the idea of a "satellite" inland port has been proposed by a number of researchers in this field in which one or more inland ports in the vicinity of the bay ports use the existing rail network (e.g., Alameda Corridor south and east) to take the containers to the major intermodal facilities. Then, in a more flexible distribution pattern, trucks are used to move the containers to the distribution centers and/or depots for redistribution. This model promotes more efficient planning, utilization, and scheduling for the Alameda Corridor and existing BNSF and UP rails, as well as county transportation agency-owned rail systems. The proposed approach follows the satellite inland port design.

4.2. San Pedro Bay port operations

Based on the information in Table 4.1, the share of the two ports in their total operations is 56% for POLA and 44% for POLB. However, in strategic planning, both ports share equal value and importance to all the stakeholders involved. The actual (2004–2006) and forecast (2010–2030) of the volume of operations in Ports of LA/LB is shown in Table 4.2.

Table 4.2. Volume of operations of SPB port terminals (in TEU millions): actual (2004-06) and forecast (2010-30).

Actual		Forecast	
Year	TEUs	Year	TEUs
2004	13.1	2010	19.7
2005	14.1	2020	36
2006	15.8	2030	44.7

Source: Ports of LA/LB

Table 4.3 gives these volumes in terms of import/export and loaded/empty containers handled by the ports.

Table 4.3 Number of regional daily truck trips for the three types of containers at SPB ports: actual (2004–06) and forecast (2010–30).

Year	Total	Import (loaded)	Export (loaded)	Export (empty)	Year	Total	Import (loaded)	Export (loaded)	Export (empty)
2004	15879	7939	3175	4764	2010	23879	11940	4775	7164
2005	17091	8545	3418	5128	2020	43636	21818	8728	13090
2006	19030	9515	3806	5709	2030	54182	27091	10836	16255

The following analysis begins with the number of import-loaded containers, transformed into daily truck trips. In doing so, the following assumptions were made:

- Half of the total TEUs are moved by train using on-dock, near-dock, or off-dock facilities ➔ yearly TEUs/2 = yearly truck TEUs in five counties.
- The distribution of 40-feet and 20-feet containers are assumed equal ➔ three TEUs = two trips.
- There are about 12 days of holidays in a year ➔ 50 weeks of operations per year.
- With PierPass now in operation, shippers have nine shifts on weekdays (five day-shifts and four night-shifts) in which to pick up or deliver cargo, plus a Saturday shift ➔ daily trips = weekly trips/5.5.
- The number of import containers (loaded) is equal to the number of export containers (loaded and empty).
- Import containers are all loaded. Export containers are 40% loaded and 60% empty.

4.3. Defining regions based on TAZs, transportation nodes, and truck VMTs

To define any location potentially designated as an inland port, one needs to determine the areas where the intensity of truck traffic is the greatest. These areas, exhibit high concentrations of truck destinations with active intermodal distribution centers. To begin, the researchers used the results of a truck travel survey conducted in 2004 by the ports in collaboration with Meyer, Mohaddas, and Associates. The survey results show traffic analysis zones (TAZs) that truck drivers were coming from or going to within the five counties. ArcGIS (ESRI, version 9.1) was used to facilitate the analysis. Figures 4.1 and 4.2 show the intensity of the truck trips to these TAZs in either directions.

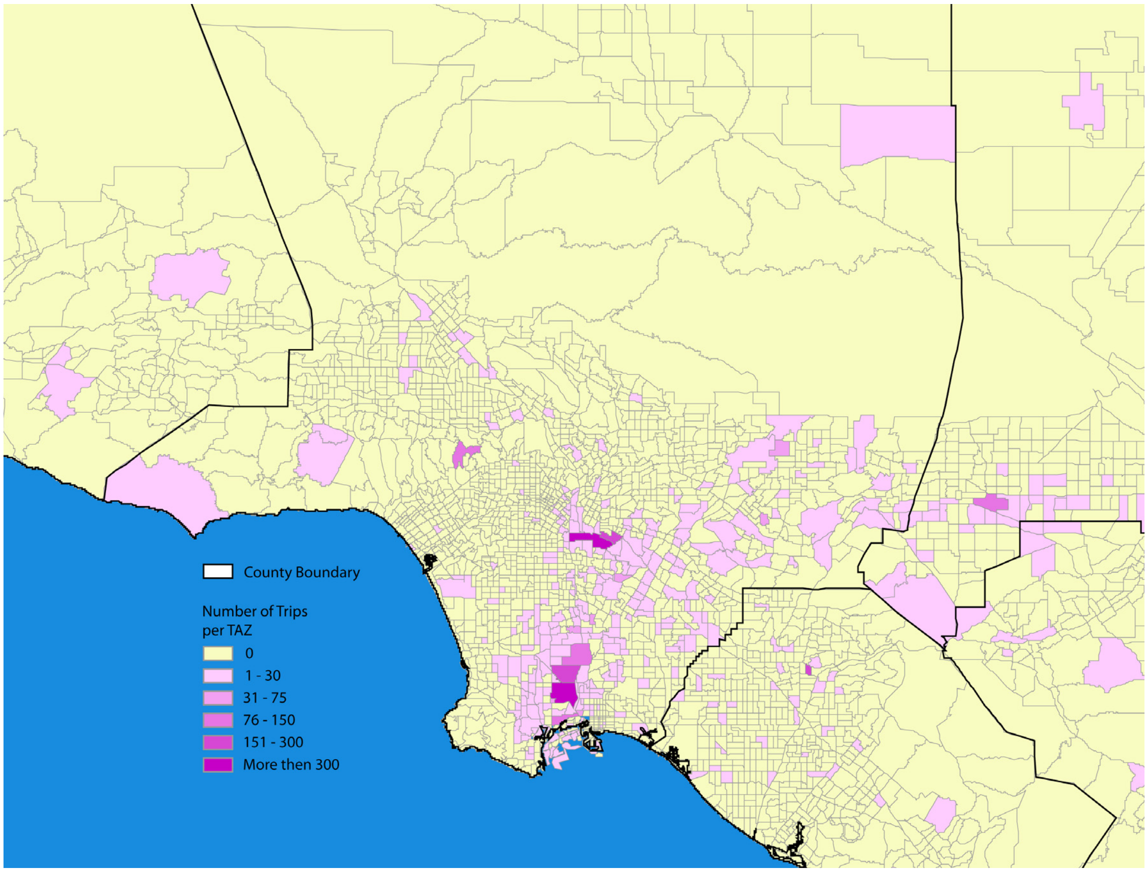

Figure 4.1. Intensity of trips from the SPB ports to the traffic analysis zones (TAZs) in the five counties.

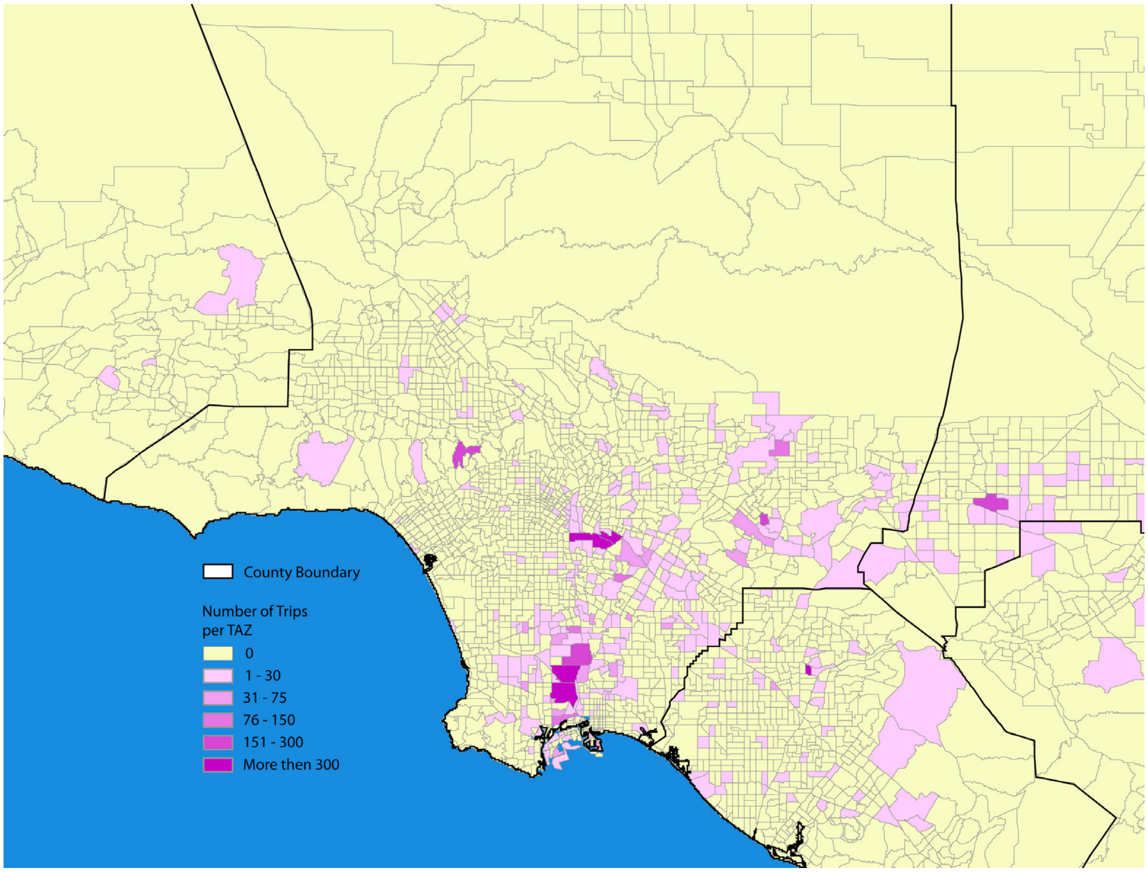

Figure 4.2. Intensity of trips from TAZs in the five counties to SPB Ports.

These maps indicate that the TAZ concentrations are too widespread and the county boundary lines are less than ideal for demarcating the regional concentration of truck travel for the next step of the analysis. A set of new regional boundaries was needed to define the concentration of truck origin/destination as the basis for determining inland port location. A combined set of homogeneous TAZs were first adopted, based on the following heuristic:

- TAZs must have similar number of trips
- TAZs have to be adjacent and have a concave shape
- There should be no more than five TAZs combined into one

Each combined TAZ was called a transportation node (TN), which is a single geographical point representing the grouped TAZs. The exact location of each TN was determined by calculating the centroid of the combined TAZs. This calculation yielded 100 TNs in the five counties. Figure 4.3 shows the location for the TNs within the five counties.

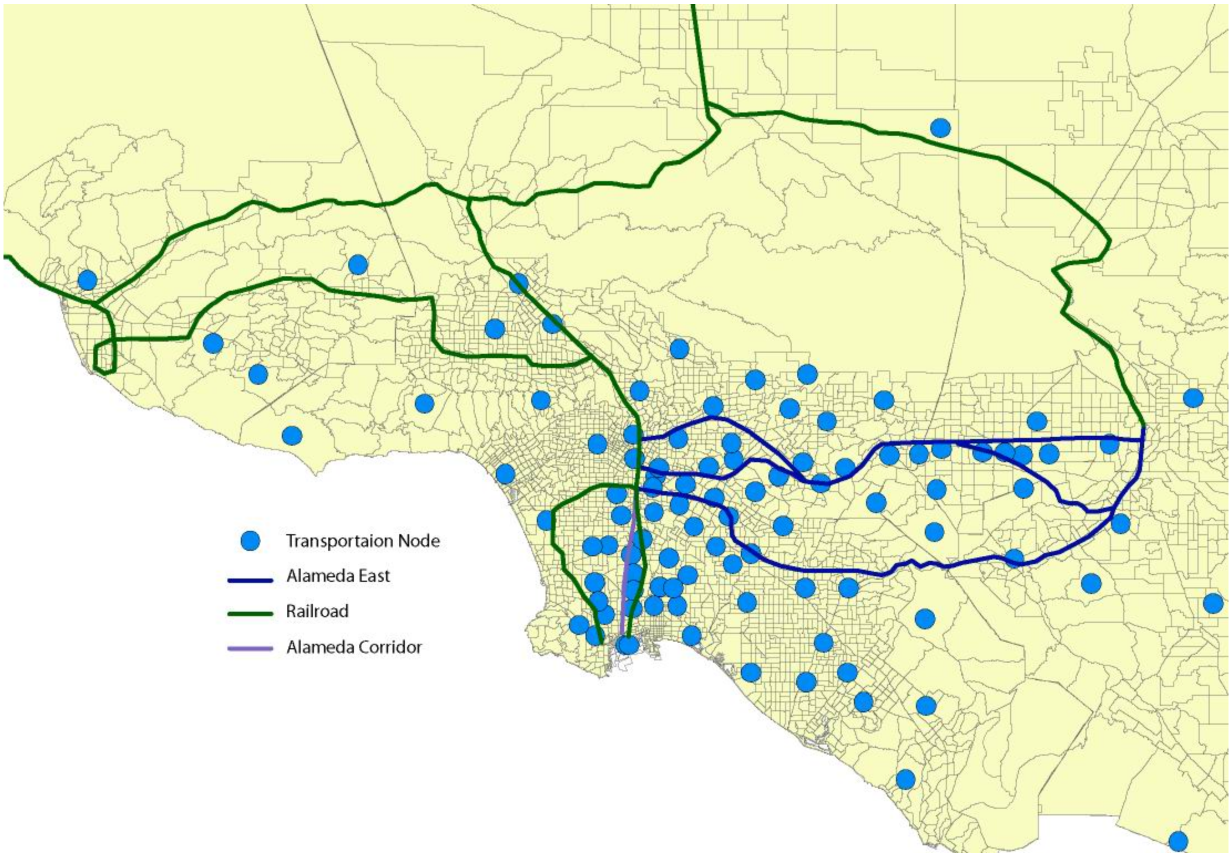

Figure 4.3. Transportation nodes generated from TAZs.

