EVALUATION OF SUPPLEMENTARY WATERBORNE SYSTEM

CITY AND COUNTY OF HONOLULU HONOLULU RAPID TRANSIT PROJECT

AMV

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PEEP II

WORK ELEMENT XIV

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SUMMARY

This study is part of the Honolulu Rapid Transit System Study, Preliminary Engineering and Evaluation Program, Phase II (PEEP II). Its purpose was to develop data which could be used to evaluate a waterborne system as a supplement to 1980 and 1995 land-based transit systems on Oahu. No conclusions regarding the feasibility of such a system were made. The major assumptions and findings of this study are listed below:

- The scope of the study was limited to the evaluation of four express waterborne routes between the Honolulu CBD and Hawaii Kai, Keehi (Moanalua), Iroquois Point (Ewa), and Waipahu. The marine transit vehicles for this system were assumed to be Boeing 929-100 Jetfoil hydrofoils. Characteristics of the system, including feeder bus routes and locations and conceptual plans for terminals, were delineated, but evaluations to refine or optimize the system were not undertaken.

- The supplementary waterborne system would attract 250 passengers during the evening peak period in 1980 and ~~1,350~~ 2,110 passengers during the evening peak period in 1995. In 1980, about 24 percent would be diverted patronage from the land-based transit systems and the remainder would be former auto users. In 1995, about 73 percent would be diverted patronage and the remainder would be former auto users.

- Two hydrofoils would be required for this service in 1980 and six hydrofoils would be required in 1995.

- The supplementary waterborne system would have the following capital and operating and maintenance costs if it were publically owned and operated:

	In Millions of 1975 Dollars	
	Total in 1980	Total in 1995
Total Capital Costs	$23.060	$55.220
Annual Capital Costs (Debt Service)	$ 2.177	$ 5.212
Annual O&M Costs	1.218	3.103
Total Annual Costs	$ 3.395	$ 8.315

- The supplementary waterborne transit system would have the following capital and operating and maintenance costs if the hydrofoils were chartered from a private operator:

	In Millions of 1975 Dollars	
	Total in 1980	Total in 1995
Total Capital Costs	$ 6.100	$ 6.240
Annual Capital Costs (Debt Service)	$ 0.576	$ 0.589
Annual O&M Costs	1.880	5.940
Total Annual Costs	$ 2.456	$ 6.529

- On the basis of 25-cent fares, free transfers, and various assumptions regarding the generation of patronage, total annual fare box revenues would be about $17 thousand in 1980 and $119 thousand in 1995. Additional revenues, up to a maximum of about $2.25 million in 1980 and $6.0 million in 1995, could be generated by leasing the vessels during off-peak periods, but would be partially off-set by increased maintenance costs.

- A comparison of the supplementary waterborne and 1980 and 1995 land-based transit systems service characteristics was found to be not very meaningful because of differences in system configurations and operations. In addition, each link of the water-borne system exhibited greatly differing characteristics, further skewing the results. A comparison of the systems in terms of costs, however, showed that annual O&M costs, total costs, and O&M subsidy requirements per various operating and passenger units for the waterborne system would be significantly higher than the costs and subsidy requirements per the same units for the land-based system.

I. INTRODUCTION

This study is part of the Honolulu Rapid Transit System Study, Preliminary Engineering and Evaluation Program, Phase II (PEEP II). This report documents the results from one of the work elements, Element XIV, of this 15-element planning program. Its purpose is to develop data to be used for an evaluation of a supplementary waterborne system to land-based transit systems on Oahu.

The data was developed for two planning years, 1980 and 1995. The waterborne transit system would supplement the all-bus transit system planned for 1980 and the 23-mile fixed guideway rapid transit system planned for 1995.

SCOPE OF EVALUATION

The scope of this study was limited to the development of data for the supplementary waterborne transit system. Data for the 1980 all-bus and 1995 fixed guideway system were provided by the City and County of Honolulu Department of Transportation Services. The data to be prepared in this study consisted of patronage estimates for 1980 and 1995, conceptual design plans for the terminals, and cost estimates based on these conceptual designs. The scope of work did not include the evaluation or the placement of values, either absolute or relative, on this data, since it was not the intent of the study to determine an optimum supplementary waterborne transit system. The general terminal locations and vessels of the supplementary waterborne system were specified as "givens" prior to initiation of the study.

GENERAL APPROACH

Waterborne transit service was to be provided between four general areas and the central business district (CBD). These four areas are Hawaii Kai, Honolulu International Airport (HIA), Iroquois Point, and

Pearl City. During the course of the study the Pearl City site was replaced by a terminal closer to Waipahu within the same general area. The general terminal areas and marine transit routes evaluated in this study are illustrated in Figure I-1.

The marine transit vehicles for the supplementary waterborne system were assumed to be Boeing 929-100 Jetfoil hydrofoils. The vessels were assumed to have a capacity of 250 passengers and a cruise speed of about 42 knots. Additional information on the characteristics of this vessel is provided in Chapter III. Its overall configuration is illustrated in Figure I-2.

Patronage estimates for the marine transit system were developed using previously developed models[1] and a submodal split model developed for this study. The specific terminal locations were selected from various candidates within the general service areas identified in Figure I-1. Conceptual designs were developed for each of the five terminals with associated cost estimates for the construction of these facilities. Cost estimates were also made for the purchase of the vessels and for the operation and maintenance of them. Revenue estimates were also made so that approximate subsidy levels, if required, could be determined.

The remainder of this report consists of three sections:

- A general review of other short-haul or commuter-type waterborne transit systems throughout the world, and a summary of the previous planning that has been done for waterborne transit on Oahu.

- A description of the supplementary waterborne transit system analyzed in this study.

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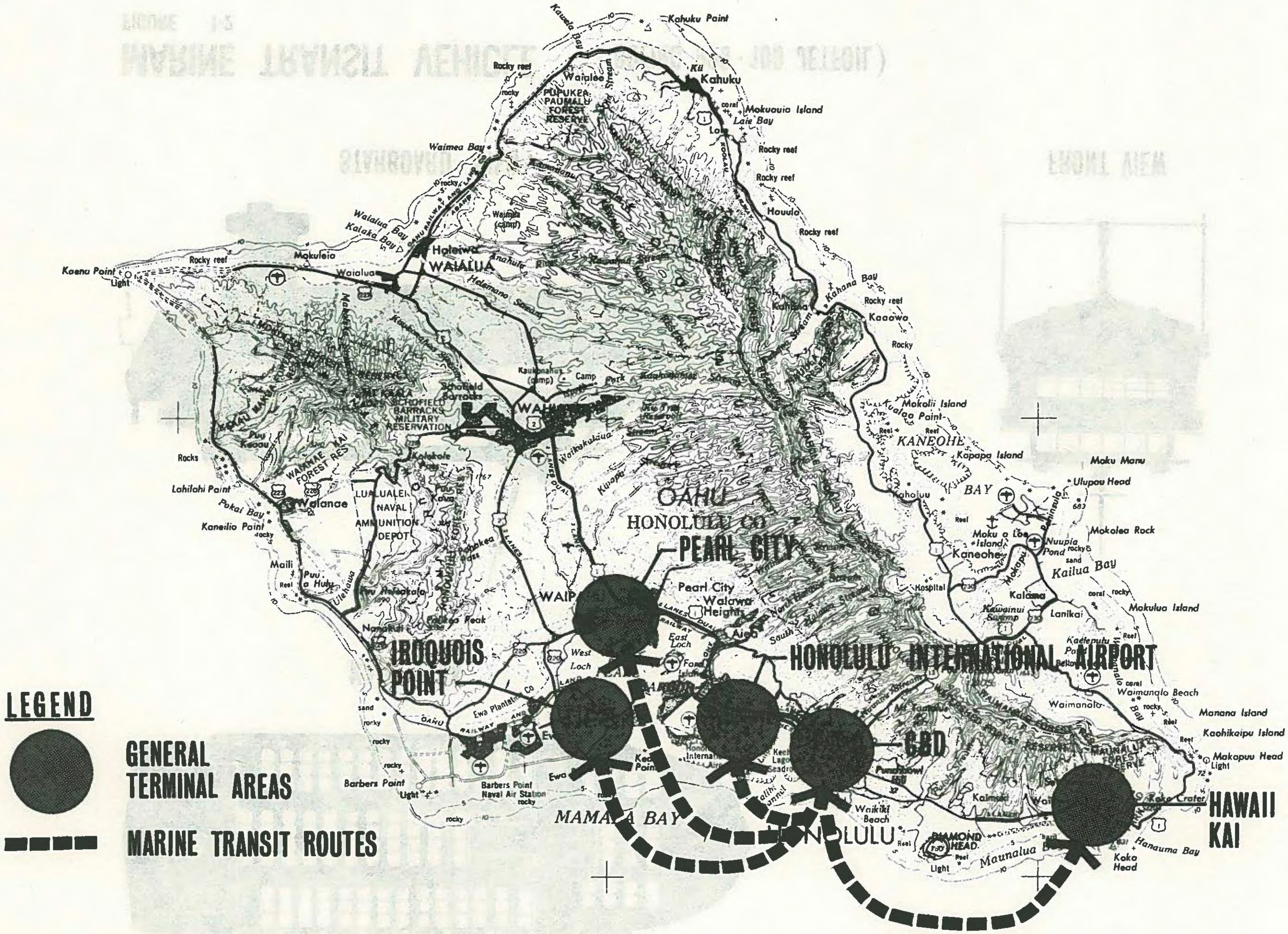
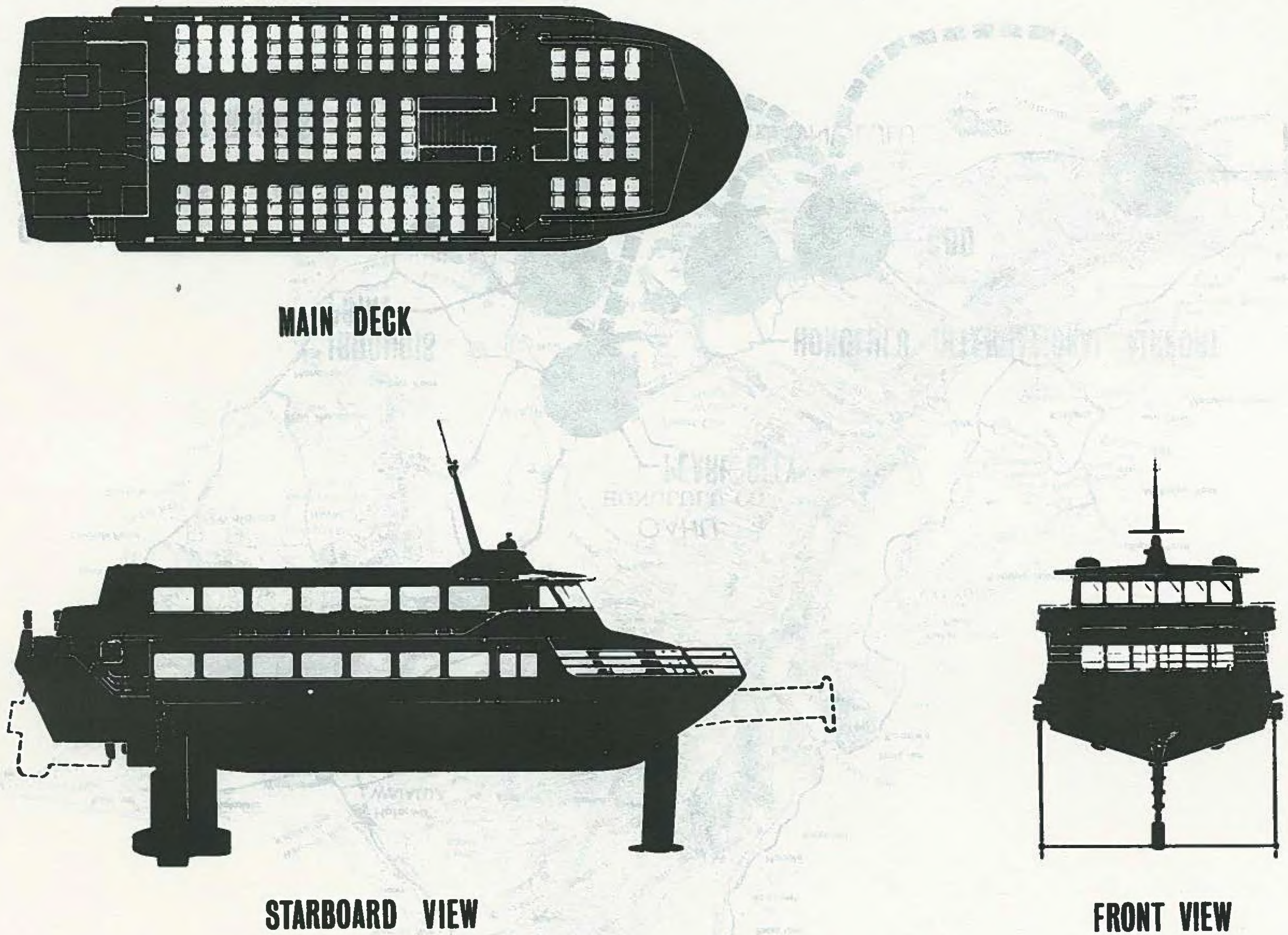
[1] The travel forecast models including the mode split model were developed as part of the Oahu Transportation Study (OTS) of 1967. These models were also used in the PEEP studies.



SUPPLEMENTARY WATERBORNE SYSTEM LOCATION MAP

FIGURE I-1



MARINE TRANSIT VEHICLE (BOEING 929 - 100 JETFOIL)

FIGURE 1-2

- The development of patronage, cost, and revenue estimates for the waterborne transit system.

It should be noted that the terms "marine transit" and "waterborne transit" are used interchangeably throughout this report, and refer to the supplementary waterborne system for which data has been developed.

II. CONTEXT OF EVALUATION

REVIEW OF WATERBORNE TRANSIT SYSTEMS

Commuter-oriented waterborne transit systems are viable modes of urban transportation in various locations in the United States and in many countries throughout the world. A variety of conventional displacement ferry craft and higher-speed hydrofoils and surface-effect vehicles are used in these systems, but operating conditions vary greatly in different locations. This form of waterborne mass transit has proven to be cost-effective and environmentally acceptable for the provision of supplementary or replacement service, especially where land-based transportation systems are not feasible or are limited.

The purpose of this section is to provide a context for the evaluation of the supplementary waterborne system by briefly reviewing the use of short-haul waterborne systems (those which provide primarily commuter service or travel over short-haul distances in less than one hour) in areas of the United States outside of Hawaii and in other countries, and by describing the recent experience of planning for these types of waterborne systems on Oahu.

Survey of Systems Outside of Hawaii

There are hundreds of ferry systems in operation throughout the world providing every conceivable type of waterborne transit, from small specialty tourist or amusement-type operations to extensive, long-haul, combination passenger and vehicle cruise-type operations. The number of systems strictly oriented to the provision of short-haul and commuter service is unknown, but regular waterborne transit is an essential service within many urban areas and densely populated regions. Most of these systems are operating in foreign countries. There has been a recent resurgence of interest, however, in the establishment of new commuter-oriented systems in the United States.

Systems in the United States. Short-haul waterborne transit systems are mostly located or are being planned for operation in urbanized areas on the east and west coasts of the United States. Because of restrictions on the use of foreign-built vessels, they typically use or anticipate using conventional displacement craft in passenger-only or combination passenger and vehicle-type configurations. The number of displacement craft ferry systems operating in the continental United States has decreased markedly since World War II, but increased interest in waterborne transit is reversing this trend because of traffic congestion, the higher costs of operating automobiles, and the ability of new vessel technology to provide more convenient service between areas separated by water.

The largest urban ferry system in the world is the Washington State Ferry System which operates conventional displacement passenger and vehicle ferries on various routes across Puget Sound and to the San Juan Islands. This system is highly oriented to the provision of weekday commuter service in metropolitan Seattle. It has 19 vessels, including four super ferries each capable of carrying 2,000 passengers and 160 automobiles. Transit service is provided at speeds up to 25 knots on runs of about 30 to 45 minutes long.

A recent study of the Washington State ferries explored alternative ways to reduce operating costs (and operating deficits) through route consolidation and new bridge construction, but recommended expansion of the existing system to 23 similar-type vessels in 1995 (Cross-Sound Transportation Study--1972). The annual costs of operating this system were expected to increase nearly three-fold between 1975 and 1990, and the AADT was expected in increase from 10,824 in 1971 to 25,987 in 1990. The study also compared the costs of new operations using Boeing 929 Jetfoils and Spaulding "165" conventional passenger boats. Although rejecting this passenger-only service as an alternative, it concluded that the hydrofoils could provide a slightly more economical operation.

Waterborne commuter service is also provided on two conventional passenger ferry systems between San Francisco, Tiburon, and Sausalito. The privately-operated Tiburon ferry carries about 580 commuters on two boats and the municipally-operated Sausalito ferry carries about 320 commuters on the 15-knot, 575-passenger MV Golden Gate each morning. Both of these services cater to non-commuters during the midday, including tourists who are attracted to the system. The Sausalito ferry carried from 1,700 to 4,500 passengers a day in 1974. The Tiburon system appears to be showing a profit, and the Sausalito system operates at a deficit of about $0.49 per passenger. The vessel for the Sausalito system was purchased and refurbished for $700,000 in 1970, and the system had an annual operating budget of $1.2 million in 1975.

The success of these short-haul services has renewed an interest in ferry service for the San Francisco Bay area. Feasibility studies have been made of route and vessel technology alternatives, and a commitment has been made for additional municipal ferry service that is integrated with the express bus system of the Marin County corridor. A total of $34.9 million is being spent to build new terminals and acquire three conventional 25-knot Spaulding-type ferries, which were favored over hydrofoils because of the limited (under 10-12 miles) travel distances involved. The new service in San Francisco Bay is expected to be initiated in 1976.

The State of Maine has a fleet of five conventional displacement ferries that operate on five routes and provide commuter and short-haul service between the mainland and offshore islands. This system carried 230,000 passengers and 73,560 vehicles in 1971. The system operating expenses for that year were $574 thousand, or about $172 thousand more than operating revenues. A proposed modernization program is expected to require $51.1 million for new terminal facilities and replacement boats.

The limited number of other ferries in the United States that provide commuter service include the combination passenger and automobile Staten Island Ferry in New York City, and various short-haul systems in developed areas that are operated as extensions of State highways. Representative of these limited systems are those operating in Chesapeake Bay (Virginia), on Cape Hattaras (North Caolina), and along the Atlantic shoreline of New Jersey. However, the resurgence of interest in short-haul waterborne transit has resulted in additional studies for completely new systems. For example, the feasibility of passenger and vehicle ferry service at ten crossings between Long Island, mainland New York, and Connecticut was recently looked at in the Long Island Sound Ferry Study (1975), and there are proposals to provide new ferry service in Miami and in areas along the Gulf of Mexico.

Foreign Systems. Short-haul ferry systems that function at least partially as commuter systems are common in foreign countries which have natural waterways or in which competing land-based modes are not available. These systems rely mostly on the use of fast ferry technology which, until recently, was more highly developed than in the United States (hydrofoils and surface-effect vessels). Commercial fast ferry systems operate in Hong Kong, Australia, Russia, Italy, Japan, Venezuela (Lake Maracaibo), Yugoslavia, Greece, Germany, Finland, Sweden, Denmark, Norway, Brazil, Canada, Switzerland (Lakes Geneva and Maggiore), and the Caribbean Islands. The most extensive system of fast ferry service in the world exists in Russia, where there are approximately 2,000 hydrofoils operating on inland seas, lakes, and rivers. Russian hydrofoils carried about 3.5 million passengers in 1969.

The ferry system in the harbor of Sydney, Australia is a very good example of a commuter operation that successfully competes with automobiles and land-based transit. Conventional ferry and hydrofoil service is provided by the publically-operated system between the central business district of Sydney and over 30 other terminals. The most important route is between Circular Quay in downtown Sydney and Manly, a distance of seven miles. In the last couple of years this route had an annual patronage of about 1.5 million (about 9,000 passengers on an average weekday). Although total patronage on the Sydney harbor ferry system has declined over the years because of new road and bridge construction, patronage on the Manly route has increased about 60 percent since 1970. With three hydrofils in operation, service frequencies on this route range from 15 to 20 minutes during peak and off-peak periods. The one-way travel time is 15 minutes and the one-way fare is about $1.00 U.S. Conventional ferry vessels traverse the route in 35 minutes.

The well-known Star Ferries in Hong Kong Harbor provide a high level of commuter service between Hong Kong Island and the Kowloon peninsula. This system provides regular service at 9-10 knots on small displacement passenger vessels, and is characterized by quick turn-around times at the terminals. The system appears to compete successfully with a recently constructed harbor tunnel. Ferry service on similar vessels is provided between Vancouver and North Vancouver and is part of an extensive system of longer-haul passenger and vehicular ferries in British Columbia. Similar displacement craft ferry service is provided in the eastern maritime provences of Canada, the Inland Sea of Japan, Northern Europe (Scandinavia), and the Mediterranean Sea.

The use of hydrofoils and hovercraft on short-haul runs is much more prevalent outside of North America. Representative European fast ferry systems are the 30-minute (16 nautical mile) hydrofoil run between Naples and Capri at a one-way fare of approximately $2.60, and the 10-minute (4 nautical mile) hovercraft run between Portsmouth and Ryde in Great Britain at a one-way fare of approximately $0.70. It appears that these and other commercial fast ferry operations throughout the world are successful because they have the following advantages over other modes of transportation: (1) they provide a connection which results in a captive patronage because routes are too short for feasible air travel or too long for bridge or tunnel construction, (2) they are competitive with other modes of transport, (3) they carry reasonably steady local traffic loads supplemented by tourist traffic, (4) their revenues from fares are supplemented by revenues from other sources or subsidies, and (5) they operate in receptive political and regulatory climates.

Existing and Proposed Systems in Hawaii

Paradise Cruise, a subsidiary of Kentron Hawaii, Ltd., operates the only private commuter ferry system in Hawaii. This system, operated in conjunction with a Pearl Harbor tour and charter boat service, is administered by Pacific Sea Transportation, Ltd. (which is also the operator of Seaflite, the recently initiated interisland hydrofoil service) and is known as SeaTransit. A conventional 93-foot, 500-passenger ferry vessel (certified for 300 passengers), the HAWAII, is used to provide weekday service between Iroquois Point in Ewa and Landing Charlie in Pearl Harbor, Hickam Pier, Pier 11 in Honolulu Harbor, and Kewalo Basin. One morning run and two afternoon runs carried the following average daily two-way patronage in 1975:

- Iroquois Point - Honolulu Harbor 13
- Iroquois Point - Hickam Pier 148
- Iroquois Point - Landing Charlie 190

The one-way trip time between Honolulu Harbor and Iroquois Point is about 35 minutes at a 15-knot service speed. Patrons are charged $1.00 for a one-way trip between Kewalo Basin or Honolulu Harbor and Iroquois Point, and $0.25 between Iroquois Point and Landing Charlie or Hickam. The operating costs of this privately-owned and operated system were not available for the evaluation, but it has been indicated by Kentron that the system operates at a loss.

