honolulu rapid transit system

PRELIMINARY ENGINEERING EVALUATION PROGRAM

FINAL REPORT

PREPARED FOR
DEPARTMENT OF TRANSPORTATION SERVICES
CITY AND COUNTY OF HONOLULU

DECEMBER 1972

Preparation of this report was financially aided through a grant from the U.S. Department of Transportation under Section 9 of the Urban Mass Transportation Act of 1964 as amended

I

consultants

PRIME CONSULTANT

DANIEL, MANN, JOHNSON, & MENDENHALL
Honolulu, Hawaii

ASSOCIATE CONSULTANTS

ALAN M. VOORHEES & ASSOCIATES
Traffic and Revenue
McLean, Virginia

DONALD WOLBRINK & ASSOCIATES
Planning and Urban Design
Honolulu, Hawaii

SUB-CONTRACTORS

DAMES & MOORE
Soils and Geology
Honolulu, Hawaii

JACK MIZUHA
Legal & Legislative
Honolulu, Hawaii

DR. RAYMOND SAKUMOTO
Sociology
Honolulu, Hawaii

GOTTFRIED CONSULTANTS, INC.
Organization & Management
Los Angeles, California

SMITH, BARNEY & CO., INC.
Financial
New York, New York

ENVIRONMENTAL CAPITAL MANAGERS, INC.
Economics
Honolulu, Hawaii

WILSON, IHRIG & ASSOCIATES
Acoustical
Oakland, California

OCEANIC INSTITUTE
Ecology
Honolulu, Hawaii

LULEJIAN & ASSOCIATES
Marine Systems
Arlington, Virginia

JOHN WITTE
Tunnel Construction
Encino, California

DR. JAMES N. PITTS
Air Pollution
Riverside, California

APPLIED TECHNOLOGY LABORATORY
Transit System Technology
Los Angeles, California

Mr. George C. Villegas
Director
Department of Transportation Services
City and County of Honolulu
City Hall Annex
Honolulu, Hawaii 96813

Dear Mr. Villegas:

We are pleased to submit our final report and our recommendations to the City and County of Honolulu for the Rapid Transit Preliminary Engineering Evaluation Program for the Island of Oahu. This work has been accomplished in accordance with the contract between the City and County of Honolulu and Daniel, Mann, Johnson, & Mendenhall, architects and engineers. Included in the report are Transportation Planning, System Concept and Vehicle Selection, Facilities and Urban Design and Planning, Patronage and Revenue Studies, Construction Cost and Benefit/Cost Analysis, and Financing and Implementation Plans.

The draft Environmental Impact Statement produced under this contract has been separately released and a summary has been included in this report.

We wish to express our sincere appreciation to the Department of Transportation Services and the various departments and agencies of the City and State governments for their cooperation and assistance in the production of this most important transportation plan for the entire Island of Oahu.

Cordially,

David R. Miller
Principal

John S. Detlie
Project Manager

DMJM

DANIEL, MANN, JOHNSON, & MENDENHALL

acknowledgments

We gratefully acknowledge the assistance and contributions of the following individuals, agencies, and organizations who aided in the gathering and assimilation of the information necessary to the development of the Honolulu Rapid Transit project.

CITY AND COUNTY OF HONOLULU

Frank F. Fasi, Mayor

CITY COUNCIL

George Koga, Chairman

Clesson Y. Chikasuye, Vice Chairman

Frank W.C. Loo
Chairman, Traffic & Transportation Committee

George G. Akahane
Chairman, Planning Committee

Rudolph Pacarro

Mary George

Toraki Matsumoto

James Y. Shigemura

Daniel Clement, Jr.

RAPID TRANSIT TASK FORCE

Richard K. Sharpless, City Managing Director (Chairman)

George C. Villegas, Director
Department of Transportation Services

Dr. Fujio Matsuda, Director
State Department of Transportation

Robert R. Way, Director
Planning Department

Edward Y. Hirata, Director
Department of Public Works

Ray C. Fisher, Director
Honolulu Redevelopment Agency

and other City Agencies

DEPARTMENT OF TRANSPORTATION SERVICES

George C. Villegas, Director

Roy A. Parker, Deputy Director of Department of Transportation Services
Harlan H. Blindauer, Rapid Transit Administrator
Mabel Chung, Special Assistant for Mass Transit
C.M. Gilliss, Consultant
Albert H.G. Chun, Bus Operations Manager
Abe Poepoe, Public Information Officer

Howard Takara, Senior Transportation Engineer
Roy Kaneko, Senior Transportation Planner
James Beckwith, Systems Planner
Hideo Arakaki, Technician

STATE OF HAWAII

State Department of Planning
and Economic Development

State Department of Transportation

and other State Agencies

In addition, presentations were made to the Lt. Governor, Cabinet, and Transportation Committees of both the House and Senate.

table of contents

list of figures

LIST OF FIGURES (cont'd)

list of tables

AR00053828

introduction 1

NEED FOR IMPROVED PUBLIC TRANSPORTATION

The State of Hawaii and in particular its economic and population center, the Island of Oahu, is presently at a crucial decision making point in planning the nature of its future. The rapid growth and development which has occurred on the Island of Oahu, the political boundary of the City and County of Honolulu, has brought an awareness of the need for sound planning to insure responsible use of the very limited land resources available. In addition to essential considerations of population size development pattern, density and open space conservation, the choice and planning of the Island's transportation system will play a vital role in shaping the future of the region.

In the past, mobility has been provided primarily by Oahu's systems of streets and highways, utilizing private automobiles, taxis, buses and trucks. Although the highway system is a necessary common denominator for all urban transportation in American cities and will probably remain so in the foreseeable future, highways have practical and economic limitations in solving rush-hour traffic problems in congested areas. This is particularly true in the City and County of Honolulu which has a limited amount of land which can be allocated for transportation.

State planners anticipate continued growth in the island's population which will result in further demands for mobility. In order to meet these increased demands, the amount of land used for transportation purposes must either be expanded, or else people must be moved with greater efficiency to minimize the use of land for transportation facilities. To provide for the efficient movement of people and goods, as well as maintain efficient land use, requires a balanced transportation system; each mode performing the function to which it is best suited. This system must include, not only highways, but also a high level, integrated public transportation system.

THE TRANSPORTATION PLANNING PROCESS

In the 1960's, there was growing concern for the transportation problem on Oahu. This concern was manifested through a cooperative planning effort of Federal, State and Local agencies to produce the Comprehensive "Oahu Transportation Study" in 1967. This study established a long range continuing transportation planning process and in its conclusions emphasized that the Island must have a balanced transportation plan as soon as possible. It further recommended that a rapid transit system be included in all long-range plans for the Island of Oahu. The Oahu Transportation Study has been accepted by the City and State as the basis for future transportation planning on the Island.

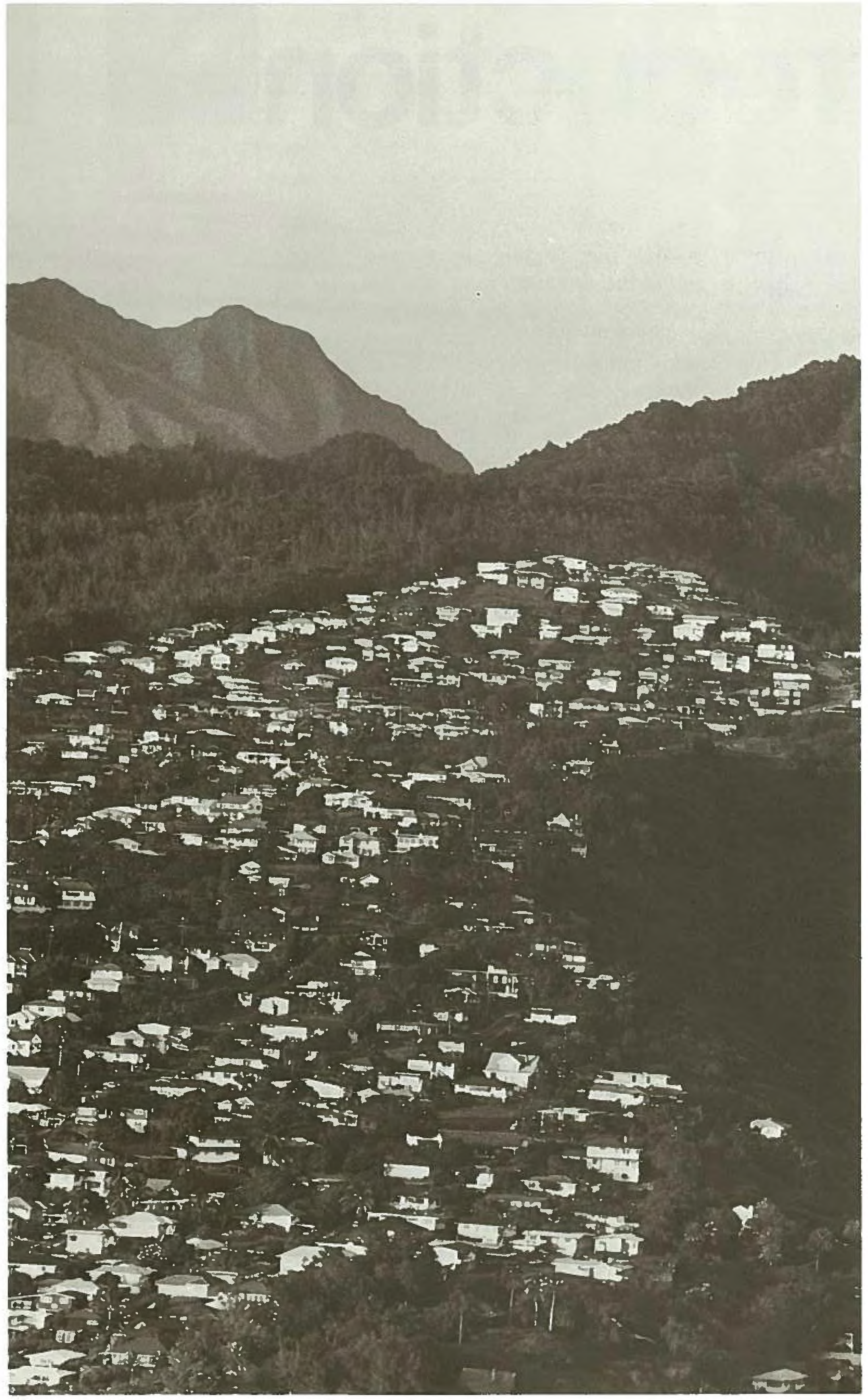
The functions of the Oahu Transportation Study organization, after completing its study in 1967, were transferred to the State Department of Transportation, Office of Advance Transportation Planning Office (ATPO). This office has been responsible for and has undertaken the continuing transportation planning function for the Island of Oahu as well as for the entire State. Recently, the Oahu Transportation Planning Program was established to deal specifically with the long-range transportation planning and programming activities on the Island of Oahu.

As a continuation of the transportation planning process, the Preliminary Engineering Evaluation Program was undertaken to bring the Island of Oahu a step closer to the realization of an improved public transportation system. The results of this study will serve as a valuable input to the Oahu Transportation Planning Program in its coordination of the long-range island-wide transportation planning process.

PURPOSE OF THIS STUDY

The purpose of the work summarized in this report has been to perform detailed planning analysis and preliminary design in order to accurately define the primary facilities and systems for a modern and efficient rapid transit system and, in turn, to permit the preparation of reliable cost estimates. This report also defines the system operations plan, construction plan, and financing requirements as well as an implementation program which includes a schedule for construction of the system.

The first step of the planning analysis consisted of a data gathering effort to gain maximum insight into factors of economic need, travel patterns, development plans, and



community desires. Through cooperation with various City, State and other public agencies the necessary land use plans, zoning ordinances and maps, traffic data, master planning studies, economic data, population and demographic data and other pertinent data were collected and reviewed. With this general information, goals, objectives and criteria were established to guide systems planning. Based upon population projections, land use, and the physical features of the Island of Oahu, an island-wide public transportation system concept was developed. A thorough comparison of all transportation concepts including trunk line, dual mode, Personalized Rapid Transit and waterborne was carried out to determine the best concept to meet the island's transportation needs. The recommended plan will provide a flexible system of local and express buses to serve and connect urban areas over the entire island and, in addition, from Pearl City to Hawaii Kai, a high volume trunk line-feeder rapid transit system to meet increased demands for mobility in urban Honolulu.

The Route Planning Study which led to the selection of the most favorable route for the fixed guideway trunk line facilities, examined alternative routes in light of their respective costs, service characteristics and their impact upon the environment. They were further assessed in terms of the expressed desires of affected communities. This citizen feedback was solicited in a comprehensive community information program involving over 300 meetings and workshops. The recommended route was determined only after a careful study of not only the results of the comprehensive evaluation methodology employed, but also analysis of pertinent feedback from local community organizations, businessmen, citizens groups and governmental agencies.

The second part of this program consisted of the preliminary design of facilities and systems for the proposed rapid transit system. The scope of this work encompassed research, investigation, comparative analysis, criteria development, design studies and the preparation of preliminary design drawings. Detail route alignment investigations, plan and profile drawings, and right-of-way maps were developed for the entire system. The preliminary design of facilities, including stations, way structures and storage and maintenance facilities was completed taking into consideration functional, aesthetic and economic factors to best meet system design objectives and criteria. The vehicle, traction power, and control and communications systems design incorporated the most modern and technologically advanced concepts. The end product of the preliminary engineering was the preparation of final estimates of construction, maintenance, and operation costs for the system's facilities and its equipment.

The development of the proposed rapid transit program was based upon the trunk line-feeder system concept. This report covers the trunk line elements of the overall system and includes all facilities required for the rapid and convenient transfer of feeder system passengers to and from the trunk line rapid transit system. Major features of the trunk line rapid transit system presented in this report are route alignment, stations, way structures, yard and shops, fare collection, transit vehicles, traction power, control and communications as well as urban design potential studies, financing studies and an implementation program. These are presented in the form of technical discussions and conclusions as well as graphics, including maps, drawings, renderings and summary tables indicating construction costs, cash flow, bond schedule and other pertinent information.

The entire planning process for the proposed rapid transit facilities was directed toward designing a system which would meet the region's travel demands effectively while at the same time aid in preserving the quality of the environment. Included in this work was a thorough analysis of the impact of the proposed system on not only the economic and social systems of the island, but also its impact on the all important environment of Oahu. This analysis was presented in a comprehensive draft Environmental Impact Statement.[1]

This study is based on various policy directives and assumptions agreed to be cognizant agencies of the City & County and State in order to properly coordinate all island-wide planning activities. Some of the major policy directives and assumptions which formed the basis of this project are as follows:

- The use of 1995 as the base projection year for transportation planning purposes and 2010 as long-range target year.
- The use of population forecast developed by the State Department of Planning and Economic Development of 924,000 for 1995 and 1,132,000 for 2010.
- The use of employment forecast developed by the State Department of Planning and Economic Development of 518,140 for 1995.
- The use of the 1995 highway network developed by the State Department of Transportation including Interstate Routes H-1, H-2, and H-3.
- The use of the City & County General Plan of 1964, as amended, as the basis for land use.
- The use of the Oahu Transportation Study of 1967 as the basis for long-range transportation development which defines the first phase rapid transit system from Pearl City to Hawaii Kai.
- The assumption that Kalanianaole Highway would be maintained with the same number of lanes as presently existing.
- The assumption that a reasonable fare structure that is commensurate with existing bus fare schedule would be established for the rapid transit system.