The TN locations were then used to calculate the total truck VMT to and from the ports to these centroid locations. Figure 4.4 shows the total TN VMTs, using graduated symbols. The rest of our analysis uses these TN locations in the proposed location allocation models.

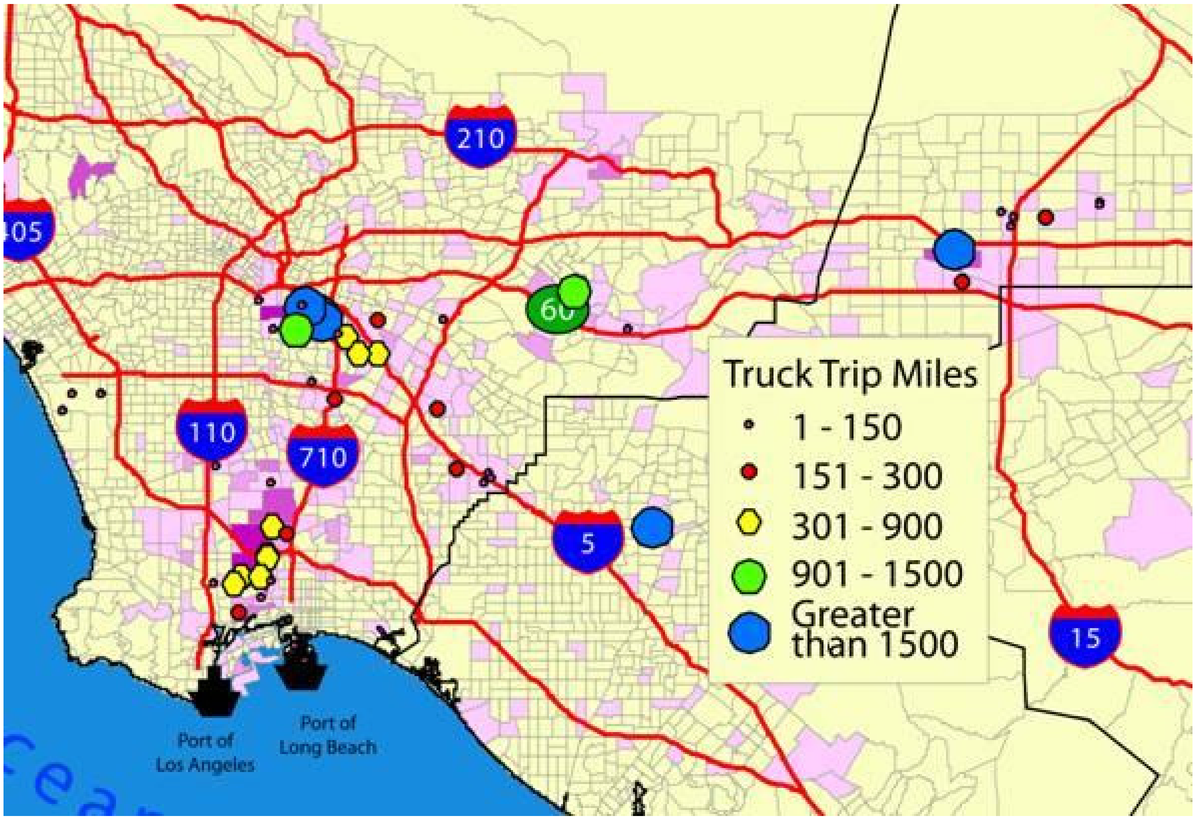

Figure 4.4. Truck trip miles to/from the transportation nodes.

In Figure 4.4, the graduated symbols show the areas with the largest number VMTs; there are six areas of concentration with high truck-trip miles. The researchers temporarily selected an arbitrary point within each concentration area—the point with the highest number of TNs. From these temporary points, the researchers defined six Thiessen polygons for each point. Thiessen polygons were drawn such that the boundaries of each polygon are equidistant between the arbitrary point and the next adjacent arbitrary point. Figure 4.5 presents the results of the Thiessen polygons for the six points. These areas define six regions for further analysis. Due to their proximity to city/county landmarks, they were named: Ventura, Commerce, North of Port (a section of LA County within 25 miles north of the ports), East LA (eastern portion of LA County), Orange, and Mira Loma (Inland Empire combining Riverside and San Bernardino counties).

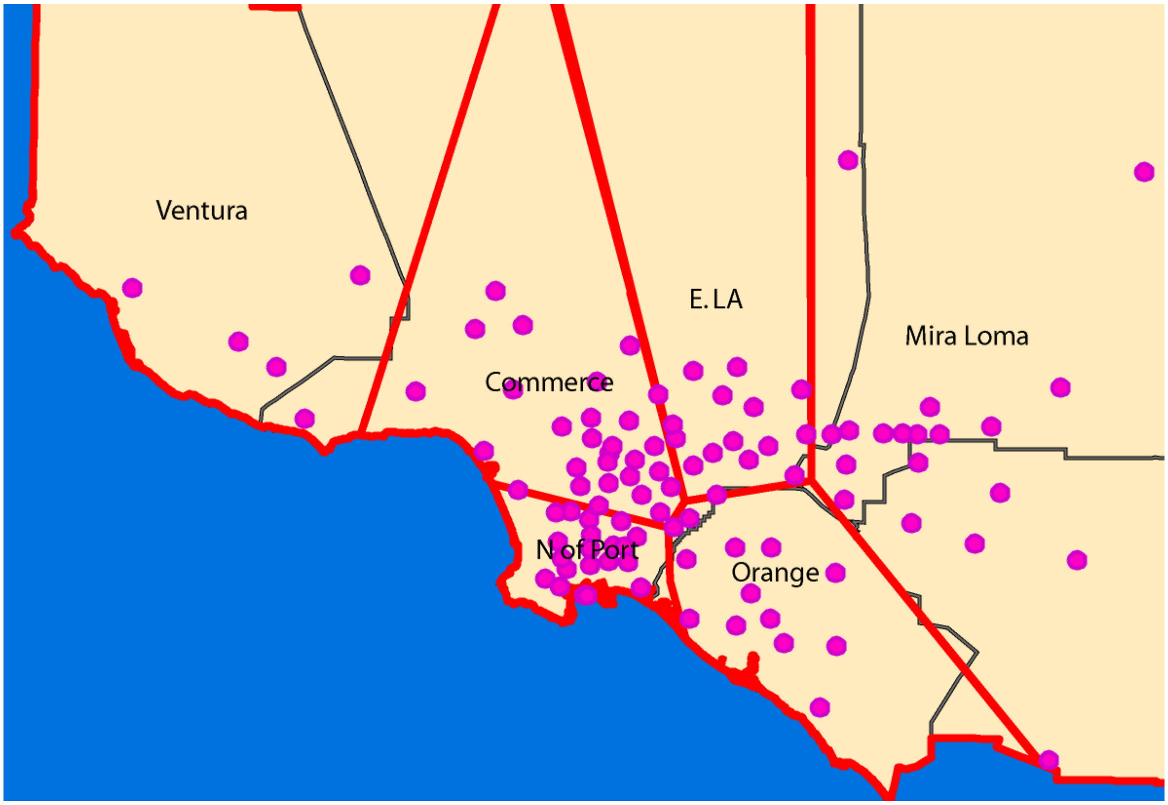

Figure 4.5. Six regions defined by the equidistant Thiessen Polygons.

These six Thiessen polygons were defined so we could conceptualize six potential inland ports, one in each polygon region. The next set of analyses then focused on the merits of allocating an inland port location to each of these regions or combining these regions for a more reasonable allocation strategy. These analyses would use the previously defined TNs contained within each region as the point of reference for mathematical optimization.

To begin this process, consider the relative importance of these regions based on their volume of port-related truck transportation. Figure 4.6 shows the estimated number of daily trips between SPB ports and the five regions. Note that empty container trips were all from the region to the port.

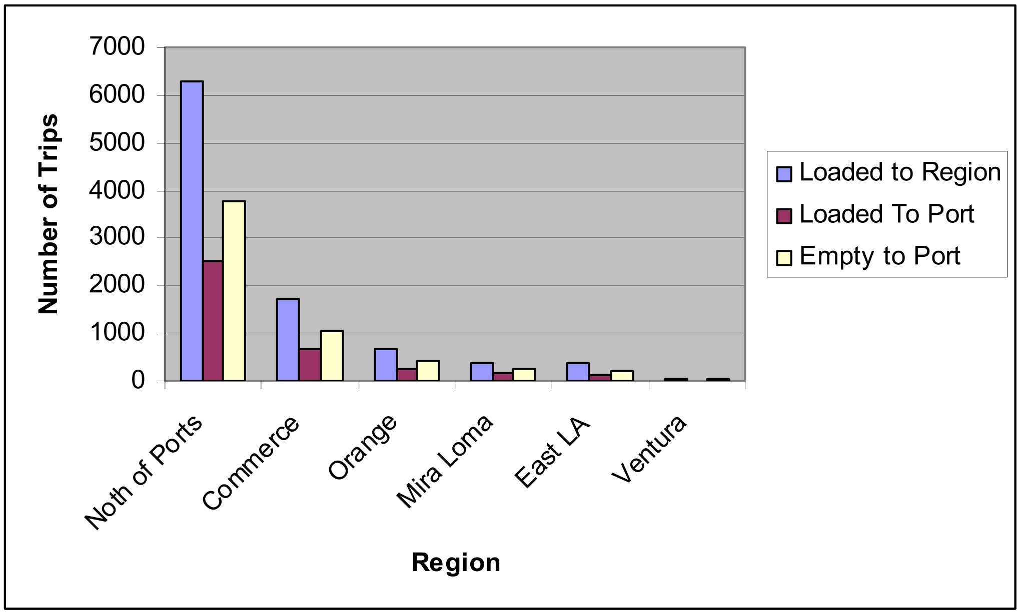

Figure 4.6. Number of daily trips between SPB Ports and the six regions.

This graph indicates that the volume for (a) North of Port was 66.4% of the trips, (b) Commerce was 18.2% of the trips, (c) Orange was 7% of the trips, (d) Mira Loma was 4.1% of the trips, (e) East LA was 3.8% of the trips, and (f) Ventura was 0.5% of the trips. The relative shares between the six regions derived from these data were used in the inland port location allocation problem discussed in the next chapter.

5. Facility Location Models

5.1. Introduction

This chapter develops the mathematical models for inland port location problem in two forms, namely: (*i*) Single Facility Location Model and (*ii*) Location Allocation Model. These models were implemented within the five counties' existing intermodal transportation network. In the single facility model, the researchers identified the location of a single inland port to serve all transportation nodes within the five counties. Also identified was the potential location of one inland port in each of the six regions of North of Port, Commerce, Orange, Mira Loma, East LA, and Ventura. The location allocation model started with the six regional allocations and one allocation for the ports and then begins to eliminate less efficient inland ports by identifying the impact on the total vehicle miles traveled (VMT). This produced an estimate of the changes in total VMT by reducing each inland port and allowing others to serve its TNs.

The objective of the model was to minimize both the flow of containers in terms of the number of trips per route, as well as the distances between the designated inland port and the transportation nodes. The researchers made an important assumption about the total travel distance as the major driver of (*i*) the total travel cost, and (*ii*) the total air and noise pollution. In other words, there is a high correlation between the independent variable of travel distance and the cost and pollution variables with a linear transformation.

The development of these mathematical models benefited from the mathematical modeling foundations and procedures developed in the work of Francis, et al (1992) and Tompkins, et al (2003). While their models and procedures have been developed for location allocation in industrial applications, the basic concepts and formulations remain the same for application to the inland port location problem.

5.2. Single facility location model

The inland port location problem can be formulated as a single-facility location model. For the formulation, let m denote the number of the transportation nodes, and P_i denote the location of the node. Let t_i denote the daily number of trips between P_i and O where O is the location of the inland port. Thus, if $d(O, P_i)$ denotes the distance between O and P_i, the total distance of transportation is $t_i d(O, P_i)$. Suppose the average speed of a truck to location P_i is equal to v_i ($i=1,2,\ldots, m$). Then $t_i/v_i d(O,P_i)$ is the total transportation time between the inland port and a transportation node i. Hence, if c_i is the transportation cost per hour, then $c_i t_i/v_i d(O, P_i)$ is the daily transportation cost between the inland port and transportation node i. Define $w_i = c_i t_i/v_i$ as the weight of the transportation node i, and therefore, the daily transportation cost between the inland port and a node i is equal to $w_i d(O,P_i)$. The objective function to be minimized is then defined as:

$$Z = \sum_{i=0}^{m} w_i d(O, P_i).$$

The weight of the transportation node is referred to w_i. One may normalize w_i by replacing $w_i = w_i / \sum_{i=0}^{m} w_i$, and assume $W = \sum_{i=0}^{m} w_i$ as a coefficient. A choice of O that minimizes Z will thus be an optimal location for the inland port, which minimizes the total cost of container handling movement to and from the transportation nodes. If the cost of transportation (c_i) as well as the speed of trucks (v_i) is the same on all routes, then w_i is simply replaced by the number of daily trips. Similarly, by defining w_i ($i=0,2,\ldots, m$) as the negative environmental impact of one mile of travel, the objective function is to minimize the emissions.

Rectilinear distances can replace actual street distances of the transportation nodes. Indeed, another name for rectilinear distance is *Manhattan distance,* because the street network of Manhattan is rectilinear. While rectilinear distances may not be exactly equal to the actual street distances, they are adequate approximations to street distances. Hence, the rectilinear distances give tight upper bounds on actual distances. Furthermore, a replacement problem can always be created by replacing the street distances with the rectilinear distances. If the replacement problem is solved and the minimum total rectilinear distance cost computed, this cost will be a tight upper bound on the cost obtained by solving the problem under street distances. In addition, the researchers observed that when the street distances are used on GIS maps, a substantial volume of flow may occur on a single link leading to the shortest distances. The travel time on such a congested link would be definitely lower than the initial estimates of the travel time. Since there are several equidistance rectilinear paths between the inland port and transportation nodes, the rectilinear trip times remain a valid estimate for street trip time.