Various studies have been made to determine the feasibility of waterborne transit systems on Oahu in recent years, but only one has resulted in a definite proposal for a new system. This was a study prepared for the Kalanianaole Highway Transportation Evaluation (State of Hawaii, Department of Transportation, 1975) which looked at waterborne transit as a supplementary "marine bus system" in conjunction with a proposal for express busway and highway improvements in the Kalanianaole Highway corridor.

The marine bus is proposed to operate on a 14-mile route between Maunalua Bay Beach Park in Hawaii Kai and Pier 7 in Honolulu Harbor with three Boeing 929-100 Jetfoils during AM and PM peak periods. The system was forecast to carry between 2,800 and 3,500 passengers daily by 1995. The annual capital and operating costs of the system were estimated at $4.867 million. The total annual cost of chartering the service has since been preliminarily estimated at about $3.75 million per year with $354 thousand in annual terminal construction costs (based on the estimates in the study). The evaluation concluded that the supplementary marine bus system would be operationally feasible and would reduce the number of required express buses on Kalanianaole Highway. Final approval of highway corridor alternatives that include the system, the refinement of estimates, and the preparation of a final environmental impact statement would be required before this service could be implemented.

PLANNING OF WATERBORNE TRANSIT FOR OAHU

In recent years, the use of waterborne transit as a supplement to land-based systems has been the subject of several planning studies by the City and County of Honolulu and the State of Hawaii.

Waterborne transit as an alternative to the proposed Honolulu Rapid Transit System was examined as part of the City and County Preliminary Engineering and Evaluation Program. The results of a parametric analysis performed by Lulejian and Associates to determine the feasibility of waterborne transit as a supplement or replacement system were reported in a preliminary draft environment impact statement in 1972. Six different alternatives were analyzed, two of which were planned to meet the 484,000 daily patronage of the rapid transit system. It was concluded that none of the alternatives would be as cost-effective as the rapid transit system. Furthermore, travel demand estimates indicated that the marine transit system would attract significantly fewer patrons than the land-based alternatives. The two systems with the highest potential capacity had capital costs of $935.7 million and 1995 annual operating costs of $96.3 million. The four other systems had lower costs but insufficient capacity to meet an acceptable level of transit demand. In addition, the hydrofoil systems were found to have adverse environmental impacts and significant operational problems for this type of service.

The Sea Grant Program at the University of Hawaii has been studying the feasibility of marine transit systems as a supplement to or replacement for the Oahu land-based transit system since 1972. These studies have proposed a system of ocean expresses consisting of hydrofoil or stable semisubmerged platform vessels, and a feeder system of smaller vessels operating on the canals and inland waterways of Honolulu. The reports published to date have been primarily concerned with the oceanographic and engineering aspects of the proposals, such as the design of ships and terminals. They have not dealt with operational efficiency, costs, or expected patronage, especially as to how these systems compare with land-based systems relative to these criteria.

The Advanced Transportation Planning Office (ATPO) of the State Department of Transportation prepared a memo in 1974 summarizing the results of a land-sea transit analysis for the following eight alternatives:

- 1980 Bus System only
- 1980 Bus System with a 17-knot marine bus (conventional ferry vessel)
- 1980 Bus System with a 40-knot marine bus (hydrofoil)
- 1980 Bus System with a 17-knot marine bus (and no competing express bus)
- 1980 Bus System with a 40-knot marine bus (and no competing express bus)
- Alternate C Rapid Transit System[1]
- Alternate C Rapid Transit System with a 17-knot marine bus
- Alternate C Rapid Transit System with a 40-knot marine bus

The analysis showed that a marine bus could increase the total peak-period transit patronage slightly although the waterborne portion was a small portion of the total. The elimination of competing land-based express buses increased the marine bus patronage but decreased the overall transit patronage.

[1] Alternate C Rapid Transit System is the 23-mile fixed guideway system with a feeder bus network.

III. DEVELOPMENT OF SUPPLEMENTARY WATERBORNE SYSTEM

The purpose of the supplementary waterborne system evaluation is to determine the requirements for a specific waterborne transit system that is coordinated and integrated with the all-bus system in 1980 and the 23-mile rapid transit system in 1995. In order to complete this evaluation, it was necessary to define the service characteristics of the supplementary waterborne system from which patronage forecasts, estimates of equipment and related fixed facility needs, and estimates of costs and revenues could be derived.

This chapter describes the supplementary waterborne system in terms of its primary transportation service characteristics, and outlines the basic service assumptions that were used in the evaluation.

ISLAND-WIDE RELATIONSHIP BETWEEN LAND-BASED AND WATER-BORNE SYSTEMS

The land-based system of buses and eventually rapid transit would provide transit service for the entire Island of Oahu. A waterborne system of feeder buses and hydrofoils would supplement the land-based system by allowing the residents of several communities close to the marine transit terminals a choice of transit modes for commuter trips to the central business district. Specifically, the residents of Ewa, Waipahu, Moanalua, and Hawaii Kai could elect to use land-based or waterborne transit systems for these trips.

The bus service in these communities will provide access to the central business district in 1980 and feeder service to the rapid transit stations in 1995, as well as to the terminals of the supplementary waterborne system. The level of bus service required to get to the marine transit terminals should be comparable to that required to get to the central business district or the rapid transit stations. In other words, the frequency of service and the number of transfers should be comparable in both cases.

The primary destination of the marine transit patrons would be the central business district. One or more CBD shuttle routes would have to be provided to distribute the passengers from the CBD terminal at Pier 7 throughout the CBD.

The following sections briefly describe the terminal site locations, the communities which would be served by both the land-based and waterborne systems, characteristics of the marine transit vehicles, and the marine transit routes that were analyzed in the evaluation.

Terminal Locations

The transportation service characteristics of the supplementary waterborne system were largely defined by the terminal locations of the system. Five general locations for the terminals on leeward Oahu were originally established in previous studies of PEEP and of the State Department of Transportation, and were considered a basic "given" for the present evaluation. These locations were as follows:

- Hawaii Kai
- Honolulu International Airport
- Iroquois Point (Ewa)
- Pearl City
- Honolulu Harbor (vicinity of the Aloha Tower)

In order to determine the specific transportation service characteristics of the supplementary waterborne system and to provide a physical basis for the evaluation, it was necessary to select and conceptually develop actual terminal sites. Surveys of existing conditions were conducted, and alternative sites in the vicinity of the five general locations were investigated for reasonableness. Various factors such as site accessibility, existing site use, environmental impacts, and the results of previous planning studies were considered. It was concluded through this survey that the following terminal site locations would be the most reasonable for the evaluation:

- Hawaii Kai--on filled land off Maunalua Bay Beach Park, immediately west of the existing small boat channel leading to the Hawaii Kai Marina. This is the site of a terminal recently planned by the State Department of Transportation for a supplementary marine bus system as part of the Kalanianaole Highway Transportation Evaluation (see discussion in Chapter II).

- Honolulu International Airport--on the west bank of Keehi Lagoon, on airport property adjacent to Keehi Lagoon Beach Park off Lagoon Drive. This site is located in an area designated for this use on the airport master plan, and is designated in the evaluation as the "Keehi" terminal.

- Iroquois Point--at Lima Landing on the U.S. Navy property in the entrance channel to Pearl Harbor. This is the location of an existing boat landing used by the SeaTransit commuter ferry and shuttle ferries of the U.S. Navy.

- Pearl City--opposite the Pearl City peninsula adjacent to Waipahu Landing off Waipio Point Road in the Middle Loch of Pearl Harbor. This terminal was relocated from the Pearl City area to a suitable site on the Waipahu side of Middle Loch because of land access constraints, and was redesignated the "Waipahu" terminal for the evaluation.

- Honolulu Harbor--at Pier 7 near the foot of Bishop Street, the main street of the Honolulu central business district. Pier 7 is the site of the other terminal location selected by the State in the Kalanianaole Highway Transportation Evaluation. It was identified as the "CBD" terminal in the evaluation.

Figure III-1 illustrates the locations of these terminals and their relationship to the community service areas of the supplementary waterborne system. Additional information on the terminal sites, including conceptual site and terminal facility plans, is provided in Chapter IV as part of the description of the facility requirements.

Community Service Areas

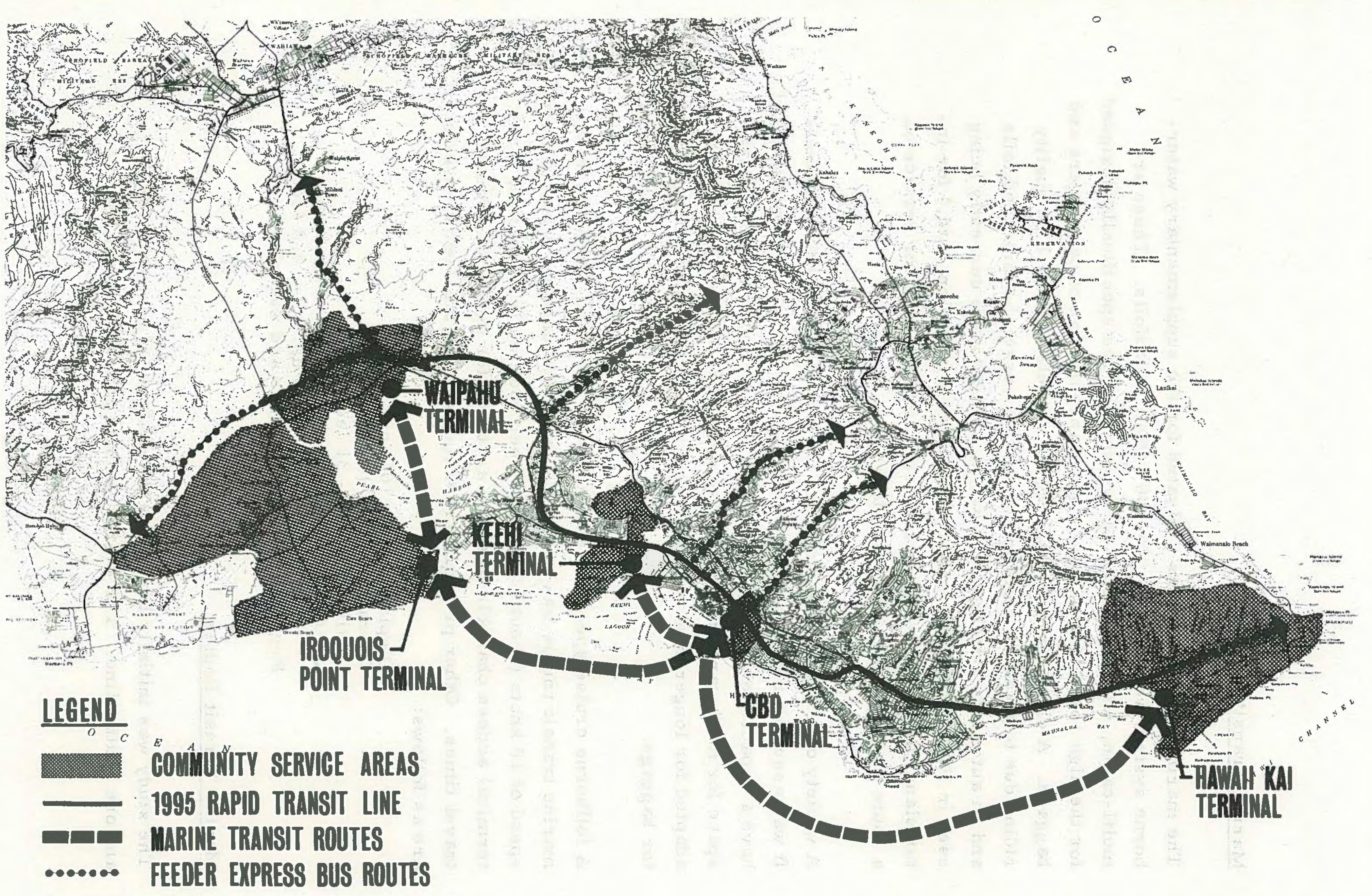
Residents of communities in the vicinity of the marine transit terminals would be able to use either the land-based or waterborne systems for trips to the CBD.

The following is a list of the communities involved and the traffic zones which would be affected by the supplementary waterborne system:

Communities	Traffic Zones[1]
Ewa	125, 128, 129
Waipahu	130, 131, 132, 133, 134, 135, portion of 137
Moanalua	152, 155, 156
Hawaii Kai	79, 80, 81, 82
CBD	1-17, 31-35, 41-43

These community service areas are identified in Figure III-1.

[1] The Island of Oahu was divided into 159 traffic zones for transportation planning purposes. Most traffic zones are based upon census tract zones; however, the numbering scheme of the two systems are not identical.



COMMUNITY SERVICE AREAS AND MARINE TRANSIT ROUTES

FIGURE III-1

Marine Transit Vehicles

The marine transit vehicles evaluated for the supplementary water-borne system were Boeing 929-100 Jetfoil hydrofoils. These are multi-cabin, waterjet propelled vessels that are specifically designed for the high speed coastal and ocean transportation of passengers and baggage. A chief characteristic of the vessels is their high quality riding due to a canard configuration of the vessels' submerged foils and an automatic stabilization system. Jetfoils are currently being used in Hawaii by Seaflite (Pacific Sea Transportation, Ltd.) for interisland passenger service, and are also being used for service on a route between Hong Kong and Macao.

A variety of internal configurations are available for Jetfoil vessels. It was assumed in the evaluation that the marine transit vessels would have a capacity of 250 passengers for the commuter service, with space for hand-carried articles and possibly bicycles, but could be adapted for longer-haul service which might require additional space for baggage.

A foilborne cruise speed of 42 knots (about 48 miles per hour) on the marine transit routes was assumed for the evaluation. A maneuvering speed of 10 knots (about 11-12 miles per hour while hullborne) in the terminal access channels was also assumed for the calculation of travel times. Other principal characteristics of the Jetfoil vessels are as follows:

Displacement - 106 long tons
Overall length - 90 feet
Maximum beam - 31 feet
Mean hullborne draft (foils down) - 16.3 feet
(foils up) - 4.8 feet
Propulsion - gas turbines and waterjet

Marine Transit Routes

The study was initially limited to the analysis of four express routes and one shuttle line. The express routes provided direct service between the CBD terminal and the Iroquois Point, Waipahu, Keehi, and Hawaii Kai terminals. The shuttle connected Iroquois Point with Waipahu and Keehi. After developing the initial patronage estimates, several changes were made to make more efficient use of the marine transit vehicles. The final evaluation was made with the following three routes:

Waipahu-Iroquois Point-CBD
Keehi-CBD
Hawaii Kai-CBD

These final routes are illustrated schematically in Figure III-1.

Based on the operating characteristics of the Boeing 929 Jetfoils, the following set of travel times was used to forecast patronage:

Express Lines	Travel Time (Minutes)
Iroquois Point-CBD	18
Waipahu-CBD	34
Keehi-CBD	13
Hawaii Kai-CBD	24

These terminal-to-terminal times reflect the elapsed time between departure from the origin dock and arrival at the destination terminal and is dependent upon a critical assumption. The hydrofoils will be able to travel at full speed (42 knots) except during docking maneuvers and acceleration/deceleration. In order to do this, speed limit variances must be obtained for operations in Honolulu Harbor and Pearl Harbor, which have speed limits from 6 to 15 knots. The current interisland hydrofoil operation already has a variance for hydrofoils to operate foilborne in Honolulu Harbor. The Pearl Harbor variance is more critical due to the longer expanse of water involved, and travel times on the Iroquois Point and Waipahu runs can be expected to increase by 7 and 20 minutes, respectively, without the waivers. This analysis proceeded on the assumption that the waivers could be obtained for future hydrofoil operations; however, patronage sensitivity to vehicle speeds is analyzed in Table IV-7.

LOCAL INTERFACE BETWEEN LAND-BASED AND WATERBORNE SYSTEMS

The effectiveness of the waterborne system as a supplement to the 1980 all-bus and 1995 rapid transit systems would be related to the nature of the interface between the community service areas and the marine transit terminals. A system of local feeder buses, based on the feeder systems previously proposed for the land-based systems, was established to serve the supplementary waterborne system. Bus routes and schedules were coordinated for each community service area so that minimum changes to the previously proposed routes or additions to the bus fleet would be required in 1980 and 1995.

The following sections briefly describe the transportation service characteristics of the local interface between the land-based and waterborne systems, in terms of the changes that were required for the local feeder bus routes and the general access and circulation requirements that were determined for the marine transit terminals.

Local Bus Routes

1980. The All Bus "Do-Nothing" System was selected as the land-based transit system for 1980. The following route revisions and new routes were made to provide feeder bus service to the marine transit terminals:

- Line 44 (30-minute headway). This line connects Makakilo, Barbers Point, and Waipahu. It travels on Waipahu Street and terminates at Farrington Highway near Waipahu High School. It was extended to the Waipahu marine transit terminal.

- Line 52 (20-minute headway). This new line was added to provide service from the Iroquois Point marine transit terminal to the Waipahu marine transit terminal. It provides service along North Road, Fort Weaver Road, and Farrington Highway.

- Line 22 (20-minute headway). This new line was added to provide parallel service with the Foster Village-Salt Lake-Umi Loop line, except this line went to the Keehi marine transit terminal instead of Umi Loop.

These changes are shown in Figure III-2.

- Line 1 (10-minute headway) and Express 15 (30-minute headway). Both these lines service Lunalilo Home Road (Hawaii Kai) from Kalanianaole Highway. These routes were diverted into the Hawaii Kai marine transit terminal from Kalanianaole Highway.

- Line 28 (10-minute headway). This new route was added to provide Kalama Valley and the west end of Hawaii Kai with feeder bus service to the marine transit terminal.

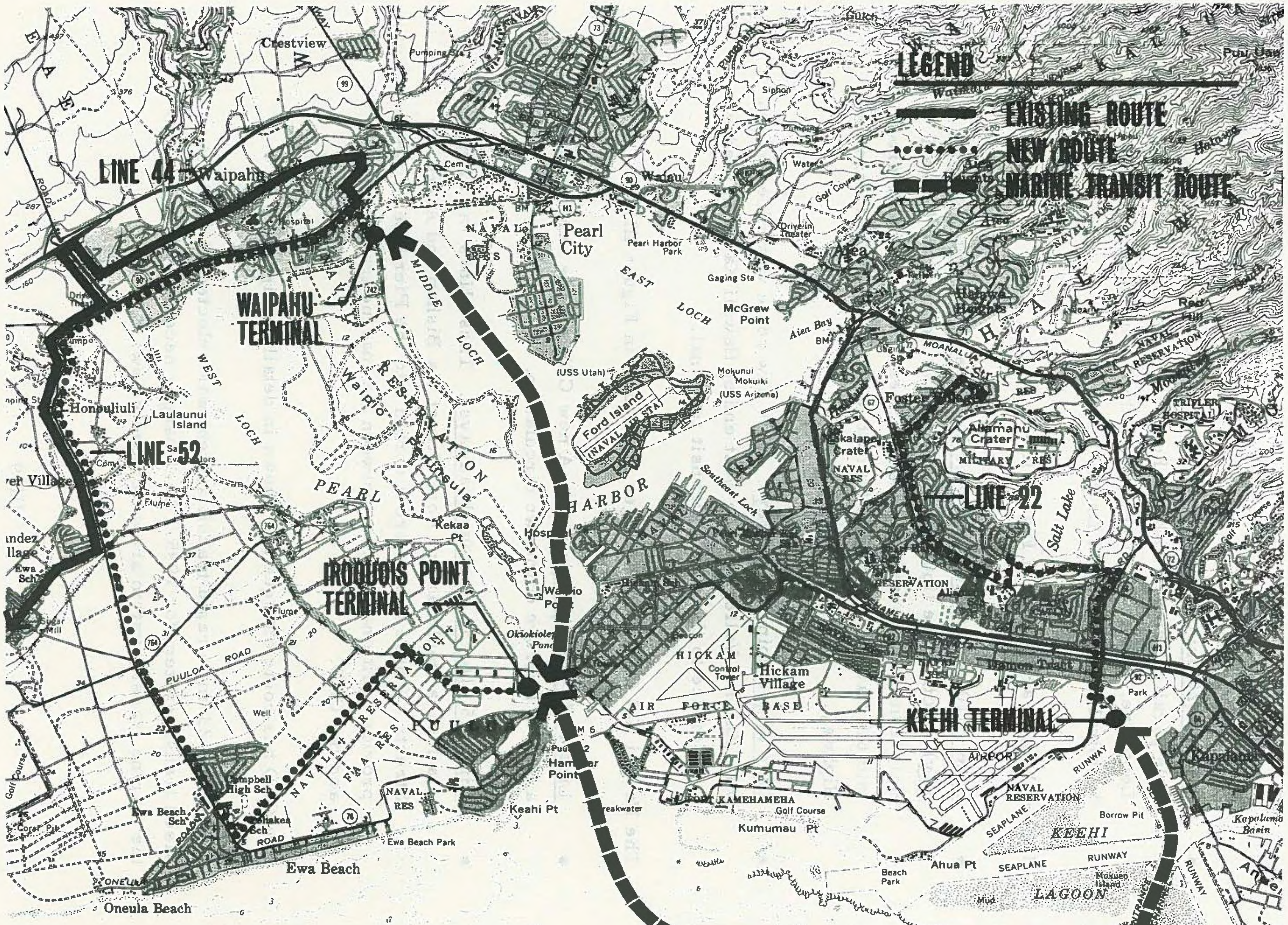
The Hawaii Kai feeder bus changes are shown in Figure III-3.

- Line 11 (5-minute headway). A new CBD shuttle service was added to improve downtown circulation.

- Lines 15, 16, 32 (various headways). These lines ran along Ala Moana Boulevard to Hotel Street via Bishop and Alakea Streets. These lines were diverted into the Pier 7 terminal to provide additional service between the marine transit system and the CBD.