THE CONSULTING TEAM

The planning and preliminary design work was performed by a team of consultants headed by Daniel, Mann, Johnson, and Mendenhall. Associate consultants were Alan M. Voorhees and Associates, and Donald Wolbrink and Associates.

A number of specialized consultants and subcontractors also participated. All engineering and planning was reviewed by a Technical Advisory Board composed of executives of the consulting team parent firms. The Technical Board and Key Staff Members included:

TECHNICAL ADVISORY BOARD

David R. Miller, Principal, DMJM (Project Director)
Donald Wolbrink, President, DWA
Jack C. Lipman, Vice President, DMJM
Thomas Deen, Vice President, AMVA

Staff

John S. Detlie, Associate Vice President, DMJM, Project Manager
Shuji Magota, Associate Vice President, DMJM, Deputy Project Manager and Chief Engineer
Richard W. Thompson, DMJM, Chief Route Planner and Urban Designer
Raymond A. MacDonald, DMJM, Project Civil Engineer
William R. Glass, DMJM, Project Urban Designer
Wayne F. Weatherford, DMJM, Project Economist
Carol S. Glass, DMJM, Project Architect
Ben E. Ibanez, DMJM, Civil Engineer
Lawrence P. Gallagher, DMJM, Project Graphics Planner
Robert M. Sumitomo, DMJM, Engineer
Dr. George Hoffman, ATL, Systems Technology
and other support staff

[1]See Referenced Document—Appendix C.

summary 2

INTRODUCTION

As the City and County of Honolulu continues to grow, the need for a well balanced transportation system will accelerate correspondingly. Transportation is not only an important element in a thriving economy, it is also a principal determinant of the quality and character of urban expansion.

The Island's highway network will continue to be the backbone of the regional transportation system. However, unless the private automobile is balanced with an efficient public transportation system, decentralization of both residential and commercial development may be necessary, requiring more and longer trips by private automobile. This in turn will result in increased travel volume and a corresponding need for expansion of the highway system and an inefficient use of the Island's limited land resource. Balancing the existing and planned highway system with a good public transportation system will help to control congestion and result in a more organized, planned, and efficient development pattern which will benefit the entire community for generations to come.

In pursuit of this objective, the "Oahu Transportation Study" sponsored by the City, State and Federal governments, recommended that a balanced transportation system be created for the Island of Oahu which would include as a major element, a rapid transit system. To continue technical studies for the improvement of public transportation on Oahu and take the initial steps toward implementation, the City and County of Honolulu engaged consultants in June 1971 to assist in carrying out this work. This report and the accompanying detailed supporting reports and analyses, design studies, preliminary engineering, and architectural drawings represent the results of this assignment.

This work has been compiled as part of an intensive program of studies and investigations of public transportation on the Island of Oahu. It provides a basis for estimates of cost and patronage and for the assessment of program feasibility.

Specifically the work of the consultants, as summarized in this report, includes:

- Establishment of an Island-wide public transportation system concept
- Establishment of general routing and station locations for the rapid transit system within the Central Honolulu corridor
- Evaluation of rapid transit system technology
- Selection of the system technology best suited to Island needs
- Definition of a supporting, feeder bus system
- Estimation of transit ridership
- Preparation of preliminary designs of the first-phase facilities
- Estimation of capital costs
- Selection of a transit operating plan
- Estimation of revenues based on a logical and feasible fare plan
- Assessment of regional socio-economic benefits
- Assessment of impact on the environment
- Investigation of possible funding sources for the program
- Investigation of funding and bond service alternatives for the program
- Evaluation of organizational form and structure
- Preparation of implementation program

CONCLUSIONS

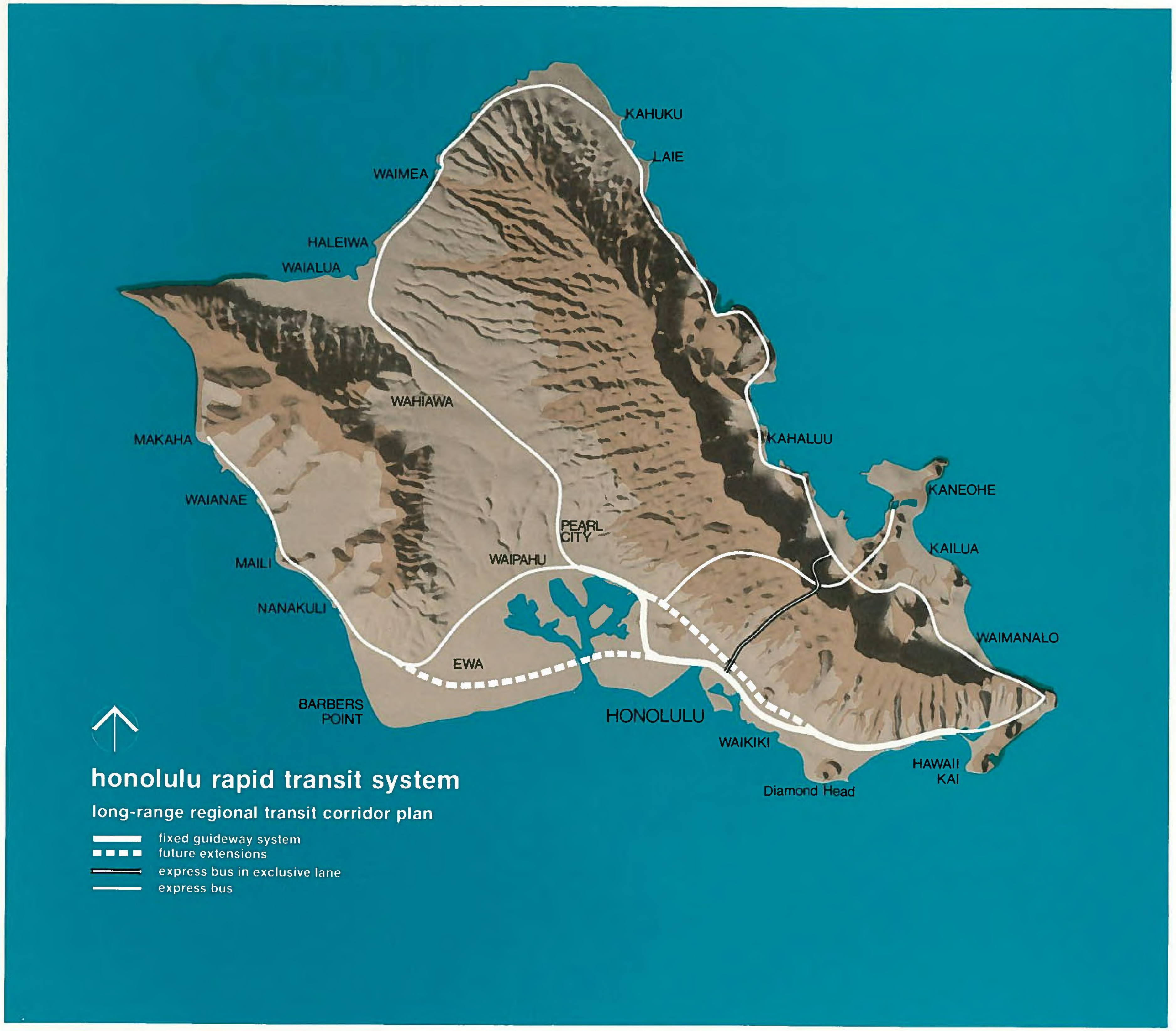
The studies performed by the consultants for this phase of work yielded the following primary conclusions:

- A rubber-tired fixed guideway transit system, supported by feeder buses, is a prerequisite in meeting the Island of Oahu's transportation needs for the remainder of the century.
- This system will greatly alleviate the critical rush hour travel congestion in urban Honolulu as well as provide efficient, rapid, comfortable, clean, safe, and dependable transportation for the urban and suburban areas throughout the day; and it will be a key element in a balanced regional transportation system.
- This system will provide significant benefits to the region, both economically and socially, and will greatly enhance the urban area as a pleasant and convenient place to live. It will be a mobility source for the young, old, handicapped, and the underemployed due to lack of mobility resulting in immeasurable social benefits to the entire Island.
- A rapid transit system, as presently conceived, can be funded by reasonable public financing means and will represent a substantial net economic benefit to the region.
- Without the implementation of a rapid transit system, including improved feeder bus service, urban and economic development in the City and County of Honolulu will be impeded, and continuing congestion will tend to nullify the benefits of the highways.

RECOMMENDATIONS

It is recommended that the appropriate State and City authorities proceed as soon as possible with the next step in the implementation of the regional public transportation system concept as described in this report, including the following:

- adopting of the long-range regional public transportation system concept utilizing the fixed guideway vehicle system in the major travel corridor of central Honolulu complemented by an island-wide express and feeder bus system.
- initiate actions necessary to provide funding and meet statutory requirements to advance the implementation of the first phase, 22-mile fixed guideway system through preparatory engineering and into final design and construction.



THE LONG-RANGE REGIONAL TRANSIT PLAN

In order to properly determine transit needs on Oahu and as a result, define solutions twenty years or more into the future, five possible island-wide development patterns were identified and analyzed, based on population and employment projections by the State Department of Planning and Economic Development.[2] These planning studies examined variations in location and distribution of the island's projected growth in order to develop a transit system which would effectively serve existing areas as well as provide flexibility to meet future demands. The result of these investigations indicated that, no matter which growth option were to be chosen for future island-wide development, the Central Honolulu Corridor from Pearl City to Hawaii Kai would remain the population, employment, and activity center of the region. This corridor will require a high level of transportation capacity regardless of future population distribution over the remainder of Oahu and was therefore selected as the first phase of the rapid transit system.

In addition, increasing demands for residential development in outlying districts such as Kailua-Kaneohe, Wahiawa and Waianae, coupled with the continued employment concentration and residential intensification in Central Honolulu will demand that major emphasis be placed on regional transit service to provide mobility between the places where people live and the places they want to go, such as offices, schools, shopping areas, and recreational facilities.

Consequently, a regional transit system was developed to provide efficient, high capacity service to major origin and destination areas within central Honolulu as well as fast and frequent service to outlying districts over the entire Island of Oahu. This concept will provide public transportation corridors over the entire island to link the Windward, Central and Leeward districts with a high capacity corridor from Pearl City to Hawaii Kai.

The corridors crossing the Koolau Range would occur at the Koko Head end around Makapuu Point and on or paralleling either Likelike Highway or H-3 Freeway to serve the Windward district. The corridors serving the Central and Leeward districts would be an extension of the corridor through Pearl City.

Based on anticipated population growth and distribution as well as preliminary estimates of corridor volumes, the following levels of public transportation service are proposed within each corridor for the first phase development of the island-wide rapid transit system, illustrated in Figure 2-1. Subsequent phases will be determined in conjunction with further land use planning for Oahu.

FIGURE 2-2

- Automated fixed guideway system—the Honolulu corridor from Pearl City to Hawaii Kai.
- Express bus in exclusive lane—the trans-Koolau corridor serving the Windward district.
- Express bus serving Leeward and Central District.
- Local feeder bus service in all areas.

The long-range regional transit plan will therefore provide a high level, integrated public transportation system using a broad coverage surface bus system to serve and connect outlying urbanized areas over the entire island.

RAPID TRANSIT SYSTEM CONCEPT

Serving as the backbone for this island-wide network would be a high capacity rapid transit system from Pearl City to Hawaii Kai. This system is a grade-separated, exclusive right-of-way system to provide safe, reliable and fast service which is attractive enough to capture a high volume of choice riders. It will also be capable of handling large volumes of riders such that when combined with both the highway and bus system, the combined capacity of this balanced transportation system can meet the future mobility needs of the region.

The City of Honolulu is uniquely suited to the trunk line-feeder rapid transit concept. The natural boundaries of the ocean on one side and the Koolau mountains on the other have caused urban development to occur in a linear pattern from Pearl City to Hawaii Kai. Within this corridor of development are the City's major centers of activity or traffic generators including:

- Honolulu International Center
- Halawa Stadium
- Honolulu International Airport
- Ala Moana
- Waikiki
- The Central Business District
- Civic Center
- The University of Hawaii
- Pearl Harbor—Hickam

Using the previous OTS study as a point of departure, a "single line" system concept 22 miles long was chosen to serve all these major centers. (See Figure 2-2) Appropriate station spacing will provide direct, reasonably fast and convenient service at a scheduled average speed of approximately 35 mph. This concept will permit extension of the fixed guideway facility to outlying areas as population growth and development occurs. The basic "single line" configuration will adequately serve the City's major attraction centers, including Waikiki with its subsystem, and with a comprehensive feeder bus system will also provide convenient service to residential or trip origin centers.

RAPID TRANSIT STATIONS

1. Pearl City	11. Ward Avenue
2. Pearl Ridge	12. Ala Moana
3. Halawa	13. Waikiki
4. Pearl Harbor	14. University
5. International Airport	15. St. Louis Heights
6. Keehi Lagoon	16. Koko Head Avenue
7. Kalihi Street	17. Kahala
8. Liliha Street	18. Aina Haina
9. Fort Street (CBD)	19. Niu
10. Civic Center	20. Hawaii Kai

The outlying communities located in the Leeward and Central districts will be served initially by local and express buses interfacing with a first stage terminal station at Pearl City. Windward area patrons will also use express buses crossing the Koolau Range on Likelike Highway and/or H-3 Freeway and interfacing with stations located on Kalihi Street and at the Halawa Stadium site respectively. For communities beyond Hawaii Kai, on the Kalanianaole Highway corridor, patrons will use local and express buses interfacing at the Hawaii Kai terminal station.

The communities in the more urbanized areas within Honolulu proper would either be directly served by the rapid transit system or by convenient feeder bus systems.

TYPE OF VEHICLE SYSTEM

All rapid transit vehicle systems currently available or being developed were reviewed and analyzed, including busways, dual mode, PRT and trunkline-feeder systems, in order to choose the best and most advanced technology for Honolulu.[5] The major criteria affecting the choice were:

- Service requirements
- Performance characteristics
- Qualities affecting community environment
- Cost

These criteria and the present state of transit-vehicle development limit the choice to the following wheeled vehicle systems:

- Conventional Steel-Wheel, Steel-Rail System
- Monorail System
- Metro-System (Paris/Montreal)
- Single-Axle, Pneumatic-Tire, Guideway System.

Higher costs with no offsetting advantages of service, performance, or qualities affecting community environment caused the elimination of the monorail and Metro systems.

Detailed comparison of the conventional steel-wheel, steel-rail and single-axle, pneumatic-tire systems indicates the choice of the pneumatic-tire system because of the following advantages:

- Greater adaptability to service requirements
- Less noise
- High quality riding characteristics
- Positive protection against derailment and overturning
- Better traction under most operating conditions
- Lighter and less massive, aesthetically superior aerial structures
- Comparable total capital and operating costs under operating conditions for Honolulu
- Greater grade climbing ability
- Lighter weight, better proportioned vehicles in scale with Oahu's environment.