The researchers used the following case study to test the reasonableness of the rectilinear distance estimation. In a study conducted by the Tioga Group for Southern California Association of Governments (SCAG), a geographical region in Mira Loma has been proposed for locating an inland port. These locations are shown in Figure 5.1. If the distance between each location and all other locations in this map is computed (*i*) using the actual street distances from GIS, and (*ii*) using rectilinear distance, on average the rectilinear distance is 12% longer than street distance (standard deviation is 2.4% with 95% confidence level). Therefore, the rectilinear distance is between 1.07 and 1.17 times that of the actual street distances. To simplify all calculations, rectilinear distances were implemented as a tight upper bound.

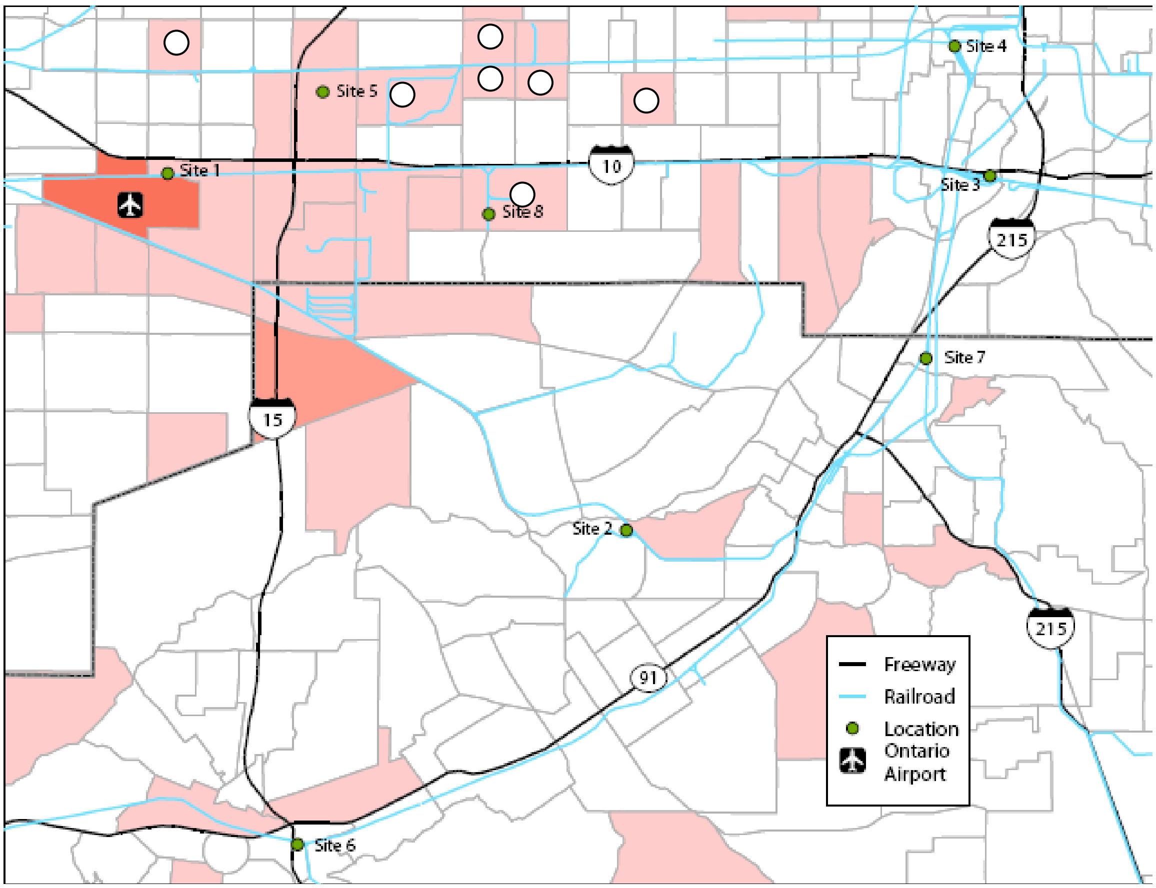

Figure 5.1. Relative location of eight potential sites in a Mira Loma region.

Now, the formulation continues using the rectilinear estimation. In a rectilinear transportation network, where x and y show the coordinates of the inland port, $P_i = (X_i, Y_i)$ are the coordinates of node i, and w_i shows the weight of node i, then the objective function $Z = \sum_{i=0}^{m} w_i d(O, P_i)$ could be replaced by

$$Z = \sum_{i=0}^{m} w_i (| x - X_i | + | y - Y_i |)$$

Therefore

$$Z = \sum_{i=0}^{m} w_i \,|\, x - X_i \,| + \sum_{i=0}^{m} w_i \,|\, y - Y_i \,|$$

Then, minimize the sum of the two separate functions of

$$Z_X = \sum_{i=0}^{m} w_i \,|\, x - X_i \,|$$

$$Z_Y = \sum_{i=0}^{m} w_i \,|\, y - Y_i \,|$$

In other words, the total cost of movement is the sum of the cost of movement in *x-direction* and the cost of movement in *y-direction*. Thus, by implication, the total cost of movement can be minimized by solving the two smaller and independent problems of minimizing the cost of movement in both *x-direction* and *y-direction*. In this approach, the best choice of *x* has no effect on the best choice of *y*. The two cost functions have exactly the same form and could be minimized simultaneously. The problem of minimizing either of these cost functions can be interpreted as a one-dimensional location problem on a line. The point *x* and the points at $X_0, X_1, X_2, \ldots\ldots, X_m$ are all points on the line, and $|x-X_i|$ is the distance on the line between *x* (the location of the inland port) and X_i (the location of the transportation nodes). Any optimal solution to the location problem will be inside the convex hull defined by the transportation nodes. In other words, to find a best location, consider only points in the convex hull. Furthermore, at least one value of *x* minimizing the cost function *f (x)* will be an *x-coordinate* of an existing facility.

If a horizontal and a vertical line are drawn through each transportation node, an optimal location lies on the intersection of the two lines. Furthermore, the minimization problem decomposes into two independent problems of the same form, one problem for each coordinate of the inland port. This symmetry of the procedure makes the problem easier to solve. Following the Tompkins et al (1992) procedure, the weight of each vertical (horizontal) line is defined as the sum of the weights of the nodes lying on that line. Also, as the function *f(x)* is convex, a local minimum is a global minimum. Because the point where the slope changes from nonpositive to nonnegative is a local minimum, it follows that it is also a global minimum. Therefore, the use of the median conditions determines a point minimizing *f (x).*

Table 5.1 shows the data regarding coordinates X_i and Y_i, and weight w_i for each transportation node $i = 0, 1, 2, \ldots\ldots, 100$ in the six regions under consideration. Coordinates were measured in metric scale and the weights were the number of daily trips. Figure 5.2 shows the total VMT between SPB ports and these 100 TNs.

Table 5.1. The *x* and *y* coordinates of the transportation nodes and their weight (daily number of trips).

Node #	Region	Weight	X_coord	Y_coord	Node #	Region	Weight	X_coord	Y_coord
1	Ventura	39	295414	3796026	51	Mira Loma	51	436048	3761278
2	Ventura	18	323731	3780497	52	East LA	21	428059	3767120
3	Ventura	15	316222	3785473	53	Mira Loma	24	433055	3767175
4	Ventura	12	340295	3798522	54	East LA	15	427185	3776042
5	Ventura	3	329293	3770211	55	Mira Loma	312	443387	3767362
6	Commerce	12	351224	3775524	56	Mira Loma	36	452546	3772460
7	Commerce	15	366845	3795471	57	Mira Loma	33	454395	3767188
8	Commerce	18	362852	3787987	58	Mira Loma	36	450055	3767128
9	Commerce	24	372297	3788717	59	Mira Loma	56	450259	3761602
10	Commerce	371	370459	3776024	60	Mira Loma	48	464560	3768788
11	North of Port	27	371348	3756204	61	Mira Loma	21	466367	3755654
12	East LA	217	411618	3774799	62	Mira Loma	18	481535	3742417
13	Commerce	24	386795	3777608	63	Mira Loma	18	494790	3818828
14	East LA	12	398915	3775123	64	Mira Loma	6	436495	3821189
15	Commerce	15	364648	3763843	65	Mira Loma	3	549219	3739926
16	Commerce	21	379895	3768788	66	Mira Loma	6	476004	3703024
17	Commerce	89	385899	3766464	67	Orange	18	421141	3730836
18	Commerce	1711	389434	3763602	68	Mira Loma	9	461426	3745766
19	Commerce	39	382884	3760704	69	Mira Loma	6	478323	3776441
20	Commerce	48	388938	3761723	70	Commerce	21	393343	3784692
21	Commerce	113	389220	3757552	71	Mira Loma	42	447062	3767406
22	North of Port	8818	384417	3735463	72	East LA	6	405900	3779567
23	North of Port	77	380858	3740610	73	East LA	59	417810	3772491
24	North of Port	1747	385612	3741534	74	East LA	12	410454	3755215
25	North of Port	77	393011	3742018	75	East LA	199	413812	3765744
26	North of Port	157	379279	3746006	76	Commerce	21	385695	3770391
27	North of Port	74	391624	3750036	77	Commerce	18	389986	3764890
28	North of Port	45	381660	3752087	78	North of Port	9	394765	3747088
29	North of Port	354	385347	3750526	79	North of Port	95	379934	3742825
30	Commerce	160	394393	3762103	80	Commerce	6	383617	3756993
31	Commerce	39	393284	3769865	81	North of Port	9	395512	3737062
32	East LA	24	402402	3766318	82	North of Port	12	376683	3738765
33	Commerce	27	398248	3764950	83	North of Port	21	379510	3737151
34	Commerce	53	399155	3759801	84	North of Port	327	385765	3747345
35	Commerce	125	395738	3755211	85	North of Port	588	385629	3744689
36	Orange	92	405145	3750724	86	North of Port	15	389250	3742188
37	Orange	83	404630	3742657	87	North of Port	12	390115	3745265
38	Orange	48	405074	3730922	88	North of Port	83	392222	3745066
39	Orange	18	414332	3729503	89	Orange	39	402125	3748957
40	Orange	39	417283	3735911	90	Commerce	89	399385	3751891
41	Orange	98	414192	3744951	91	North of Port	77	378914	3751799
42	East LA	71	409721	3763594	92	Commerce	205	387203	3753133
43	East LA	18	420755	3764790	93	Commerce	45	401483	3756801
44	Orange	856	421328	3744988	94	East LA	15	405824	3760978
45	Orange	9	423814	3726177	95	Commerce	146	393467	3758876
46	Orange	9	430890	3713379	96	East LA	18	401938	3769030
47	Orange	15	434110	3725457	97	East LA	12	416743	3762218
48	Orange	12	433907	3739897	98	East LA	12	414487	3780403
49	East LA	9	425803	3759202	99	Mira Loma	39	436648	3767995
50	Mira Loma	15	448860	3749729	100	Mira Loma	9	435569	3754247

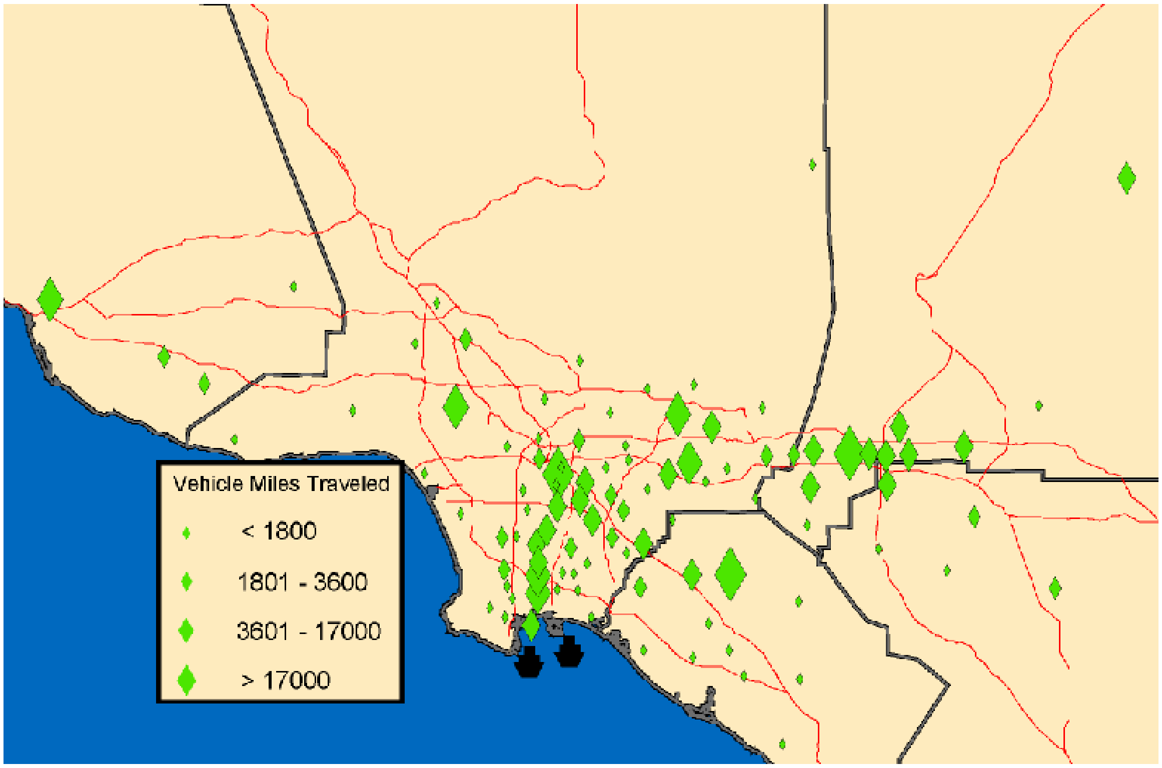

Figure 5.2. Location and graduated symbol (intensity in VMT) for each one of the 100 transportation nodes.