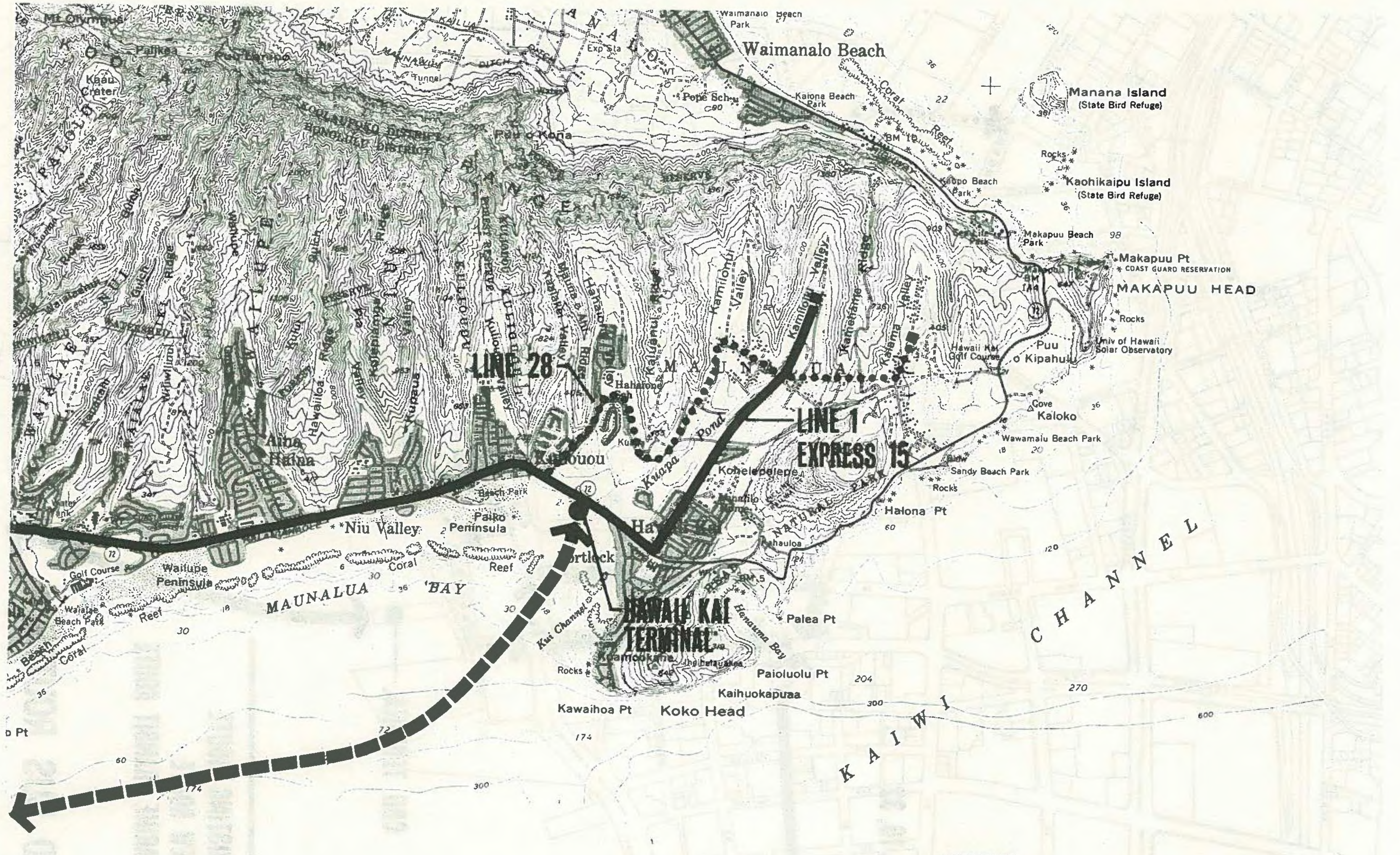
The CBD bus route changes are shown in detail in Figure III-4.

1995. The 23-mile rapid transit system was selected as the land-based transit system for 1995. The changes necessitated to service the marine transit system are described below:



1980 LEEWARD BUS ROUTES

FIGURE III-2

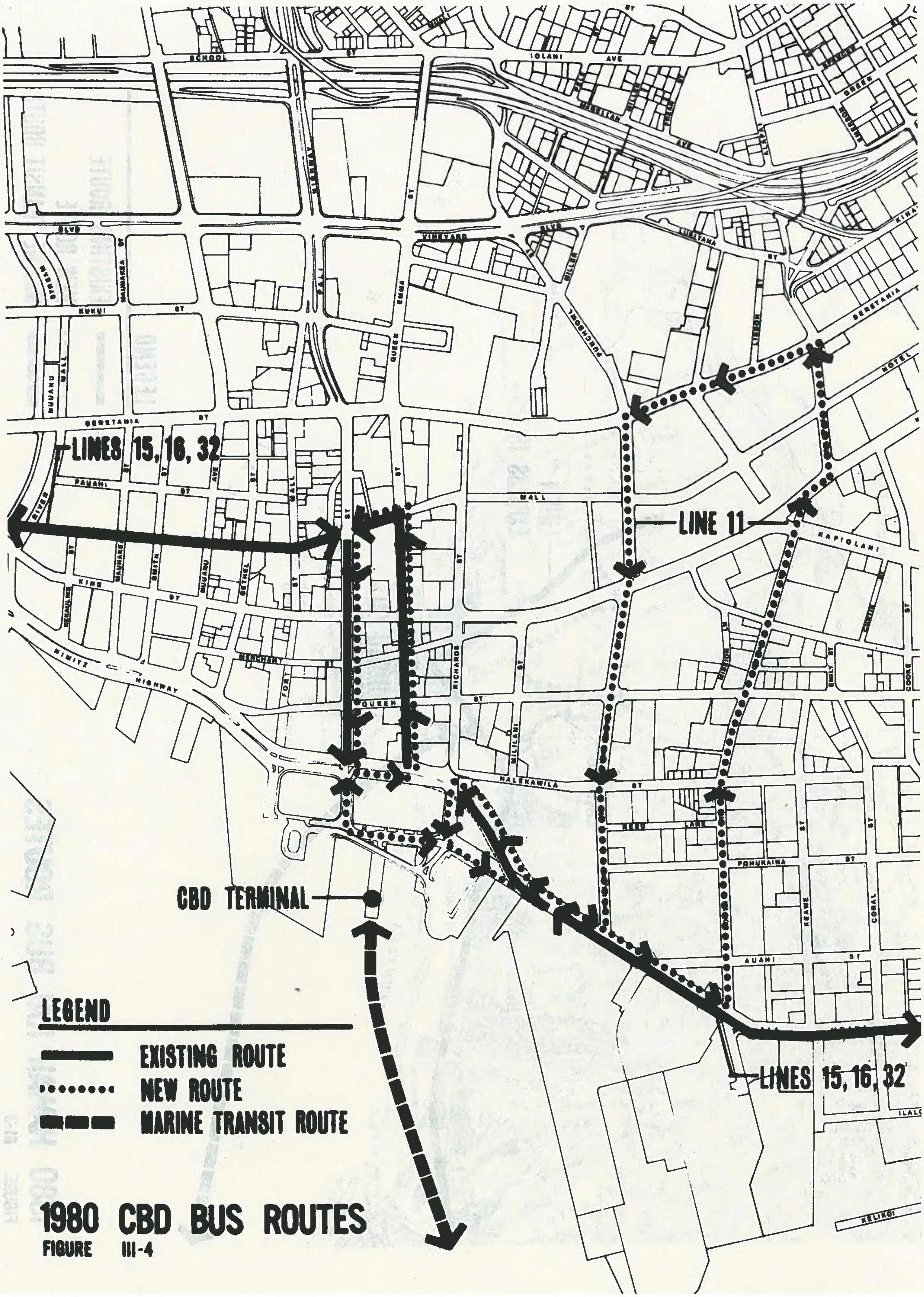


LEGEND

- EXISTING ROUTE
- NEW ROUTE
- MARINE TRANSIT ROUTE

1980 HAWAII KAI BUS ROUTES

FIGURE III-3



1980 CBD BUS ROUTES
FIGURE III-4

- Waipahu Shuttle (15-minute headway). A new shuttle route was added to provide service from Farrington Highway, Kunia Road, Waipahu Street, and Paiwa Street to the Waipahu marine transit terminal.

- Express 17 (8-minute headway). The Pearl City to Honouliuli express was extended along Fort Weaver Road and North Road to provide feeder bus access to the Iroquois Point pier.

- Lines 28 and 29 (3-minute headway). These feeder buses from Salt Lake and Moanalua Road were extended from their terminus at the Keehi rapid transit station to the Keehi marine transit station.

The above changes are shown in Figure III-5.

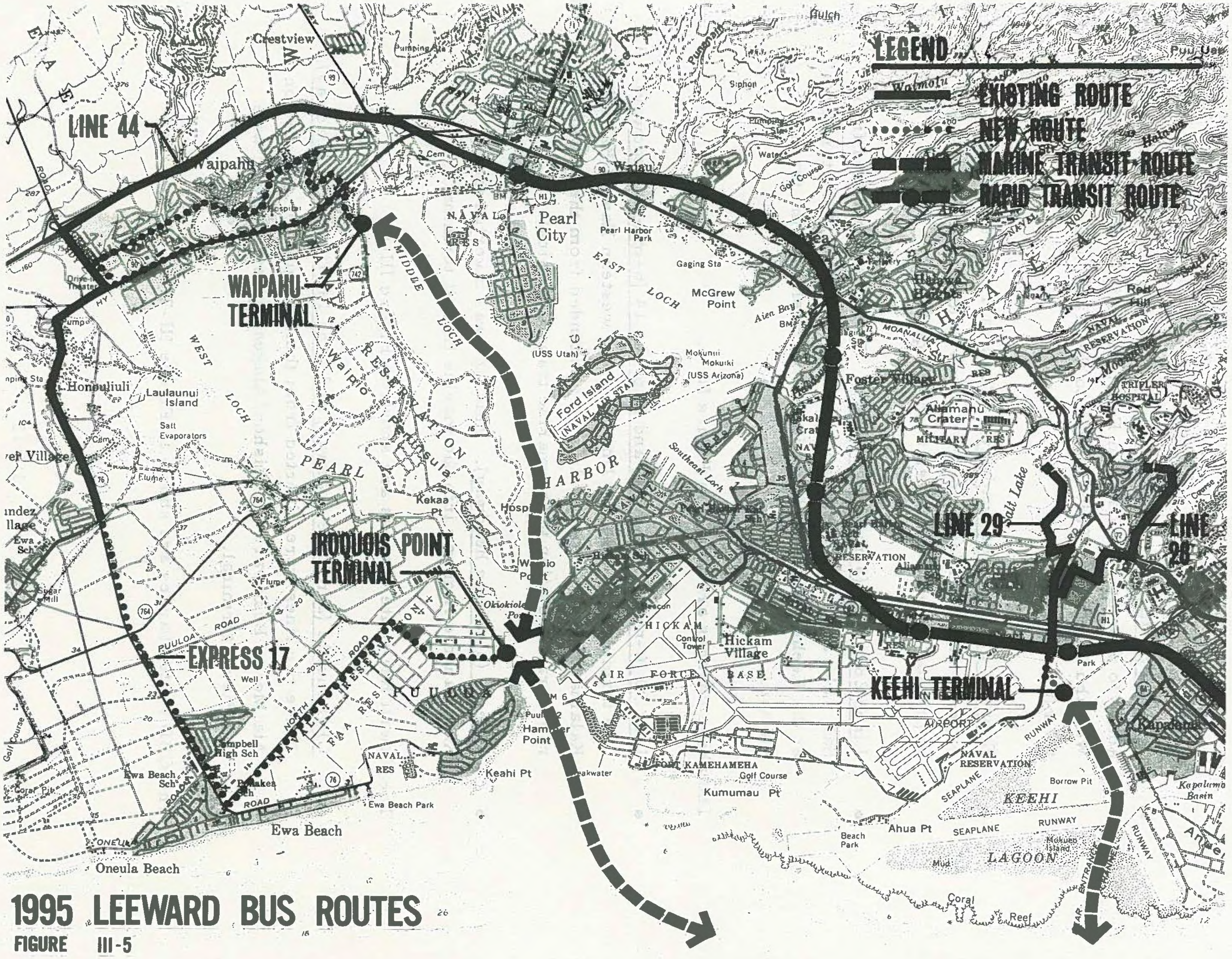
- Line 50 (6-minute headway) and Express 14 (6-minute headway). The terminus of these two lines serving western Hawaii Kai and Kalama Valley, respectively, were extended from the Hawaii Kai rapid transit station to the marine transit terminal.

- Line 51 (6-minute headway). This line was diverted from Kalanianaole Highway into the marine transit terminal.

The Hawaii Kai route changes are shown in Figure III-6.

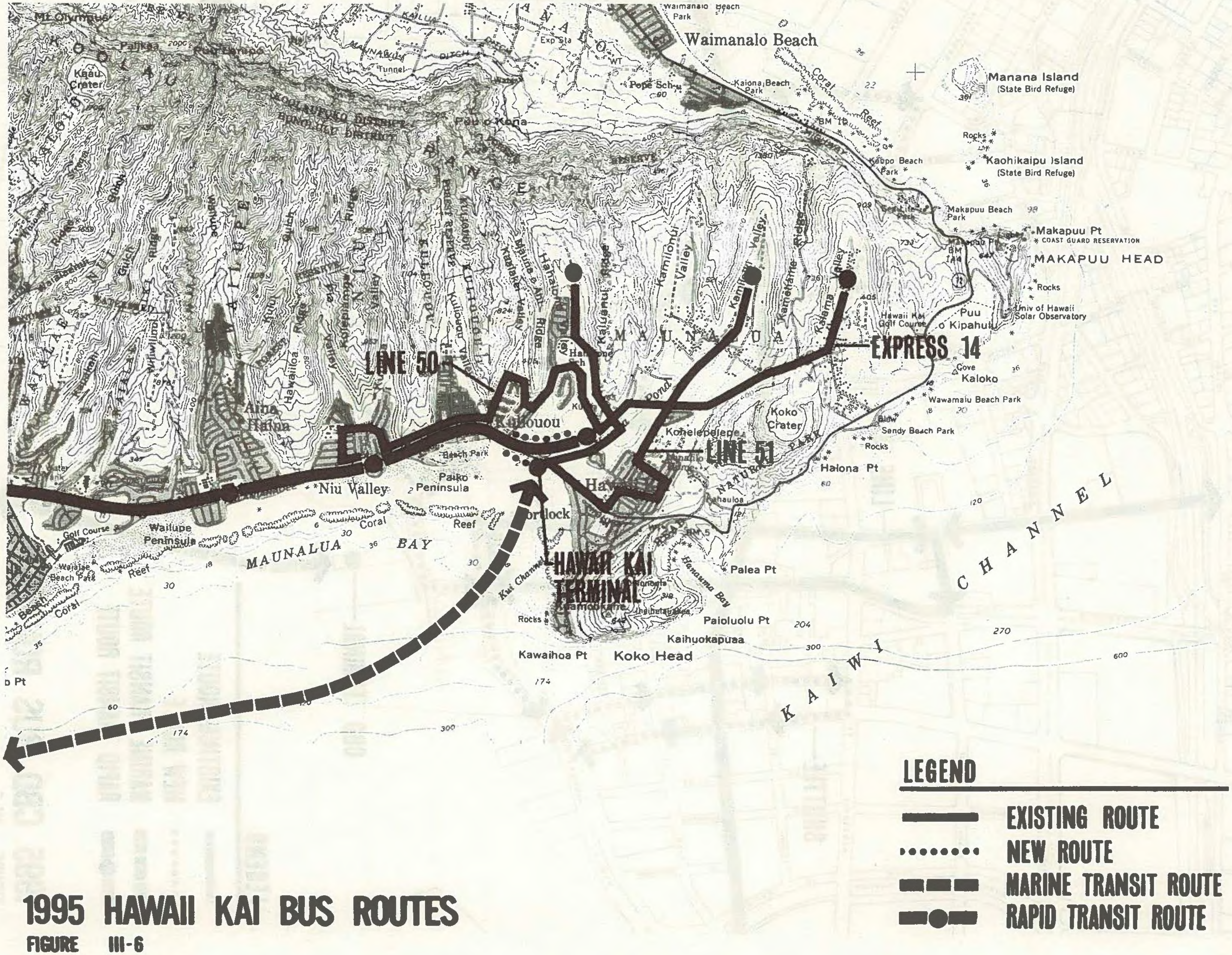
- CBD Shuttle (2-minute headway) and Line 18 (10-minute headway). These two lines were diverted from their original alignments on Ala Moana Boulevard and Bishop/Alakea Streets to tie in with the Pier 7 terminal.

The CBD route changes are shown in Figure III-7.



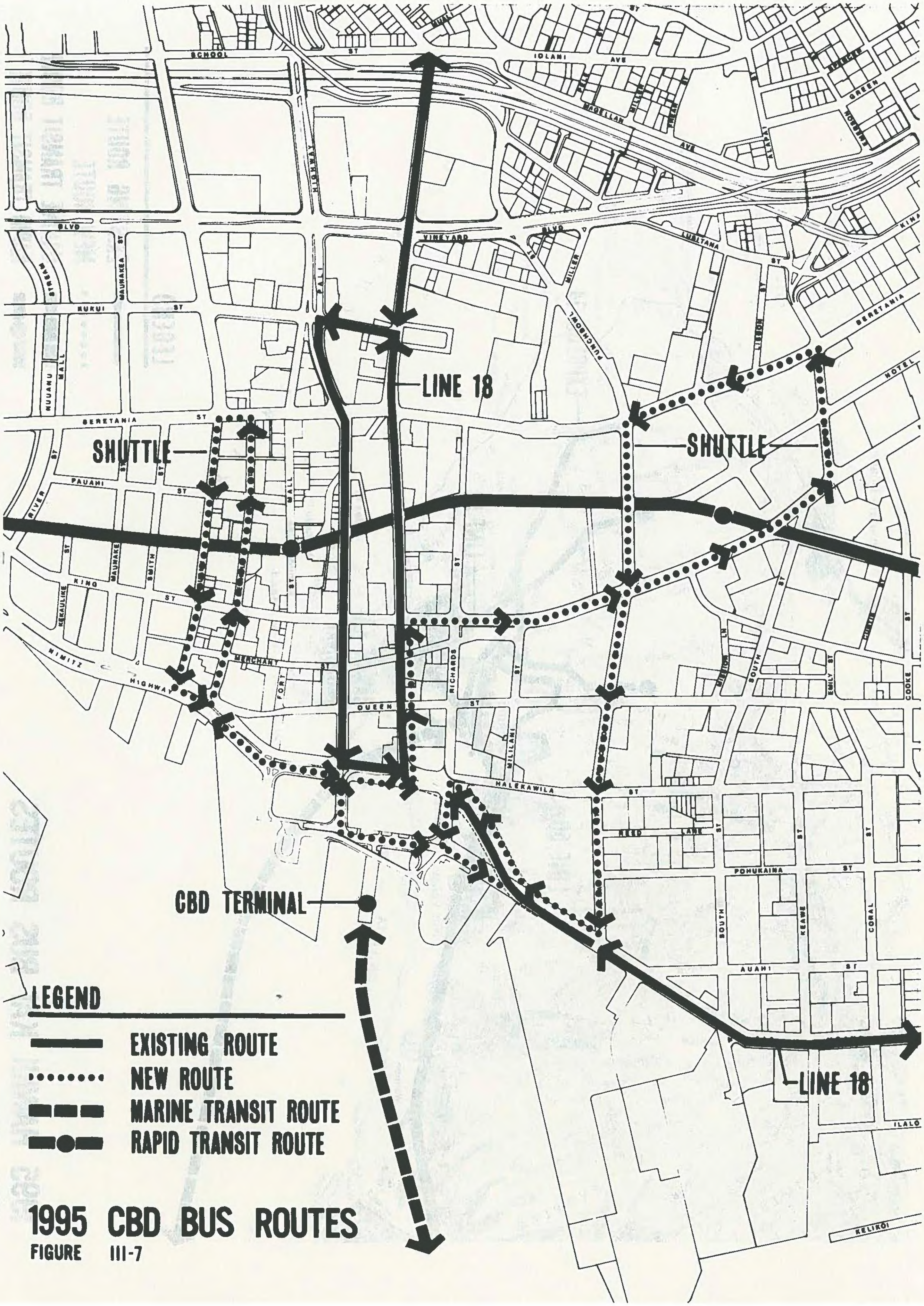
1995 LEEWARD BUS ROUTES

FIGURE III-5



1995 HAWAII KAI BUS ROUTES

FIGURE III-6



1995 CBD BUS ROUTES
FIGURE III-7

Terminal Access and Circulation

Access and circulation requirements for the marine transit terminals were dictated by their location and the need for an efficient interface between the terminals and the local street system. Since most of the supplementary waterborne system patrons would arrive at or depart from the terminal by buses or private automobiles, it was assumed that convenient access and circulation schemes would be developed to minimize transfer times between the land-based modes and the marine transit vehicles. In effect, the marine transit terminals would function in a similar way as bus stops or rapid transit stations for the land-based modes.

With the exception of the CBD, all the terminals would require new access roads to circulate bus and automobile passengers between the nearest local streets and the terminal facilities. These would vary in length for the different terminal sites, but were assumed to incorporate convenient drop-off areas for bus and kiss-and-ride passengers. It was also assumed that vehicles arriving at the terminals could easily park, or circulate through the sites and return to the local street system. The local access and circulation requirements that were assumed for each of the terminal sites are further described in the section on terminal requirements in Chapter IV (see Figures IV-2, IV-5, IV-7, IV-9, and IV-11).

At the Hawaii Kai terminal, the local feeder buses and automobiles would enter Maunalua Bay Beach Park at the intersection of Kalanianaole Highway and Keahole Street. It was assumed that traffic signals at this intersection would be phased to allow turning movements to and from both directions on Kalanianaole Highway. A new terminal access road approximately one-fifth of a mile long would be required at this site.

Access to the Keehi terminal would be via Lagoon Drive and a new loop road that is planned for construction on the adjacent airport property. The access road would be about 500 feet long, and no special traffic controls would be required at this site.

Access to the Iroquois Point terminal would be via a new extension to the local street which is located off of North Road. Access would be most efficiently provided by a loop road that ties in with the existing parking lot for the SeaTransit terminal and the U.S. Navy facilities at Lima Landing. No special traffic controls would be required at this site.

The Waipahu terminal would require construction of a new access road several hundred feet long, off the existing Waipio peninsula access road. No special traffic controls would be required at this site.

Access to the CBD terminal for bus passengers would be provided by a curb-side bus stop area adjacent to Pier 7 on the local service road portion of the Ala Moana Boulevard. It was assumed that the large proportion of pedestrian traffic anticipated for this site would utilize existing sidewalks and pedestrian street crossings in the area.

IV. EVALUATION OF SUPPLEMENTARY WATERBORNE SYSTEM

PATRONAGE ESTIMATES

Methodology

Implementation of the marine transit system would offer the residents of several communities a choice of two transit modes in addition to the choice of the auto mode. This selection from three transportation modes precluded the use of traditional mode split models which assume a binary choice; therefore, a submodal split model was developed for multimodal analysis.

Existing Model. Traditional modal split models have been developed primarily on two assumptions:

- A binary choice between transit and auto. The trip maker had a choice between the auto and an unspecified transit mode only.
- All-or-nothing assignment to the minimum transit path. The transit rider is constrained to using the minimum path transit system and the alternative modes would not be utilized at all.

The end result of these two assumptions is that the modal split is based upon the best transit service level between any origin-destination pair, and all transit trips would be on the minimum path. The modal split model developed by the Oahu Transportation Study (OTS) has these features. This model (and other binary models) work well with an all-bus system or a rapid transit with feeder bus system because there are no alternative transit modes.