In addition to having two single axles, with two pairs of rubber tires on each axle, the selected rapid-transit vehicle is electrically powered, fully reversible, capable of speeds in the 60 to 65 mph range, capable of being automatically operated, and has the necessary acceleration and deceleration characteristics.

All cars will be powered. The vehicles will be coupled in trains of two to ten cars in length (front and rear cars will contain automatic train control equipment) with end cars having a sculptured, pleasing appearance.

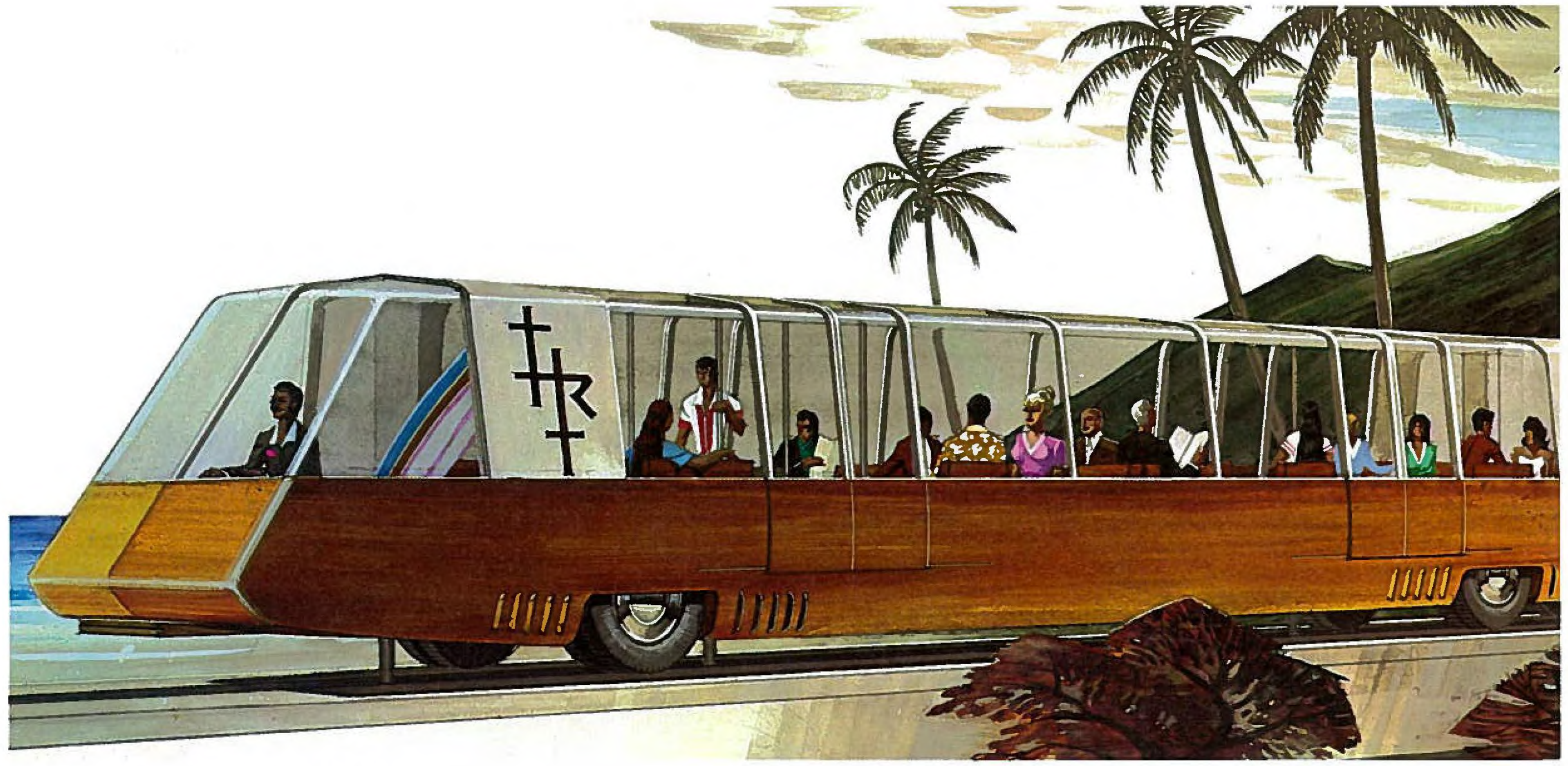


FIGURE 2-3 Rapid Transit Vehicle

The vehicles will run on a roadway consisting of two 30-inch concrete guideways. Guide wheels attached to the undercarriage steer each axle and firmly position the vehicle on the roadway by rolling along a guide beam mounted between the concrete guideways. Additional physical features of the vehicle include:

- Climate-controlled interior
- Well lighted interior
- Large window areas
- Convenient exit and entry
- Comfortable seats and seating arrangement
- Pleasing interior design
- Pleasing exterior appearance
- Storage space for personal articles

Each car seats 36 passengers comfortably with ample room for rush-hour standees. Two 50-inch-wide sliding doors allow easy entrance and exit on each side. The tentative vehicle dimensions are:

- Length: 41′-8″
- Width: 9′-8″
- Height above Guideway: 11′-0″
- Inside Headroom: 7′-0″

SERVICE CHARACTERISTICS

The key characteristics of the suggested operating plan for the Honolulu transit system are:

- Rapid, comfortable, clean and dependable service
- High frequency service throughout the day
- Daily service period of 20 hours
- Almost total accessibility to the trunk line system by a maximum 10-minute bus ride for the service area.

Trains will operate at close intervals (headways) throughout the transit line from the terminal at Pearl City to Hawaii Kai with train length rather than train intervals reduced in the off-peak hours and on weekends and holidays. Operating hours are from 5 a.m. to 1 a.m. seven days a week. Train frequencies for the major portion of the system, until 8 p.m., will be 2 minutes and 4 minutes. Train frequencies after 8 p.m. for the major portion of the system will be 4 minutes. See Table 2-1 for specific frequency and train length information.

Table 2-1

RAPID TRANSIT OPERATIONS

1995

Peak Hour: 9-car consists @ 2 minute headway
Base Period: 6-car consists @ 4 minute headway
Evening Period: 2-car consists @ 4 minute headway

1980

Peak Hour: 7-car consist @ 3 minute headway
Base Period: 5-car consist @ 6 minute headway
Evening Period: 2-car consist @ 6 minute headway

Table 2-2

1995 TOTAL TRIPS AND TRANSIT TRIPS

Purpose	Total Trips	Transit Trips	Percent by Transit
Home-Based Work	674,000	193,000	29
Home-Based Nonwork	1,697,000	193,000	11
School	289,000	32,000	11
Non-Home Based	616,000	40,000	7
Other Special Trips	86,000	26,000	30
TOTAL	3,362,000	484,000	14

ESTIMATED PATRONAGE

Transit travel forecasts for the proposed rapid transit system have been based on analysis of an assumed population growth of 924,000 in 1995, current and future residential and employment patterns in accordance with the General Plan, origin and destination studies revealing desired travel patterns, current and future family incomes, current and future highway development including H1, H2, and H3, availability of parking and cost of alternative transportation modes.[6] Two major categories of trips have been considered: home-based and non-home-based. The home-based trips, by far the largest number, have been divided as follows:

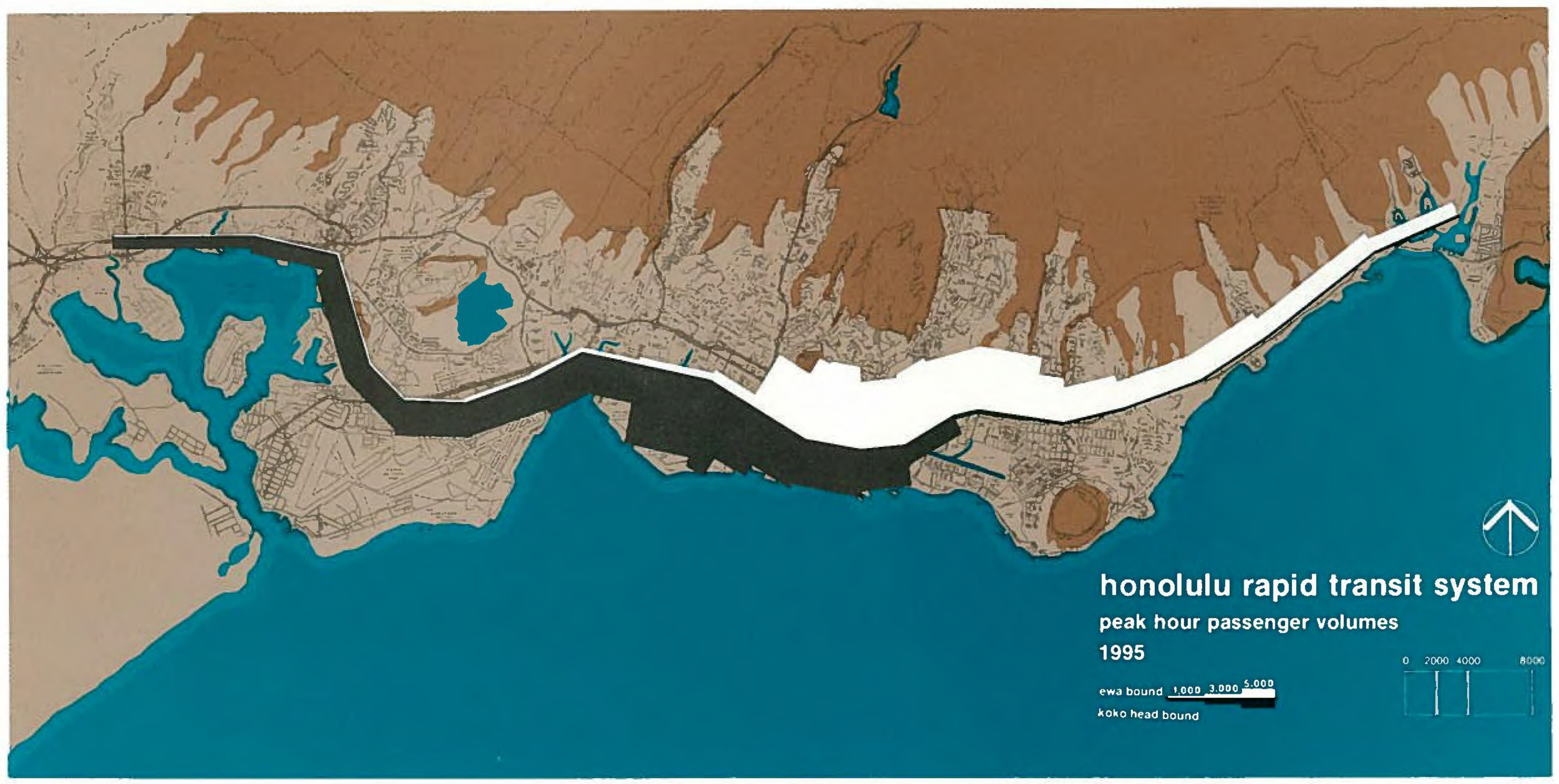
- Work
- School
- Shopping
- Personal Business
- Social and Recreation

The total travel forecast for all trips for all modes and the total transit travel for home-based and non-home-based trips, including H.I.A. to Waikiki, is given in Table 2-2. These projections indicated that, in 1995, the transit system would carry 484,000 riders per day.

The prime transportation problem in Honolulu, as in almost all other major urban areas, is the congestion caused by home-to-work travel in and out of the urban core during the peak morning and evening hours. The salient results of the daily travel forecast estimates which relate most directly to this problem are:

- Total daily transit trips are estimated to be 484,000 in 1995.
- Approximately 72% of these total estimated daily transit trips would be on the proposed rapid transit facility with the remaining 28% on the bus system.

These estimates support the conclusion that a fixed-guideway rapid transit trunkline system, with a feeder bus network, is the most efficient means of handling projected peak-hour traffic.



FARE STRUCTURE

The optimum fare schedule for a rapid transit system is one which will maximize patronage and at the same time will produce sufficient revenues to meet operating and maintenance expenses.[6] It must also be related to the existing fare structure of the City's bus system as both the rapid transit and bus system will operate as an integrated system.

Of the various possible fare structures applicable for the proposed system such as flat fares, zone fares, and graduated fares, the flat fare is concluded to be best for the Honolulu system. The relatively short trip length for most trips on Oahu suggests a simple flat fare structure with no transfer privileges as an equitable and economical fare structure scheme.

The flat fare structure for Honolulu would have the characteristics of a flat fare for each of the major system components and with two possible types of fare schedules as follows:

	Type I	Type II
Feeder and Local Bus	10¢	-0-
Express Bus	25¢	35¢
Rapid Transit	25¢	35¢

The basic difference in the two types is that one would have a fare of 10¢ while the other would have no fare for the feeder and local bus. In order to compensate for the no fare on feeder and local bus under Type II, the other system components would have a higher fare than that proposed under Type I. Both types of fare schedules are projected to generate sufficient revenues to meet the estimated operating and maintenance costs based on 1972 prices.

DESIGN OF FACILITIES

The fixed facilities of a rapid transit system must be designed with particular care and sensitivity due to stringent functional requirements. However, it is also essential to provide attractive structures which can influence the attraction of riders and have a positive effect on the communities through which they are constructed. Functional elements must perform efficiently and reliably. Facilities used by patrons must be convenient, comfortable, and aesthetically pleasing. Stations must enhance community environment and encourage urban and suburban growth by providing increased accessibility, and by providing pleasing nuclei which will attract development. Visible way structures must be attractive and should permit the least possible disruption to community life within practical cost limitations. The major system facility elements are:

- Stations
- Way structures
- Yards and shops
- Electrification systems
- Control and communication systems
- Automatic fare collection system
- Surveillance and Security system

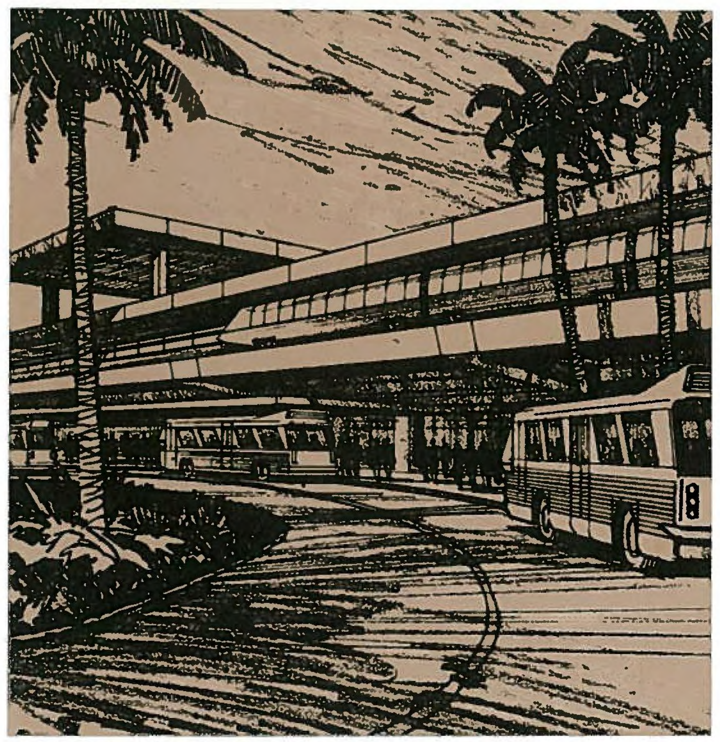


FIGURE 2-4 Waikiki Station

STATIONS

The 22-mile Honolulu rapid transit system will have 20 stations (see Figure 2-2). These stations will function primarily as the entry and exit points of the system. They must accommodate large numbers of people and provide convenient and efficient interconnections for buses, automobiles, and pedestrian traffic. The design of the stations must satisfy these functional requirements in a tasteful architectural environment. Spacious interiors will permit easy pedestrian movement. Prominent, attractive, and clearly legible graphic identification will direct passengers to desired boarding locations and in the use of ticketing equipment.