Next, the mathematical formulation was implemented in order to identify the optimal location of the theoretical inland port serving one of the six regions: Mira Loma. Figure 5.3 shows the transportation nodes in Mira Loma and their relative weights.

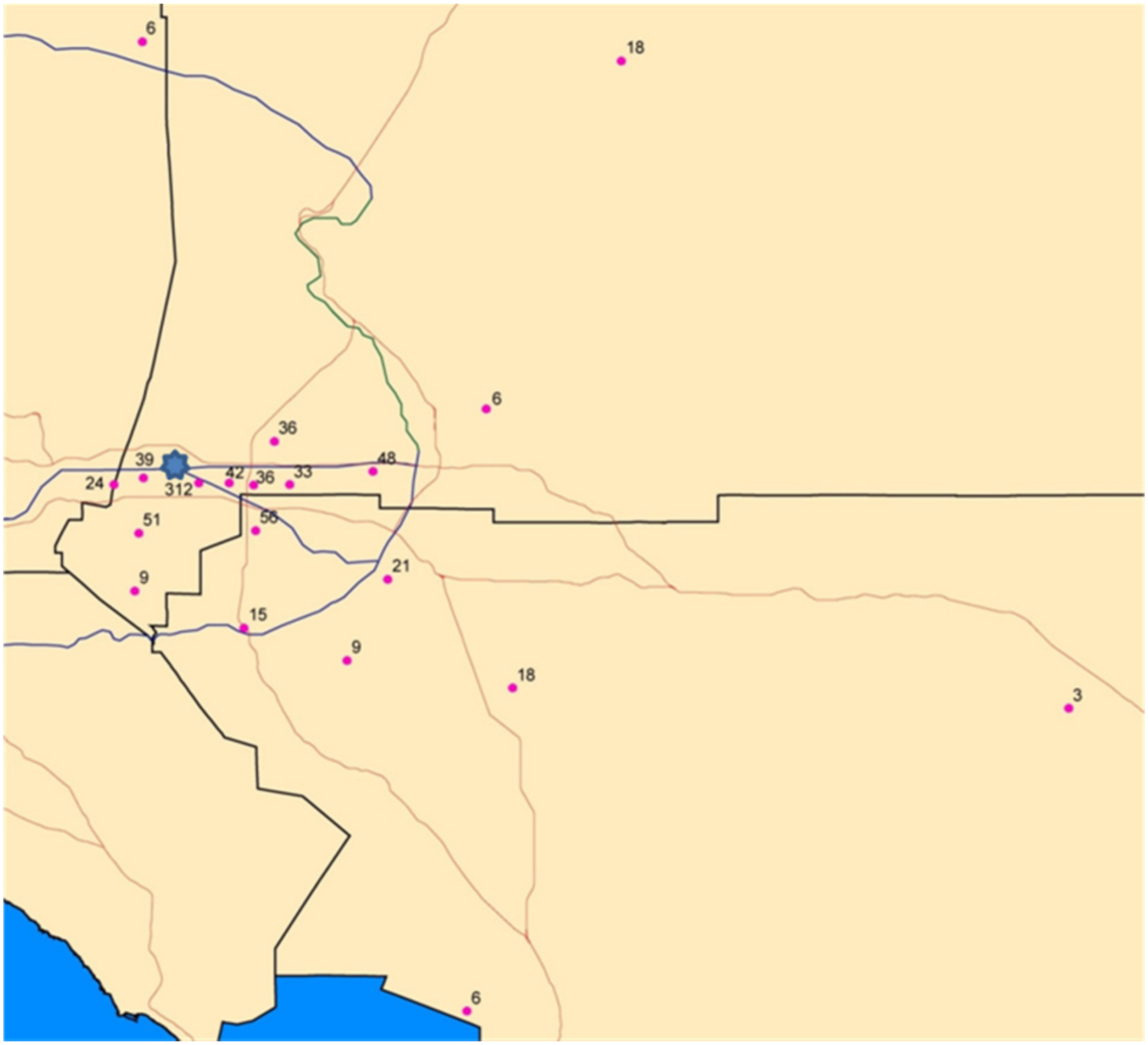

Figure 5.3. Transportation nodes in Mira Loma and their relative weights.

In order to do this, first the *partial sum of the weight* W_i is defined for the vertical line *i* as the weight of line *i* plus the weight of all lines with their *x-coordinates* less than or equal to *x-coordinate* of line *i*. Given $W = \sum_{i=0}^{m} w_i$, an optimal *x-coordinate* of the inland port is the coordinate of the first vertical line where $W_i \geq W/2$. Similarly, the *partial sum of the weight* W_i is defined for the horizontal line *i* as the weight of line *i* plus the weight of all lines with their *y-coordinates* less than or equal to *y-coordinate* of line *i*. Given $W = \sum_{i=0}^{m} w_i$, an optimal *y-coordinate* of the inland port is the coordinate of the first horizontal line where $W_i \geq W/2$.

The contour line construction procedure (given later, in Section 5.3) can be used to evaluate locations other than the optimal location against the optimal point.

Figure 5.4 shows the partial weights of the horizontal and vertical lines passing through the transportation nodes in Mira Loma. Nodes 63 to 66 are excluded to make the pictorial representation readable, due to their relatively large x-coordinate or y-coordinate. The optimal solution is at the intersection of the first horizontal and the first vertical lines that have partial weights greater than or equal to 392 (this number is half of the total weights). This number is half of the total number of daily trips to the transportation nodes in Mira Loma including nodes 63 to 66 (with weights of 18, 6, 3, and 6), which were deleted for reasons already given.

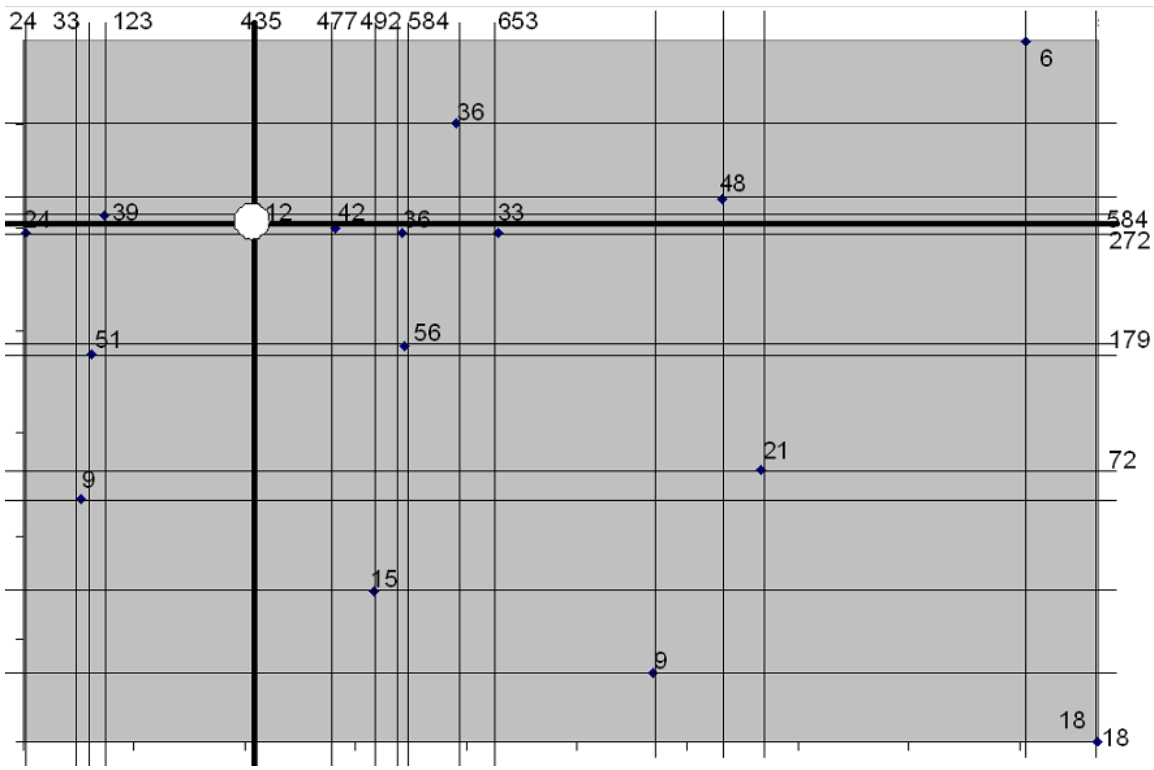

Figure 5.4. Partial weights of the horizontal and vertical lines passing through the transportation nodes in Mira Loma, and the location of the theoretical inland port in Mira Loma.

The total VMT to Mira Loma with no inland port is 46,559 miles, and the average truck trip length is 59.4 miles. If the inland port is initiated, the total VMT is reduced to 6,480 miles, and the average trip length is reduced to 8.3 miles.

The same calculation was used for a "global optimal" or central inland port for all six regions. This is the point where total VMT for all 100 transportation nodes is minimum to the ports. The total vehicle miles traveled from SPB ports to all the transportation nodes in the six regions was 220,100 miles, without a global inland port. If a central inland port is initiated then the total VMT is reduced to 132,200 miles, e.g., a reduction of 87,900 miles. The average trip length is reduced from 11.7 miles to 3.2 miles.

For the case where an inland port is initiated in each of the six regions, the location of the inland port associated with each of the regions is given in Figure 5.5.

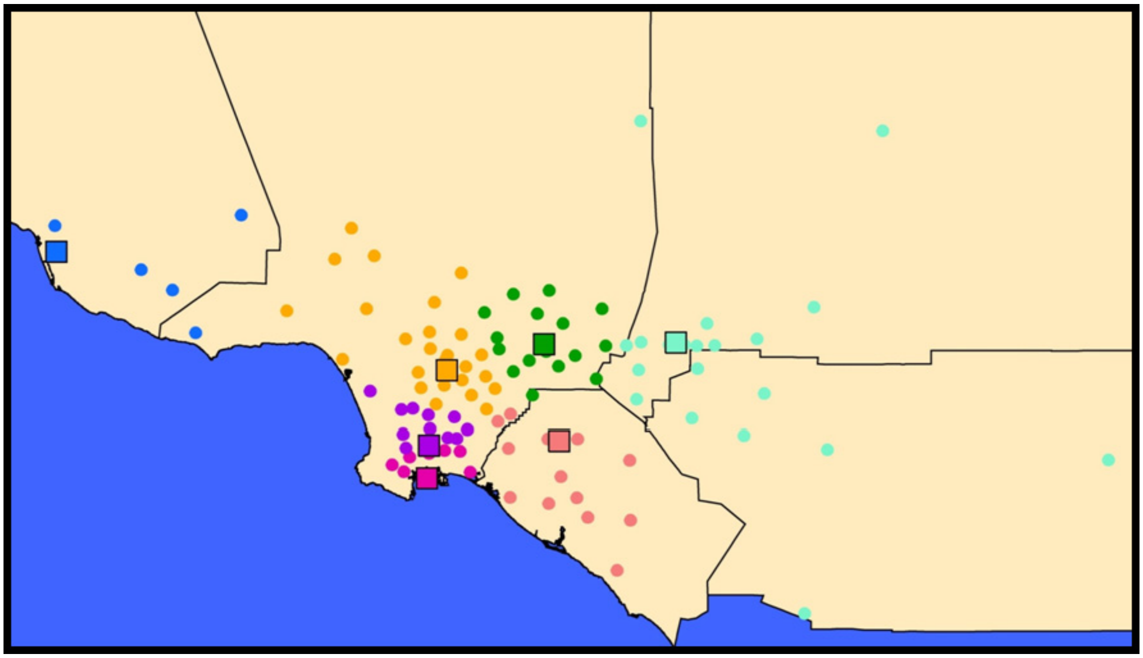

Figure 5.5. Optimal location of the six inland ports, one in each region.

The total VMT for each region, as well as the average length of truck trips, before and after initiating the inland port is shown in Table 5.2 and Figure 5.6.

Table 5.2. Total VMT before and after initiating one inland port in each of the six regions.

Region	Daily Trips	Served by SPB ports		Served by Inland Port		%Improvement
		VMT	Average trip length	VMT	Average trip length	
Ventura	87	6837	78.6	1120	12.9	83.6
Orange	1334	34855	26.1	5622	4.2	83.9
Commerce	3452	76069	22.0	18358	5.3	75.9
E. LA	719	30482	42.4	3743	5.2	87.7
MiraLoma	784	46559	59.4	6480	8.3	86.1
N. Port	12624	28197	2.2	25342	2.0	10.1
Average	19000	223000	11.7	60665	3.2	72.8

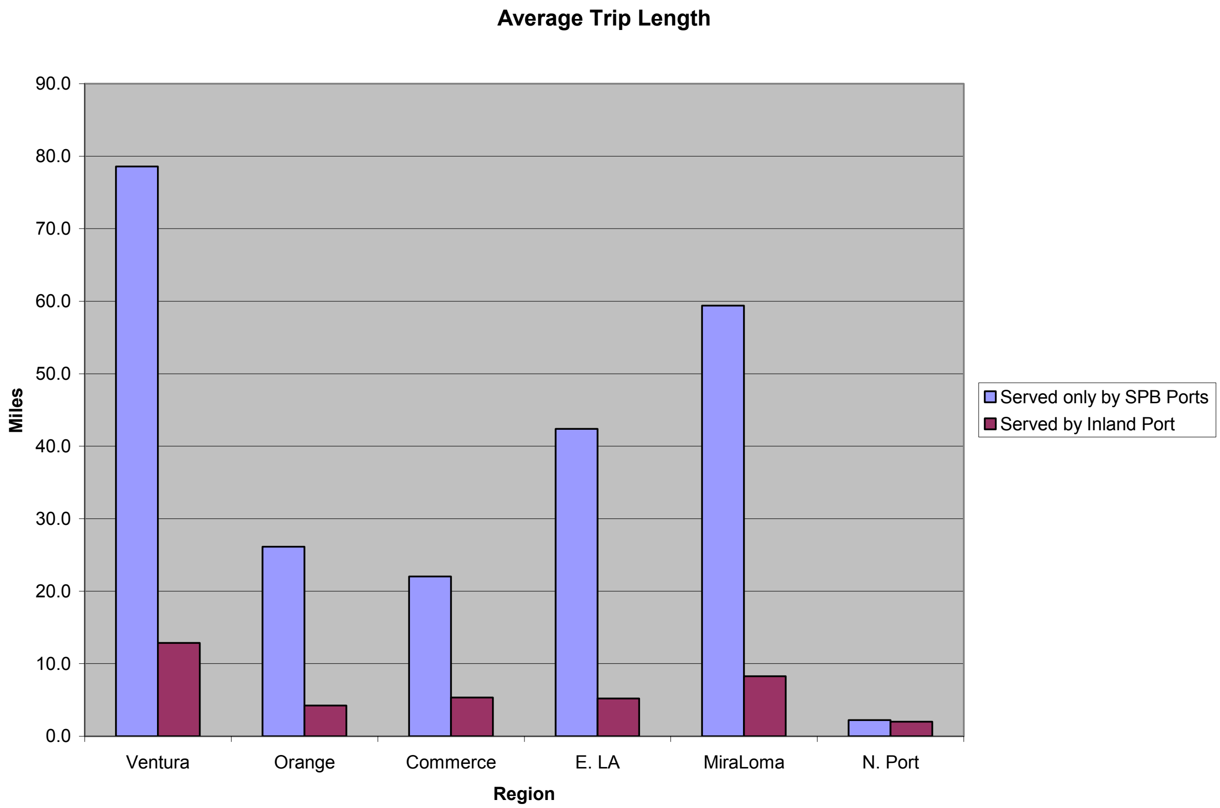

Figure 5.6. Average trip distance before and after initiating an inland port in each of the six regions.