The inclusion of additional transit modes (such as a supplementary waterborne transit system) limits the usefulness of the binary choice model. The all-or-nothing assignment would assign all transit trips to the minimum path transit system and none to the alternative systems. In reality, some trips would be made on the slower alternative system depending upon the relative levels of service of the competing transit systems. This fact should be reflected in the submodal split model.

The binary choice model would calculate modal split based upon the characteristics of the best transit system. In reality, the addition of competing transit modes may increase transit ridership above the patronage obtained with the "best" transit system. These additional trips shall be called induced trips[1] and should also be accounted for in the submodal split model.

Submodal Split Model. The submodal split model developed for this study is based upon the "strict utility model" or choice axiom developed in the behavioral sciences by Luce and Supples.[2] The choice axiom literally interpreted states that the probability of choice associated with a particular alternative contained within a finite set of alternatives is independent of what other alternatives are available. In other words, the ratio of transit riders to auto riders remains constant for a particular mode no matter how many transit modes are introduced. For example, if the probability of choice between auto and bus transit alternatives is 50/50, the introduction of a third mode which captures 10 percent of the market would reduce the auto and bus transit of the market to 90 percent. However, the probability of choice between these two modes would be reduced to 45 percent each, still a 50/50 ratio. Similarly, the probability of choice ratio between the third mode and auto would remain constant if the second mode were present or not.

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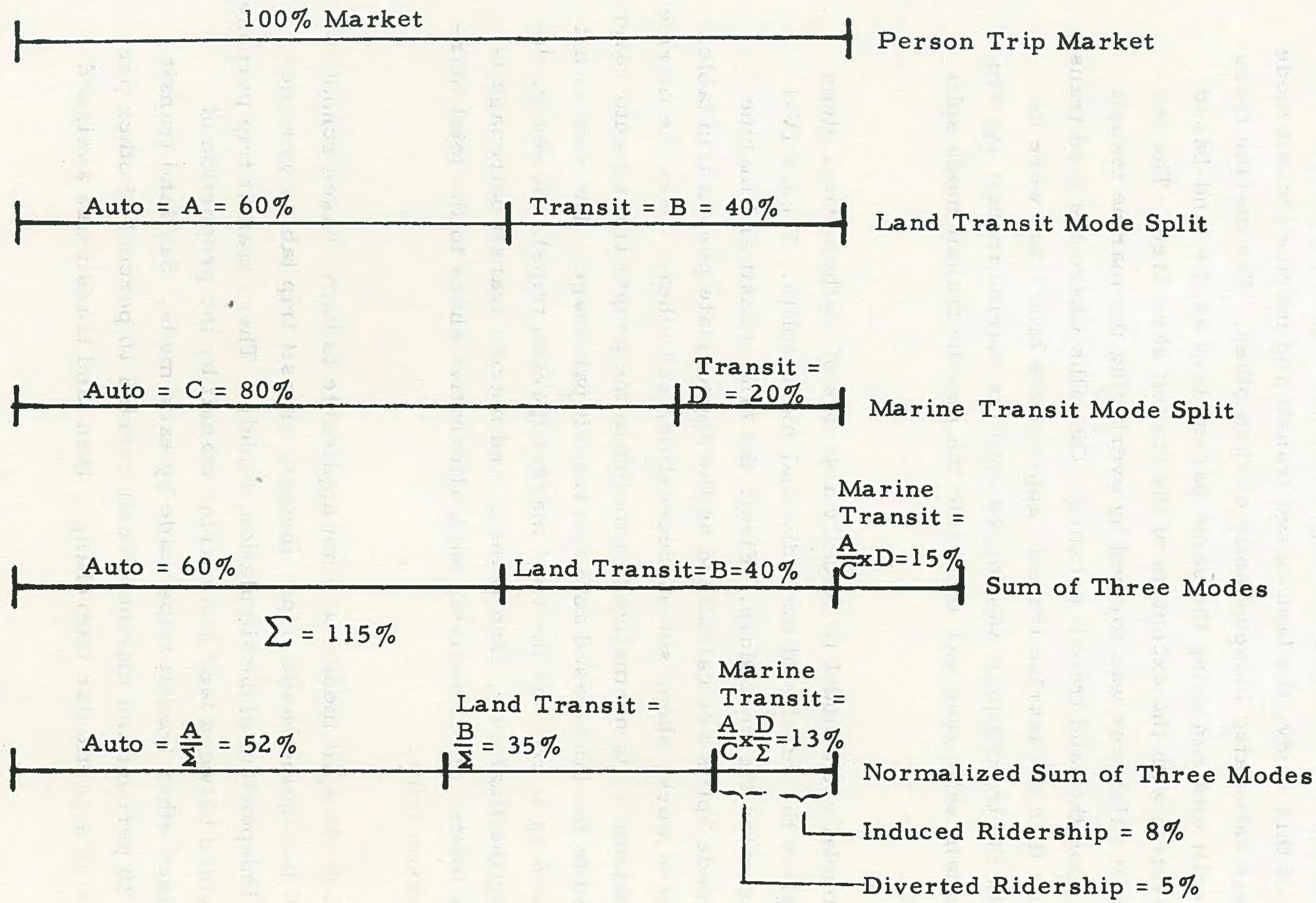
[1] This nomenclature (induced trips) will be used although technically incorrect since it normally refers to trips which were not made at all until the introduction of the new mode.

[2] Luce, R. and Supples, P., "Preference, Utility, and Subjective Probability," Handbook of Mathematical Psychology, Luce, Bush, Galanter, eds, Vol. III, John Wiley (New York, 1965).

In order to do the submodal split model, the mode splits of the individual transit modes must first be calculated to determine the relative attractiveness of each system compared to the highway network. In the case of this study, the land-based transit and marine transit mode splits were calculated independently of each other. The marine transit mode split was run using the same parameters as the land-based transit system with the exception of the transit skim tree. The marine transit skim tree was formed by overlaying the marine transit network upon the land transit network. On paths where the land transit was faster than the marine transit, appropriate land links were deleted until the transit path was forced onto the marine transit system. The resultant skim tree was input into the marine transit mode split model.

The submodal split model is actually a series of mathematical steps to normalize the results of the individual mode splits. Figure IV-1 best illustrates the procedure. First, the land transit and marine transit mode splits are calculated on the appropriate person trip tables: home-based work, shop, social-recreation, and other. Then the marine transit patronage is normalized to maintain the proper transit auto ratio and added to the land-based auto and transit patronage. The sum is not normalized as it exceeds the total market (person trips). However, determining the final auto, land transit, and marine transit patronage is simply a matter of normalizing each alternative share to the total market of person trips.

The OTS mode split models are not applicable to home-based school trips and non-home based trips; instead, transit trip tables were developed independent of the simulation models. These transit trip purposes were divided between land and marine transit by the proportion of home-based other transit trips made by each mode. Say land transit carried 20 percent and marine transit carried 10 percent of other person trips on a particular interchange, then land transit was assigned



SUBMODAL SPLIT PROCEDURE

FIGURE IV-1

67 percent of the school and non-home based transit trips, marine transit 33 percent. The 1995 Hawaii Kai transit overage was divided between land and marine transit in a similar manner, using the work trip transit mode split as the basis for proportioning.

The marine transit patronage is composed of diverted riders and induced riders. The diverted riders are former land transit riders who are diverted to the introduced marine transit mode. Induced riders are former auto users who are now induced to use transit because of the additional service provided. All the induced transit ridership is assumed to be on the marine transit system. As previously stated, induced ridership is not meant to imply that additional person trips have been added to the total trip market or total number of person trips. Numerically, the magnitude of diverted trips is the difference between the transit share for land transit only and the land transit share with competing marine transit system. In the example shown in Figure IV-1, the diverted trips are equal to 5 percent (40-35) of the total market. The induced ridership is the difference between the sum of land and marine transit share, and the land transit only share. In the example, the induced ridership is equal to 8 percent ((35+13)-40). As a final check, the sum of diverted and induced ridership should equal the marine transit share. In the example, the marine transit share is 13 percent (5+8).

The output from the mode split and submodal split models was a daily person trip table by transit in a production-attraction format.[1] The production-attraction trip tables were transposed into the daily origin-destination format[2] and then converted to peak-period and peak-hour values. The coefficients illustrated in Table IV-1 were used to convert

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[1] The production-attraction format is used in the trip generation, trip attraction, trip distribution process. Round trips are shown as two one-way trips from the production zone to the attraction zone; therefore, the return trip is not shown in the true direction.

[2] The origin-destination format shows the true direction of each trip. It is mathematically obtained by adding the production-attraction trip table to its transpose, and dividing the sum in half.

TABLE IV-1

EVENING PEAK PERIOD TRIP TABLE COEFFICIENTS

Trip Purpose	Home-To	To-Home
Home-Based Work	.034	.683
Home-Based Shop	.191	.326
Home-Based Social-Rec.	.108	.361
Home-Based Other	.173	.304
Home-Based School	.009	.395
Non-Home Based	.153	.153

the daily origin-destination trip tables to peak-period values. Finally, these trip tables were multiplied by 0.60 for conversion into peak-hour values. The above factors were developed as part of the PEEP II patronage estimation studies.

<u>1980 Patronage Estimates</u>

The initial patronage estimates were developed with the marine transit headways shown in Table IV-2. These headways were comparable to those of the local and express buses going to the CBD from the respective communities. The initial patronage values are for the peak direction in the evening peak hour only. The marine patronage is the estimated ridership on the marine transit system. The land patronage is the transit patronage on the land-based transit system for trips originating and terminating in the same market areas as the marine transit trips.

The initial set of headways was optimistic in view of the large capacity of the hydrofoils (250 passengers). To better utilize this large capacity, the following route changes were made:

- The CBD-Waipahu express was eliminated and the Iroquois Point express extended to Waipahu to replace the CBD-Waipahu service. The frequency of service was reduced to one morning and one evening run.

- The Waipahu-Iroquois Point-Keehi shuttle was eliminated due to insufficient demand.

- The frequency of service on the Keehi and Hawaii Kai runs were reduced to one morning and one evening run.

These changes had an adverse effect on marine transit patronage, as can be seen in the final patronage estimates on Table IV-3. The combined patronage from Iroquois Point and Waipahu dropped from 220 to

TABLE IV-2

INITIAL 1980 MARINE TRANSIT HEADWAYS AND PATRONAGE ESTIMATES

Route	Headways (Minutes)	Evening Peak Hour Peak Direction Patronage	
		Land Transit	Marine Transit
CBD-Iroquoise Point Express	40	40	140
CBD-Waipahu Express	30	140	80
CBD-Keehi Express	40	190	80
CBD-Hawaii Kai Express	20	440	150
Waipahu-Iroquois Point-Keehi Shuttle	40	N/A	10

N/A = Not analyzed.

TABLE IV-3

FINAL 1980 PATRONAGE ESTIMATES

Route	Evening Peak Hour, Peak Direction Patronage			
	Land Transit	Marine Transit	Diverted	Induced
CBD-Iroquois Point	40	80	10	70
CBD-Waipahu (combined with Iroquois Point Express)	140	30	10	20
CBD-Keehi Express	220	20	0	20
CBD-Hawaii Kai Express	450	120	40	80

110 passengers per hour. Keehi patronage declined to 20 passengers an hour from 80. Hawaii Kai patronage showed the least decline, from 150 to 120 passengers an hour. Most of the decline was the result of providing just one peak-period trip. Waipahu patronage also declined due to the additional travel time incurred by stopping at Iroquois Point.

Past experience with express bus operations indicates that the off-peak direction patronage is negligible and ~~was~~ set to zero for this study.

<u>1995 Patronage Estimates</u>

The set of headways shown in Table IV-4 was used to develop the initial patronage estimates. The headways were developed as follows:

- The peak-hour patronage on the 1995 23-mile rapid transit system was analyzed to estimate the volume of land-based transit traffic traveling between each marine transit market area.
- Marine transit was assumed to divert half of the above volume to itself.
- The diverted volume was divided by the hydrofoil capacity (250 passengers) and the resulting hourly frequency was converted to the appropriate headway. The maximum headway was set at 40 minutes.

The initial patronage estimates shown in Table IV-4 are for the evening peak hour in the peak direction (away from the CBD). The land transit estimates are also included to provide a base for comparison. The Hawaii Kai patronage estimate includes the Hawaii Kai overage. These are the peak-period trips which would normally be made by auto

TABLE IV-4

INITIAL 1995 MARINE TRANSIT HEADWAYS AND PATRONAGE ESTIMATES

Route	Headways (Minutes)	Evening Peak Hour Peak Direction Patronage Land Transit	Marine Transit
CBD-Iroquois Point Express	40	190	110
CBD-Waipahu Express	15	220	90
CBD-Keehi Express	20	610	80
CBD-Hawaii Kai Express	10	2910	1290
Waipahu-Iroquois Point-Keehi Shuttle	30	N/A	10

N/A = Not analyzed.

TABLE IV-5

FINAL 1995 PATRONAGE ESTIMATES

Route	Evening Peak Hour, Peak Direction Patronage Land Transit	Marine Transit	Diverted	Induced
CBD-Iroquois Point	190	100	50	50
CBD-Waipahu (combined with Iroquois Point run)	240	50	25	25
CBD-Keehi Express	610	60	20	40
CBD-Hawaii Kai Express	2910	1140	890	250

but were expected to utilize the transit system due to insufficient vehicle capacity on Kalanianaole Highway. The concept of the Hawaii Kai overage was developed as part of the PEEP II patronage studies and was incorporated in this study to ensure that it would be consistent with previous results.

As in 1980, the initial set of headways was optimistic and the same route changes had to be made with one exception:

- The Hawaii Kai express headway was increased to 15 minutes from 10 minutes.

The results of these changes can be seen in Table IV-5. The Iroquois Point, Waipahu, and Keehi patronage declined for the same reasons as in 1980. The Hawaii Kai patronage showed little decrease for the following reasons:

- The slight increase in headway did not have any appreciable effect on marine transit patronage.

- The concept of the Hawaii Kai overage produces the effect of maintaining the transit patronage from Hawaii Kai at a relatively high level. Because it is dictated by capacity constraints on the highway system, changes in level of service on the transit system will not effect patronage.

The final patronage estimates include a breakdown of the portion of the marine transit trips which were diverted from land transit and induced from the automobile. As previously discussed, induced trips imply an increase in total transit patronage but not an increase in the total number of trips; however, the total transit patronage for Hawaii Kai is not projected to increase despite the presence of induced trips, due to the Hawaii Kai overage. The transit patronage between Hawaii Kai and the CBD will increase by the amount of the induced patronage because of the addition of the supplementary waterborne service, but this will be accompanied by an equal decrease in the land-based transit patronage from Hawaii Kai to areas outside of the CBD. These trips are expected to be made by automobile since the highway facility will have additional capacity caused by the induced trips leaving the highway for marine transit. Thus, the volume of the Hawaii Kai overage will decrease but the total number of transit trips to Hawaii Kai will remain the same.

The off-peak direction traffic was again assumed to be negligible.

The peak-hour transit patronage figures of Table IV-5 are compared with the estimated number of peak-hour person trips between the CBD and the other four marine transit market area in Table IV-6. This gives some indication as to the relative importance of transit service for CBD trips to each of the non-CBD market areas. Hawaii Kai was the most transit-dependent area with 70 percent of the peak-hour trips from the CBD being made by transit. However, the Iroquois Point and Keehi market areas were just about as transit-dependent with 67 percent and 64 percent of peak-hour persons trips from the CBD made by transit, respectively. The Waipahu market area was the least dependent with only 53 percent of the peak-hour trips from the CBD made by transit. The waterborne transit system was most effective for Iroquois Point and Hawaii Kai, where it served 23 percent and 20 percent of the peak-hour person trips from the CBD, respectively.

<u>Sensitivity to Travel Speeds</u>

This section analyzes the effect of varying several assumptions used to develop the 1995 patronage estimates. Specifically, it looks at the effect of:

- Not being able to exceed speed limits in Pearl Harbor; increasing travel times to Iroquois Point from 18 to 25 minutes, and to Waipahu from 34 to 54 minutes.

TABLE IV-6

TRANSIT SHARE OF 1995 PEAK-HOUR PERSON TRIPS
BY MARINE TRANSIT MARKET AREAS

CBD to	Peak Hour Person Trips	Land Transit		Marine Transit		Total Transit	
		Peak Hour Patronage	Percent of Person Trips	Peak Hour Patronage	Percent of Person Trips	Peak Hour Patronage	Percent of Person Trips
Iroquois Point	430	190	44	100	23	290	67
Waipahu	550	240	44	50	9	290	53
Keehi	1,050	610	59	60	6	670	64
Hawaii Kai	5,810	2,910	50	1,140	20	4,050	70

- Use of a non-hydrofoil vessel on the Hawaii Kai link capable of operating at 25 knots, which increases travel time from 24 to 35 minutes.

The results of this analysis can be seen in Table IV-7. While the land transit patronage increased slightly percentagewise, each of the marine transit routes had a decrease in patronage. The Iroquois Point route decreased 20 percent to 80 passengers in the peak period. The Waipahu marine patronage had the biggest percentage decrease of 80 percent to 10 passengers. The Hawaii Kai route had a 13 percent decrease with the slower vessel. The patronage remains high due to the previously discussed Hawaii Kai overage which is forced onto the transit systems. Overall, the sum of land-based and marine transit patronage decreased on each route.

TABLE IV-7

SENSITIVITY ANALYSIS TO VARIATIONS IN VEHICLE SPEEDS

Route	1995 Transit Patronage			
	Original Analysis		Travel Time Change	
	Land	Marine	Land	Marine
CBD-Iroquois Point[1]	190	100	200	80
CBD-Waipahu[1]	240	50	250	10
CBD-Hawaii Kai[2]	2,910	1,140	3,020	990

[1] Assumes speed limit waivers for operations within Pearl Harbor not obtained.

[2] Assumes use of 25 knot vessel.

VESSEL REQUIREMENTS

The number of hydrofoils required to satisfy marine transit patronage demand were based on two considerations:

- The estimated hourly patronage and hydrofoil capacity (250 passengers).
- Scheduling constraints such as desired arrival and departure times and round-trip travel times.

The ratio of estimated hourly marine transit patronage and hydrofoil capacity gave the hourly frequency of service required to carry the demand on a route. On routes where demand was less than capacity, only one run was provided. Then, vessel schedules were developed to provide the requisite frequency of service. The following scheduling constraints were used:

- The peak arrival hour in the CBD was from 7 to 8 AM. The peak departure hour was from 4 to 5 PM. The peak period is about two hours long.
- On routes with just one run, the morning arrivals at Pier 7 were about 7:30 AM. The evening departure from Pier 7 was scheduled about 4:30 PM.
- The following round-trip times were used:

Route	Round-Trip Time (Min.)
CBD-Iroquois Point-Waipahu	72
CBD-Hawaii Kai	67
CBD-Keehi	55

In all, two vessels were required for 1980 and six boats for 1995.

1980 Results

Two boats were required in 1980, one for the CBD-Iroquois Point-Waipahu route and the other for the CBD-Hawaii Kai and CBD-Keehi routes. Each route would have one morning and one evening run, with the Iroquois Point-Waipahu and Hawaii Kai runs scheduled to the desired arrival and departure times at the CBD. One additional boat would be required to service the CBD-Keehi line at the desired arrival and departure times; therefore, the route was serviced before the Hawaii Kai run to effect a substantial savings in capital costs. The Keehi route was given second preference because of its lower patronage estimate. The undesirable arrival and departure times were not expected to have any appreciable effect on the low patronage.

1995 Results

Six boats would provide 8 round trips to Hawaii Kai, and one each to Waipahu-Iroquois Point and Keehi. The morning and evening schedules for each boat are shown in Table IV-8. The first four boats would be assigned to the Hawaii Kai run and would make two round trips each. The fifth boat would make one round trip to Iroquois Point and Waipahu. The sixth boat would provide one round trip to Keehi.

TABLE IV-8

1995 SCHEDULES

A. M. Boat Number	Departures Hawaii Kai	Waipahu	Iroquois Point	Keehi	Arrivals Pier 7
1	6:00AM	--	--	--	6:24AM
2	6:15	--	--	--	6:39
3	6:30	--	--	--	6:54
4	6:45	--	--	--	7:09
5	--	6:50	7:06	--	7:25
1	7:07	--	--	--	7:31
6	--	--	--	7:20	7:34
2	7:22	--	--	--	7:46
3	7:42	--	--	--	8:06
4	8:00	--	--	--	8:24

P. M. Boat Number	Departures Pier 7	Arrivals Keehi	Iroquois Point	Waipahu	Hawaii Kai
1	3:45PM	--	--	--	4:12PM
2	4:10	--	--	--	4:37
3	4:25	--	--	--	4:52
5	4:30	--	4:51	5:00	--
6	4:35	4:52	--	--	--
4	4:40	--	--	--	5:07
1	4:52	--	--	--	5:19
2	5:17	--	--	--	5:44
3	5:32	--	--	--	5:59
4	5:47	--	--	--	6:14

TERMINAL FACILITY REQUIREMENTS

Implementation of the supplementary waterborne system would require the construction of new terminal facilities at the Hawaii Kai, Keehi, Iroquois Point, Waipahu, and CBD terminal site locations. These facilities would provide for the transfer of passengers between the land-based and waterborne systems, facilitating the local interface for the transit systems in 1980 and 1995.

Preliminary terminal requirements were determined from the estimates of patronage and marine transit vehicle operations presented in the preceding sections. On this basis, plans were delineated in sufficient detail to convey, in concept, the types of terminal facilities that would be required for the supplementary waterborne system, from which order-of-magnitude capital cost estimates were prepared.

A program for planning the terminals was established to translate the patronage estimates and marine transit vehicle operations into specific terminal requirements. Activities expected to take place at the terminals, standards for sizing of passenger facilities, physical opportunities and constraints at the terminal sites, and operational requirements of the Boeing Jetfoils were analyzed in the program. The results of previous planning by the State Department of Transportation for terminal facilities at Hawaii Kai and Pier 7 in Honolulu Harbor were also reviewed. From this analysis, specific planning and design criteria were identified, functional site plans were prepared, and terminal facilities were conceptually delineated.

The following paragraphs briefly describe the major facility requirements at the terminals of the supplementary waterborne system. Included are discussions of general planning considerations at the terminal site locations and illustrations of site and terminal facility concept plans.