In addition to those functions directly related to transporting passengers, certain key stations will provide special opportunities for improving the surrounding urban environment. The Fort Street station will be particularly important in this respect. This station will provide an attractive, partially protected plaza area one level below the Hotel Street Mall which will be easily accessible to pedestrians in the surrounding commercial and business complexes. By greatly improving accessibility to the downtown area, the potential for development will be enhanced. The Ward Street station will introduce a focal point for new growth in the West Kewalo area around the Honolulu International Center. New development can be structured around this station to provide direction for revitalization of the area appropriate to its location within the urban core.

WAY STRUCTURES

Way structures provide the grade-separated guideways along which the rapid transit vehicles will travel with no interference from any other transportation modes. These structures will be on-grade, subway, and aerial, the choice depending upon factors such as economic and environmental effect on surrounding communities, net tax gain or loss, cost, and dislocative effects on families and businesses.

To minimize the amount of land required for the transit structure and at the same time provide the necessary grade-separation, an aerial configuration was utilized for over 90% of the 22-mile rapid transit system. The structure will be simple and gracefully proportioned to become an attractive element in the urban environment. The land below the aerial guideway will be pleasantly landscaped and returned to the City for public use as linear park areas.

In the downtown area the rapid transit line was placed underground in a cut and cover configuration to preserve the historic heart of Honolulu. Careful planning and coordination of construction to minimize disruption resulted in no impact on the numerous historic landmarks in the area.

Only a small portion of the line would be in an at-grade configuration. This would occur in the Makalapa area from Halawa Stadium to Plantation Boulevard as the rapid transit line parallels the new H-1 Freeway.

YARDS AND SHOPS

The primary purpose of yards and shops is storage and inspection of rapid transit vehicles, alteration of train size, dispatch of trains, and maintenance and repair of vehicles. Thus, proper appearance, cleanliness, and reliable operation of vehicles is facilitated, and train sizes and schedules are maintained in accordance with volume requirements. The maintenance, overhaul, and storage yard will be located in the Kalihi-Kai Industrial area, makai of Nimitz Highway.

ELECTRIFICATION SYSTEMS

The method of propulsion for rapid transit vehicles will be electric power. This method offers the most economic and operational advantages of all propulsion methods currently available within the time requirements of this program.

Power for vehicle propulsion has been tentatively selected to be 600-volt direct current (dc) delivered to the wayside through a 600-volt dc contact rail and transmitted to the rapid transit vehicle by sliding shoes. The power source will be from facilities of the Hawaiian Electric Company, Inc. Source power will be 46-kilovolt, 3-phase, alternating current, which will be transformed and rectified to 600-volt dc. Maximum power reliability characteristics are planned for the system by using multiple power sources and distribution circuits.

While the 600-volt dc electric power system is the most widely acceptable and proved method for transit use, continuing investigation is planned for higher voltage dc or ac systems to assure the best selection for Honolulu.

Station electric power will be standard alternating current received from local Hawaiian Electric Company facilities serving the various neighborhoods in which the stations are located. Emergency station power will also be provided.

CONTROL AND COMMUNICATION SYSTEMS

The control and communication systems fall into three major categories:

- Equipment supervisory systems
- Automatic train control system
- Voice communication system

EQUIPMENT SUPERVISORY SYSTEM. This system provides a method of monitoring all critical system elements to assure proper and safe operation and to indicate trouble spots requiring maintenance or other corrective action. This system monitors propulsion equipment, train operation equipment, and critical auxiliary equipment such as fans, pumps, and alarms.

AUTOMATIC TRAIN CONTROL SYSTEM. This system monitors and regulates the movements and operations of the trains. This includes three sub-systems:

- Train protection
- Train operation
- Line supervision

Train protection. This sub-system senses relative speeds and separation distances between all adjacent pairs of moving trains. If train separations and relative speeds approach unsafe conditions, signals are sent to the train operation sub-system for automatic corrective action.

Train operation. This sub-system automatically regulates speed, acceleration, braking, berthing, train direction, and passenger doors. These actions are controlled by computer programming or by commands from the monitoring devices in the train protection and line supervision sub-systems.

Line supervision. This sub-system regulates train scheduling, route assignments, and train entrance to and exit from the mainline. Both the equipment supervisory and automatic train operation systems are operated electronically from a control center to be located in the Civic Center station.

VOICE COMMUNICATIONS SYSTEM. This system will use telephones and public address systems. Telephones will provide internal communications for operating and maintenance personnel. Telephone connections to locations outside the rapid transit system will be provided as appropriate. Public address systems will permit station attendants to speak to patrons in station areas.

FARE COLLECTION SYSTEM

An automatic fare collection system ensures economical and efficient operation, and concurrently facilitates passenger speed and convenience in entering and departing from the transit system.[4] The flat fare structure considered, with no transfer privileges, requires a relatively simple collection system comprised of:

- Ticket vendors
- Turnstiles or fare gates
- Change making equipment

The ticket vendor accepts coinage and bills up to the amount of maximum number of tickets determined to be handled by the equipment. The vendors do not accept pennies nor will they dispense change. Therefore, for the convenience of the passengers, change makers will be provided adjacent to the ticket vendors.

Turnstiles or fare gates are designed for use as entrance and exit gates. They are normally programmed by the station agent to operate in only one direction, but are easily reversed for changes in peak traffic direction. In entrance mode, the gate accepts a ticket, ascertains its validity, and releases the gate for entrance. The turnstiles will also be provided with an automatic counter to provide ready passenger information.

SURVEILLANCE AND SECURITY SYSTEMS

Each passenger station will have an attendant on duty whenever the station is open. He will normally be in the ticketing area where he can monitor the status of air conditioning systems, tunnel ventilation systems, train screens, fire and police alarms, escalators, and fare-collection equipment. He can also communicate with central control through a voice link, with passengers in the station through a public address system, and with local fire and police stations through established alarm systems. Certain sections of the station, primarily the platforms, cannot be seen directly by the attendant. Closed circuit television will let him observe these areas on monitors in the attendant's station. Cameras will scan the platform area at all times. Controls for the remote cameras will be in the attendant's staion.

FIGURE 2-5 Station Surveillance

CONSTRUCTION PHASING AND ESTIMATED COSTS

The implementation schedule was structured on the assumption that final design would commence before the end of calendar year 1973. Allowing 1 year to prepare plans and specifications for the first contract package, construction can then commence by the end of 1974 and the first increment of the system ready for revenue service by late 1978.

The initial 12 to 14 mile increment of the system would require approximately 4 years to construct and test. The remaining segments of the system would be staged for completion between 1 to 1½ years later with the entire 22-mile system in revenue service by early 1980. System phasing is shown in Figure 2-6.

The estimated capital costs of the total system and the first stage increments are shown in Table 2-3.

Table 2-3

COST SUMMARY

($ Thousands)

	12-Mile Increment	14-Mile Increment	22-Mile System
Fixed Facilities & Equipment			
Way Structure & Stations	$115,090	$131,570	$188,500
Power & Control System	32,520	41,930	57,000
Yard & Shop	15,400	15,400	16,500
Vehicles	31,340	37,000	52,200
Subtotal	$194,350	$225,900	$314,200
R.O.W. & Relocation	84,240	92,170	95,600
Admin., Engrg., Constr., Mgmt., & Pre-Operating Expenses	25,260	29,360	40,850
Contingency	45,570	52,120	67,590
Escalation	89,920	107,700	159,060
Total	$439,340	$507,250	$677,300
4% Excise Tax	12,870	15,100	21,700
Grand Total	**$452,210**	**$522,350**	**$699,000**

OPERATING COSTS

The estimated annual operating and maintenance expenses for the rapid transit and the feeder and express bus systems, based on wage and cost levels in effect in 1972 are as follows:

	1980	1995
	($ Million)	
Rapid Transit	13.0	17.0
Feeder & Express Bus	14.5	19.0
Total	27.5	36.0

FINANCING

Financing requirements to implement the proposed rapid transit system have been investigated including possible sources of funds.[7] The proposed rapid transit system is estimated to cost $699 million for a full, first phase 22-mile system. A minimum 12-mile system increment is estimated to cost $452 million and an intermediate 14-mile system estimated to cost $522 million. Depending upon the availability of Federal and local funds, the system could be initiated with a smaller first increment which could be extended to the full, first phase 22-mile system.

The major Federal program aiding mass transit projects is the Urban Mass Transportation Act of 1964, as amended, and the Urban Mass Transportation Assistance Act of 1970. Presently the Urban Mass Transportation Administration (UMTA) may assist local programs with up to two-thirds of the net project cost. In this study, it has been assumed that Federal grants of two-thirds of the project capital cost would be provided. Accordingly, it was assumed that the local share of the project cost would be one-third or $150 million for the minimum 12-mile system and up to $233 million for the full 22-mile system.

The City and County of Honolulu has the authority to finance mass transit facilities through the issuance of general obligation bonds. The payment of interest on the principal of general obligation bonds constitutes a first charge on the general fund of the City and County. The City Council has the power and is obligated to levy ad valorem taxes without limitation as to rate or amount on all real property subject to taxation in the City and County for the payment of principal and interest on general obligation bonds.

The Hawaii Constitution limits the funded debt of the City and County to 15 per cent of the total assessed value for tax purposes of the real property in the City and County. This limitation is applied against debt outstanding. Recognizing that the legal debt is unduly liberal, the City and County follows a policy limiting debt service to 15 percent of general fund revenues. This is a more meaningful yardstick of a community's debt burden which municipal credit analysts consider as the key indication for bond rating.

A bond financing analysis was conducted based on issuance of general obligation bonds by the City and County. Certain basic assumptions were made with respect to such bonds as follows: 25 year bond maturity, level annual debt service, average interest rate of 5½%, and re-investment rate of 4½% for surplus funds. Based on these assumptions, the annual debt service was computed to be $10.9 million for the 12-mile system and $16.8 million for the full 22-mile system.

BENEFITS TO THE ISLAND

The economic benefits of rapid transit which will accrue to the Island of Oahu and its citizens during the useful life of the system have been conservatively estimated to be $3,200,000,000.[8] When compared to the total project costs, capitalized, the result is a benefit/cost ratio of 3.79 to 1. This means that for every dollar invested in the Honolulu rapid transit system, more than $3.79 will be returned in quantifiable benefits. A summary of the benefits and costs is given in Table 2-4.

Economic and social benefits accruing to the region from the construction of rapid transit are:

- Inexpensive, rapid, comfortable, clean, and dependable transportation
- Greater ease of movement into and out of central Honolulu and over the entire Island
- Decrease of surface traffic congestion in the City and on traffic arteries throughout the region
- Reduced requirement for all-day downtown parking.
- Access to jobs in the suburbs for residents of the inner city, and greater work force selection for suburban employers
- Enhancement of real estate values
- Net increase in tax bases

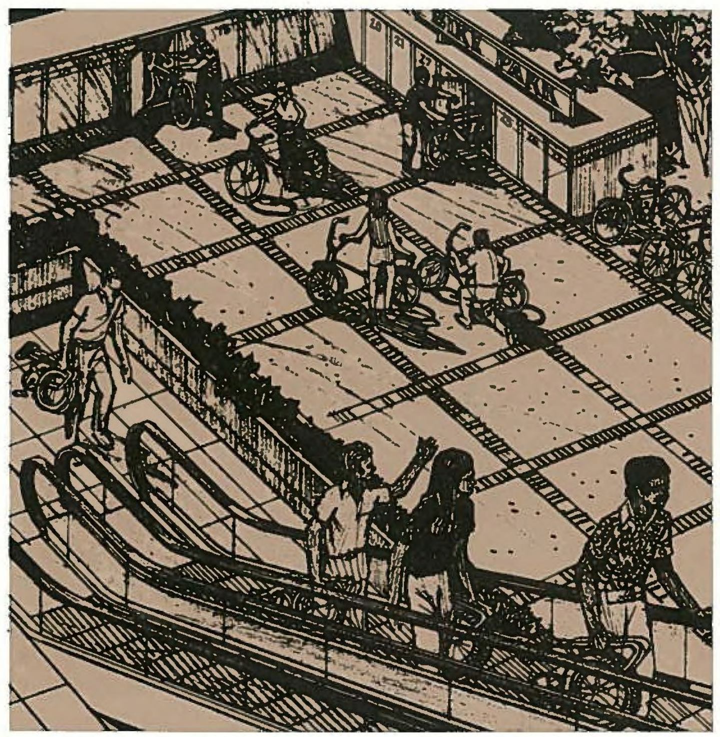


FIGURE 2-7 Bicycle Storage in Transit Stations

Table 2-4

TANGIBLE BENEFITS AND COSTS

Benefits	Present Value [1979] (million of $)	Total
Travelers		
transit users*	1384	
non-transit users	1534	
regional	277	
TOTAL BENEFITS**	3195	**3195**
Costs		
Initial System Cost (Rounded)	700	
Cost of additional equipment and replacement	141	
TOTAL COST	841	**841**
Benefit Cost Ratio 3.79 to 1		
*Net of Fares		
**Net Present Value of Benefits	2354	

- Expansion of job opportunities
- De-emphasis of the dependence on surface vehicles for movement in the heart of the city
- A transportation service that will operate 20 hours daily, serve central city stations every two minutes during most of the day
- Better and more efficient use of existing transportation facilities, both public and private
- An efficient feeder bus system that will place the great majority of Oahu residents within a short walk of public transportation
- A rapid transit plan that can be expanded into new areas when needed
- Prevent urbal sprawl by providing structured growth for the orderly development of Oahu.
- Creation of thousands of jobs by the construction of the system and its operation
- Stations and structures designed to make a distinctive and favorable contribution to the Island environment
- Encouragement of economic development around station service areas.

Table 2-5

POTENTIAL ANNUAL SAVINGS OF A TYPICAL COMMUTER (1972 DOLLARS)

	Diverted Motorist Using Rapid Transit	Non-Rapid Transit User
Vehicle Operating Savings	$ 223	$ 45
Automobile Insurance Savings	28	—
Downtown Parking Savings	300	—
Time Savings	130	116
Subtotal	$ 681	$161
Vehicle Ownership Savings	$ 914	$ —
Potential Savings	$1,595	$161
Less: Fares Paid	$ 198	$ —
Total Potential Savings	$1,397	$161
Rapid Transit System Capital Cost	$ 20	$ 20
Net Potential Savings (Annual)	**$1,377**	**$141**

In order to illustrate the possible monetary impact of rapid transit on Island residents, the potential savings which could accrue to a typical head of household are given in Table 2-5. The costs are the result of assumed taxes and transit fare. The benefits are primarily the result of reductions in automotive transportation costs and time savings. Additional secondary benefits might accrue to both transit users and non-users in the form of taxes not incurred for building and maintaining other transportation modes, such as highways; property taxes not incurred through net loss of assessed valuation; and decreased property taxes caused by the overall increase in property tax base from higher investment around transit stations. Although the transit user will benefit more than the non-user, even the secondary benefits received by the non-user will more than offset the costs.