5.3. Contour lines (level curves)

These mathematical solutions were undertaken without considering the realities of whether the optimum location can actually be used as an inland port or not. What if for practical reasons—land use designation, regulations, sizing—an inland port cannot be developed on the optimal location? It would be useful to have a general procedure to evaluate the costs of using the next nearest possible location. For instance, as stated earlier, in the feasibility study conducted by the Tioga Group, eight sites have been identified as potential inland port locations in the Inland Empire (one in Mira Loma). The question here is how much VMT is added to the optimal value if one of these adjacent locations is selected as the inland port serving Mira Loma. To develop this procedure, the researchers used the concept of *contour lines,* also called *level curves*, in classic location allocation literature (Francis et al, 1992). A contour line is analogous to a line of constant truck trip time from SPB ports to a transportation node on a traffic time map. Every point on the contour line has the same value of the function *f(x)*. Each contour set, whose boundary is a contour line, is the set of all points having values of *f(x)* no larger than those of the points on the contour line. Hence, to evaluate other possible locations for an inland port, one first considers locations in the innermost contour set. If none of these locations is suitable, consideration would go to locations inside the second innermost contour set, and so on. The following is a level curve procedure for facility layout design problem in Francis et al (1992) adopted for the inland port location problem.

1. Pass a horizontal line and a vertical line through each existing transportation node. The weight of each vertical (horizontal) line is defined as the total weights of the nodes lying on that line.
2. The vertical lines partition the plane into columns. For each column compute the *coefficient-of-x* as the sum of the weights of the lines to the left of the column minus the sum of the weights of the lines to the right of the column.
3. The horizontal lines partition the plane into rows. For each row compute the *coefficient-of-y* as the sum of the weights of the lines below the row minus the sum of the weights of the lines above the row.
4. The slope for every contour line passing through a given box is the negative ratio of the *coefficient-of-x* to the *coefficient-of-y*.
5. To determine those points that minimize *f(x)*, identify the points where the margin numbers change from negative to nonnegative or, equivalently, use the median conditions.
6. To construct a single contour line, start with any point in the interior of any box other than a point that minimizes *f(x).* Pass a line through the point that has the slope computed for the box, and extend the line until it intersects the boundary of the box. Choose either of the points intersecting the boundary. Such a point will be in another box, so the same procedure can be used to construct another line segment through the second box. Continue until a complete contour line is constructed. As a computational check, end at the same point started from. Note that this contour line construction procedure requires that the starting point of the procedure is not a point minimizing *f(x),* as no contour line can pass through such a minimizing point. In computing the slope for a box, if the *y* coefficient in the left margin is zero but the *x* coefficient is not zero, then the slope of the contour lines passing through that box is infinity, i.e., they are vertical lines. *If both the x and y coefficient for the box are zero, then in fact every point in the box is an optimal solution, i.e., multiple optimal solutions.*

The researchers implemented the level curve technique on the Mira Loma region and its theoretical optimal solution. Mira Loma has been named in several reports as an attractive location for an inland port. The main reasons for its attractiveness could be its proximity to Colton intermodal facility, a number of small airports for logistic support, potential for finding a site with attributes sufficient for future growth, and relatively low land cost. As shown in the previous section, the optimal location of Mira Loma inland port is on node 55 and the total VMT is 6,600. However, considerations such as physical restrictions, unreasonable costs, or environmental impact restrictions may not allow locating the inland port on this node. Should the optimal location prove unavailable, then the level curves represent all the nodes with the same total VMT, which is greater than the optimal solution. For example, as shown in Figure 5.7, if the inland port is located on any point on the fourth level curve from the center, then the total VMT will increase to 10,000. That is about a 54% increase in VMT compared to the optimal location.

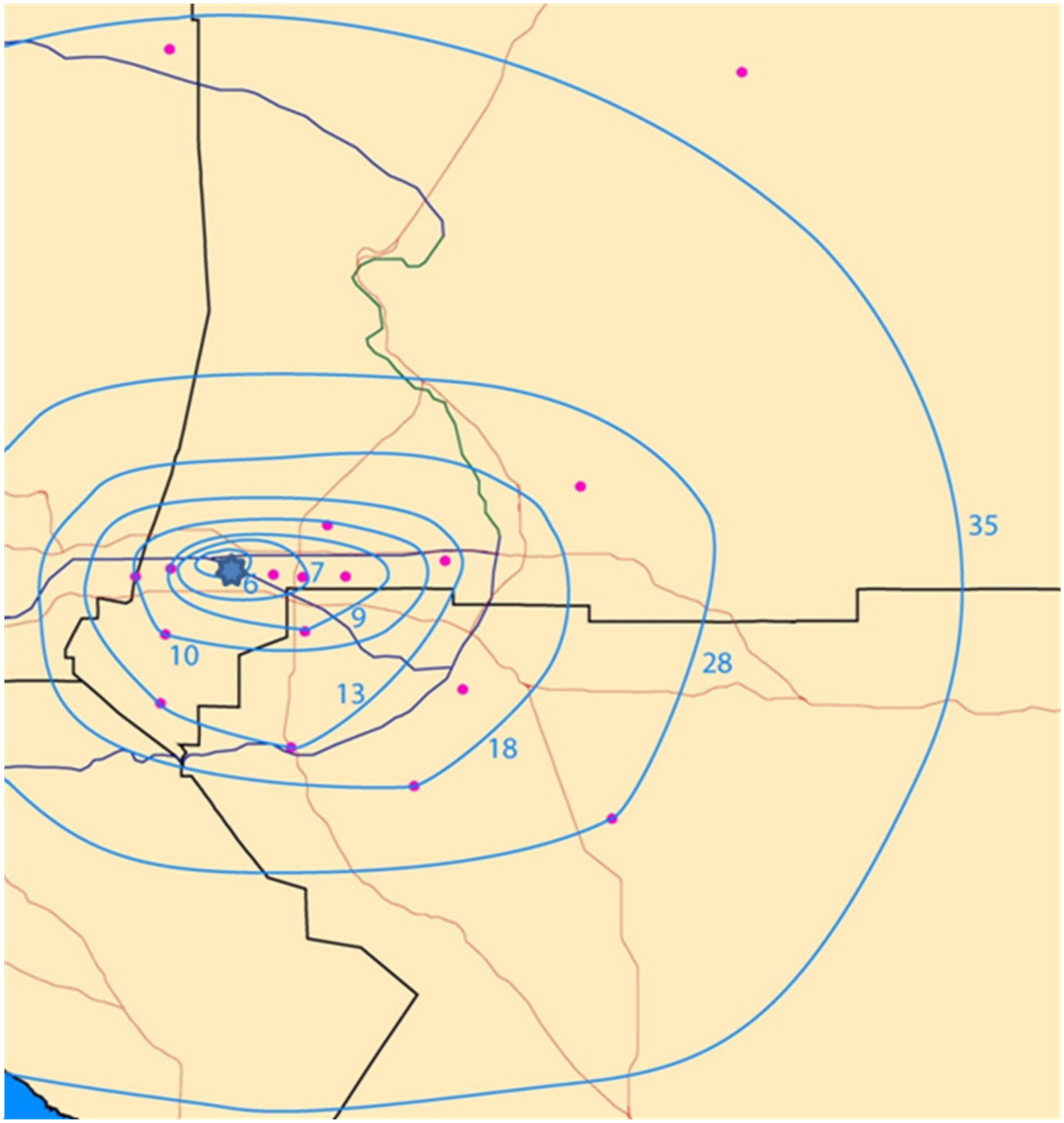

Figure 5.7. The optimal solution and estimates of equivalue level curves for an inland port location in Mira Loma.

5.4. Location-allocation model

This section develops a mathematical model to find the optimal location for *more than one* inland port. This model not only determines the optimal number as well as the location of each inland port (i.e., a location problem), but also it determines which transportation nodes will be served by which inland port (i.e., an allocation problem). This class of problem is referred to as "location-allocation." One main difference between the single facility location model and the location-allocation model is the fact that in the latter model requires a set of candidate locations, while the optimal solution in the single facility location model is obtained without this requirement.

In its most general form, the location-allocation problem also involves a determination of the optimum number of new facilities. A mathematical formulation of the location-allocation problem is given as follows:

Minimize $Z = \sum_{j=1}^{n}\sum_{i=1}^{m} r_{ij} w_i d(O_j, P_i) + G_n$

Subject to

$$\sum_{j=1}^{n} r_{ij} = 1 \qquad i = 0,1,.....,m, \qquad j = 1,2,.....,m \qquad (1)$$

$$\sum_{i=0}^{m} r_{ij} t_i \le C_j \qquad j = 1,2,.....,m \qquad (2)$$

Where

Z: the total daily cost of the transportation as well as the initial investment
n: the number of inland ports
m: the number of the transportation nodes
r_{ij}: a decision variable that is equal to 1 if node i is served via inland port j, and is 0 otherwise
w_i: weight of node i as defined earlier in the single facility location problem
$O_j = x_j, y_j$: coordinates of inland port j
$P_i = X_i, Y_i$: coordinates of transportation node i
$d(O_j,P_i)$: rectilinear distance between inland port j and transportation node $\boldsymbol{i}$
G_n: the initial investment (depreciated daily) and daily operating costs of n inland ports
t_i: daily number of trips to/from node i
C_j: capacity of inland port i (FEUs per day)

Constraints (1): ensure that each transportation node interacts with only one inland port.
Constraints (2): ensure that volume of activities at inland port j does not exceed its capacity.

The researchers assumed the six optimal inland port locations obtained using simple facility location model for each of the six regions, as well as the SPB ports, as the candidate locations for the location-allocation model. If all six inland ports, along with the SPB ports, serve the transportation nodes, the total daily VMT is reduced to 59,500. Average truck trip length is 3.1 miles. If the total number of inland ports is set to 5, then the inland port of Ventura (the least costly) is dropped, and the total daily VMT is increased to 64,000. Average truck trip length is now increased to 3.4 miles. If the total number of inland ports is set to 4, then the inland port of the North of Port is also dropped, and the total daily VMT is increased to 67,300. Average truck trip length becomes 4 miles. In case of n=3, all three inland ports of Ventura, North of Port, and East LA are dropped, and the total daily VMT is increased to 75,700. Therefore, the contribution of the last three important inland ports in VMT is limited to 16,200 miles per day. The contribution of the first three inland ports is more fundamental. For n= 2, two inland ports are initiated in Commerce and Mira Loma, and the total daily VMT is increased to 101,200. Average truck trip length is 5.3 miles. For n=1, the only inland port considered is Commerce, and the total daily VMT is 131,600. Average truck trip length is 6.9 miles. With no inland port, the total daily

VMT is back to the original 220,100, and the average trip length is 11.6 miles. Figure 5.8 is a graphical representation of the total daily miles as each inland port is added to the system.

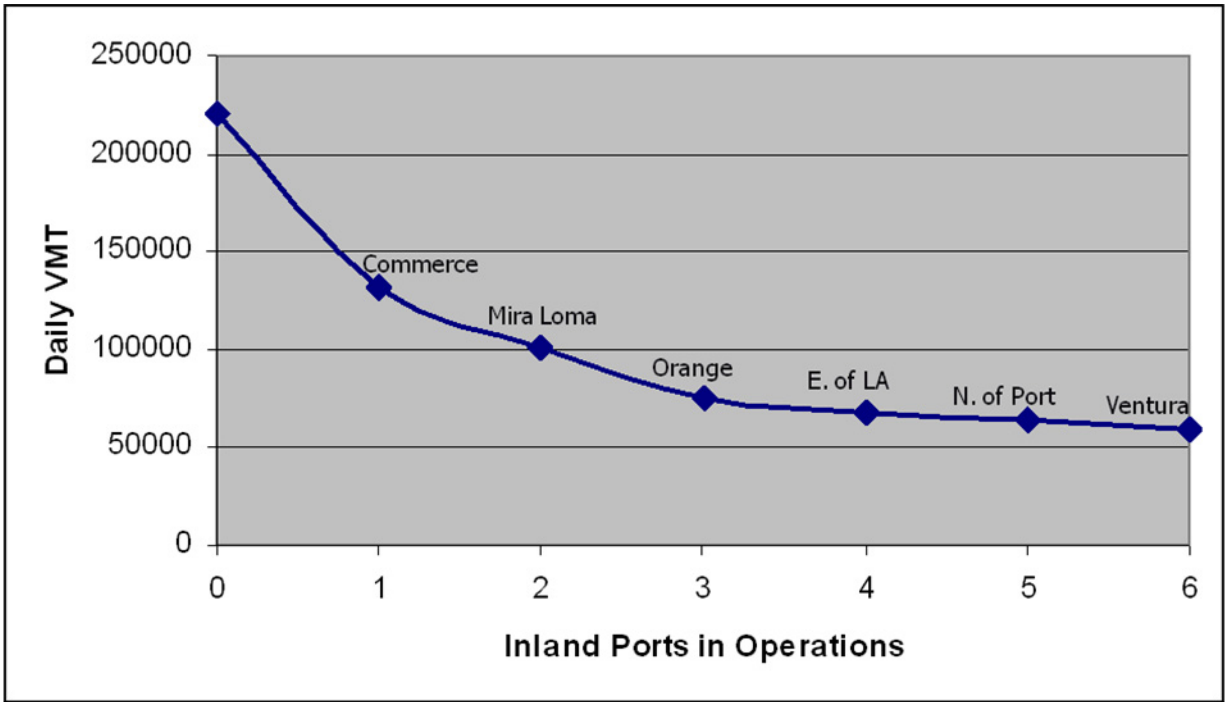

Figure 5.8. Impact of each additional inland port on the total daily VMT.