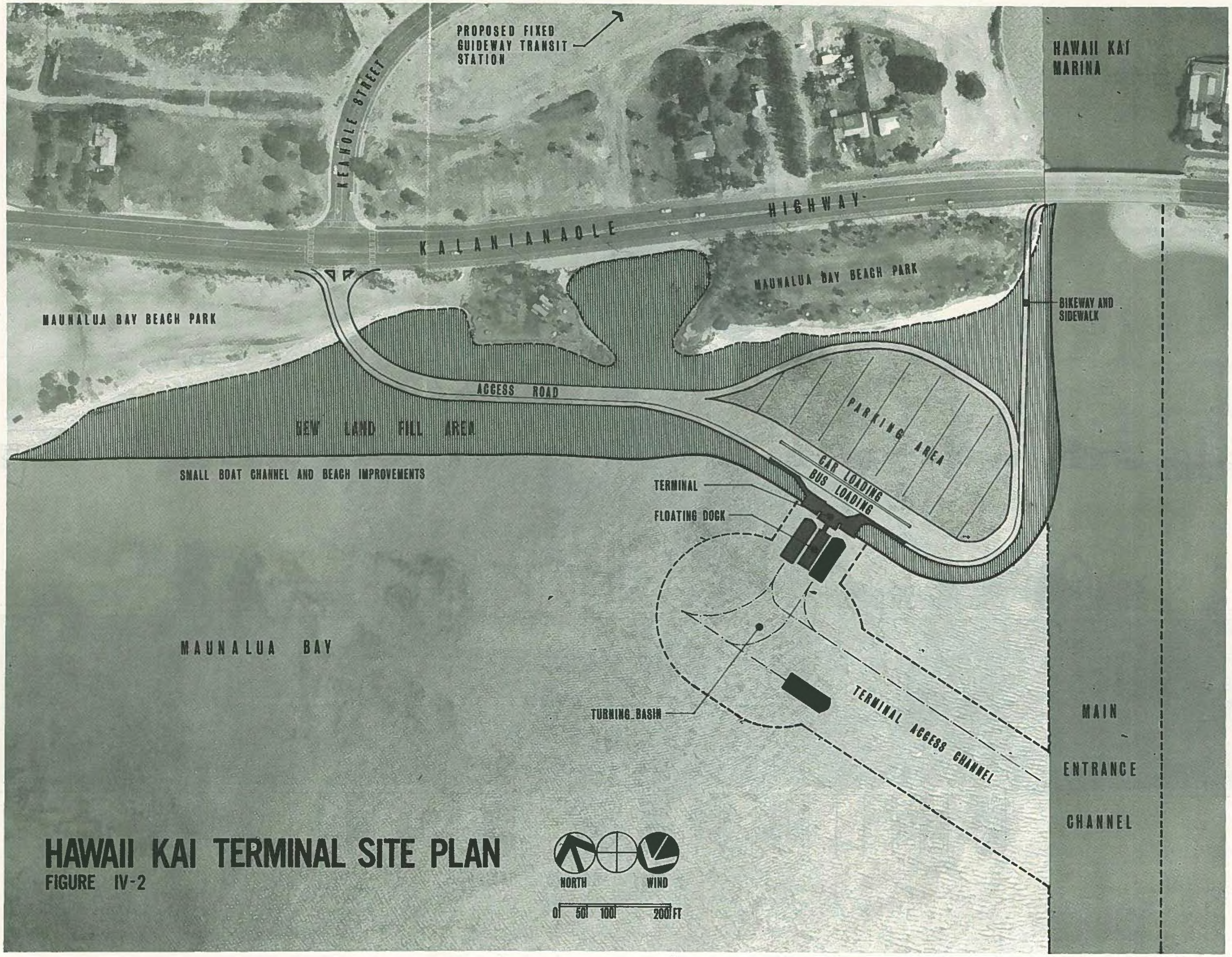
Hawaii Kai Terminal

As described in Chapter III, the Hawaii Kai terminal was located on filled land off Maunalua Bay Beach Park at the site of a terminal recently planned by the State Department of Transportation. Other locations in the area were initially considered by the State, but were eliminated after an evaluation of transportation service requirements, oceanographic and other environmental conditions, and the need to minimize encroachment on the existing park. The site selected by the State was reviewed and verified as being the most reasonable location for a Hawaii Kai terminal. It is situated on property owned by the State and is an allowable use within the residential zoning designation of the property.

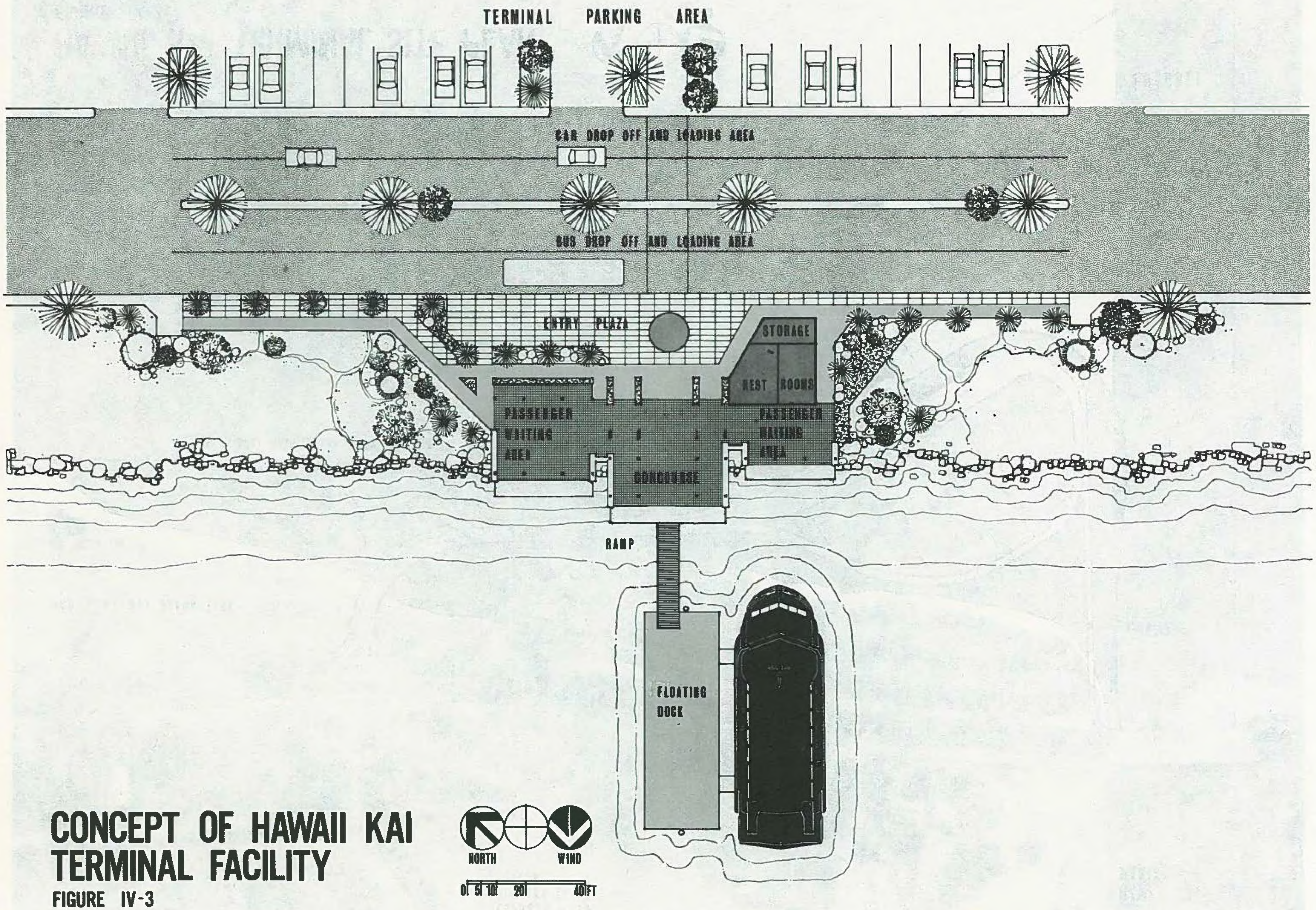
Figure IV-2 presents a conceptual site plan for the Hawaii Kai terminal. As in the State's previous planning, it was assumed that the terminal would be located on about ten acres of new land-fill area. This addition to the park would be created from material dredged to improve the existing entrance channel in Maunalua Bay and to construct a turning basin for the marine transit vehicles. The existing channel would be dredged to a uniform depth of 22 feet and a width of 200 feet and the 300-foot diameter turning basis would be dredged to a depth of 25 feet, requiring the removal of approximately 400,000 cubic yards of material.

Development of the terminal site would also require the construction of a terminal shelter with utilities, docking facilities, an access road, a bikeway and sidewalk, a parking lot for up to 210 cars, site landscaping, and other incidental improvements. The facilities would be developed on about 3.5 acres, and the remaining filled land could be used to expand the existing park facilities.

Figure IV-3 is a conceptual illustration of the terminal and pier facilities that would be required at Hawaii Kai. A permanent terminal structure of adequate size to accommodate peak passenger loads



HAWAII KAI TERMINAL SITE PLAN
FIGURE IV-2



CONCEPT OF HAWAII KAI TERMINAL FACILITY

FIGURE IV-3

(approximately 6,600 square feet), and a floating dock with a connecting ramp to accommodate two berthed Jetfoils, oriented into the prevailing wind, were delineated. The terminal structure was assumed to be a simple, open design containing entry, waiting, restrooms, and other functional areas.

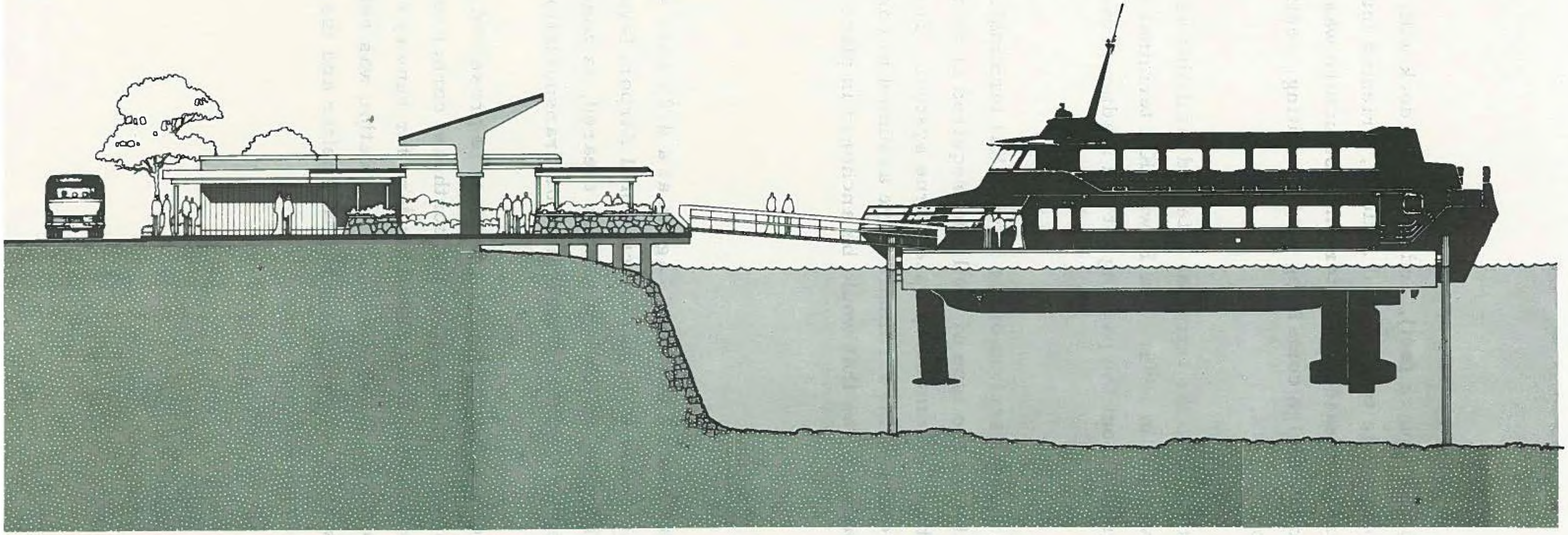
The illustrations indicate the terminal site and facilities as they would be ultimately developed in 1995. The Hawaii Kai terminal required in 1980 would be similar, but the parking lot and loading areas would be smaller.

Figure IV-4 is a typical section of the Hawaii Kai terminal. This figure further illustrates the type of facilities required at all the terminal locations of the supplementary waterborne system. The marine transit vehicle berths at the terminals were assumed to consist of standardized floating docks that would be anchored in place with guide piles.

Keehi Terminal

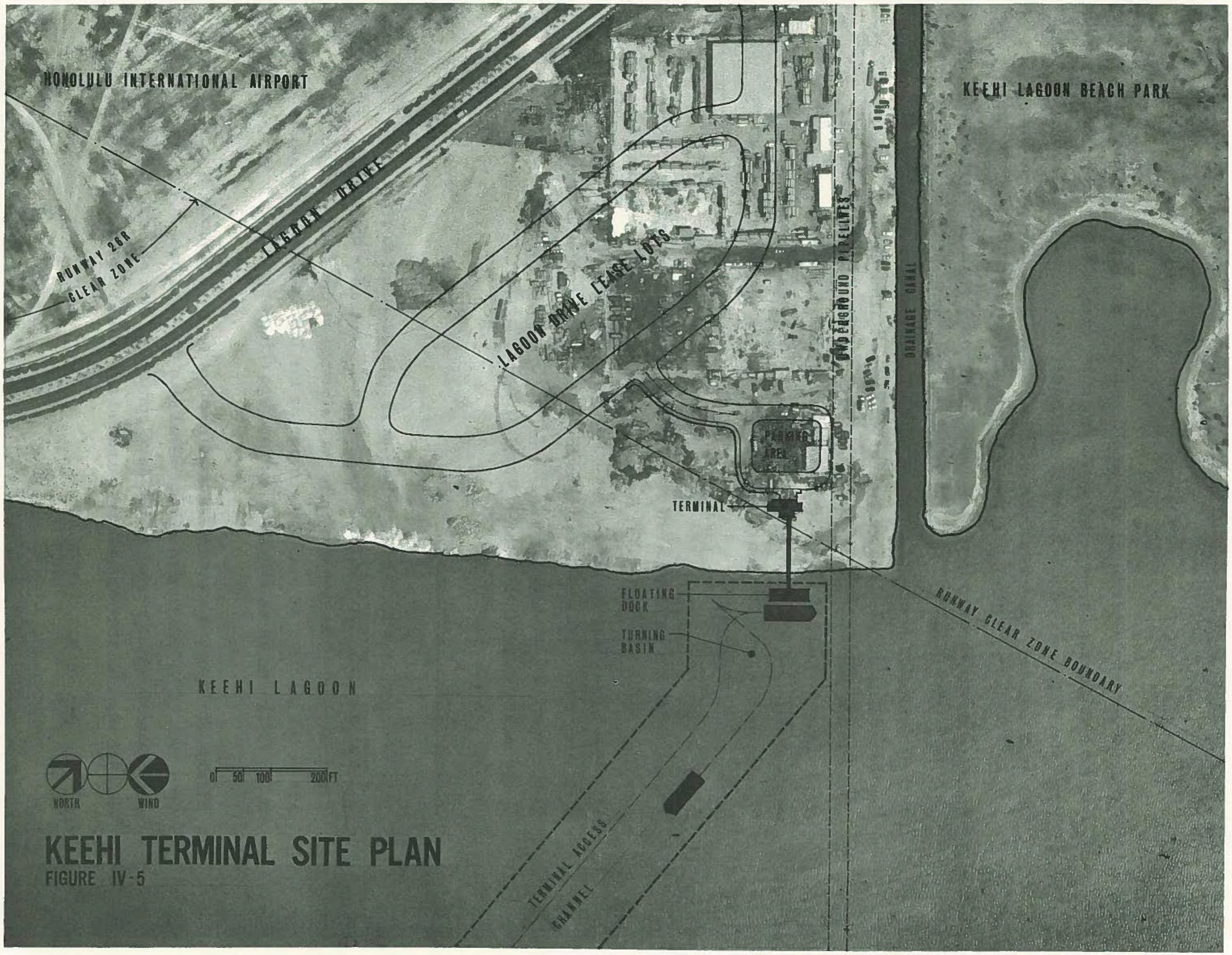
This terminal was located on Keehi Lagoon at a 4.25 acre site designated for this use on the Honolulu International Airport layout plan (June, 1971). The site, which is presently cleared, is zoned industrial and is owned by the State Department of Transportation.

A conceptual site plan for the Keehi Terminal is presented in Figure IV-5. The terminal was situated in the northeast corner of the site near the intersection of a clear zone boundary for runway 26R and an easement for underground fuel lines. This location was selected to minimize the distance between the terminal shelter and the pier facilities on Keehi Lagoon.



TYPICAL SECTION OF HAWAII KAI TERMINAL
FIGURE IV-4

0 5' 10' 20 FT



KEEHI TERMINAL SITE PLAN

FIGURE IV-5

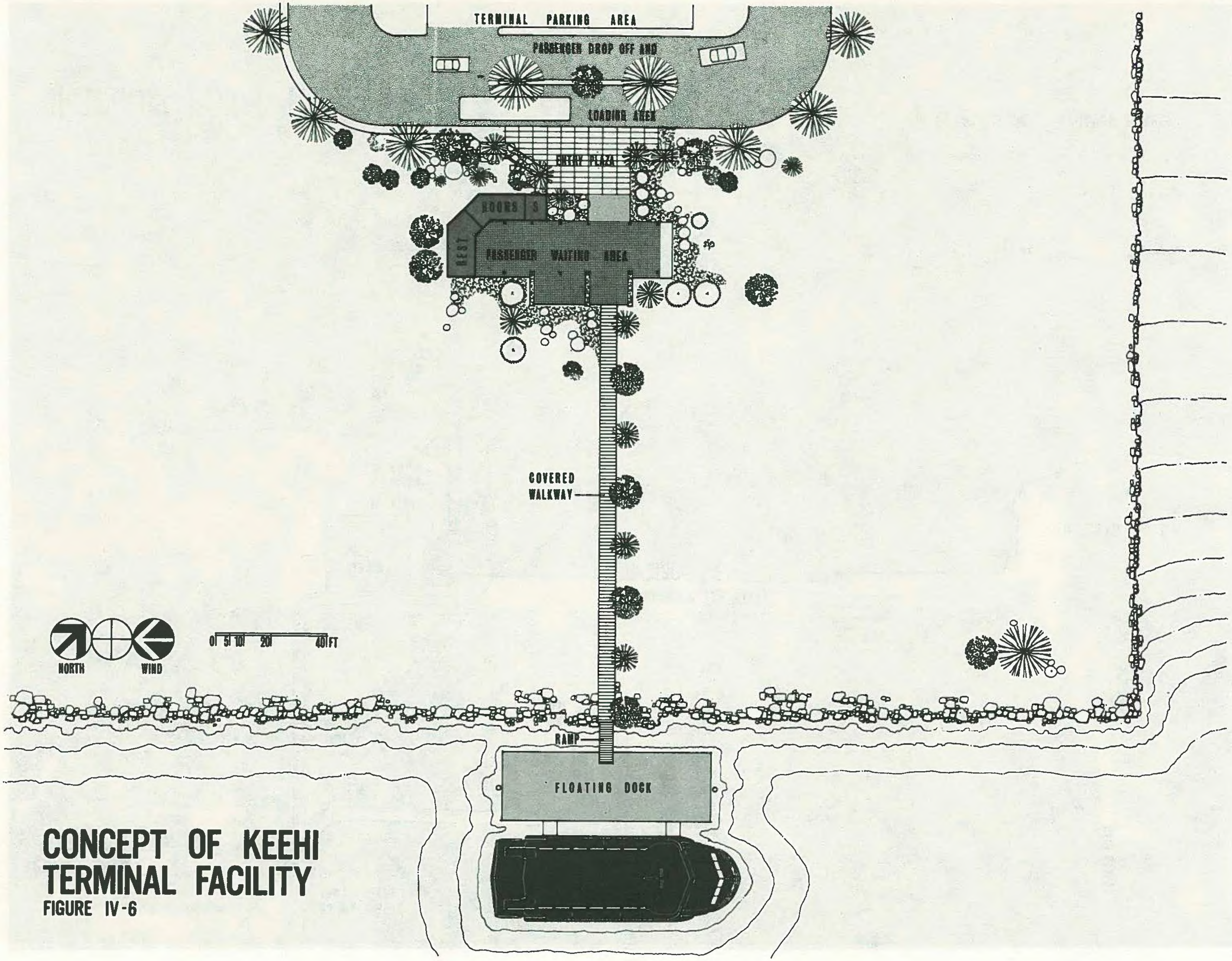
Development of the terminal site would require the construction of land and marine access improvements, a small terminal shelter with utilities, pier facilities connected to the terminal by a covered walkway, site landscaping, and other incidental improvements. Access to the terminal would be via Lagoon Drive, a recently-constructed loop road on property adjacent to the site, and a new access road to a terminal parking lot for about 35 cars and to a passenger drop-off area in front of the terminal. Access for the marine transit vehicles would be via the Keehi Lagoon seaplane runway between the Kalihi Channel of Honolulu Harbor and the terminal site. A 200-foot wide and 22-foot deep channel would be dredged in the runway, which has an estimated average depth of 10 feet. About 560,000 cubic yards of material would have to be removed to create the 5,800-foot long channel and a turning basin at the terminal.

Figure IV-6 is a conceptual illustration of the terminal and pier facilities that would be required at Keehi. A permanent, 3,500 square foot terminal structure, similar in concept to the Hawaii Kai terminal, and a floating dock with a connecting ramp to accommodate one berthed Jetfoil were delineated. The terminal facility requirements at Keehi would be the same in 1980 and 1995.