IMPLEMENTATION

The Preliminary Engineering Evaluation Program constituted the first major step of the long-range transit development program for the Island of Oahu. The program defines the type of vehicle system, route and facilities location, capital, operation and maintenance costs, environmental impact, benefit-cost ratio, and financing and implementation requirements. Based on the above, the City Administration has adopted the policy to take necessary action leading towards implementation of the program at the earliest possible date.

By expeditiously advancing the program, it is estimated that the earliest date to place the rapid transit system in operation would be late 1978. With this as a goal, an implementation schedule with major activities and milestones to be met has been identified. The critical period in the schedule is 1973 wherein most of the key policy decisions must be made. Concurrent activities involving the obtaining of capital funding and meeting of certain statutory requirements before any funds can be expended should be initiated at an early date. The major activities required to be initiated in early 1973 in order to meet the implementation goal are as follows:

- Initiation of Definitive Design Project
- Securing of local and federal capital funds
- Processing of the Environmental Impact Statement
- Plan adoption by the City including public hearings leading to General Plan Amendment
- Initiation of relocation assistance program

As part of the implementation analysis, the organizational form and structure best suited to implement and operate the Island-wide transit system was studied. Relative to the form of organization, 3 basic organizational alternatives were found to be equally suitable since the City and County of Honolulu encompasses the entire Island of Oahu which in effect, makes it a regional or metropolitan form of government. The 3 forms of organizational alternatives are:

- Division or Department of the City
- Board of Transportation—a semi-autonomous agency of the City
- Transit Authority—an autonomous entity

The organizational structure best suited to operate and maintain the proposed system was developed to basically fit any of the alternative organizational forms.

It is recommended that the operation of the existing bus transit system and the implementation of the long-range rapid transit program be continued under the Department of Transportation Services as currently existing. This would permit continuity with the least amount of disruption to effectively advance the proposed program. The form of organization to operate the transit system can then be selected and implemented after the financing of the project is secured.

ENVIRONMENTAL IMPACT

The Preliminary Engineering Evaluation Program was undertaken to develop a modern and efficient rapid transit system in sufficient detail to permit the preparation of reliable cost estimates both financially and environmentally. An extensive draft Environmental Impact Statement[1] was prepared to provide the necessary information by which all interested parties could evaluate the socio-environmental impact of the proposed system. The proposed system was evaluated in terms of its own advantages and disadvantages as well as compared with the long-range alternative means of providing the same level of transportation mobility. The three alternatives compared were:

- **AUTO-DOMINANT—**This system alternate utilizes surface streets and highways for an expanded bus fleet and continued reliance on the automobile.
- **BUS ON BUSWAY—**This system uses buses operating on exclusive grade-separated rights-of-way for express service and an expanded surface bus operation for collection and distribution.
- **WATERBORNE—**This alternative uses high speed hydrofoils as an ocean express and smaller canal feeder boats in the waterways in and around Honolulu for collection and distribution.

Each system was evaluated on the basis of the following major elements of impact:

- Air Pollution
- Noise Pollution
- Impact to surrounding environment
- Cost
- Ability to meet long-range transportation requirements

CONCLUSION

The electrified fixed guideway rapid transit system in the urbanized area of Honolulu, combined with a comprehensive bus system serving the entire island, is the best long-range alternative to meet Oahu's transportation demands. The introduction of a rapid transit system would provide an alternate mode of transportation which would be less polluting, require less land and allow more contained or structured growth than the present system of highway construction which brings with it more pollution, large land takings and scattered growth patterns.

PUBLIC INFORMATION PROGRAM

In order to insure that the planning of a rapid transit system for Oahu would correspond to community goals and desires, a public information program was developed to obtain community opinions and ideas concerning all aspects of system planning.[9] Over 300 meetings and workshops were held to provide a continuing educational process through all stages of the program. The community feedback received during the course of these discussions influenced the direction of final recommendations to produce a public transportation system which not only satisfied travel demands and engineering requirements, but also responded to community standards and desires.

FIGURE 2-8 Civic Center Station Sunken Garden

SANDWICH ISLANDS

BY THE

U. S. Ex. Ex.

1841.

the island of oahu 3

THE ISLAND'S HERITAGE

No one knows the exact date the polynesians first set foot on these islands but by 1778 when Captain James Cook arrived, Hawaii was a loose congress of local feudalistic societies with a population of about 300,000.

In the later 18th and early 19th century, one chief, King Kamehameha I, succeeded, largely by conquest, in unifying the entire chain of Hawaiian Islands into one kingdom. Over the next 100 years, the power of that monarchy was gradually eroded by growing western sugar interests as well as influential American missionary groups until in 1893 the monarchy was overthrown.

During this period the old Hawaiian culture slowly disappeared as rapid changes brought not only new people and new customs to the Islands but new diseases as well. The polynesians, due to their long isolation, were left with little, if any, resistance to western diseases and as a result the native population dwindled to less than 60,000 by the late 1800's. The overall population of the Islands, however, continued to grow. The development of the sugar and pineapple industry brought thousands of immigrants from many different parts of the world to work on Hawaii's plantations. This influx in immigrants from Asia and other countries gave rise to the immense variety of cultural and ethnic groups, which make up Hawaii's present population.

In 1898, shortly after Queen Liliuokalani was deposed and the monarchy ended, the Hawaiian Islands were annexed by the United States and the Territory of Hawaii was established.

The pattern of growth began to accelerate even more rapidly. In addition to agriculture; cattle ranching and tourism began to take on greater importance in the island economy. The United States established strategic military bases on Oahu which further diversified and aided the economy. With the attack on Pearl Harbor which precipitated the United States' entry into the Second World War, Hawaii changed radically. The civilian economy was quickly replaced by a military economy, geared entirely toward the war effort. The military services became Hawaii's principal source of income. The Islands and her people played an important role throughout the war and prospered economically even while under martial law.

The postwar period until 1954 was largely one of stagnation, however, in the middle 50's Hawaii began to experience spectacular growth. On August 21, 1959 Hawaii was admitted as the 50th State of the Union and since that time the Islands have expanded in virtually all economic and social aspects.

Hawaii today is a state with a strong and increasingly diversified economy and a society made up of a multiplicity of races and cultures. Lying roughly in the center of the Pacific Ocean, Hawaii is and will continue to be the hub of a variety of East-West international activities.

THE STATE OF HAWAII AND HONOLULU

Hawaii is unique, not only because it is discontiguous from the mainland states, but also because it is discontiguous within itself. It consists of eight major islands and 124 minor islands with a total area of 6,425 square miles.

The City and County of Honolulu which includes the entire Island of Oahu is the most heavily populated of the state's four counties. The population in 1970 was 630,000, including 55,000 military personnel, which represents 81% of the entire state. Honolulu is not only the capital of the State of Hawaii, it is also the state's financial and visitor center.

In the past 25 years, since the Second World War, Honolulu has exploded from a leisurely sub-tropical paradise into the 16th largest city in the United States. Bordered on one side by the sea and the Koolau Mountains on the other, Honolulu has developed from a coastal town into a modern linear city which reaches far up the mountain sides above the shoreline.

The State Department of Planning and Economic Development estimates that the Island's expanding economy will

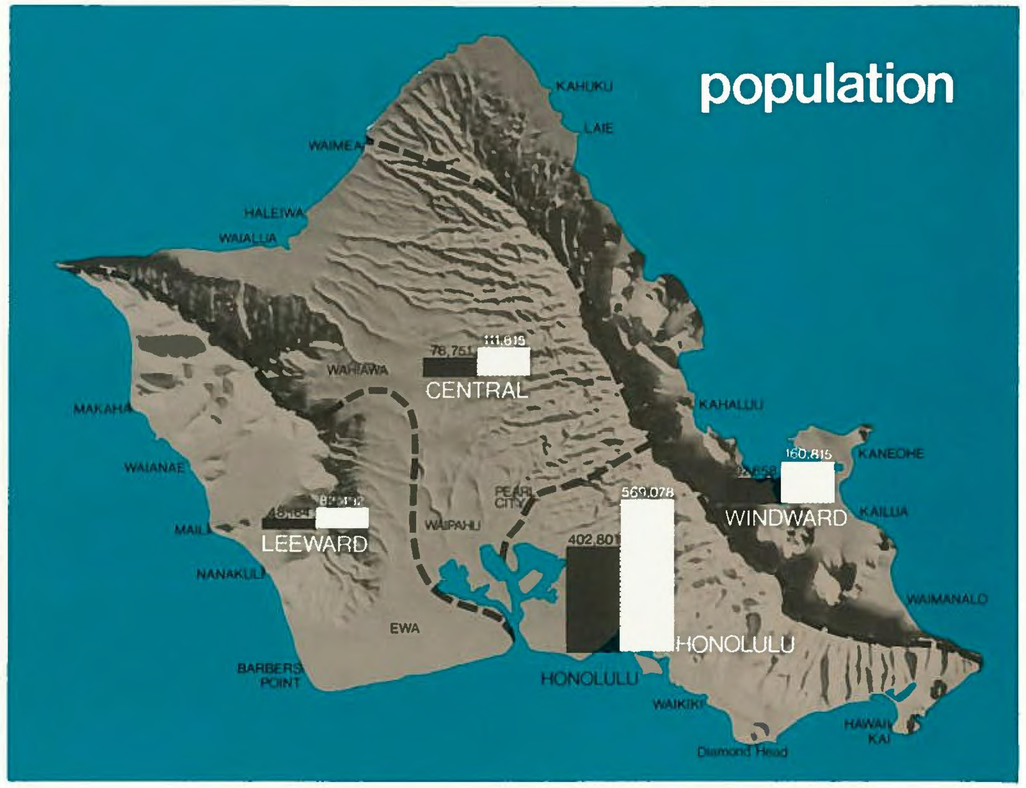


FIGURE 3-1 Population Distribution Island of Oahu

FIGURE 3-2 Employment Distribution Island of Oahu

provide enough jobs to support a population of 1,132,000 by the year 2010. That growth will require even more development to provide housing, schools, public facilities and an expanded transportation system to provide mobility for this growing population as well as make more accessible, the city's resources.

TRANSPORTATION, EMPLOYMENT AND POPULATION

Projections of future employment patterns indicate that by 1995 the total number of jobs on Oahu will have increased by 158,143 over 1960.[2] Approximately 78% of these additional jobs will be located in the metropolitan Honolulu area from Pearl City to Hawaii Kai. The only major employment center outside this area expected to show a significant employment increase in 1995 is the Campbell Estate Industrial Park at Barbers Point. In 1970 this industrial park employed approximately 1,500 persons, the 1995 land use model predicts this employment will increase to 25,000.

The State Department of Planning and Economic Development has estimated a resident population of 924,000 on Oahu by 1995. In 1960, approximately 65% of the island-wide population resided within the central corridor from Pearl City to Kahala. Between 1960 and 1970 this corridor experienced a numerical increase of 46,500 people, but a percentage decline to 59% of the island-wide population. In this period, population increased in the Hawaii Kai area, Kaneohe and Kailua on the Windward side, Mililani and Waipahu in the Central Valley, and Waianae and Makakilo on the Leeward side of the island. The 1995 output from the land use model projected a population of 511,269 for the central corridor, or 55% of the total island population. These figures substantiate analysis indicating a trend toward suburban residential development on the island.

The continuing concentration of employment in the urban core and increasing suburban residential growth emphasizes the need for expanded transportation capacity, particularly during rush hours, to provide mobility between the home and place of work. This expanded transportation capacity has been difficult to achieve with an automobile-oriented street and freeway system because of geographical constraints and other reasons. Thus, attention is focused on public transportation as a mode capable of supplying additional capacity in the most efficient manner with a minimum of financial and environmental impact. In addition, an expanded public transportation system can provide for increased access to jobs for the disadvantaged.

TRANSPORTATION AND EDUCATION

An expanding population and economy produce and require a corresponding expansion of the educational base. In 1969-70 a total of 205,857 students attended classes in schools and colleges on Oahu. That figure will increase to 295,598 by 1990 requiring construction of many new educational facilities.

Students traditionally are best served by public transportation modes which relieve pressure for automobile ownership. In addition, parking and local street congestion are serious problems at the University of Hawaii and many secondary schools. Public transportation could serve to link major urban school centers with themselves and with residential areas and in the process provide expanded educational opportunities for the people of Oahu.

TRANSPORTATION AND PUBLIC SERVICES

Government and public services are major economic factors on the Island of Oahu. In 1969 expenditures by government agencies amounted to over $481 million.

Honolulu houses both the State and County governmental offices and employed over 71,200 persons in 1969. That total included 34,700 Federal workers, 26,100 persons employed by the State, and 10,300 persons on the county payrolls. Many of these employees commute from outside the central city and efficient public transportation must be made available to them.

Governmental services also attract the customers of government who use public services. Getting to these services in Honolulu is presently time consuming and expensive for many persons. A low-cost, efficient public transportation system would reduce travel costs, eliminate parking requirements and save time for people using these public services.

While not all health facilities are public, they all provide vital public services. These major medical facilities attract large numbers of employees, outpatients and visitors who would all benefit greatly from reduced travel time and costs as well as increased convenience. Adequate public transit would, in fact, make these facilities more readily accessible to those outpatients unable to drive automobiles such as the physically handicapped.

The percentage of older people to the total population in Honolulu is growing. People 65 years and older now represent about 5% of the island's population and is likely to increase as advances are made in geriatric care. Public transportation will particularly benefit the aged, since they are less likely to have private means of transportation, for both financial and physical reasons. In addition, public transportation is a must for another large segment of the populace whose life style is constrained by lack of automobile availability. The young, the handicapped, the poor, and those unable to drive constitute a substantial proportion of the total population.

TRANSPORTATION AND RECREATION

Hawaii's residents live in an environment of recreational opportunities. As the time and money available for leisure activities increases, the use of recreational, cultural and entertainment facilities becomes more important. On Oahu these facilities range from the natural beach and water recreation areas to sports arenas and theatres. The new Halawa Stadium seating up to 50,000 people will become a major focal point for sporting events when completed. The Honolulu International Center contains in addition to a sports arena, exhibition halls and concert facilities. Throughout the city are numerous other cultural and recreational institutions such as the Academy of Arts, the Bishop Museum, the Symphony Hall as well as many theatres and historic sites.

A convenient public transportation system connecting these recreational and cultural facilities will become increasingly important for the growing population, as well as for visitors.

TRANSPORTATION AND SHOPPING

Retail trade in the State of Hawaii has undergone rapid growth in recent decades with metropolitan Honolulu accounting for more than 83% of the market. From $522 million in 1958, retail sales increased to over $1.7 billion by 1969.

Shopping centers are common on Oahu, one of the largest in the world is the multi-leveled Ala Moana Center. It covers 50 acres, located between downtown Honolulu and Waikiki, with parking for 7,800 cars and an average of 1.8 million shoppers every month. Other major shopping centers are the Kahala Mall and the recently opened Pearl Ridge Mall. In addition there are intensive shopping areas in Waikiki and the Fort Street Mall.