It is interesting to note that adding the last three inland ports does not cause a significant drop in the total daily VMTs. The most significant impact on the VMT is the Commerce inland port. In fact, it may not be an accident that the largest intermodal facility for BNSF is located in the City of Commerce (Hobart Yard). BNSF is currently in the process of upgrading this facility to handle in excess of a million boxes per year (close to the maximum capacity), making it one of the largest intermodal facilities in U.S.

After Commerce, the analysis shows that Mira Loma area is the next best alternative (in terms of total VMT) for reprocessing and moving the containers. An unexpected finding was the indication that Orange may be the next best location for area VMT reduction. The researchers found no indication of any attempts by the regional planners to consider this region for developing large intermodal facilities. Based on our data, the next three locations (east of Los Angeles County, North of Port, Ventura) are not as helpful and could be easily absorbed into their adjacent inland port activities without impacting the total VMT in a significant way.

6. Conclusions and Recommendations

The overarching question is whether it is feasible to increase regional transportation efficiencies and decrease negative impacts associated with the current volume of trade entering the U.S. through Southern California's container terminals. Clearly, this trade provides important economic benefits to both the state and nation, yet it has now reached a level that requires intervention on the part of transportation planners, in part to limit social costs and but also to maintain regional mobility. The challenge is how to address this in a manner that can be understood by all participants, is equitable in its approach, and efficient in terms of its recommendations. This work constitutes a building block for efficiency improvement in the goods movement system in the five counties. The team first decided that the evaluation of truck vehicle miles of travel (VMT) should be the platform of the basic work. First, VMT represents an important cost in the logistics chain and so links any recommendations related to highway use. Second, VMT is relatively easy to collect, and a data item familiar to state and metropolitan transportation planners. Third, it forms an important element of highway demand and contributes to congestion, a major concern to CalTrans and SCAG. Finally, VMT correlates with air quality—an increasingly sensitive problem for the Southern California urban communities—that together with accidents and noise forms much of the current interest in social costs. The analysis of these costs, which are external to the direct costs paid by users, is gaining in strength as a critical element of future sustainable transportation systems.

Truck-based container operations will remain a significant factor in future landside terminal operations, notwithstanding the success of on-dock rail and the Alameda Corridor. Currently all landside movements radiate from the port terminals to a wide variety of sites in the region where logistical services are provided, as illustrated in Figure 6.1. These sites cover a wide variety of services and terminal sizes, ranging from transloading the container contents into larger, lighter truck semitrailers to full service logistics hub operations. These sites have arisen over the past twenty years (with faster growth patterns since 1996 Asian trade boom) based on business decisions that have generally required little or no partnering with state or metropolitan transportation planning agencies. In some cases, planners were only made aware of a facility and it's potential as a truck-generating site as it was being constructed. A majority of these sites are served only by truck and their wide dispersion throughout the region creates complex truck flow patterns. The question to be addressed is whether this system could serve the predicted future demand at port terminals and, if not, what other system might work better.

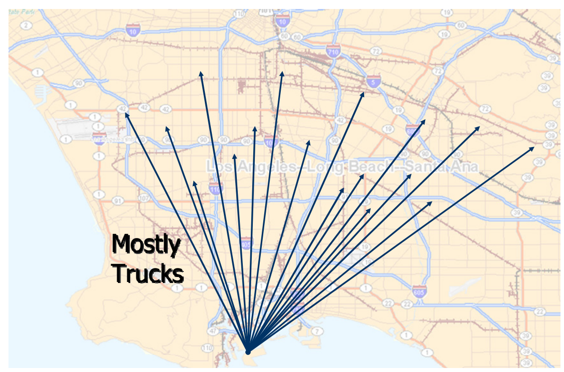

Figure 6.1. Current container flows

The research team began by testing a simple strategy, namely concentrating current distribution site activities into a series of large-scale logistics hubs, termed *inland ports*, and then evaluating the reduction in truck VMT compared with the current pattern serving existing sites. Technical literature, particularly in the trade journals, supports the idea that larger-scale inland ports are likely to make the most significant contribution to the efficient distribution of future international trade, given its predicted growth rate (Leurig, 2007). The scale of such sites, and their need to access modal networks, necessitate that those developing the site undertake a significant degree of partnering with state and metropolitan entities, be they state Departments of Transportation, Council of Governments, or single cities. It is hoped that this work will assist this partnering effort by indicating those sites that reduce total truck VMT and estimating the magnitude of the reduction.

It should also be recognized that the larger-scale hubs will be fewer in number and so the overall system will comprise a variety of sizes and operations. If a small number of the large-scale sites are developed, however, there is the potential to develop a different, more efficient, and socially beneficial transportation system. Trade would move on fewer, higher volume arterials to the large-scale inland ports where, after completing all necessary value-added services, commodities would be moved out on a variety of modes and types. These would include goods destined for out-of-state rail locations (inland ports and intermodal terminals) and state locations served by increasingly cleaner trucks (with further lowering of truck emissions due in 2010). Eventually, zero-emission trucks could be used for shorter area deliveries. And as cleaner technologies—low carbon fuel, hybrid, kinetic energy storage, maglev, and so forth—emerge to power rail and truck-based systems, the main arteries from the port terminals to the key large-scale regional centers could benefit from their economies of scale and justify investments in such systems. The overall design is a variation on the "hub and spoke" system familiar to planners and is illustrated in Figure 6.2.

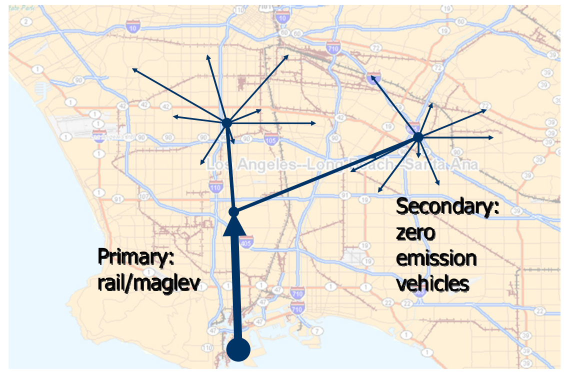

Figure 6.2. Hub and spoke system

The hub-and-spoke system is an extension of the approach first taken in the planning of the Alameda Corridor but broadened to a macro scale, serving the whole region. The two Class One railroads—UP and BNSF—are investing in their operations in the region and likely to be partners in planning certain large-scale hubs (inland ports) of the type envisaged in this research. If truck operations served fewer, larger sites, it is also likely that economies of scale and scope would raise their efficiencies, further reducing truck VMT. Finally, this approach brings together an important planning trinity, namely raising transportation system efficiencies, lowering truck VMT, and mitigating social costs. This provides the state planner with a guide to assist in negotiations with transportation companies such as railroads and site developers like Hillwood or the Allen Group when highway or rail connectivity is needed.

The major conclusion of this work centers on developing a series of location-allocation models, using truck VMT, to measure the impact of network changes. The team has been able to formulate the problem in its simplest form first as a single location determination and then as a multiple location allocation problem, using facility design approaches that are widely used in the field of industrial engineering. Although currently the work is theoretical, the formulation shows that improved models could be made to reflect the consequences of moving goods through large-scale inland ports. The most interesting component of the location-allocation work is that it is now possible to define the increases in truck VMT from the theoretical minimum based on the concept of contour lines or level curves. As a practical example, it would be possible to estimate the increase in truck VMT (for the entire system) from the newly planned BNSF intermodal facility (about four miles north of POLA), given a theoretically optimum inland port location in Commerce. This ability is the key to a search for the most practical location of an inland port in an urban setting with few feasible locations.

The Southern California goods movement infrastructure system is large, complex, and comprises multiple stakeholders. The stakeholder issue is particularly sensitive when large-scale hubs served by railroads are considered. A theoretical single optimum inland port location might benefit one rail system and not be acceptable to another. The same applies to the system-wide solutions to minimize the environmental impacts of the rail/truck operations in the region.

6.1 Future plans

The team was able to develop a theoretical approach to evaluate the location impacts on system-wide truck VMT of various large-scale inland ports. The next steps are twofold. First, current truck VMT data need to be collected and the study formulation rerun to see what changes have occurred since 2004. In addition, existing planning systems, calibrated with current data, should be evaluated to see if the study formulations can be incorporated to produce a broader range of impacts. These could include systems like TransCAD or DYNASMART-P. Each of these model traffic in a different way: TransCAD provides a static network solution (with average daily traffic figures), while DYNASMART-P gives traffic data that varies by time of day and so provides greater discrimination to capture traffic changes (like traffic spikes) within a specific daily time period. Second, the development of a location model that captures a wider range of impacts, perhaps including those used by developers, might be desirable. This could suggest that a multiple criteria approach (MCA) could be useful to broaden the inland port selection process. MCA variants are recognized as useful and familiar tools in transportation planning. Also, the formulation developed in this work can be extended to produce two minima problems—one for each railroad. Or, further extensions could deliver multiple inland ports for each rail operation. These types of improvements would strengthen the location tools available to the transportation planner.

Elements of environmental justice could also form one of the criteria of such an approach. This might provide insight about and data on what is frequently an emotional debate. The models from this study formulation could be extended to include exposure to environmental burdens, human toxicity, ecotoxicity, and resource depletion. A further stage of this study could devise a GIS-based algorithm that would incorporate not only the VMT reduction, but also include variables such as distances to schools, shopping centers, open parks, sporting facilities, and locations with potentially negative impacts to environments where children live and play. This direction requires that it is treated as a multi-objective problem (MOP)—an increasingly useful approach to solving large dimensional optimization problems. Each problem domain (e.g., environmental impacts on schools) could be formulated with its associated variables such as distance to the inland port, wind direction, and noise. Air pollution dispersion modeling approaches could also be added to increase realism in pollution concentrations and target population exposures. The integrated objective would then take into account all variables simultaneously, rendering a more comprehensive offering of the inland port location maps in the region. Computer simulation and sensitivity analyses could be performed to fine-tune the solution set.

Finally, the team did not address inland port throughput requirements for container handling, including efficiencies that could be obtained through automation. However, previous research on port automation and simulation (Asef-Vaziri et al, 2008) provides numerical results to integrate inland port throughput efficiencies with the truck/rail operations.

7. Implementation

This research was the first step to a deeper understanding of improved inland port location allocation using mathematical formulations that are routinely used in the field of industrial engineering. This is also the first treatment of its type that the team is aware of since the term inland port was linked to large-scale logistics hubs in early 1990s. It complements work reported by a multi-university Texas team, which examined the impact of an inland port location on the existing city network (Harrison et al., 2006). The work in Southern California is timely because it coincides with the announcement of a significant number of national large-scale logistic hubs or inland ports in the 2006-8 periods. As noted earlier, these sites cannot be built without state transportation planning awareness and cooperation. Tools such as those formulated in this study and proposed in further related work carry the promise of assisting planners to sharpen investment focus and support those key sites that carry the potential to both reduce truck VMT and lower social costs.

The real benefit of this work will emerge as it is further developed to meet the needs of the planning community and implemented in stages. It could start with a segment of the regional network so that the team can clearly see how the models are working and ensure that their output is both reliable and useful to planners. The team feels confident that this work succeeds in passing the important "proof of concept" test for theoretical work and now the challenge is to move it towards implementation as a useful planning tool. The ideas offered in the previous section represent future directions that would be substantially strengthened by combining them with those from planners facing the problem of maintaining the viability of freight transportation in the region. The team believes that the literature review, analysis, and the models presented in this report represent a sound basis for successful future implementation.

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Appendix A. Goods Movement System Stakeholders

A.1. Introduction

Due to the multimodal and fragmented industry structure of goods movement in the ports, the interests of several parties are affected at each stage of a container logistics strategy. *Interchange*, the transfer of a container (and usually a chassis) from the responsibility of one party to the responsibility of another, is the defining characteristic of intermodal transportation. Thus, the designation of an inland port location must take into account and accommodate the wide range of participants. The parties in the container business and logistics chain attempt to minimize the total cost of maintaining the desired level of service and adequate capacity.

For the purposes of this project, only the stakeholders involved in activities outside of the ports are identified. In addition, port-related activities beyond the distribution center stage of container logistics are not included on this list.

- **Container owner**: a leasing company or ocean carrier.
- **Chassis owner**: a leasing company, ocean carrier, or pool operator. A very few drayage firms own specialized chassis (e.g., three-axle chassis for heavy loads).
- **Motor carrier:** a drayage or cartage firm that takes responsibility for picking up and delivering containers on chassis. Drayage firms are typically clustered in the same areas with a heavy concentration in the gateway cities north of the ports.
- **Driver/contractor**: The vast majority of truck drivers in the drayage industry are independent contractors who own the tractors they drive, with only a few being employees of the drayage companies. Independent contractors are ordinarily paid a share of the drayage fee, usually about 70%. They are paid by the loaded move, not by the mile or the hour, and are usually not paid separately for moving empties. Empties are returned as part of the loaded movement assignment.
- **Distribution Centers:** These locations serve as routing hubs for inbound container movement from the ports. The centers are stocked with products to be redistributed to

retailers or wholesalers. Although the primary role of a distribution center is to receive large quantities of products and ship small quantities to individual stores, an important secondary role is storage.