Iroquois Point Terminal

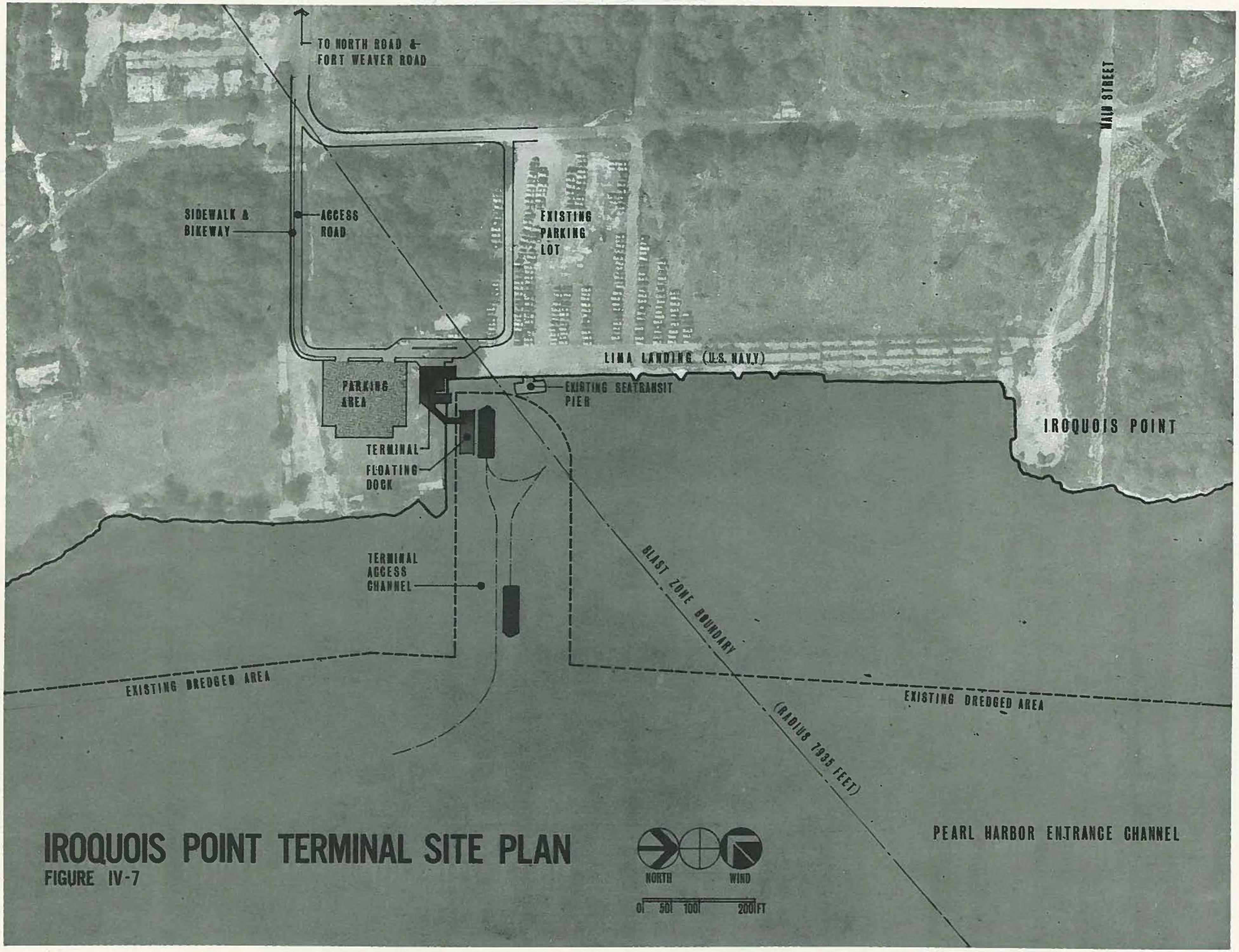
This terminal was located on a one-acre site adjacent to Iroquois Point at the U.S. Navy's Lima Landing in the entrance channel to Pearl Harbor. The terminal site was situated at the southwest corner of the landing, adjacent to a mooring for the SeaTransit commuter service and an existing, unimproved parking area.

Figure IV-7 presents a conceptual site plan for the Iroquois Point terminal. The location of the terminal was dictated by a U.S. Navy requirement which restricts the development of new structures within a 7,935-foot blast zone boundary around ammunition piers located in



CONCEPT OF KEEHI TERMINAL FACILITY

FIGURE IV-6



IROQUOIS POINT TERMINAL SITE PLAN

FIGURE IV-7

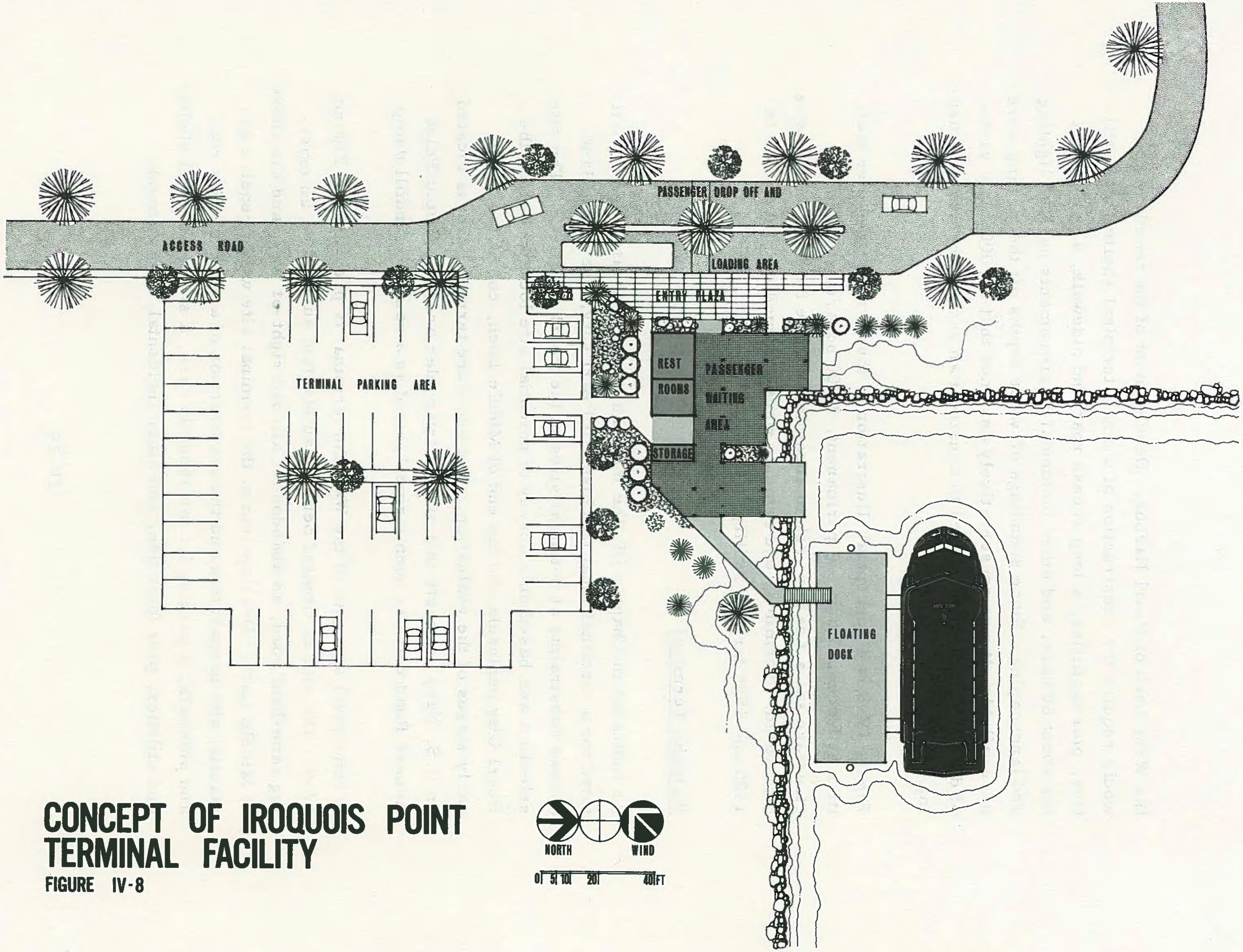
the West Loch of Pearl Harbor. Development of the terminal site would require the construction of a small terminal shelter with utilities, pier facilities, a loop access road and sidewalk, a parking lot for about 60 cars, and other incidental improvements such as lighting and landscaping. Since soundings of water depths off the landing were not available, it was conservatively assumed that 26,000 cubic yards of dredging would be required to construct an access channel and turning basin.

Figure IV-8 is a conceptual illustration of the terminal and pier facilities at Iroquois Point. A permanent, 3,500 square foot terminal structure and a floating dock to accommodate one berthed Jetfoil were delineated. Terminal requirements were assumed to be the same in 1980 and 1995 for this facility.

Waipahu Terminal

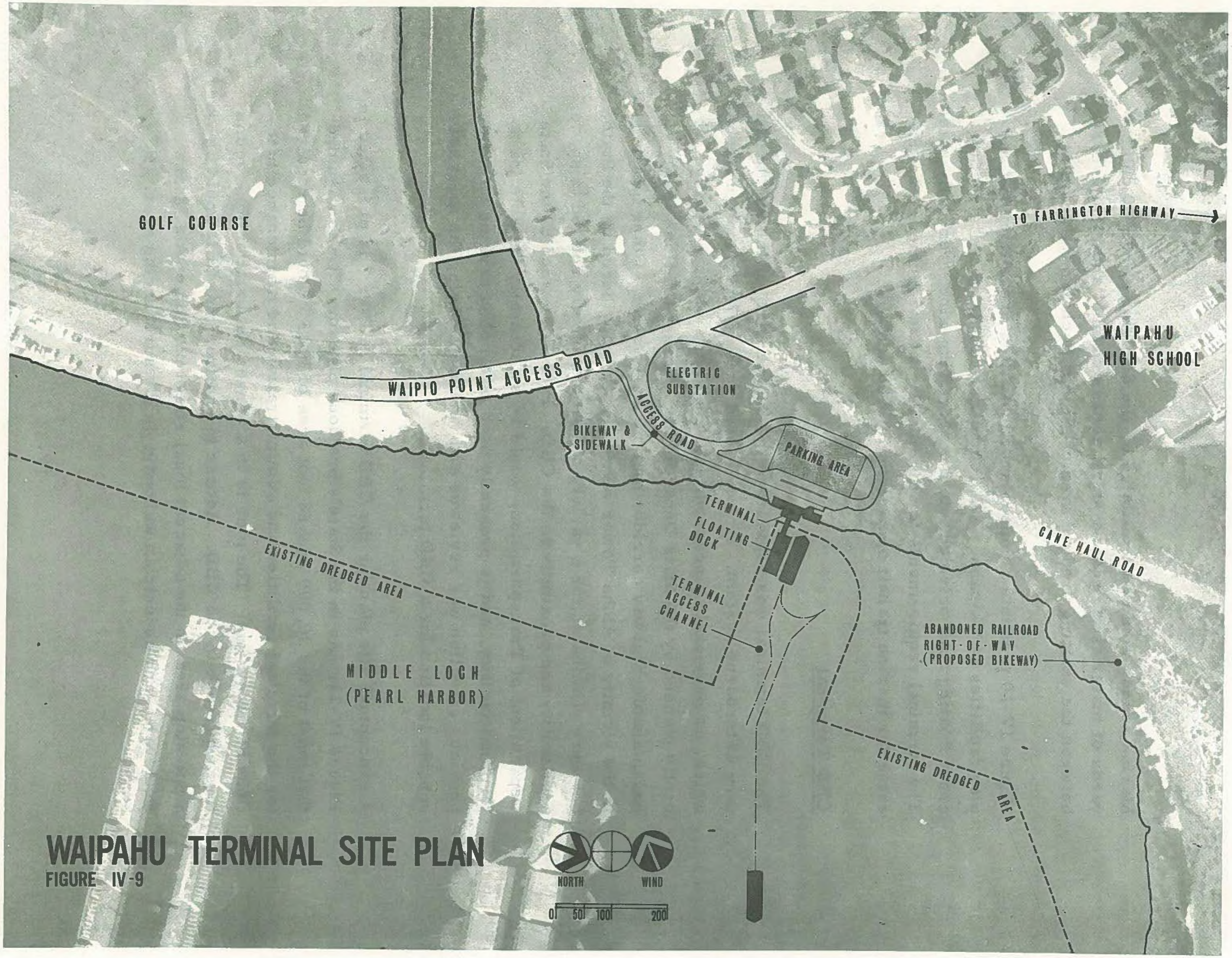
As indicated in Chapter III, the Waipahu terminal location was substituted for a terminal location closer to Pearl City, because of land access constraints at potential sites in the Pearl City area. The site selection was based on a survey of potential site locations along the Pearl City peninsula and the end of Middle Loch, conducted in the early stages of the evaluation. The one-acre terminal site is located on U.S. Navy property in a small, triangular area off Waipio Point Access Road that has been formerly used as a sanitary landfill dump.

A conceptual site plan of the Waipahu terminal is presented in Figure IV-9. The site is situated between an electric substation, an existing cane-haul road, an abandoned railroad right-of-way, and the shore of Middle Loch. Development of the terminal site would require substantial site preparation and the construction of a short access road and sidewalk, a parking lot for about 35 cars, a small terminal shelter and utilities, pier facilities, and other incidental improvements.



CONCEPT OF IROQUOIS POINT TERMINAL FACILITY

FIGURE IV-8



WAIPAHU TERMINAL SITE PLAN
FIGURE IV-9

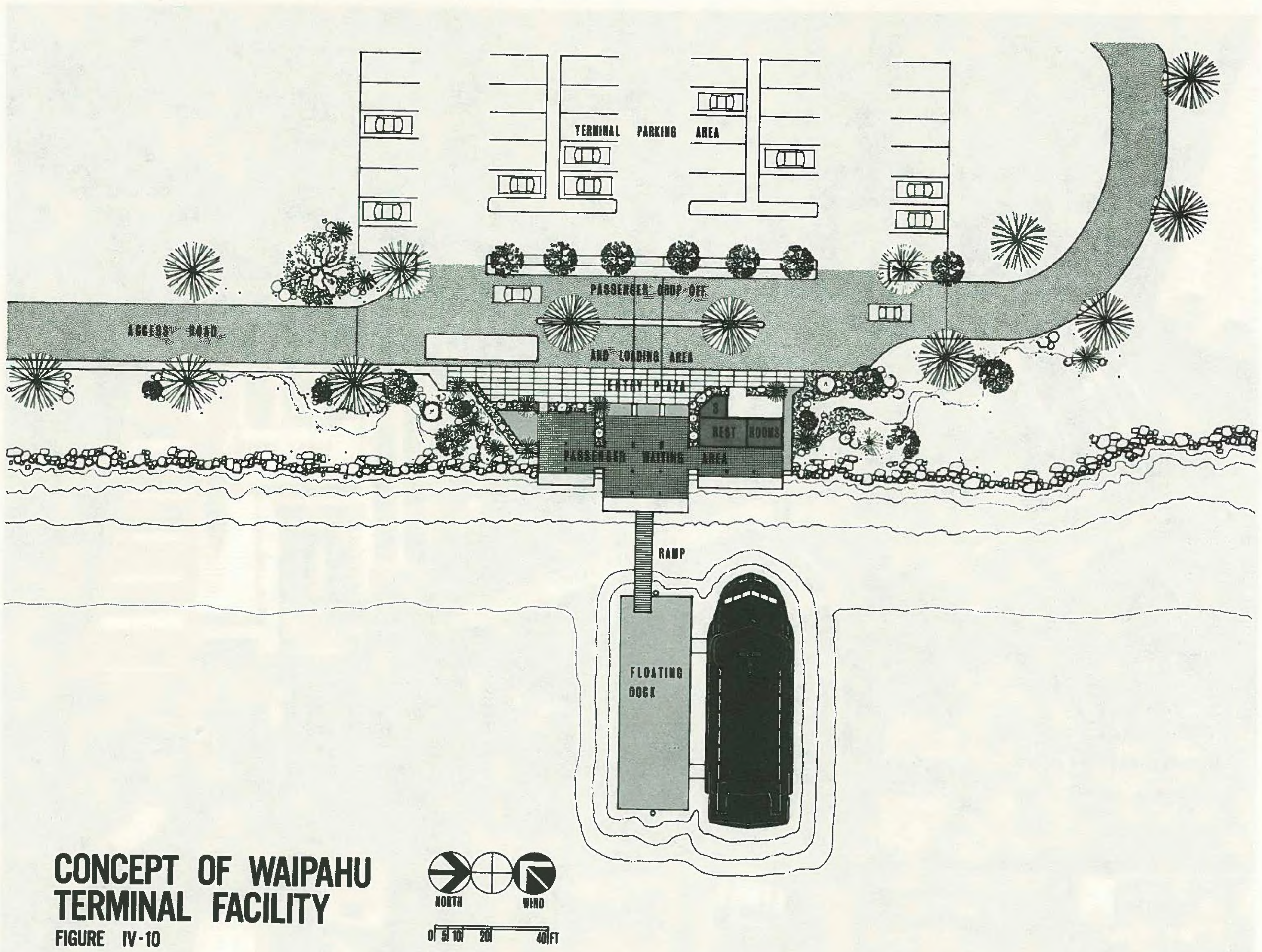
Marine access would be facilitated by the dredging of 60,000 cubic yards of material to create a small access channel and turning basin between the existing dredged area of Middle Loch and the terminal.

Figure IV-10 presents a conceptual illustration of the terminal and pier facilities at Waipahu. A 2,100 square foot terminal structure, and a floating dock oriented into the prevailing wind, were delineated. The terminal requirements for this facility were assumed to be the same for marine transit operations in 1980 and 1995.

CBD Terminal

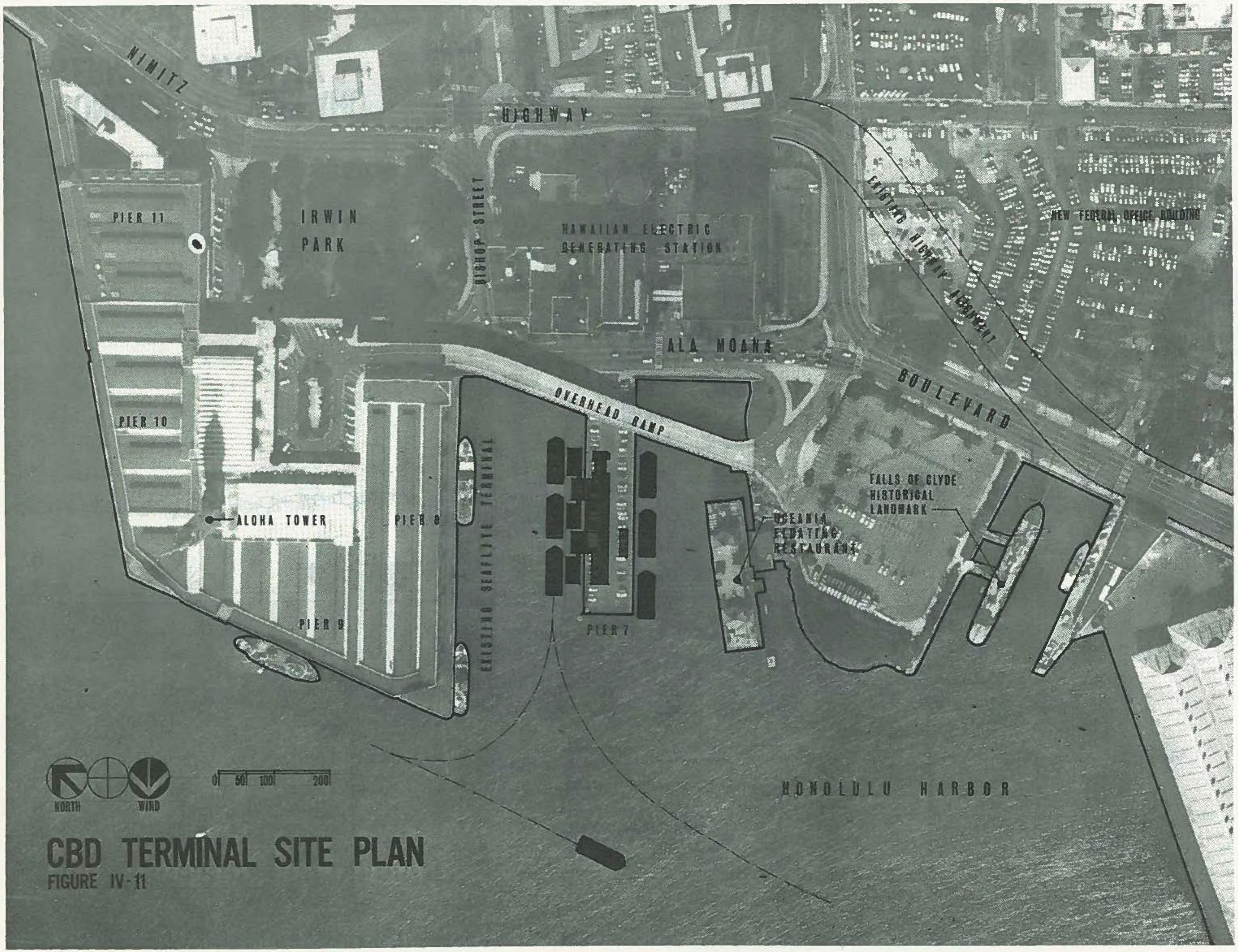
The CBD terminal was considered the "home port" of the supplementary waterborne system. It was located at Pier 7 in Honolulu Harbor which, as previously discussed, is the site of a similar terminal recently planned by the State Department of Transportation for the Kalanianaole Highway corridor marine bus system. Other locations in the vicinity of Aloha Tower were initially considered by the State, but were eliminated for a variety of reasons mostly related to space availability and proximity to the CBD. Pier 7 is owned by the State Department of Transportation, would be structurally suitable for a terminal facility, and is presently used as an open parking lot. Its previous selection was reviewed and verified as being the most reasonable location for a CBD terminal.

A conceptual site plan for the CBD terminal at Pier 7 is presented in Figure IV-11. As in the State's previous planning, it was assumed that most of the 36,000 square foot area of Pier 7 would be required for the terminal facilities and administrative and maintenance functions of the system. The pier is in a convenient location for commuters who work in the CBD. Access to and from the CBD would be via a bus stop area on the adjacent local street portion of Ala Moana Boulevard, and pedestrian walkways in the surrounding area. No



CONCEPT OF WAIPAHU TERMINAL FACILITY

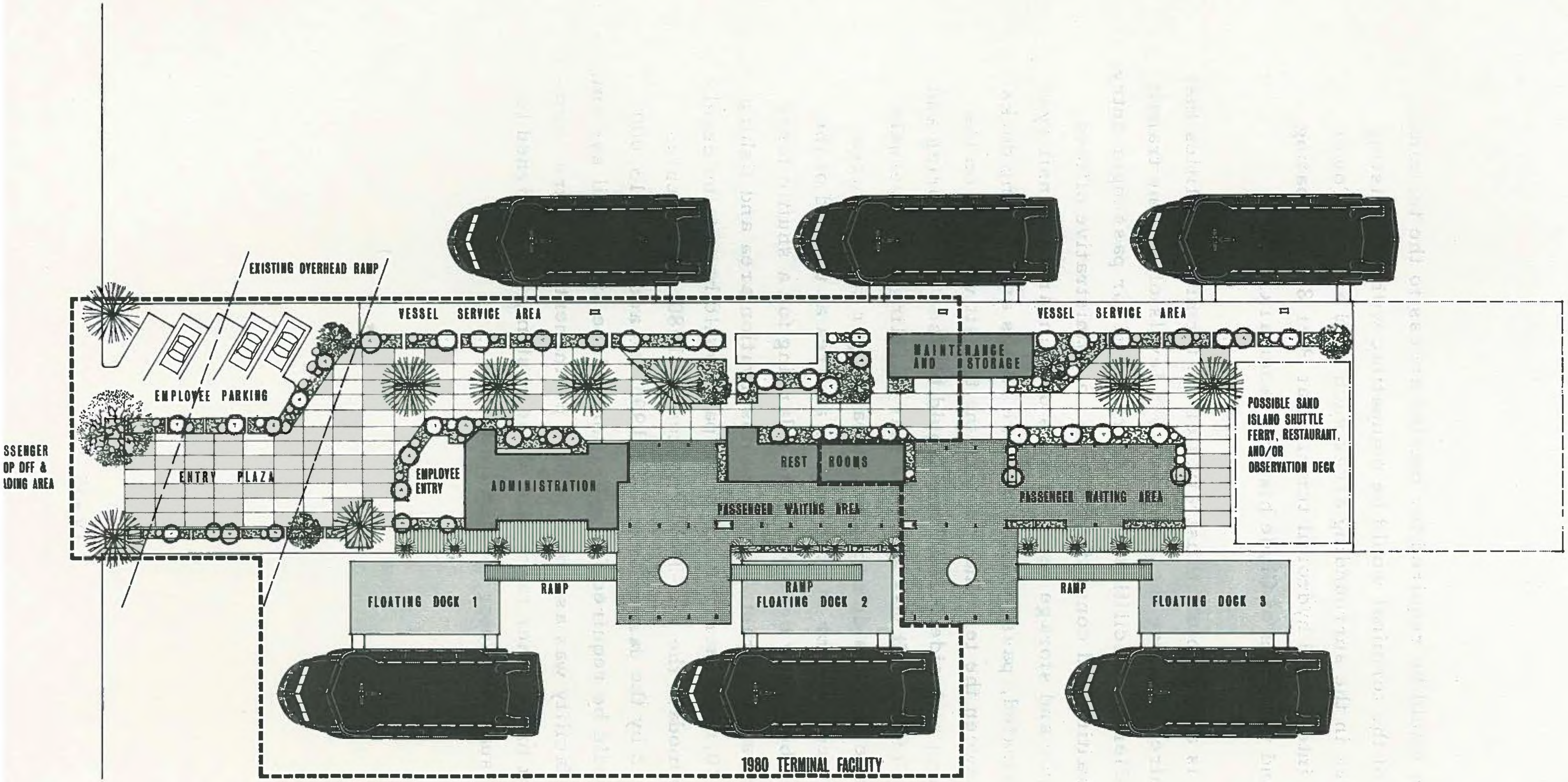
FIGURE IV-10



CBD TERMINAL SITE PLAN
FIGURE IV-11

improvements would be required for marine access to the terminal. Development of the terminal would be compatible with the existing waterfront uses in the surrounding areas such as the Aloha Tower complex, the interisland hydrofoil terminal at Pier 8, the floating restaurant, and the Falls of Clyde historic landmark.