While the Central Business District remains the financial core of Honolulu, it has declined as a major commercial center due to the development of new and more convenient suburban shopping facilities.

All of these shopping areas, both suburban shopping centers and those in the central city, can be made more accessible to shoppers with good public transportation and bus services. Stations can be located adjacent to all existing commercial centers to the advantage of both merchants and shoppers.

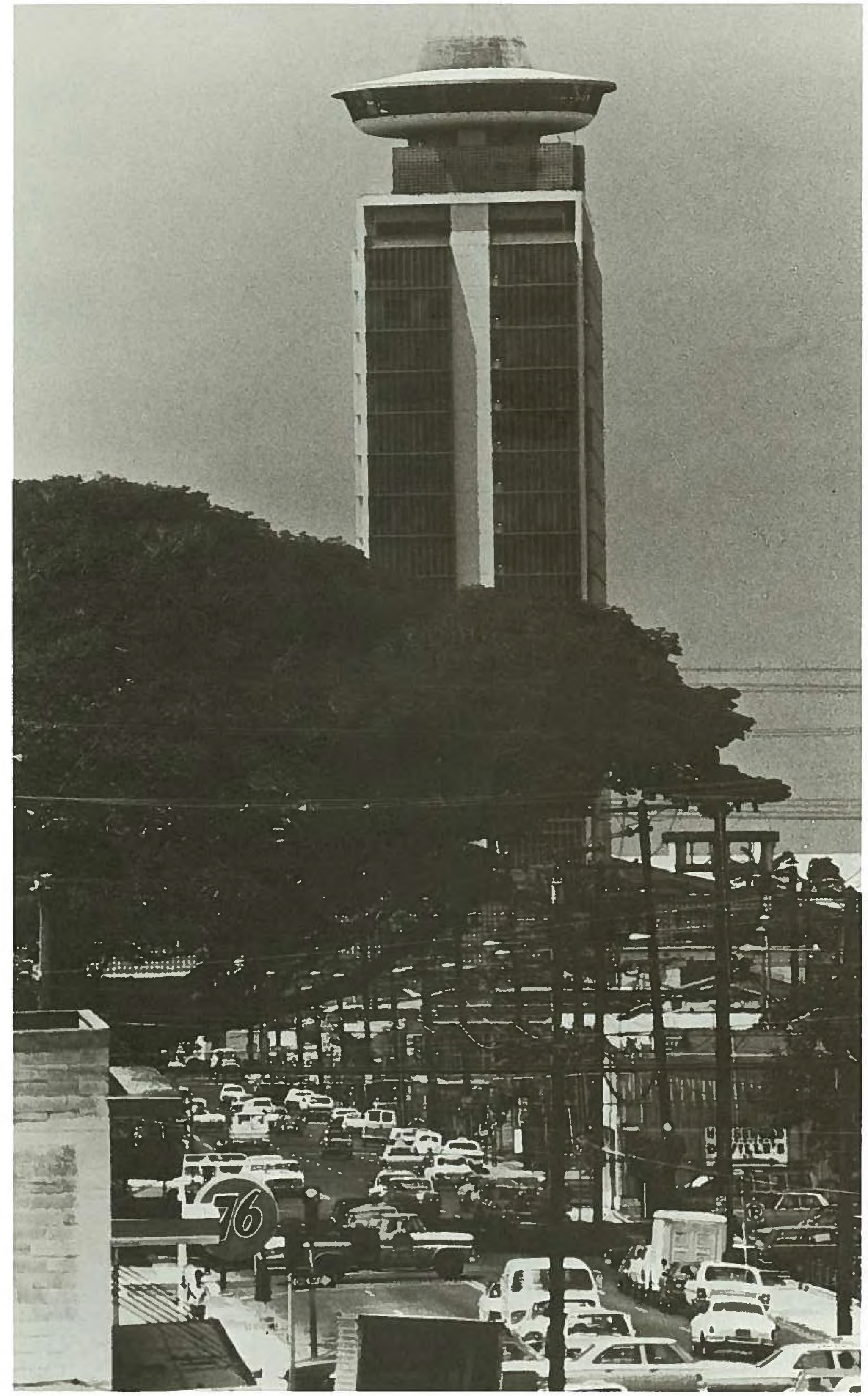
In the downtown area of Honolulu a unique opportunity exists to integrate a major transit station with the retail trade area allowing transit patrons to shop while going to and from work in the financial and office center of the city. More convenient access could also act as a catalyst for the revitalization of the urban core.

TRANSPORTATION AND TOURISM

Hawaii attracts millions of tourists every year to enjoy her tropical climate and beautiful environment. The number of visitors staying overnight or longer in Hawaii has increased from 32,000 in 1941 to 1,800,000 in 1970. Visitor expenditures during that same period rose from $16.4 million to over $600 million making tourism the second most important source of income for the State behind defense expenditures.

There are over 27,000 hotel units throughout the State; two thirds of which are located on Oahu, primarily in Waikiki. With lower air fares, jet travel and new direct air routes to key mainland cities and other Pacific countries, the number of visitors to the islands will continue to increase.

A convenient public transportation system designed and styled for the Hawaiian environment could provide these visitors with an attractive means of moving about on the island and thereby offer improved accessibility to the city and county's cultural and recreational attractions.



transportation requirements 4

INTRODUCTION

Honolulu, like most mainland urban regions, experienced very rapid growth during the fifties and sixties which coincided with the coming of the automobile era. During this period, public transportation began to decline as automobile ownership increased. This created an enormous demand for private transportation facilities; over 1200 miles of public streets and highways have been developed on Oahu.

With both population and mobility of the people to increase, travel demand on the Island of Oahu will continue to grow. During the past decade, from 1960 to 1970, population rose from 500,000 to 630,000, an increase of approximately 25%. Over the same period, motor vehicle registration rose from some 180,000 to nearly 320,000, an increase of 75%. The increase in number of motor vehicles was therefore three times greater than the population growth during this period. Consequently, the motor vehicle per capita ratio increased from 350 vehicles per 1,000 persons to 500 vehicles per 1,000 persons or the equivalent of one vehicle for every 2 persons. (Figure 4-1)

The motor vehicle registration is projected to increase to over 500,000 by 1995 giving a ratio of nearly 550 vehicles per 1,000 persons. Thus, the future number of motor vehicles on the Island will continue to increase but at a decreasing rate as compared to past trend. In 1970, over 1.5 million total trips per day were estimated to have been made on the Island. By 1995, it is projected that some 3 million trips will be made by the forecasted population of 924,000. The future volume of total trips is projected to increase at a higher rate than the population growth which implies greater mobility demand by the people in the future.

The future population and employment distribution is projected to generally follow the past locational trend with continuing intensification of the present urbanized areas.[2] Relative to traffic pattern and volume, the most significant factor is the future location of major traffic generators. This is reflected in the projected distribution of nearly 80% of Oahu's employment in the central core of Honolulu stretching from Pearl Harbor to Diamond Head. With most of Oahu's major activity and employment centers located in this intensively developed central core, travel demand to and through this area can only increase in the future. The population growth, the location of major activity and employment centers, and the basic mobility needs of the people underlie the future travel demand of the Island. Current travel volumes existing on major travel corridors will continue to grow with increasing congestion to be expected during peak hours.

The existing streets and highway facilities serving the Honolulu urban core are operating at or near capacity with the contemplated improvements expected to provide only short-term relief. Any wholly new transportation facilities required to meet future demand will tend to be very costly and disruptive to the community. Therefore, future transportation programs to meet the travel demands of Honolulu must be carefully scrutinized in terms of both financial and environmental effects on the region.

EXISTING TRANSIT SYSTEM

The three privately owned bus companies that had been providing scheduled transit service on the Island of Oahu were the Honolulu Rapid Transit Company, Ltd. (HRT), Wahiawa Transport System, Inc. (WTS), a subsidiary of HRT, and Leeward Bus Company, Ltd. (LBC). In addition, the City and County of Honolulu operated transit routes by contracts with WTS and LBC in serving areas which the private companies did not serve.

Of the 24 basic bus routes that existed on the Island in 1970, 16 were operated by HRT, 2 by WTS, 1 by LBC, and 5 by the City and County of Honolulu. HRT, the largest and oldest company, primarily served urban Honolulu and carried close to 90% of the daily passenger volume of the whole Island. Due to a labor dispute, HRT and WTS curtailed operations on January 1, 1971. At that time, the City and County of Honolulu terminated its contracts with WTS. The City and County then purchased some 70 buses and began operating its own bus system to provide services in urban Honolulu and to the North Shore and Wahiawa areas. Subsequently, additional buses were purchased to augment the initial fleet to a current total of 143 buses. In its endeavors to achieve a goal of free public transportation, in September of 1972, the City and County of Honolulu initiated a policy providing that senior citizens would ride free at any time of the day on all city-owned buses. Also included were those buses operated and owned by the Waianae Coast Transportation Services, Inc., and the public transportation system operated by the Model Cities program in the Waianae-Makaha region of Leeward Oahu. In August of 1972, the City and County of Honolulu terminated its contracts with LBC and began their own bus service between Windward Oahu and urban Honolulu.

Currently, there are three operating properties providing scheduled transit service on Oahu, the City and County of Honolulu, Leeward Bus Co., Ltd. (LBC), and the Waianae Coast Transportation Services, Inc. (WCTS). The City and County of Honolulu provides bus service in urban Honolulu and also provides bus service between Windward, Central and North Shore areas of Oahu and urban Honolulu. The LBC and WCTS provide bus service in the Leeward area and between Leeward Oahu and urban Honolulu. The three bus transit properties operate a total of 137 buses during peak periods, over 392 route miles. Of the total 137 buses, the City and County of Honolulu operates 120 buses, LBC operates 8 buses and WCTS operates 9 buses.

The City & County is embarking on a short-range bus transit development program in order to continue upgrading its bus transit service. Currently, the acquisition of the two remaining private bus companies, the LBC and the WCTS, is in process in order to improve all bus transit services under a single public entity. In the next two years, it is planned to increase the current 143 buses to a total of 360 buses. In anticipation of this increased bus fleet, the City & County has initiated a study for developing a new major storage and maintenance facility in the Pearl City area.

As part of these improvement programs, major steps are being taken to provide reserved highway lanes for buses. One of these would be in the Kalanianaole Highway where the City & County and the State Department of Transportation are jointly planning for reserved bus lanes. Another similar program would be the Likelike Highway which, with reserved bus lanes, could immeasurably improve bus service to the Windward areas of Oahu.

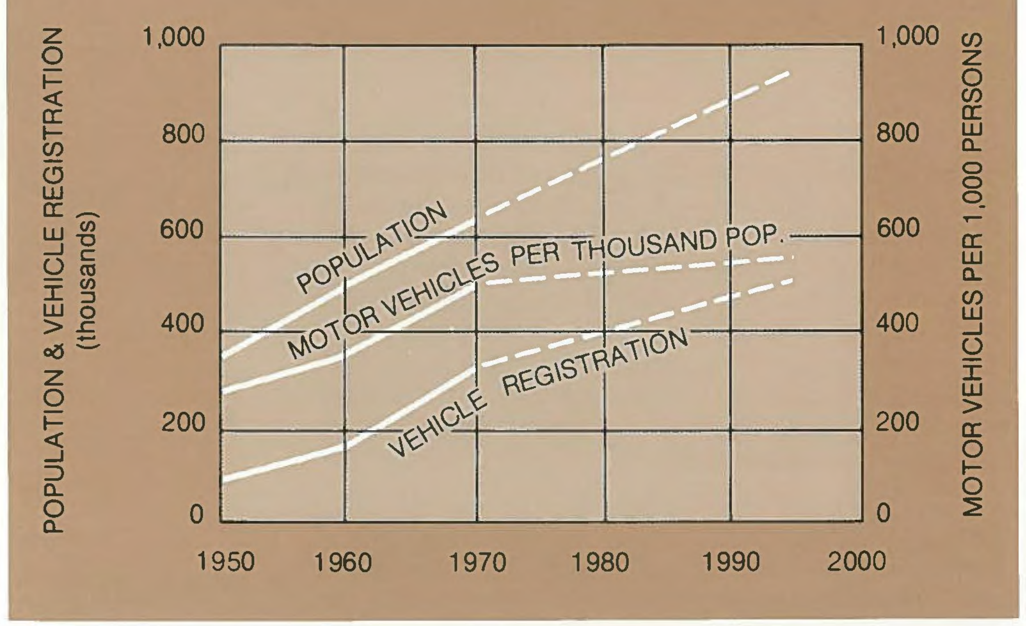
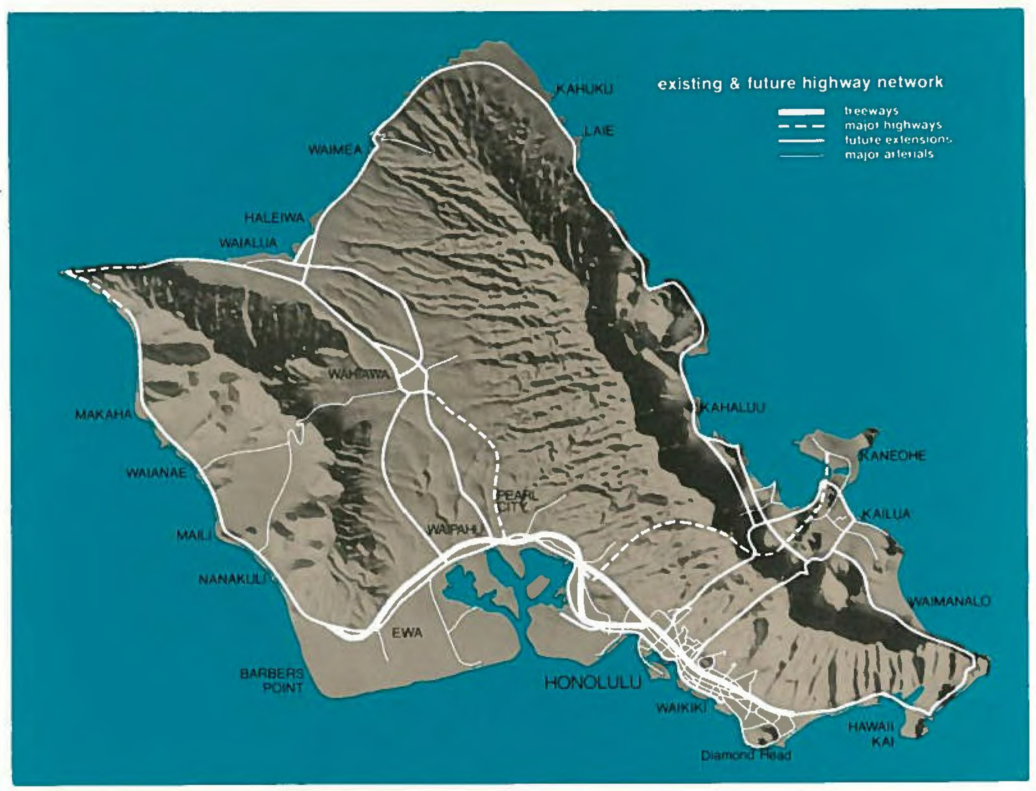


Figure 4-1

MOTOR VEHICLE REGISTRATION ON OAHU



EXISTING AND PLANNED FREEWAY AND ARTERIAL SYSTEMS

The existing and planned Federal interstate highway system (H-1, H-2, and H-3) comprises some 52 miles of freeways and is scheduled to be completed between 1976-78. Of the total 52 miles of the interstate highway system, approximately 22 miles is completed and in use. Approximately 8 miles of the H-1 Freeway currently serves central Honolulu with an additional 14 miles from Aiea to the vicinity of Barbers Point also completed and in use. The connecting link between these two segments of H-1, the H-2 to serve the Wahiawa area, and the H-3 to serve Windward Oahu are currently in various stages of design and construction. (See Figure 4-2)

The interstate highway system when completed will provide improved access with adequate capacity to central Honolulu from the Leeward, Central, and Windward regions of Oahu. With heavy concentration of government and commerce located in central Honolulu, the existing segment of the H-1 (Lunalilo Freeway) will be heavily used and become the critical link in the interstate system.