- **Container depot:** An area designated for the stowage of cargo in containers. Usually accessible by truck, railroad, and marine transportation, the terminal is where containers are picked up, dropped off, maintained, and stored. Container depots are usually owned and operated by separate, specialized firms. They handle both carrier-owned containers and leasing company containers, and have the capability of accepting containers from one trucker and releasing them to another.
- **Consignee:** Also called the receiver, the consignee is the party who is receiving the goods, whether or not it owns the goods at that point. A consignee might be a third party or consolidator.

The relationship between the main parties involved in container logistics is detailed in Figure A.1. As previously mentioned, this project considers only the container depots and consignees outside of the ports, which contribute to a higher amount of VMT for port-related traffic, compared with on-dock facilities. The inclusion of an inland port, which can be served by both truck and rail, has the potential to decrease congestion at the ports and on major freeways by a substantial amount. This can be accomplished by diverting the truck flows to rail, and encouraging the relocation of container depots to an inland port. New modes (such as efficient high speed or Maglev train systems) could create a primary (terminal to inland port) and secondary (inland port to tertiary distribution) system that is more efficient and less polluting than that of the present system. It is necessary for all stakeholders mentioned to contribute to and aid in the planning and development efforts to achieve an efficient container logistics strategy.

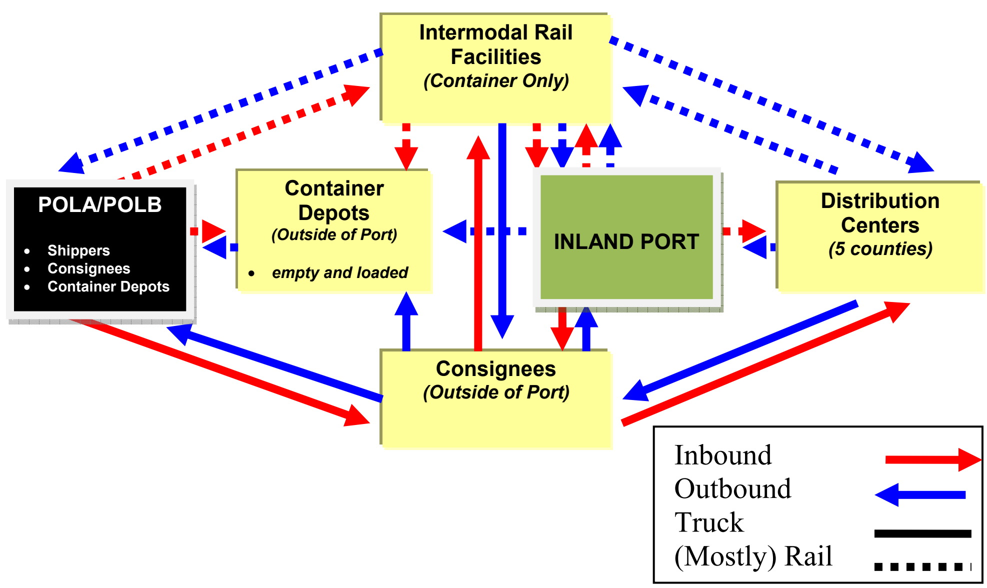

Figure A.1. A depiction of POLA/POLB container logistics system including an inland port.

A.2. Regional agencies and organizations as stakeholders

Major stakeholders are also found in several transportation agencies and port-related organizations. The stakeholder interests and available data are summarized in Table A.1.

Table A.1. Stakeholder Roles and Available Data

Stakeholder	Role	Available Data
Regulatory Agencies		
CalTrans	• Caltrans manages more than 45,000 miles of California's highway and freeway lanes, provides inter-city rail services, permits more than 400 public-use airports, and works with local agencies. • The agency's primary goal related to the ports is to improve mobility of people and goods. This includes reducing freight processing times and vehicle congestion on major freeways as well as maintaining road and rail.	CalTrans gathers data to facilitate their goal of improving mobility. This includes data related to freeway conditions, such as truck volume.
Southern California Association of Governments (SCAG)	• As the designated Metropolitan Planning Organization, the Association of Governments is mandated by the federal government to research and draw up plans for transportation, growth management, hazardous waste management, and air quality. • The primary role of SCAG related to this project is to develop long-range regional plans and strategies that provide for efficient movement of people, goods, and information, enhance economic growth and international trade, and improve the environment and quality of life.	SCAG gathers data related to goods movement in the Southern California region. This includes destination stops for inbound port cargo and truck/rail volume on major transportation routes.
United States Environmental Protection Agency, Region 9 (EPA)	• The major goal of the EPA is to protect human health and the environment and is directly related to this project's goal of reducing port-related traffic emissions. • To effectively integrate common goals for air quality in the South Coast Air Basin, POLA and POLB have worked together in close coordination with the EPA, South Coast Air Quality Management District (SCAQMD), and the California Air Resources Board (CARB) to develop the San Pedro Bay Ports Clean Air Action Plan. This plan is the first of its kind in the country, linking the emissions reduction efforts and visions of the two largest ports in the United States with similar efforts and goals of the regulatory	The agency monitors emissions for carbon monoxide, organic gasses, oxides of nitrogen, and particulate produced by operations at the San Pedro Bay ports. In addition, they collect data on the current and projected emissions for "dirty" diesel trucks and clean retrofitted vehicles.

Stakeholder	Role	Available Data
	agencies in charge of ensuring compliance with air quality standards.	
Federal Highway Administration (FHWA)	• The Federal Highway Administration (FHWA) is a part of the U.S. Department of Transportation. FHWA is charged with the broad responsibility of ensuring that America's roads and highways continue to be the safest and most technologically up-to-date. • Two of their highest priorities are congestion mitigation and environmental stewardship and streamlining. • FHWA's primary responsibility related to the ports will be overseeing highway regulations and providing funding for inland port projects, which attempt to alleviate traffic congestion and harmful emissions.	The agency has data on the vehicle size and weight restrictions for freeways surrounding POLA and POLB. The maximum allowable weight for inbound/outbound trucks at the ports is affected by these regulations.
	Ports	
Port of Los Angeles (POLA), Port of Long Beach (POLB)	• POLA is a department of the City of Los Angeles. A five-member Board of Harbor Commissioners are appointed by the Mayor and confirmed by the Los Angeles City Council to provide direction and create policy for the port. • The City of Long Beach established the Harbor Department (Port of Long Beach) to oversee port development and operations. • The interests of the ports, related to this project, involve the impact of inland port locations and environmental regulations on international and domestic trade. • The biggest contributors to the economy, port users, are businesses that use the ports to receive imports or ship exports. Export manufacturers are major port users. Other port users include local manufacturers. Port customers are the retail and other non-cargo businesses in the port.	POLA and POLB collect detailed data on the number inbound/outbound cargo at the ports and also the number of trucks accessing the ports, based on gate of entry, time of entry, and type of cargo.
	Container Depots	
Major Depots: **Containercare, Global Intermodal**	• Containers are stored and maintained at these locations. • These parties are primarily concerned with the impact of an inland port on	The various depot locations collect data on the number of containers that are

Stakeholder	Role	Available Data
Services, Stevedoring Services of America (SSA), and FastLane	transportation logistics. This includes the accessibility of rail and major trucking routes and the proximity of the depot to the inland port location.	entering/exiting the facility on a daily basis, as well as the number of containers stored and the period of time. These locations would also have information on the container specifications (size weight, cargo, etc.).
	Distribution Centers	
Major Distribution Centers	• Containers are routed to other locations from this multimodal transportation hub. • These parties are primarily concerned with impact of an inland port on transportation logistics. This includes the accessibility of rail and major trucking routes and the proximity of the depot to the inland port location. Because containers leaving the DCs fan out in several directions, direct access to several modes of transportation is crucial.	The DCs collect data on the number of inbound containers that are entering/exiting the facility on a daily basis and their end location (retail stores, warehouses, etc.). These centers would also have information on the container specifications (size weight, cargo, etc.).
	Consignees	
Major Consignees	• In a contract of carriage, the consignee is the person to whom the shipment is to be delivered, whether by land, sea, or air. • These parties are primarily concerned with impact of an inland port on transportation logistics. This includes the accessibility of rail and major trucking routes and the proximity of the depot to the inland port location.	The consignees collect data on the number of inbound containers that are entering/exiting the facility on a daily basis and their end location (retail stores, warehouses, etc.). These centers would also have information on the container specifications (size weight, cargo, etc.).
	Transportation Companies (trucks and rail)	
Major Drayage Firms	• Drayage service is usually provided by a national trucking/shipping company or an international shipment brokerage firm in addition to the transportation of the	These firms maintain data on the most efficient trucking routes, distance

Stakeholder	Role	Available Data
	freight to and from the site. • Drayage service provides for completing inbound carrier's receiving documents, unloading and delivery of the goods to the booth/stand space from the receiving dock, storing of empty cartons/crates and extra products at an on/near-site warehouse, pickup of the goods from booth/stand space to the receiving dock and loading back into the carrier, and completing outbound carrier's shipping documents. • Their concerns include the efficiency of mandated transportation vehicles, meeting delivery deadlines on congested trucking routes, and ease of transfer to other modes of transportation.	between pickup locations and destinations, and vehicle and cargo specifications.
Major Railroad Companies: **Union Pacific (UP) and Burlington North Santa Fe (BNSF) Railroads**	• POLA and POLB have worked to support and accommodate the development of rail facilities to expedite the movement of containerized cargo and other freight through the ports, including development of the Alameda Corridor and four on-dock rail facilities. • The railroads are responsible for hauling a major percentage of inbound/outbound container traffic at the ports through an intermodal network, facilitated by container rail yards and intermodal rail facilities. • The off-dock intermodal facilities predominately consist of three major rail-yards: ICTF, East LA Yard, and Hobart Yard. • The primary concern of the railroad is efficiently transporting goods in a cost-effective manner. An inland port will potentially be serviced by both rail companies, so it must be strategically located to provide easy rail access and intermodal services.	These rail carriers have information on the major routes utilized by the ports for good movement. This also includes the capacity of the rail, trackage rights, and the allowable freight train specifications. The rail carriers would also have information on the location and number of containers passing through their rail yards, container yards, and intermodal rail facilities.

Appendix B. Further Inland Port Literature

Recent studies have shown that most major U.S. ports are not able to handle the growth of their cargo volumes without massive infrastructure investments or impacts on their surrounding environments (Grenzeback, 2007). Therefore, the concept of identifying and developing inland ports away from the waterfront became more attractive in the mid 1990s. Gooley (1997) provided a potential definition of an inland port, although he used *freight gateway* and *freight hub* as alternative terms for inland ports.

Some of the U.S. ports are experiencing exponential growth as they become the key links in the global supply of goods in this country. As such, Mogelluzzo (1998) argues that significant bottlenecks are found in the ports' intermodal transportation of containers to trucks and rails. To alleviate these bottlenecks, ports are looking to more innovative solutions like intermodal corridors and inland sorting facilities. Robinson (1999) explains how inland ports provide the physical and commercial infrastructure to allow efficient and effective production and distribution of ports goods movement.

A number of states are looking at new logistics strategies regarding initiating inland sites that are not focused on traditional seaports or airports. For example, the Columbus Inland Port Program gives background on the conceptual idea of an inland port. Gessner et al. (1999) provide a description of the process Columbus underwent to define and establish the city as an inland port and determine the value of this transformation to the city. In another example, Gardner (1996) provides a description of the creation of the Global TransPark, which includes a 15,300-acre transportation complex with multimodal connections.

Converting brown fields to inland ports appears to be an attractive alternative to new development. Gogoll (1996) highlights several former U.S. military bases that are converting to commercial airports, including the San Bernardino International Airport, formerly Norton Air Force Base. Due to the size and impact of these developments, LaLonde (1997) emphasizes the need for public-private partnerships in planning for inland ports. Lang (1999) discusses the ways to use both competition and community coordination to provide the transportation services that the private market does not or cannot supply for inland port activities.

Gooley (1998a) defines logistics-friendly industrial parks and their ability to provide shippers one location where transportation, communication, and building options are available. Gooley (1998a) uses three main factors of site selection to illustrate why the Midwest is a favorite location for distribution centers. The three factors are proximity to markets, physical infrastructure, and economic and tax considerations.

In late 1990s, the term "inland ports" was used to describe the link between the U.S. ports and the rest of the trade/transportation corridors. Recently, transportation planners have begun to consider how multi-modal inland ports might enhance both trade corridor performance and efficiency. Some planners now believe that inland ports have the capability to enhance corridor efficiencies and thus trade competitiveness, reduce both public and private costs, create local employment, and strengthen the tax base. Traditionally, inland ports were rarely promoted by public agencies and currently are not part of the standard transportation planning and programming activities carried out by state transportation agencies. It is believed in the next 10 years there will be a range of inland ports evolved in the U.S., some promoted by large retailers (Wal-Mart) and transportation companies (Burlington Northern Santa Fe).

Giermanski (2000) conceptualized a multimodal Foreign-Trade Zone to focus on agriculture, automobiles, dry bulk, chemicals, grain, intermodal transportation, and public warehousing. According to Ellis (2001), the Port Authority of New York and New Jersey in their efforts to build a 21st-Century port, have identified the need to build a Port Inland Distribution Network as a total logistics provider. Mottley (2001) analyzed the problems that might be alleviated by shipping through more localized and regionally oriented inland ports. A newer approach to inland port planning has been suggested by Dooms and Macharis (2003). They offer a conceptual framework that builds upon a multi-stakeholder/multi-criteria approach, which takes into account all the short-term and long-term stakeholder preferences and objectives, in order to realize a sustainable inland port development. Table B.1 summarizes the findings of these studies in relation to inland port characteristics.