Figure IV-12 is a conceptual illustration of the terminal facilities that would be required to serve the 1980 and 1995 levels of marine transit patronage at Pier 7. Facilities would be required for passenger entry, circulation, waiting and convenience areas, administrative offices, and maintenance and storage requirements of the marine transit system. As illustrated, passengers would use ramps and floating docks to transfer between the terminal and marine transit vehicles on the Pier 8 side, and both sides of the pier would be used for mooring and servicing the Jetfoils. It was assumed that refueling of the vessels would take place on the side opposite the passenger transfer area. Included in the concept for the terminal is an area at the end of the pier that could be jointly developed into a landing for a shuttle ferry to Sand Island, a restaurant, and/or an observation area and fishing deck. About 20,000 square feet of pier space would have to be developed to accommodate the two-Jetfoil system in 1980, as indicated in Figure IV-12 by the dashed area. By 1995, an additional 13,000 square feet would be required for operations of the six-Jetfoil system. The terminal facility was assumed to be a permanent structure, similar in concept to the other terminals of the system, and designed to enhance the visual character of the waterfront.



CONCEPT OF CBD TERMINAL FACILITY

FIGURE IV-12

MAINTENANCE REQUIREMENTS

Maintenance for the supplementary waterborne system would primarily include routine in-service maintenance, yearly and emergency drydocking for the marine transit vehicles (major maintenance), and periodic dredging to maintain the marine access channels at the terminals. Requirements for maintenance of the marine transit vehicles were determined by evaluating operation recommendations for Boeing Jetfoils and the maintenance experience of the existing interisland hydrofoil operation and by analyzing the alternatives of constructing a special maintenance facility or utilizing existing private services in Honolulu Harbor for drydocking of the vessels. Preliminary requirements for maintenance dredging were determined by preparing a generalized estimate of the probable rates of channel siltation at the terminals from information provided in various studies, and by assuming that maintenance dredging would be accomplished on a periodic basis.

Boeing Jetfoils are designed to minimize the need for maintenance that would require their removal from the water. Most of the maintenance for these vessels would be preventative in nature and could be accomplished during scheduled downtime periods such as at the end of daily or weekly operations. This type of maintenance is characterized by a large number of routine cleaning, replenishment, adjustment, and component replacements tasks on a daily, weekly, monthly, and semi-annual basis. A staff of skilled maintenance personnel, in addition to cleaning personnel, would be required for these tasks. It was assumed that all maintenance of the marine transit vehicles, with the exception of the annual hull inspection and testing required by the U.S. Coast Guard plus an average of one emergency drydocking per vessel per year for major corrective maintenance, would be accomplished on an in-service basis at the CBD terminal facility.

The use of existing private maintenance services in Honolulu Harbor was found to be the most desirable alternative to meet major maintenance requirements. A specially constructed maintenance facility would be underutilized and would have higher total major maintenance costs than if private maintenance services were used.

Facilities required for the annual inspection testing and overhaul and for emergency maintenance would include a drydock, marine railway or cranes for removal of the vessels from the water, a specially designed cradle for securing the Jetfoils out of the water, small chainfalls or gantry cranes for moving heavy vessel components, and the maintenance facilities, services, and personnel that are typically available at small shipyards accommodating vessels up to 100 tons. Emergency repairs would be corrective in nature, generally requiring the modification or replacement of vessel components, and relying on the available inventory of spare parts or special orders from the vessel manufacturer. The annual inspection and overhaul would involve the following major activities: examination, cleaning and painting of hulls; dismantling, checking and replacement of underwater components; correction of major machinery problems; checking of steering and control mechanisms, testing of bilges and fuel tanks; and other general inspection and cleaning work.

Private facilities appropriate for this maintenance are located in the vicinity of Piers 13 and 14 in Honolulu Harbor. A shipyard complex at Pier 41, which includes a 1,400 ton marine railway and a 3,000 ton drydock, could easily accommodate the maintenance, especially if the present configuration of the Jetfoil cradle available from Boeing is modified (as was assumed in the evaluation).

The use of private maintenance services would not result in a loss of service for the supplementary waterborne system. It is not anticipated that emergency maintenance requirements would result in excessive downtime due to scheduling conflicts at the shipyard facilities. Emergencies would be handled on a priority basis and the vessels could be removed from the water with cranes at another location if necessary.

In any case, it was assumed that during the time the vessels would be out of service (an average of eight days during a 250-day operating year), replacement service would be chartered from Seaflite for the CBD-Keehi run (approximately two hours per day).

The annual average requirements for maintenance dredging of the marine access channels at the terminals were estimated as follows: Hawaii Kai--1,900 cubic yards, Keehi--4,700 cubic yards, Iroquois Point--200 cubic yards, and Waipahu--200 cubic yards. It was assumed in the evaluation that maintenance dredging would be accomplished an average of once every five years.

COST ESTIMATES

The costs of a supplementary waterborne transit service for the 1980 all-bus and 1995 rapid transit systems will depend on the extent of public involvement in providing the service. Two options for the provision of this service were considered in the evaluation:

- Complete public ownership and operation of the entire system.
- Public ownership and operation of the system's terminals, and a contractual arrangement whereby the actual commuter service (vessels, crews, and the costs of operating the vessels) would be obtained from a private operator.

For the complete public ownership option, costs would include an investment in capital equipment and facilities, as well as regular expenditures to operate and maintain the system at its intended level of service. For the chartering of service option, costs would include an investment in terminal facilities and an operating expenditure at an agreed-upon charter rate for the required service.

It was assumed for purposes of the evaluation that commuter service for the charter option would be obtained through a concession with Seaflite (Pacific Sea Transportation, Ltd.) who is currently operating an interisland marine passenger service. Seaflite has long-range plans to expand its interisland operations in Hawaii, has indicated that it would consider a proposal for this type of operation, and has an established charter rate for the use of its Jetfoil vessels. Seaflite has also indicated that it may be possible to arrange schedules in the future so that expansion plans for interisland service would not conflict with the provision of daily commuter service on a regular schedule, such as that evaluated for the supplementary waterborne system.

Estimates of the capital and operating and maintenance costs for the public ownership and private charter options in 1980 and 1995 were developed for the supplementary waterborne transit system, and are summarized in this chapter. The estimates were prepared in terms of 1975 dollars,[1] and were based on the vessel, facility, and maintenance requirements described in the previous sections, and various other assumptions about operating conditions, quantities, and unit costs.

Capital Costs

Capital costs for the public ownership option would include the costs of purchasing the marine transit vehicles and the costs of constructing new facilities at all the terminal locations of the system. Capital costs for the private charter option would include only those costs associated with the construction of new facilities at the Hawaii Kai, Keehi, Iroquois Point, and Waipahu terminal locations. It was assumed for the charter option that the existing facilities of Seaflite at Pier 8 would be used for the CBD terminal, and that there would be no requirements for the construction of new terminal facilities at Pier 7.

[1] The possibility of different system elements being subject to different rates of inflation between 1976 and 1980 or 1995 was not accounted for.

A summary of the capital cost estimates developed for the supplementary waterborne system is presented in Table IV-9. Included are estimates of total implementation costs in 1980 and 1995, an indication of how development of the system would be phased-in between 1980 and 1995, and a calculation of the annual capital costs (or debt service) that would be required for operations in 1980 and 1995.

For the public ownership option, the total cost of the two vessels for the 1980 system would be $16.3 million and the total cost of the six vessels for the 1995 system would be $47.9 million. These costs were estimated from information previously developed by the State Department of Transportation for the supplementary marine bus system of the Kalanianaole Highway Transportation Evaluation. They were based on a recent price quote of The Boeing Company for the 1977 factory delivery of Jetfoils, and include assumptions about spare parts requirements, delivery costs, and ocean and handling insurance. The total costs of constructing the terminals for the public ownership option would be $6.76 million in 1980 and $7.32 million in 1995, resulting in total capital costs of $23.06 million in 1980 and $55.22 million in 1995. The $32.16 million difference in total costs for these two years represents an average annual requirement of $2.144 million for phasing-in of additional service. For the charter option, total capital costs were estimated at $6.10 million in 1980 and $6.24 million in 1995.

The annual capital costs, or debt service, for the publicly-owned and operated system would be approximately $2.177 million in 1980 and $5.212 million in 1995. These costs for the charter option would be approximately $576 thousand in 1980 and $589 thousand in 1995. The calculation of debt service was based on the assumption that capital improvements for the system would be financed with 7.0 percent, long-term general obligation bonds over a 20-year term. This assumption was considered conservative, but reasonable for purposes

TABLE IV-9

PUBLIC OWNERSHIP OPTION
CAPITAL COST ESTIMATES
(In Millions of 1975 $)

Cost Items	Total 1980	1980-1995	Total 1995
Vessels:			
Boeing 929-100 Jetfoils	$15.00	$30.00	$45.00
Spare Parts Inventory	1.00	1.00	2.00
Delivery and Insurance	0.30	0.60	0.90
Subtotal	$16.30	$31.60	$47.90
Terminals:			
CBD	$ 0.66	$ 0.42	$ 1.08
Hawaii Kai	2.58	0.14	2.72
Keehi	2.51	--	2.51
Iroquois Point	0.42	--	0.42
Waipahu	0.59	--	0.59
Subtotal	$ 6.76	$ 0.56	$ 7.32
Total Capital Costs[1]	$23.06	$32.16	$55.22
Annual Capital Costs (Debt Service):			
Vessels	$ 1.539		$ 4.521
Terminals	0.638		0.691
Total Annual Costs[2]	$ 2.177		$ 5.212

[1] For public ownership option. Capital cost items for the private charter option include only the terminals at Kawaii Kai, Keehi, Iroquois Point, and Waipahu at a cost of $6.10 million in 1980 (annual cost of $576 thousand) and $6.24 million in 1995 (annual cost of $589 thousand).

[2] Based on a 7.0 percent interest rate for 20-year term general obligation bonds.

of the evaluation.[1] The bonds would be amortized with system revenues, UMTA grant funds, local subsidies, or a combination of these and other sources of funds.

Table IV-10 provides additional information on terminal costs. These costs were estimated for the terminals illustrated in the conceptual site and terminal facility plans presented in Figures IV-2 through IV-12. They were based on order-of-magnitude quantity estimates for a detailed breakdown of the construction requirements under each of the cost items listed in Table IV-10, and on assumptions of current unit costs for these items.

As shown in Table IV-10, the construction costs of the Hawaii Kai terminal would be highest for all the terminals in the system. This is primarily due to the extensive channel dredging and site preparation requirements at Maunalua Bay Beach Park. The construction costs of the Keehi terminal were the second highest for the system because of the extensive amount of dredging that would be required to create a channel for the marine transit vehicles in Keehi Lagoon. It should be noted that there would be no land rental or acquisition costs associated with development of the terminal sites. All terminals would be located on U.S. Government, State, or City and County property, and it was assumed there would be no inter-agency charges for the use of this land.

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[1] The most recent G. O. Bond issue of the City and County of Honolulu ($3.5 million over 20 years sold on May 5, 1976) sold at a rate of 5.88 percent.

TABLE IV-10

TERMINAL COST ESTIMATES

(In Thousands of 1975 $)

Cost Items	CBD[1]	Hawaii Kai[2]	Keehi	Iroquois Point	Waipahu	Total
Site Preparation	$ --	$ 338	$ 27	$ 37	$ 118	$ 520
Land Access	24	258	55	71	57	465
Marine Access	--	1,600	2,240	104	240	4,184
Terminal Facilities	900	257	164	149	107	1,577
Other Items[3]	153	251	22	56	69	571
Total Costs	$1,077	$2,724	$2,508	$ 417	$ 591	$7,317

[1] Total costs for CBD terminal estimated to be $664 thousand in 1980.

[2] Total costs for Hawaii Kai terminal estimated to be $2,584 thousand in 1980.

[3] Includes landscaping of terminal sites, design and administration, contingency amounts, and other pre-operating costs.

Operating and Maintenance Costs

Operating and maintenance (O&M) costs for the public ownership option would include the variable costs directly related to operations of the commuter service and the fixed or indirect overhead costs that are more closely associated with system support and maintenance functions. For the private charter option, operating costs would be equal to the costs of chartering the required service for the supplementary waterborne system. Total annual O&M costs for both options were estimated for the system in 1980 and 1995.

A summary of the public ownership O&M costs are presented in Table IV-11. It was estimated that total O&M costs would be about $1.218 million for the two-vessel system in 1980 and about $3.103 million for the six-vessel system in 1995. These estimates were based on the assumptions about operating and maintenance requirements described in the previous sections, on information provided by Seaflite and The Boeing Company, and on cost estimates previously developed by the State Department of Transportation.

It was estimated that one crew of five members would be required for each vessel of the system, and that the total number of employees required for system-wide operations would be 36 in 1980 and 78 in 1995. Fuel costs were estimated from fuel consumption rates for Jetfoils, travel speeds on the marine transit routes, total hours of vessel operations, and the current price of fuel. Hull and liability insurance was estimated at $135 thousand per vessel annually. As previously discussed, major maintenance costs would include the costs of annual and emergency drydocking at a private shipyard facility in Honolulu Harbor and the cost of periodic maintenance dredging at the terminal facilities.

The O&M costs for the private charter option would include an operating expenditure based upon an agreed charter rate for the required

TABLE IV-11

PUBLIC OWNERSHIP OPTION

OPERATING AND MAINTENANCE COST ESTIMATES

(In Thousands of 1975 Dollars)

Cost Items	1980	1995
Labor (System Operations):		
Vessel Crews	$ 186.3	$ 558.9
In-Service Maintenance	247.1	594.0
Terminal Attendents	40.5	81.0
Fuel	147.7	559.0
Vessel Insurance	270.0	810.0
Administration:		
Personnel	194.4	206.6
Administrative Support	20.0	25.0
Major Maintenance:		
Maintenance Dredging	33.0	33.0
Vessels	78.5	235.6
Total Annual O&M Costs	$1,217.5	$3,103.1

service. Included would be the incidental costs associated with administration of the system, and operating and maintaining the terminal facilities at Hawaii Kai, Keehi, Iroquois Point, and Waipahu.

It was assumed, for purposes of the evaluation, that the current rate for chartering vessels from Seaflite of $1,000 per hour would apply to the charter option of the supplementary waterborne system. On the basis of approximately 1,750 total vehicle operating hours in 1980 and 5,750 total vehicle operating hours in 1995, this cost would be about $1.75 million and $5.75 million, respectively, in 1980 and 1995.[1] Including estimated administrative and terminal operating and maintenance costs, total O&M costs for the charter option would be $1.88 million in 1980 and $5.94 million in 1995. Table IV-12 summarizes the O&M costs for the private charter option.

TABLE IV-12

PRIVATE CHARTER OPTION
OPERATING AND MAINTENANCE COST ESTIMATES
(In Thousands of 1975 Dollars)

Cost Items	1980	1995
Charter Costs	$1,750.0	$5,750.0
Administration:		
Personnel	90.0	143.0
Administrative Support	7.0	14.0
Maintenance Dredging	33.0	33.0
Total Annual O&M Costs	$1,880.0	$5,940.0

[1] This cost would be a conservative assumption if there are economies of scale in Seaflite's operations. It is reasonable to assume that the expansion of Seaflite's existing fleet of three Jetfoil vessels could result in a reduction of unit costs upon which the current charter rate is based.

REVENUE ESTIMATES

The marine transit system will be capable of generating revenue from more sources than a traditional land-based transit system due to the special nature of the waterborne transit vehicles and the proposed operating schedule. Two primary sources of revenue were considered for the marine transit system. The commuter patronage revenue will be derived from the fare assessed the users of the system during peak periods of the day. These revenue estimates are based on the patronage estimates previously developed. The system may also be expected to generate revenue during the off-peak periods, 9 AM to 3 PM on weekdays and all day on weekends, by leasing the vessels for non-commuter uses.

Patronage Revenue Estimates

Annual revenues from commuter patronage were based on the following assumptions:

- 25-cent fare
- Free transfer between feeder bus and marine transit, and vice versa
- Morning patronage equal to evening patronage
- 250 workdays a year

Three sets of revenue estimates were developed based on different assumptions regarding the allocation of revenues.

The full ridership revenue estimate assumes that every rider on the marine transit system is counted as a full fare. This figure has no meaningful significance other than being the maximum value of revenues which could be allocated to marine transit.

The fare box revenue is the revenue actually collected on the marine transit system. Due to the free transfer assumption, passengers whose mode of access is feeder bus will not pay any fare to use the marine transit bus. Hence, only those passengers who walk, park-and-ride, kiss-and-ride, or bike to the marine transit terminal will have their fares accounted for. The mode-of-access figures used to design station facilities were used to determine the number of morning fares collected. In the evening, it was estimated that about 50 percent of marine transit riders used the feeder bus to get to the Pier 7 terminal from the CBD. Hence, the fares of half the evening patronage were counted. The induced ridership revenue is the fare collected from the induced patronage, and counted each induced rider. This figure represents the gross increase in transit revenues generated by the introduction of the marine transit system. As such, it is the marginal revenue of the marine transit system.

1980 Revenues. Table IV-13 summarizes the full ridership, fare box and induced revenues for individual market areas, and the total system for 1980. The Iroquois Point and Waipahu markets are served by the same line; hence, the Waipahu revenues should be considered as the marginal revenue of extending the Iroquois Point line to Waipahu. The daily patronage is also shown as a review of the patronage estimates developed earlier.

The Iroquois Point-Waipahu and Hawaii Kai lines contribute about equally to the total system revenues, by each of the three definitions. Full ridership revenues for the first line is $13,750 as opposed to $15,000 for the latter line. The system fare box revenue ($15,630) is about half the full ridership revenue ($31,250). The induced revenue of $23,750 is about 75 percent of the full ridership revenue, indicating a high percentage of induced trips on the system.

TABLE IV-13

1980 ANNUAL REVENUE ESTIMATES

	Iroquois Point	Waipahu	Hawaii Kai	Keehi	Total
Full Ridership Revenue					
Daily PM Patronage	80	30	120	20	
Annual Patronage	40,000	15,000	60,000	10,000	
Annual Revenues ($)	10,000	3,750	15,000	2,500	$31,250
Fare Box Revenue					
Daily AM Patronage	50	15	50	10	
Daily PM Patronage	40	15	60	10	
Annual Patronage	22,500	7,500	27,500	5,000	
Annual Revenues ($)	5,620	1,880	6,880	1,250	$15,630
Induced Revenue					
Daily PM Patronage	70	20	80	20	
Annual Patronage	35,000	10,000	40,000	10,000	
Annual Revenues ($)	8,750	2,500	10,000	2,500	$23,750

TABLE IV-14

1995 ANNUAL REVENUE ESTIMATES

	Iroquois Point	Waipahu	Keehi	Hawaii Kai	Total
Full Ridership Revenue					
Daily PM Patronage	100	50	60	1,900	
Annual Patronage	50,000	25,000	30,000	950,000	
Annual Revenues ($)	12,500	6,250	7,500	237,500	$263,750
Fare Box Revenue					
Daily AM Patronage	60	25	30	740	
Daily PM Patronage	50	25	30	950	
Annual Patronage	27,500	12,500	15,000	422,500	
Annual Revenues ($)	6,880	3,120	3,750	105,620	$119,370
Induced Revenue					
Daily PM Patronage	50	25	40	250	
Annual Patronage	25,000	12,500	20,000	125,000	
Annual Revenues ($)	6,250	3,120	5,000	31,250	$45,620

1995 Revenues. Table IV-14 summarizes the three sets of revenue figures by individual market areas and the total system for 1995. Again, the Iroquois Point and Waipahu markets are served by the same line. Also, the daily patronage estimates are shown.

The Hawaii Kai line revenues dominate the entire system. It constitutes 90 percent of the full ridership and fare box revenues, and 70 percent of the induced ridership revenue. The Iroquois Point-Waipahu line revenues are about twice the Keehi line revenues.

The fare box revenues of $119,370 are only 30 percent of the full ridership revenues of $263,750. It dropped from the 50 percent of 1980 because of the dominance of the Hawaii Kai line which is heavily dependent (61 percent of patrons) on feeder bus as a means of access.

The share of induced revenues also decreased from 75 percent in 1980 to 20 percent in 1995 due to the Hawaii Kai line dominance. Much of the 1995 patronage on the Hawaii Kai line is part of the Hawaii Kai overage; hence, the share of induced trips on the line and system is very small. On the Iroquois Point-Waipahu line, the induced patronage share also decreased from 80 percent in 1980 to 50 percent in 1995, indicating the better land transit service provided by the rapid transit system.