Within the central Honolulu area, the major arterials are Beretania Street, King Street, Kapiolani Boulevard, Dillingham Boulevard, and Nimitz Highway/Ala Moana Boulevard which, together with the Lunalilo Freeway, provide for major east-west movements. Various north-south arterials provide access from the residential areas to the makai side of the central Honolulu area. In a recent TOPICS report, it was indicated that all major east-west and north-south arterials are classified as having a level of service at or near "unstable flow with intolerable delay."

In the central Honolulu area, the theoretical capacities of the existing freeway and arterial network providing major east-west movements ranges from 250,000 to 275,000 vehicles per day. Based on 1970 screen line traffic counts, there were some 250,000 vehicles operating in this area. Therefore, through the central Honolulu area, the existing roadways are carrying traffic volumes near or at capacity.

The only major arterial serving the area from Waialae-Kahala to Hawaii Kai is the Kalanianaole Highway. The theoretical capacity of this arterial ranges up to 40,000 vehicles per day for the 6-lane segment with the present volume approaching 40,000. Therefore, with rapid growth anticipated in the Hawaii Kai area, this 4 and 6 lane arterial which is currently heavily congested during peak hours will be in need of immediate increase in capacity.

In summary, the critical transportation needs of the island based on the existing and planned highway and arterial system are in central Honolulu and the Kalanianaole corridor to Hawaii Kai. The following statements are quoted from State of Hawaii, General Plan Revision Program, Part 5 Report:

> "The most urgent need for freeway service is in the makai corridor between Middle Street and Kapahulu Avenue according to the traffic volumes forecast for the east-west major streets in the area."
>
> "Forecasts of traffic volumes on Kalanianaole Highway indicate that rapid transit and roadway capacities equivalent to twelve (12) lanes would be required to satisfy the 1985 travel demand for this corridor."

THE NEED FOR AND THE ROLE OF PUBLIC TRANSPORTATION

Travel demand will continue to increase corresponding to population growth and the increased mobility needs of the people. With a forecast for increased total travel demand, additional transportation facilities will be required. The high concentration of work trips during relatively short periods of the day, combined with other non-work trips also occurring during the same periods, will cause heavy strain on transportation facilities. These short duration, peak period travels require overcapacity facilities to be provided or as is the usual condition existing throughout most metropolitan regions, a high level of congestion would be forced on the traveling public.

To provide street and highway facilities to meet urban travel demand at a desirable level of service is becoming more and more difficult. The 1967 Oahu Transportation Study stated that to provide transportation facilities for a high level of service for Honolulu would not be within the resources available and would not meet with general public acceptance. The high cost of providing facilities to meet future travel demand combined with large land area requirements and detrimental environmental impact have caused this region to re-evaluate its future transportation programs.

In planning for long-range transportation systems, the preservation of existing developments is a major criterion to be met. Large amounts of both private and public funds are invested in existing developments and public facilities, including streets and highways, and are valuable community assets to be preserved and used during their economic life. When these streets and highways can no longer provide for the efficient movement of people and goods, they must be augmented with additional facilities in the least costly and disruptive manner to the community.

The integration of any new with existing modes of transportation wherein the best of each mode is used to meet present and future travel demands is the prime transportation objective. The most personalized and attractive mode of transportation is the private automobile operating on facilities that can provide high levels of service. There is no public transportation mode available presently or in the foreseeable future, that can provide comparable service features of the private automobile operating under ideal roadway conditions. However, certain types of public transportation system can provide fast, high capacity, and efficient service in high volume travel corridors. A broad coverage public transportation system can also provide increased mobility to those segments of the population with restricted mobility. These basic service features highlight the type of mass transit required to complement the existing street and highway system to provide economic and balanced transportation for the region.

There is an urgent need for additional transportation capacity in the urban core of Honolulu. The urgency is due to the current travel volumes approaching design capacities and the length of time required to implement any major new facilities. Furthermore, to accommodate the anticipated population increases, future developments must be planned and coordinated with transportation facilities for the orderly and efficient growth of the Island.

The transportation needs of the Island may be related to the projected growth. Between 1970 and 1995, a 40% increase in total Island population is projected from 630,000 to 924,000. Similar growth is anticipated within the urban core area as well as a 50% increase in employment. These factors imply that the urban core area, which is currently highly developed, will continue to increase in population density and to remain and grow as the regional employment center containing nearly 80% of the Island's total employment.

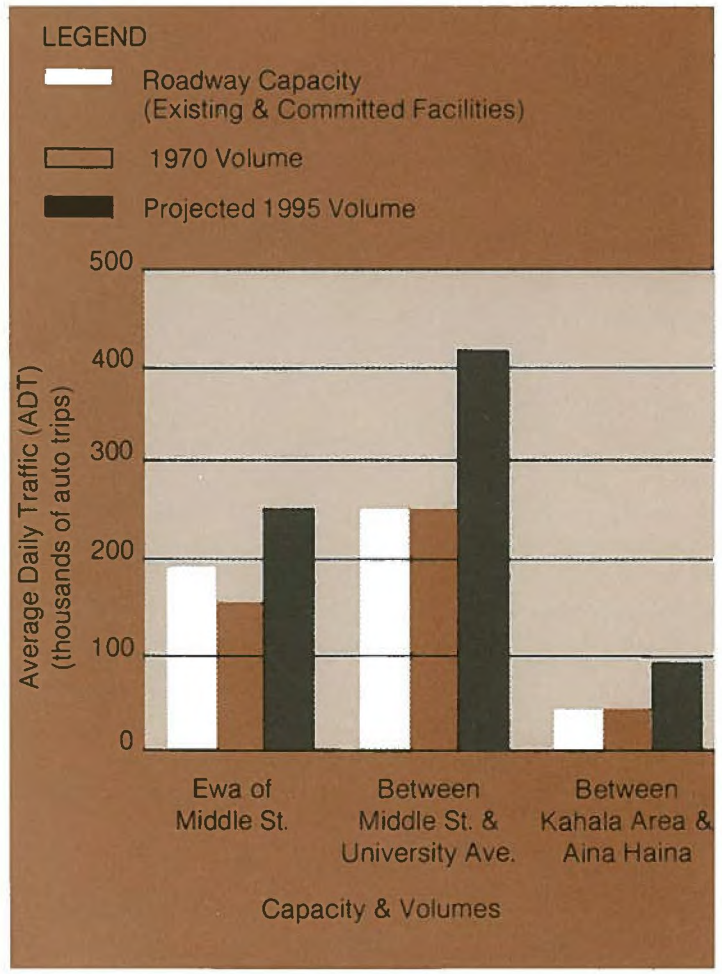
Based on these population and employment growths projected for the urban core, it is reasonable to assume a corresponding increase in the current travel volumes experienced on the major east-west travel corridor of the area. Recent studies conducted under the TOPICS and National Transportation Needs Study programs indicate an urgent need for improvements to the transportation facilities. These studies indicate the current vehicular traffic volumes are near or at the design capacity of the existing highways and arterials. (See Figure 4-3).

The anticipated increase in travel volume by 1995 can only be accommodated by major facilities provided in the relatively narrow and highly developed travel corridor of central Honolulu. This corridor is defined as approximately 1 mile in width bounded by the H-1 (Lunalilo) Freeway on the mauka side and the Nimitz Highway/Ala Moana Boulevard on the makai side. Within this narrow corridor there are presently 4 major arterials and highways with a combined carrying capacity of some 250,000 vehicles per day. The projected need for 1995 is for a corridor capacity to handle total travel volume equivalent of over 400,000 vehicles per day. The Kalanianaole Highway corridor is also very critical, with projected volumes estimated to be over two times the existing capacity.

The critical transportation need of the Island is in the urban core of Honolulu where supplemental capacity must be provided in the very near future. Certain improvements to existing facilities could be made to increase their capacities as well as to improve safety but these are only short-range solutions to the problem. The long-range program to be implemented should have the capability of being expanded to accommodate volumes well beyond that expected for 1995. Translated into peak hour volume, the system facility must have the capability of handling over 25,000 persons per hour in the peak direction. Therefore, a high capacity transportation system that can be implemented with minimum impact on the community resources within the corridor is needed.

Figure 4-3

PRELIMINARY ROADWAY CAPACITY & VOLUMES



In addition to the capacity requirements, the future transportation system must meet the social needs of the region. In Honolulu, there are approximately 90,000 transit trips on the City's bus system. Of these trips, some 85% are captive riders or persons who are dependent on public transportation for their mobility. Senior citizens, under a free fare plan, constitute about 12% of the total trips and school children make up over 30% of the total trips. These statistics indicate a relatively high dependence on public transportation in Honolulu.

In consideration of the transportation capacity and social needs together with other factors such as noise and air pollution, urban growth and development, shortage of developable lands, costs to the traveling public, etc., it is clear that an improved mass transit system must be implemented at an early date. This determination is based on the critical need for a new form of public transportation system to complement private transportation necessary to achieve balanced transportation in the most economical manner.

From the above discussions and background presented, the role of mass transit as an element of the total regional transportation system is defined as follows:

1. provide fast, high capacity and efficient rapid transit service on exclusive, grade-separated rights-of-way in the major urban travel corridor, capable in particular of serving efficiently the peak hour trips to the most congested areas of central Honolulu.
2. provide appropriate express bus service to outlying suburban developments utilizing highways and freeways in both mixed traffic and exclusive lanes.
3. provide broad coverage local and collection-distribution services outside the rapid transit corridor.
4. plan for providing future people-mover service in high activity centers.
5. plan for integrating future goods movement and special passenger services with the rapid transit system.

system concept and vehicle selection 5

INTRODUCTION

The public mobility system for an urban area is an important and vital factor in enhancing the life style and socio-economic health of the city. In urban America today, the automobile plays the dominant role in providing the means for the majority of trips required for daily activities. However, Honolulu—as with many other large United States cities—has found that automobiles cannot exclusively carry the whole burden of urban mobility. A complementary system is urgently needed for at least two purposes—to provide for peak-hour trips to congested activity zones as an alternative to the automobile; and to provide mobility to that segment of the population which does not have access to an automobile or cannot or does not want to drive.

For these reasons, and to minimize the environmental impact of the transportation activities, the public transit system must be attractive, economical, safe and reliable, and relatively fast. There are various forms of public transit that can meet these requirements, but to a varying degree. Therefore, it was necessary to carefully analyze the alternatives and select the proper system concept that can best serve the needs and aspirations of the people of Honolulu.

The Oahu Transportation Study (OTS) in 1966 and 1967 accomplished some of this analysis by identifying the trunk-line feeder transit concept as the basis for comprehensive transportation planning for the island. However, it was necessary to review in greater detail the public transportation needs of the area and to confirm and define the basic concept of the public transit system to be implemented.

Two basic forms of public transportation systems were examined—waterborne and ground-based systems. For the ground-based system, there are various transit system concepts to be applied, each with its basic type of vehicle and service features. Further, with each concept there are variations in type and physical feature of the vehicle equipment. A comprehensive evaluation was conducted from the broadest aspect of transportation form to the basic type of vehicle equipment in selecting the recommended transit system.[5]

WATERBORNE TRANSIT SYSTEM CONCEPT

A study of the geography of the Island indicates major developments existing on or near the coastline. Therefore, various forms of waterborne transportation have been considered for providing supplemental service in corridors such as the airport to Waikiki and Hawaii Kai to Honolulu Harbor. These systems have been proposed by private entrepreneurs and would utilize fast hydrofoil vessels. In most cases, the service proposed would be somewhat limited in that the same vessels would be utilized for other services such as inter-island trips and tours.

Currently, a waterborne passenger service, utilizing a conventional vessel, is being provided on a trial basis between Honolulu and Pearl Harbor. The service is provided only during the peak periods and is attracting some several hundred commuter trips per day. The vessel is used for tourist excursions during the day and in the evenings.

In order to evaluate the feasibility of a complete waterborne commuter system, a study of alternative waterborne[1] systems was conducted. This study tested and analyzed a waterborne system utilizing high speed hydrofoils for the fast link service together with a feeder system which included both conventional buses on surface streets and canal boats on the inland waterways in and around Honolulu. It was found that the waterborne system would attract less than one-half the patronage of a high level ground-based rapid transit system with complementary feeder buses. It was further verified that the total cost per unit of travel or trips would be considerably higher than any land-based form of transportation system. Various other negative factors, including service reliability and environmental impact, were identified with the waterborne systems but the primary conclusion was that this form of transportation would not meet the long-range public transportation needs of the island as the primary mode. It may, however, offer potentials for inter-island service or for supplemental or special service on Oahu.

LAND-BASED TRANSIT SYSTEM CONCEPTS

There are various types of land-based transportation systems capable of providing commuter service in an urban environment. The method by which the line haul and collection-distribution functions are performed distinguishes one system concept from another. One basic system concept utilizes a common vehicle to perform both the line haul and collection-distribution functions. The second basic concept utilizes two or more different types of vehicles to perform service functions.

The use of a single type of vehicle to perform both functions is represented by three different system concepts; dual-mode, personalized rapid transit (PRT), and flexible bus. The concept utilizing two or more types of vehicles is referred to as the trunk line/feeder concept and most commonly represented by the conventional rapid transit system with complementary feeder bus system. Thus the basic transit system concepts which must be considered are:

- Dual-Mode
- Personalized Rapid Transit
- Flexible Bus
- Trunk Line/Feeder

DUAL-MODE CONCEPT

A dual-mode concept is generally defined by the capability of the vehicle system to operate under manual control on surface streets and under fully automatic control on the transit guideway. The vehicle system must have an on-board power plant to operate on streets as well as an electric motor with wayside power source to operate on the guideway. Hence, it can be both manually operated as a standard road vehicle and automatically operated as a fixed or captive guideway vehicle.

A dual-mode vehicle system has not been fully developed and proven as an operating system. The primary advantage of this concept is cited as the potential elimination of transfers between the collection-distribution service and the line haul service where a trip involves both services. A dual-mode concept may be most applicable to and efficient in providing service from a single concentrated origin to a single concentrated destination. It is less applicable to and efficient in providing service from a dispersed origin to a single concentrated destination. Its effectiveness further reduces when both origin and destination are dispersed. It also becomes less efficient as the collection-distribution route distance and travel time are much greater than the fast link operations.