Table B.1. Inland Port Characteristics and Site Selection

Inland Port Characteristics	
Site Selection	**Literature**
• Proper size • Proper shape • Low-cost development • Expandability • Highway access • Rail access • Local community considerations	The Tioga Group (2006)
• Base population of 3 million • Multiple transportation modes • 5,000 to 10,000 acres • Tax and local incentives • Strong employment base • Telecommunications infrastructure • Foreign-Trade Zone status	Hillwood (2001) Brimble (2000)
• Market factors (customer clusters, specific customer requirements) • Physical factors (proper size and shape, low-cost development, expandability, highway and rail access), and local community considerations • Sufficient demand for intermodal freight transportation • Local supply of competitive motor carrier service	Harder (1999)

Inland Port Characteristics	
• Practical basis for successful community relationships • Adequate public/private-sector capital to fund development • Metropolitan planning organizations (MPOs)	
• Intermodal transportation capacity • Demographic advantage • Geographic advantage • Presence of shippers • Information technology infrastructure • Public/private cooperation • Councils • Aggressive marketing • Capable program management: Leadership to move the inland port forward	Robinson (1999)
• Location • Cost • Service • Reliability • Time • Security • Labor • Infrastructure • Market • EDI • Customs • Equipment • Facility • Environmental Issues • Foreign-Trade Zone	Richardson (1999)
• Physical infrastructure • Proximity to suppliers and customers • Political and tax considerations • International trade considerations	Gooley (1998b)
Intermodal Hubs	**Literature**
• Infrastructure: air cargo, capacity, rail links with intermodal ramps, accessible highway system • Demographic advantage	is-Trade (1999)

Inland Port Characteristics	
• Geographic advantage • Presence of large shippers • Presence of an information technology infrastructure • Cooperation among public and private entities • The formulation of councils to expand public and private involvement • The willingness to aggressively market the inland port concept locally, nationally, and internationally	
• An inland port is a regional hub that offers shippers "a complete range of domestic and international transportation and distribution services"	Gooley (1997)
• "Traditionally, a port is located on navigable waters. Now, it is information, used to coordinate transportation and distribution, instead of water, that allows an inland area to operate as a port"	LaLonde (1997)
Value Added Activities	**Literature**
• Cargo-handling functions • Customs inspections • In-bond transport • Customs bonded warehouse • Foreign-Trade Zones • Container depots • Heavy commodities and "overweights" • Empty container supply • LTL terminals	The Tioga Group (2006)
• Cargo consolidation and deconsolidation centers • Logistics zones • Two types of value-adding logistical services (VAL): low-end (e.g. labeling, insertion of manuals, etc.), and high-end value-adding logistical services (e.g. distribution, container handling, etc.)	Notteboom and Rodrigue (2005)
• Transportation center	Walter and Poist (2003)

Inland Port Characteristics	
• Multi-purpose business center • Port of entry for customs clearance & inspection • Public warehouse services • Bonded warehouse services • Intermodal transfer facility for containers • Foreign-Trade Zone • Travel plaza • Single source for federal and state transportation agencies • Single source for federal and state trade support agencies • Information clearinghouse or library for transportation and trade publications • Internet Web site(s) providing transportation and trade information	

Appendix C. Annotated Bibliography

This annotated bibliography provides summaries and abstracts of important sources of information related to our study. If an abstract is available, it is generally given, together with comments on the relevance of the work written by the project authors. If an abstract is not available, an excerpt from the introduction, expressing the main goals of the study, is provided.

Chang, H., Jula, H., Chassiakos, A., Ioannou, P. *Empty Container Reuse in the Los Angeles/Long Beach Port Area.* Metrans Final Report, 2007.

The authors give an overview of empty container logistics and the potential benefits of optimizing the system of container exchange. Solutions are proposed to alleviate port traffic issues, based on various mathematical optimizations methods and simulation tests.

Abstract:
In the Los Angeles/Long Beach (LA/LB) port complex, the empty containers are handled twice: once they are recycled from importers and the second time they are trucked to exporters. Clearly a system is needed to facilitate the interchange of empties outside the ports, to reduce the traffic congestion and emissions around the ports.

In this paper, the deterministic and stochastic empty container reuse problems are considered. The problems are modeled analytically, and approximation solution methods are developed. The developed optimization methods are evaluated using realistic simulation scenarios generated using past, current, and projected data from the LA/LB port area. Simulation results show the efficiency of the developed algorithms in terms of computational time and solution quality.

***Inland Empire Railroad Main Line Study Final Report,* prepared for the Southern California Association of Governments by Leachman and Associates LLC, Gill V. Hicks and Associates, Inc., George R. Fetty and Associates, Inc., and Weston Solutions, Inc. Contract number 04-010, June 30, 2005.**

This study examines railroad infrastructure needs and operations for both freight and passenger trains in Southern California.

Executive Summary:
This document serves as the Final Report for this study. The existing railroad main line infrastructure from downtown Los Angeles east and north to Barstow and Indio is described. Passenger and freight traffic patterns are documented, and future train volumes are forecasted. Alternatives for routing future main-line train movements are formulated and analyzed. Results are presented from simulating Year 2010 and Year 2025 train operations in scenarios of increasing track capacity. These results identify track capacity improvements for each alternative required to maintain Year 2000 transit times while accommodating forecasted 2010 and 2025 traffic levels. Capital costs for these infrastructure improvements are estimated. Emissions from locomotives powering through train movements and from vehicular delays at grade crossings are estimated. Finally, the alternatives are ranked along the dimensions of capital costs, total

emissions, population exposure to main-line freight train operations, and population access to passenger train operations.

***Empty Container Logistics Study*. Prepared for Gateway Cities Council of Governments Port of Long Beach Southern California Association of Governments. The Tioga Group, Meyer, Mohaddes Associate*,* Integrated Intermodal Services, Inc. May 8, 2002.**

This document analyzes the current system of empty container transportation in and around the ports. Several strategies to improve operations and reduce VMT are discussed, including direct depot off-hiring, reuse of empty containers, use of Internet-based systems, virtual container yards, and container depots. Transportation impacts before and after the improvements are also analyzed.

Project Objectives:

- Understand and document the current and projected flows of empty ocean containers in the study area
- Contact and interview industry participants to define empty container logistics practices, limitations, and potential for improvement
- Investigate the use of an Internet-based information system to assist motor carriers, ocean carriers, and other participants to interchange empty containers and support off-dock empty returns
- Describe an empty container logistics strategy
- Determine the legal, procedural, insurance, and other institutional requirements of an empty container logistics strategy

***Inland Port Feasibility Study*. *Task 1&2 Draft Report*. The Tioga Group, Inc. Railroad Industries, Inc. Meyer, Mohaddes Associates (Iteris). Prepared for the Southern California Association of Governments. August 4, 2006.**

This report defines an inland port and its primary characteristics and uses. A comprehensive evaluation of the existing port-related facilities in and around San Pedro Bay is also performed, including container depots, distribution centers, and Federal Trade Zones. In addition, inland port benefits are outlined, including all value-adding operations. An analysis of potential inland port sites is provided, based on surrounding transportation infrastructure, the potential for value-adding operations, and benefit/cost analysis.

Scope of work:
The broad potential benefits of an inland port include facilitating goods movement, encouraging economic development, reducing traffic congestion, and otherwise promoting the regional objectives of the 2004 RTP. The overall study objective is to determine which of these benefits can be realized, in which kinds of facilities, and at which sites. To attain this objective the study scope covers the following tasks:

• Task 1: Define the concept and purpose of an Inland Port facility.
• Task 2: Describe existing Inland Port concepts in the SCAG Region.

- Task 3: Conduct interviews and surveys to determine feasibility, potential demand, and community acceptance.
- Task 4: Estimate the costs and benefits.
- Task 5: Final Report and Site Evaluation.

Leitner, S., and Harrison, R. The Identification and Classification of Inland Ports. Center for Transportation Research. Bureau of Engineering Research The University of Texas at Austin. Conducted for the Texas Department of Transportation. August, 2001.

This study provides a detailed analysis of the classification of inland ports and important characteristics that are essential in the planning and implementation. The report also contains a lengthy summary of prior research and case studies on currently operating inland ports.

Purpose of research:
The primary purpose of this research is to create a classification methodology to better understand how different inland ports can support efficient supply chains and enhance corridor operations. Research findings should enhance transportation planners' understanding of inland ports and how their actions can best support inland port activities.

Mallon, L., Magaddino, J. *An Integrated Approach to Managing Local Container Traffic Growth in the Long Beach-Los Angeles Port Complex, Phase II*. December 31, 2001.

The authors perform an in-depth analysis of port-related factors including cost/benefit, social and traffic impacts, and container logistics. A time-phased throughput redistribution strategy is proposed to optimize port operations and efficiently handle the growth in container traffic.

In this seminal effort the authors have interweaved both quantitative and qualitative economics and social science analytical techniques, original survey data, and modern supply chain management theory into a systemic view of the stakeholder implications in terms of costs, benefits, tradeoffs and impacts on aggregate throughput and regional mobility and traffic congestion. This study considers changes in best practices in the form of extended gate hours of operation by the fourteen privately-operated marine terminals comprising the Long Beach-Los Angeles port complex.

The report utilizes microeconomic break-even analysis to describe the economic, private and social costs and benefits, validated with stakeholder workshop input likely to result from the implementation of an extended gate hours of operation for marine terminals regime upon terminal throughput velocity and regional mobility over time. The concept of throughput velocity is utilized as an original benchmark measurement of comparative terminal operating efficiency in a capacity constrained operating environment. This study also combines the traditional temporal dimension of dwell time (average time spent on terminal by individual container) with spatial dimension of throughput per acre thereby allowing accurate performance comparison of terminals independent of size or geographic (transshipment, entrepot) and operating conditions.

Nottemboom, T., Rodrigue, J. Port Regionalization: Towards a New Phase in Port Development. ***Maritime Policy and Management*****. 33(3). July, 2005.**

The authors discuss and extend existing models on the spatial and functional development of individual port terminals and larger port terminal systems. A 'regionalization' phase in port and port system development is introduced and further substantiated. The paper furthermore elaborates on governance issues linked to the regionalization phase and the development of sustainable hinterland concepts that add to a port's competitive position.

Abstract:
Inland distribution is becoming a very important dimension of the globalization, maritime transportation and freight distribution paradigm. Observed logistics integration and network orientation in the port and maritime industry have redefined the functional role of ports in value chains and have generated new patterns of freight distribution and new approaches to port hierarchy. Existing models on the spatial and functional evolution of ports and port systems only partially fit into the new freight distribution paradigm. This paper aims to add to existing literature by introducing a port regionalization phase in port and port system development. It is demonstrated that the regionalization phase and associated hinterland concepts demand new approaches to port governance and a functional focus that goes beyond the traditional port perimeter.

Port of Los Angeles Baseline Transportation Stu**dy. Prepared for Port of Los Angeles. Meyer, Mohhades Associates Inc. April, 2004.**

The study includes an analysis of existing and future vehicular traffic demand, transportation system deficiencies, and necessary improvements. Major freeways and roads that carry the majority of port-related truck traffic are discussed and traffic mitigation strategies are proposed to relieve congestion.

Summary:
This report describes the methodology, findings and recommendations of the POLA Baseline Transportation Study. The purposes for undertaking the Transportation Study include:

- Determine the growth in truck traffic that is projected to occur as a result of the forecast growth in cargo moving through the port
- Develop transportation planning tools to address the technical challenges associated with port growth
- Identify existing and future transportation system deficiencies in and around the port
- Recommend physical and operational strategies to mitigate future system deficiencies

San Pedro Bay Ports Clean Air Action Plan**. Overview. CA AIR Resources Board, POLA/POLB. 2006.**

This document details the joint efforts of the ports, the EPA, and several air quality regulatory agencies to reduce emission at the ports. The Clean Air Action Plan requires a faster replacement of existing cargo-handling equipment with new equipment that will meet the U.S. Environmental Protection Agency emissions standards.

Introduction
This document is the first San Pedro Bay Ports Clean Air Action Plan (Clean Air Action Plan). This joint Clean Air Action Plan describes the measures that the Ports of Los Angeles and Long Beach will take toward reducing emissions related to port operations. In March 2006, a groundbreaking meeting occurred at the highest level between the two ports and the South Coast Air Quality Management District (SCAQMD) where all parties expressed the need to work jointly toward solutions. Shortly thereafter, the ports engaged the California Air Resources Board (CARB) and the United States Environmental Protection Agency Region 9 (EPA Region 9) in the spirit of cooperation to help the ports develop the Clean Air Action Plan for their respective Boards of Harbor Commissioners' approval. It should be emphasized that these entities have committed to continuing their efforts associated with the development, review, implementation, and update/revision of the Clean Air Action Plan on an annual basis.

Walter, C., Poist, R. Desired attributes of an inland port: shipper vs. carrier perspectives. *Transportation Journal*. American Society of Transportation and Logistics, Inc. Sept, 2003.

This study provides a summary of literature related to inland port services and desired attributes. Based on the results of focus groups and field interviews, as well as literature and Internet reviews, a list was compiled of twelve characteristics and attributes that were considered for inclusion in an inland port and these are summarized in the paper along with documentation on the survey responses.

Abstract:
The concept of an "inland port" has been proposed to help reduce logistics barriers to exporting and importing by interior companies with little prior international shipping experience. An inland port facility might assist exporters and importers by providing information necessary for individual transactions (e.g., customs, packaging and labeling requirements) and by providing consolidation, loading facilities, and transportation equipment, such as containers. Domestic shippers with limited transportation capabilities would benefit, as well, from the availability of alternative shipping facilities that incorporate their needs. The purpose of this article is to report the major findings of a study of shipper and carrier perceptions of the importance and anticipated use of inland port features and characteristics. The implications of these results may guide policymakers in state and local governments, as well as provide alternative implementation strategies for future inland port development.