Off-Peak Revenues

The potential for generating off-peak revenues was estimated by establishing a relationship between hourly lease rates for the Jetfoils and the hours that would be available for their leasing for non-commuter uses in 1980 and 1995. Only leasing of the vessels during off-peak periods was considered, since County-owned transportation systems are not allowed to engage in charter operations under State law.[1]

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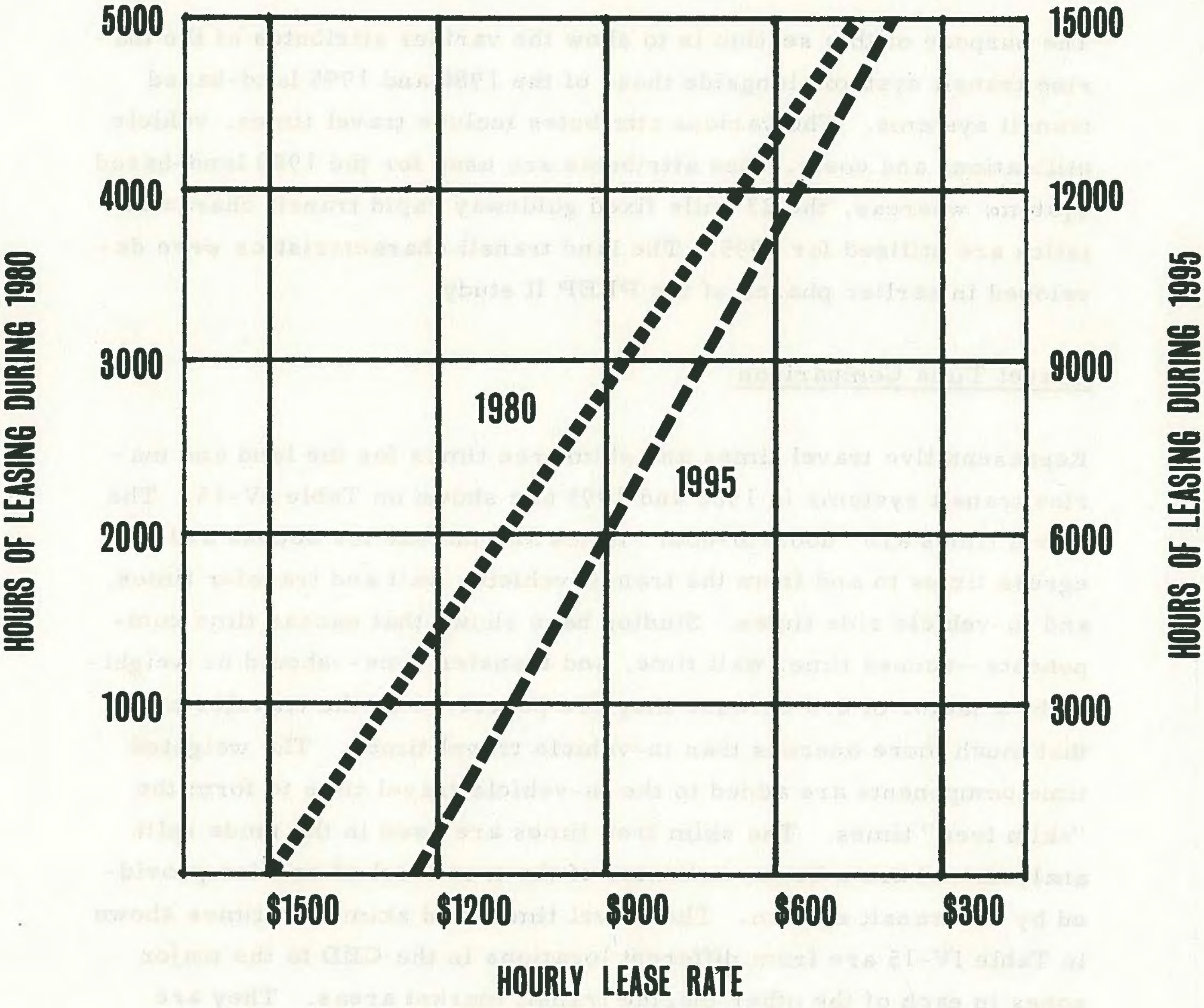
[1] Chapter 51, Hawaii Revised Statutes (as amended in 1973). Although not specifically stated in the law, it was assumed this restriction would also apply if the system were State-owned.

To avoid the elimination of private competition, off-peak lease rates were based on the private costs of financing the purchase of the two vessels in 1980 and the six vessels in 1995. An estimated private market rate of interest of 8.5 percent on a 20-year bond issue secured by mortgages guaranteed by the U.S. Maritime Administration was assumed. To these financing cost amounts, prorated over the additional hours of operation, were added the prorated costs of the annual vessel insurance and the additional in-service maintenance and major maintenance costs that would be attributed to off-peak operations.

As illustrated in Figure IV-13, a total lease rate ranging from $1,500 per hour at zero percent utilization to $450 per hour at 100 percent utilization would generate sufficient revenues to reimburse these costs in 1980. The range of lease rates would be $1,230 at zero percent utilization to $400 at 100 percent utilization in 1995.

It was assumed that the costs would be incurred in a linear relationship with the hours of off-peak utilization. Off-peak revenues can be estimated for any level of off-peak utilization by multiplying the hours of leasing involved times the corresponding hourly lease rate. The maximum amounts of off-peak revenue that could be generated by leasing the vessels would be about $2.25 million in 1980 and $6.0 million in 1995.



RELATIONSHIP OF HOURLY LEASE RATE TO LEVELS OF OFF-PEAK UTILIZATION

FIGURE IV-13

COMPARISON WITH OTHER SYSTEMS

The purpose of this section is to show the various attributes of the marine transit system alongside those of the 1980 and 1995 land-based transit systems. The various attributes include travel times, vehicle utilization, and costs. Bus attributes are used for the 1980 land-based system; whereas, the 23-mile fixed guideway rapid transit characteristics are utilized for 1995. The land transit characteristics were developed in earlier phases of the PEEP II study.

Travel Time Comparison

Representative travel times and skim tree times for the land and marine transit systems in 1980 and 1995 are shown on Table IV-15. The travel times are "door-to-door" times and include the access and egress times to and from the transit vehicle, wait and transfer times, and in-vehicle ride times. Studies have shown that excess time components--access time, wait time, and transfer time--should be weighted by a factor of 2.5 because they are perceived by the traveler to be that much more onerous than in-vehicle travel times. The weighted time components are added to the in-vehicle travel time to form the "skim tree" times. The skim tree times are used in the mode split analysis and are a better indicator of the true level of service provided by the transit system. The travel times and skim tree times shown in Table IV-15 are from different locations in the CBD to the major zones in each of the other marine transit market areas. They are meant to be representative of the level of service between the CBD and the market areas and to show the effect of CBD location upon access times.

The marine transit door-to-door travel times to Ewa Beach (Zone 128) are shorter than their corresponding 1980 land transit travel times and about equal to the 1995 land transit travel times. All the other marine transit travel times to other zones are longer than their corresponding land-based transit travel times. In about the same

TABLE IV-15

LAND AND MARINE TRANSIT
REPRESENTATIVE TRAVEL AND SKIM TREE TIMES

(All Times Shown are in Minutes)

		1980				1995			
		Land Transit		Marine Transit		Land Transit		Marine Transit	
From Zone	To Zone	Travel Time	Skim Tree	Travel Time	Skim Tree	Travel Time	Skim Tree	Travel Time	Skim Tree
8	80	44	59	67	113	33	45	49	70
	128	97	133	76	134	59	78	64	117
	132	72	96	82	135	41	60	75	125
	155	46	67	69	121	19	30	55	86
13	80	49	69	62	111	36	49	48	72
	128	101	143	71	132	63	85	62	117
	132	76	96	77	132	44	65	73	125
	155	50	73	64	119	23	35	51	94
41	80	51	66	70	121	35	51	50	73
	128	103	137	79	143	63	87	64	118
	132	78	99	86	143	45	69	75	126
	155	54	75	73	130	23	38	53	95

Approximate location of zones:

Zone 8 is the heart of the CBD (King and Hotel Streets)
Zone 13 is near the Pier 7 terminal
Zone 41 is the government center district
Zone 80 is Hawaii Kai
Zone 128 is Ewa Beach (outside of the military district)
Zone 132 is Waipahu, below the Sugar Mill
Zone 155 is Salt Lake

manner, the marine transit skim tree times are significantly higher than those of the land transit system, with the exception of Zone 128 skim trees in 1980. These two factors indicate that land-based transit provides a higher level of service than marine transit in most cases. The primary reason for the high marine transit skim tree times is the longer wait times for the hydrofoils. Most marine transit routes operate just once in the morning and once in the evening, as opposed to every two minutes for the rapid transit system. A wait time of 20 minutes was used to reflect the one peak-period trip for simulation modelling purposes, as opposed to the one-minute wait time for the rapid transit (one-half of the headway time). This resulted in a weighted time difference for wait time alone of up to 47.5 minutes (20x2.5-1x2.5) between the rapid transit and waterborne transit systems.

The travel time difference between the transit skim tree and the highway skim tree is one of several inputs into the modal split model. The average auto ownership at the trip origin zone, the trip purpose, the destination parking costs, and travel time difference are used to select the proposed diversion curve and the exact point on the diversion curve when calculating a mode split.

The effect of CBD location upon access times appears to be less important in 1995 than in 1980 due to the much more frequent CBD shuttle service provided in 1995. Most passengers walked to the marine transit terminal or bus stop in 1980, but found it faster to use the shuttle bus in 1995 because of the more frequent service. The travel times by walking are much more distance-sensitive than bus travel times, therefore, access times would show greater variance in 1980 than in 1995.

Table IV-16 compares station-to-station travel times from the CBD to the other marine transit market areas. The station-to-station travel time is the line-haul time spent getting from the origin station or terminal to the destination terminal and does not include access, wait, and transfer times.

TABLE IV-16

COMPARISON OF STATION-TO-STATION TRANSIT TRAVEL TIMES FROM CBD TO OTHER ZONES

(Excluding Wait, Transfer, and Access Times)

To	1980 Bus*	1995 Rapid Transit and Bus*	1980 & 1995 Hydrofoil
Iroquois Point	58	46	18
Waipahu	51	28	34
Keehi	15	6	13
Hawaii Kai	29	21	24

*NOTE: Travel times for the Bus and Rapid Transit includes stops at all bus stops and/or rapid transit stations between the CBD and the destination points.

Due to the physical inconsistencies between each of the three systems analyzed, the following definitions were developed to make the three as comparable as possible:

- For the marine transit system, the hydrofoil travel time from departure at Pier 7 to arrival at the other marine terminals was used.

- For the 1995 rapid transit system, the Fort Street station was used as the point of origin. For Keehi and Hawaii Kai, the rapid transit travel times to the Keehi and Hawaii Kai stations were used. For Waipahu and Iroquois Point, the rapid transit and bus travel times to Waipahu (Farrington Highway and Depot Road) and Iroquois Point (Fort Weaver Raod and North Road) were used.

- For the 1980 bus system, the intersection of Hotel and Bishop Streets was used as the point of origin. Bus travel times to equivalent points on the 1995 rapid transit network were used.

Although the land-based and marine transit terminals at each site are not in the same location, they are in proximity to one another and are suitable for comparison purposes.

In terms of station-to-station run times, the hydrofoil is superior to all the 1980 bus times. Travel times from the CBD to Iroquois Point and Waipahu are much less and slightly less to Keehi and Hawaii Kai. With the development of the 23-mile rapid transit system by 1995, however, hydrofoil travel time is superior for Iroquois Point only and becomes less attractive at the other three sites. Despite the relative attractiveness of the hydrofoil times, the station-to-station run time does not constitute the entire door-to-door travel time. As previously noted, the excess time components are a significant portion of the total skim tree time, particularly after being weighted by the 2.5 factor.

Vehicle Utilization of Various Modes

Two indices were selected to measure vehicle utilization on the marine transit system. The number of passengers per vehicle-mile is the ratio of patronage and the vehicle-miles of operation in the evening peak period. The load factor is the ratio of patronage to the vehicle capacity provided in the evening peak period. It is calculated on a link-by-link basis to form the system average in Table IV-17.

In 1980, the number of passengers per vehicle-mile ranged from 1.7 to 5.8 with an average value of 4.2. The CBD-Iroquois Point link had the highest value because of the Waipahu patrons also on the link and the relatively short travel distance. The average system load factor was 14 percent and ranged from 4 percent on the Keehi-CBD link to 24 percent on the Hawaii Kai route. The load factor values were low due to the deadhead run on each link. The deadhead run did not carry any passengers since it is the off-peak direction run used to get the vehicle into the proper position for the peak-direction run.

The average number of passengers per vehicle-mile increased to 8.1 in 1995, with the highest value (8.3) found on the Hawaii Kai route. The Keehi line had the lowest utilization with 5.2 passengers per vehicle-mile. The Hawaii Kai run also had the highest load factor (48 percent) and the CBD-Keehi links and Iroquois Point-Waipahu links had the lower load factors of 12 and 10 percent, respectively.

The marine transit vehicle utilization measures are compared with those of the 1980 bus system and the 1995 23-mile rapid transit system in Table IV-18. The land transit valued are from previous PEEP II data and do not account for the diversion of transit trips to marine transit.

TABLE IV-17

1980 AND 1995 MARINE TRANSIT VEHICLE UTILIZATION
(PM Peak Period)

Link	2-Way Route Miles	2-Way Vehicle Miles (V.M.)	PM Peak Period Passengers	Passengers/ V.M.	2-Way Vehicle Capacity	Load Factor (%)
1980						
CBD-Iroquois Pt.	19.1	19.1	110	5.8	500	22
Iroquois Point-Waipahu	7.0	7.0	30	4.3	500	6
CBD-Keehi	11.6	11.6	20	1.7	500	4
CBD-Hawaii Kai	28.5	28.5	120	4.2	500	24
Total		66.2	280	4.2	2,000	14
1995						
CBD-Iroquois Pt.	19.1	19.1	150	7.9	500	30
Iroquois Point-Waipahu	7.0	7.0	50	7.1	500	10
CBD-Keehi	11.6	11.6	60	5.2	500	12
CBD-Hawaii Kai	28.5	228.0	1,900	8.3	4,000	48
		265.7	2,160	8.1	5,500	39

TABLE IV-18

LAND-BASED AND MARINE TRANSIT
VEHICLE UTILIZATION IN EVENING PEAK PERIOD

	1980		1995	
	Passengers/ V.M.	Load Factor (%)	Passengers/ V.M.	Load Factor (%)
Marine	4.2	14	8.1	39
Land	5.0	N/A*	4.2	39

*N/A - Not applicable, see text.

NOTE: The numbers in this table are not directly comparable because it compares a 250-passenger hydrofoil with a 70-passenger bus or a 72-passenger rapid transit car. The hydrofoil, bus, and rapid transit car are each counted as one vehicle.

The passengers per vehicle-mile value was nearly equal for marine and land-based transit. The load factor for the 1980 bus system is not shown for several reasons. Primarily, it is a meaningless number because the hourly capacity of a bus system is very difficult to define. A standard bus has room for about 70 sittees and standees; however, the actual number of passengers which can be carried in an hour will depend on the mix of long and short trips. Local feeder routes which carry many short trips will have more turnover and a higher capacity than express routes with longer trips. One alternative is to find the average of the load factors on each link (which can be every block) of every bus route; however, the volume of calculations required for any sizeable bus system makes this task almost impossible. Finally, the capacity of any bus route can be efficiently altered to meet variations in demand. Extra runs can be added or deleted, and turnbacks can be put in to efficiently serve the peak demand. Hence, bus schedules can easily be adjusted to maintain high vehicle utilization.

In 1995, the peak period system load factor of the marine transit system was equal to that of the 23-mile rapid transit. Despite the likeness of the two load factors, the utilization of each system was not due to the different criteria used to develop the capacity on each system. The hydrofoils were planned to carry passengers in one direction only and deadhead on the return trip; hence, the load factor for the peak direction is 78 percent and zero for the return trip. The rapid transit system, on the other hand, was designed to carry passengers in both directions. The capacity was set at the peak one-way link demand and had to be maintained over the entire length of the system in both directions. The highest two direction load factor was 80 percent between the Ward Avenue and Ala Moana stations and the lowest was 22 percent at the Pearl City terminus.

The marine transit also had twice as many passengers per vehicle-mile than the 23-mile rapid transit. This is due to the fact that the hydrofoil has 250 seats while the rapid transit car has only 36. If the rapid transit car were made equivalent to the hydrofoil (i.e., capacity increased to 250 seats), then the rapid transit would have four times as many passenger per equivalent vehicle-mile than the marine transit. Also, the marine transit was primarily designed to carry long trips; in fact, three of the four marine areas are at or beyond the rapid transit terminals. The rapid transit, on the other hand, was meant to carry long as well as short trips.

Relative Costs

The final comparison between land-based and marine transit systems involved various unit costs. The three costs used include the total annual costs, the annual operations and maintenance (O&M) costs, and the annual O&M subsidy (O&M costs minus revenues) for the public ownership option, which had higher total costs but lower O&M costs. The above costs were divided by the following operating and patronage data to obtain the various unit costs:

- Annual Operations Data: Vehicle-hours of operation, vehicle-miles of operation, seat-hours of operation, seat-miles of operation.

- Annual Patronage Data: Passenger trips, passenger hours, passenger miles.

All the cost, operations, and patronage data used to develop the unit costs are shown in Table IV-19. All cost data is given in 1975 dollars. Data shown for the 1980 all-bus system includes the entire system of local and express buses. 1995 rapid transit data is for the 23-mile fixed guideway only and does not include the supporting bus system. The marine transit figures are shown to three decimal places (as opposed to two for the land-based system) due to the

TABLE IV-19

ANNUAL COST, OPERATING AND PATRONAGE DATA OF LAND-BASED AND MARINE TRANSIT SYSTEMS

(All Figures in Millions)

Data Item	1980 Bus	1980 Marine	1995 Rapid Transit	1995 Marine
Cost (in 1975 $)				
Total cost	32.87	3,395	75.89	8.315
O&M cost	28.71	1.218	21.48	3.103
O&M subsidy	15.47	1.186	-3.63	2.839
Operating				
Vehicle-hours	1.52	0.002	1.05	0.006
Vehicle-miles	21.58	0.033	33.67	0.133
Seat-hours	74.35	0.404	37.78	1.381
Seat-miles	1057.28	8.275	1212.12	33.212
Patronage				
Passenger-hours	20.65	0.047	16.07	0.416
Passenger-miles	337.84	1.491	527.31	14.515
Person-trips	64.72	0.125	100.44	1.055

NOTE: Marine transit data is for weekday, peak-period service. Land-based transit data is for all year, all day service.

NOTE: Marine transit and rapid transit subsidies are based on full patronage revenues. The total system patronage is multiplied by the full fare (25 cents) to obtain the revenue. This was done because of the free transfer assumption between the feeder bus system and rapid transit/marine transit and does not represent the true subsidy required for the system.

smaller magnitude of the numbers. It is not meant to imply a greater degree of accuracy. The land transit data was developed in previous phases of the PEEP II study and not as part of this analysis.

The marine transit system data is for weekday peak-period commuter use only and does not include costs and revenues for off-peak period charters. The land-based transit data, on the other hand, reflect operations every day of the year, from early morning to late at night. Hence, comparisons shown on Table IV-18 between the land-based and marine transit systems are not compatible. Peak-period values for the land-based transit systems would have been more appropriate but were not available. Since peak-period service is generally more cost-effective than daily service, the unit costs shown for land-based systems would probably be lower were peak-period costs used.

Total Costs. The total annual costs shown in Table IV-19 were based on the following assumptions:

- Annual total cost is the sum of annualized capital costs and annual O&M costs.
- Capital costs are annualized at seven (7) percent. The marine transit assumed 20-year general obligation bonds; land-based transit costs were amortized over different time spans for various components.
- Federal share of capital costs is not deducted from total costs.

The unit costs developed from the annual total costs are shown in Table IV-20.

O&M Costs. The unit O&M costs are shown in Table IV-21. The unit marine transit costs reflect peak-period service only; whereas, the unit land transit costs reflect all-day service.

TABLE IV-20

ANNUAL TOTAL COST
PER OPERATING UNIT AND PATRONAGE UNIT

	Cost per Unit in 1975 $			
	1980		1995	
Operating Unit	Bus	Marine	Rapid Transit	Marine
Vehicle-Hour	21.62	2099.96	72.28	1504.98
Vehicle-Mile	1.52	102.57	2.25	62.59
Seat-Hour	0.44	8.40	2.01	6.02
Seat-Mile	0.03	0.41	0.06	0.25
Patronage Unit				
Passenger-Hour	1.59	75.75	4.72	20.00
Passenger-Mile	0.10	2.28	0.14	0.57
Passenger Trip	0.51	27.16	0.75	7.88

NOTE: Unit costs of marine transit is for weekday peak-period service. Unit costs of land-based transit is for all year, all day service.

TABLE IV-21

ANNUAL O&M COST
PER OPERATING UNIT AND PATRONAGE UNIT

Operating Unit	Cost per Unit in 1975 $ 1980 Bus	Marine	1995 Rapid Transit	Marine
Vehicle-Hour	18.89	753.077	20.46	561.65
Vehicle-Mile	1.33	36.78	0.64	23.36
Seat-Hour	0.39	3.01	0.57	2.25
Seat-Mile	0.03	0.15	0.02	0.09
Patronage Unit				
Passenger-Hour	1.39	26.09	1.34	7.47
Passenger-Mile	0.08	0.82	0.04	0.21
Passenger Trip	0.44	9.74	0.21	2.94

NOTE: Unit costs of marine transit is for weekday peak-period service.
Unit costs of land-based transit is for all year, all day service.

O&M Subsidy. The O&M subsidy for the 1980 bus system was obtained by subtracting annual revenues from annual O&M costs. For the marine transit and fixed guideway system, full patronage revenues were subtracted from the O&M costs. The free transfer assumptions between bus and hydrofoil/fixed guideway reduced the farebox revenues of the latter systems because each is a line-haul system and must depend on buses to act as the feeder mode. Thus, the farebox revenues underestimated the patronage on hydrofoil and rapid transit. The full patronage revenue was developed by multiplying the patronage by the full fare, 25 cents, to reflect the full patronage. The resultant O&M unit subsidies are shown in Table IV-22. The O&M subsidies for the marine transit and fixed guideway systems do not represent the true subsidy required for the system but is lower than the actual subsidy required; hence, the negative subsidy for the fixed guideway system.

TABLE IV-22

ANNUAL O&M SUBSIDY
PER OPERATING UNIT AND PATRONAGE UNIT

	Subsidy per Unit in 1975 $			
	1980		1995	
Operating Unit	Bus	Marine	Rapid Transit	Marine
Vehicle-Hour	10.18	733.47	- 3.56	513.91
Vehicle-Mile	0.72	35.84	- 0.11	21.37
Seat-Hour	0.21	2.93	- 0.10	2.06
Seat-Mile	0.01	0.14	- 0.002	0.08
Patronage Unit				
Passenger-Hour	0.75	25.41	- 0.22	6.83
Passenger-Mile	0.04	0.80	- 0.01	0.20
Passenger Trip	0.24	9.49	- 0.04	2.69

NOTE: Unit subsidies of marine transit is for weekday peak-period service. Unit subsidies of land-based transit is for all year, all day service.

Marine transit and rapid transit subsidies are based on full patronage revenues. The total system patronage is multiplied by the full fare (25 cents) to obtain the revenue. This was done to eliminate the free transfer assumption between the feeder bus system and rapid transit/marine transit and does not represent the true subsidy required for the system.