There are several key factors that are primary in considering the dual-mode concept as the regional transit system concept for Honolulu. The first factor is the unavailability of a fully developed, proven, and reliable vehicle hardware to meet the operational date of 1980 or earlier. The second factor, and perhaps the more important, is the operational and cost problems associated with this concept to meet the public transportation needs of the island. To best explain these problems, the following is quoted from a Special Report on New and Novel Transportation Systems by the Institute of Traffic & Transportation Engineering, University of California:

> "All dual-mode systems have a conceptual appeal. It always seems, at first glance, as if a vehicle that will operate in two modes must be at least twice as good as a single-mode vehicle. But the dual-mode vehicle has some significant disadvantages. First, it must be equipped for both modes. This means it is always carrying equipment which is not in use, thus entailing the cost of idle investment. Second, the dual-mode capability is usually achieved by sacrificing performance in at least one of the modes taken singly."

As was previously stated, the dual-mode concept is most applicable for serving areas with concentrated origins and destinations. Normally the development pattern of origin areas are low to medium density residential developments requiring hundreds of miles of transit route to provide adequate service. For example, to provide local transit service for urbanized Honolulu, i.e. from Pearl City to Hawaii Kai, some 30 feeder bus routes with a combined route length of 150 miles were identified. A feeder bus would travel an average of 5 miles, each direction, on surface streets in the urban area. If each of these feeder buses were to operate under a dual-mode concept, it would also travel an average of some 5 to 6 miles on the automated guideway.

Similarly, if express buses serving suburban areas were to be operated under the dual-mode concept, they would have an aggregate of 180 route miles with 13 different bus routes. This would average nearly 14 miles per bus route of surface street operations as compared to some 12 to 14 miles of operations on the automated guideway. In both the feeder and express bus operations, the ratio of travel distance on the surface street to guideway is about one to one.

This analysis indicates that each dual-mode vehicle will be traveling, on the average, one-half its trip on the surface street and one-half on the guideway. In terms of time of operation, it would be on the surface street longer by 2 to 3 times the time expended on the guideway. This simply shows one of the problems of a dual-mode concept whereby an expensive, sophisticated, and heavy vehicle required for automatic guideway operation is spending considerably more time performing non-guideway, collection-distribution function which could be more efficiently provided by conventional road vehicles.

Relative to cost implications, a 40-ft. vehicle for automatic guideway operations would weigh some 15 tons as compared to a conventional 40-ft. bus which weighs 10 tons. There is a significant capital cost differential between the two vehicles as well as in the operating cost in terms of the extra 5 tons of dead weight that must be carried while the vehicle is operating off the guideway. An added cost consideration is the necessity for large, off-line stations to accommodate the number of individual vehicles required under a dual-mode concept. It therefore appears that the dual-mode concept, in addition to the unavailability of fully developed and proven hardware, would be costly to build and operate with a highly questionable application as a regional mass transit system.

PERSONALIZED RAPID TRANSIT (PRT) CONCEPT

The PRT system is conceived as a fixed-guideway, fully automated, small vehicle system operating on a fine-grained network of guideways. It operates on an origin-destination mode in that the vehicle by-passes all intermediate stations and only stops at the rider's final destination station. It is further characterized by the small vehicle which is to provide a highly personalized service.

In order to provide a high level of service, a fine-grained network of guideways is required over a large area. The system also permits vehicles to travel on any part of the network through numerous interchanges between lines to minimize transfers. The vehicle, by virtue of it being fully automated, permits the rider to simply indicate his destination upon boarding and have the computerized control center direct the vehicle to his selected destination.

The PRT vehicle system, including an advanced type of headway command and control system and high speed switching system, capable of safely and reliably operating as a fast link concept has not been developed. In fact most new small vehicle systems currently under development or ready to enter revenue service shortly are people-mover type systems. This type system, although very similar to the PRT system in operating concept is primarily designed to operate at low speeds for application in activity centers such as airports and university campuses.

The PRT system concept, as discussed herein, is a high-speed, small vehicle system operating on an origin-destination mode. The system is also characterized by the off-line station concept to permit vehicles to by-pass intermediate stations. These features suggest close headway operations and relatively high switching speeds to obtain maximum line capacity. Very short headways, ranging from a fraction of a second to several seconds, have been quoted or claimed as theoretically possible but acknowledged as high risk and not currently acceptable as a safe operating condition. Using current safe operating standards, a theoretical minimum headway of 5 seconds is about the best that can be assumed with the practical minimum headway approaching 10 seconds considered to be the limit under a complex network operation.* Thus, even assuming a high risk and unacceptable theoretical headway of 1 second, the maximum line capacity would be some 4,000 vehicles per hour. The maximum practical headway has been estimated to be 500 vehicles per hour or less.

Under the PRT system concept, the highly personalized and demand responsive features combined with origin to destination mode of operation results in a very low vehicle occupancy or utilization factor. The occupancy factor should therefore be comparable to the private automobile or 1.5 to 2.0 persons per vehicle. Even applying the upper range of 2 persons per vehicle to the absolute maximum theoretical line capacity of some 4,000 vehicles per hour, this would result in only 8,000 passengers per hour, one way, on a single guideway. By using the estimated practical line capacity of 500 vehicles per hour, the capacity is only 1,000 passengers per hour, in each direction, for a single guideway operating under a true PRT system concept.

A true PRT system could be extremely attractive from the service standpoint but also very costly due to the extensive network required. Large sums of funds for further research and development are required, and based on the current

*Control Concepts for Automated Urban Transit Systems, E.J. Hinman, APL/JHU

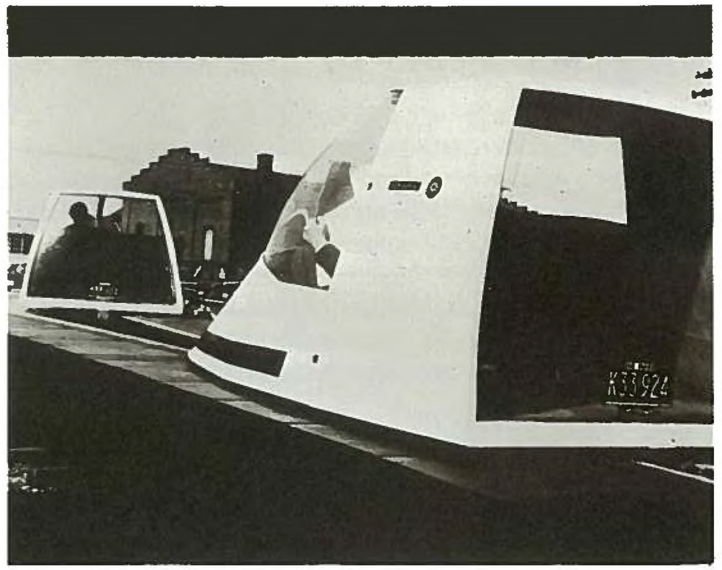


FIGURE 5-1 Dual-Mode System

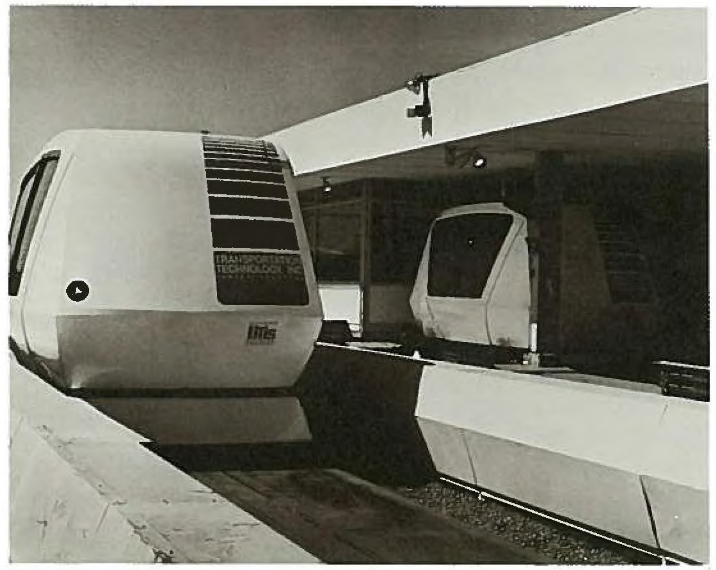


FIGURE 5-2 Personalized Rapid Transit System

FIGURE 5-3 Tracked Air Cushion Vehicle

level of funding by the Federal government, there is no indication that a fast link PRT vehicle system could be developed and tested in less than 5 years.** It would therefore appear that the PRT system would not meet the City's objective to implement a regional mass transit program by 1980, and furthermore, it could be beyond the economic resources of the region to implement such a system to meet the basic objective of providing a high-capacity transit system with broad coverage to serve the needs of the area.

FLEXIBLE BUS CONCEPT

The concept of a flexible bus system utilizes manually operated buses on streets and highways. The operating method is "flexible" in that the buses can be routed over nearly any street or highway to best serve the needs of the area without being fixed permanently to a specific route.

Like the dual-mode and PRT concepts, the flexible system, is characterized by a single vehicle performing both collection-distribution and line haul functions which implies no transfers. However, in terms of actual bus system operation, it does not imply that all persons traveling on buses do not have to transfer depending on his origin and destination and the operating bus route.

As was previously mentioned, public transportation service may be broken down into two basic functions, collection-distribution and line haul. The line haul element, in a metropolitan region, generally applies to high volume movement channels or travel corridors. Any public transportation system utilizing streets and highways in mixed traffic can only move as fast as the rest of the traffic. Therefore, in most major travel corridors, buses must be operated on exclusive bus lanes or busways in order to provide any reasonable level of service.

In the collection-distribution portion, the type or size of buses is governed by local traffic and state highway regulations plus physical limitations relative to street widths, curves, and grades. For the line haul portion, the most economical size would be the largest bus that is available. However, to maximize the non-transfer operation of the bus system, the line haul buses must also perform the collection-distribution function which normally limits the bus size to the standard 40-ft. buses. For certain routes where the surface streets are wide, it may be possible to use 60-ft. articulated buses.

A "bus on busway" concept is a viable concept depending on the system volume and the availability of suitable rights-of-way for constructing the busway and station facilities. The concept is characterized by the manual operation of individual vehicles with a relatively high unit operating cost when compared to trained-vehicle operations. Therefore, the concept is most applicable as a low to medium capacity system where the busway and station facilities can be provided economically.

TRUNK LINE/FEEDER CONCEPT

The principle of the trunk line/feeder concept is to have independent vehicle systems perform various functions which they are best suited to provide and all integrated into a total public transit system. Under this concept, physical transfer from one vehicle system to another is necessary through convenient transfer or interface facilities. All currently existing rapid transit systems are operating under this trunk line/feeder concept. Most of these systems operate with every train making a stop at each station which is known as the "transit mode" of operation.

The concept features a high capacity, high speed, line haul vehicle system operating on fixed guideway for the trunk line element. The feeder elements must perform the collection-distribution as well as the short line haul function to the nearest trunk line station and consequently the use of the word "feeder." The feeder elements permit the use of the most appropriate vehicle systems for varying conditions and required service levels since each system does not constrain or is not constrained by the other systems. For example, small minibuses operating under the demand-responsive method could serve low density areas. A fixed route standard bus system could serve medium density areas, and an automated, fixed guideway, people mover system could serve high activity centers, each interfacing with the trunk line system.

**Transit Options for the Twin Cities Metropolitan Region, Daniel, Mann, Johnson, & Mendenhall/Midwest Planning and Research, Inc. Jan. 1971

COMPARATIVE ANALYSIS OF SYSTEM CONCEPTS

The objectives of the long-range mass transit system development have been defined to aid in selecting the most suitable system for Oahu. The system requirements can be defined in terms of basic parameters whereby the alternative concepts can be qualitatively judged. These parameters may be categorized into 4 basic factors as follows:

- Operational capability by 1980
- Performance capability
- Environmental Impact
- Public Acceptance

A comparative analysis on a qualitative basis for selected factors has been made and presented in matrix form, Table 5-1, and discussed herein.

OPERATIONAL CAPABILITY BY 1980

Conventional buses and fixed guideway vehicles are both fully developed with proven hardware that are currently available. Steel-wheel and rubber-tire rapid transit vehicles are currently in use in many parts of the world with years of proven operating experience. Conventional buses on busway operating at high speed and carrying over 20,000 passengers per hour with frequent station stops are not currently in existence. Therefore, operating data can only be extrapolated from available information from buses operating on surface streets and on exclusive bus lanes to a central terminal station.

Relative to the dual-mode and PRT concepts, no proven vehicle hardware or operating sub-systems currently exist and therefore, the possibility of either of these concepts being sufficiently developed by the operational date of 1980 is very remote. There are and will be special systems in operation but these are for special application and not for a full regional transit system. Therefore, it is concluded that the vehicles systems for dual-mode and PRT concepts would not be available to meet the operational date of 1980 for Honolulu.

PERFORMANCE CAPABILITY

One of the critical requirements for the Honolulu system is for the system to be capable of handling up to 30,000 passengers per hour, each direction. The trunk line/feeder concept utilizing trained-units can accommodate this volume while the other concepts, utilizing single, un-trained vehicles, cannot meet this capacity requirement without building multiple guideways.

However, the other three concepts have a higher scheduled speed than the trunk line/feeder concept due to the off-line stations whereby the vehicles do not necessarily stop at each station. It should be pointed out that the acceleration and deceleration rates and maximum speed are essentially comparable for and attainable by all systems with the basic difference being the use of on-line or off-line stations.

ENVIRONMENTAL IMPACT

Based on the assumption that any concept utilizing on-board internal combustion engines would generate more noise and air pollution than electrically-powered vehicles, it is concluded that the PRT concept would generate the least amount of noise and air pollution. The dual-mode concept would be similar to the PRT concept if the off-guideway operation is by means of battery-driven motors. The flexible bus concept being an all-bus system would have the greatest magnitude of noise and air pollution. The trunk line/feeder concept being a combination of electrically-powered and internal combustion engine vehicles would generate less pollution than an all-bus system but more than an all-electric system.[1]

The visual and environmental impact due to the physical facilities would be the least with the trunk line/feeder concept due to its single-line, high capacity facilities. The greatest detrimental impact would be created by the PRT concept with its multiple line network, assumed to be aerial structures, intruding over large parts of the region.

PUBLIC ACCEPTANCE

Public acceptance is defined as those factors contributing to system attractiveness from the standpoint of service quality and cost. The first factor, user convenience, denotes as a primary factor the number of transfers required. The trunk line/feeder ranks the lowest since the principle of this concept is the use of various types of vehicles which requires a passenger to make transfers. The next factor, service frequency, can be best accommodated by the PRT concept with its demand responsive operations and the trunk line/feeder concept with frequent, scheduled service provided on the trunk line portion of the system operations.

The other important factor is cost. Based on the inherent high-capacity and automatic operation on the trunk line portion of the trunk line/feeder concept, the unit cost for providing this service is the lowest of the alternatives.

CONCLUSIONS ON SYSTEM CONCEPTS

In reviewing the alternative concepts to the various parameters, it should be emphasized that the primary requirements for a system are based on the stated objectives to implement a system by 1980 and to develop a public transportation system which will complement the Island's street and highway network. The vehicle systems for the dual-mode and PRT concepts are neither developed nor operating for detailed evaluation and there is no positive evidence of a major thrust for fully developing these systems in the very near future.[5]

The basic deterrent to full and early development of these newer systems appear not to be entirely in the area of hardware technology but also in the institutional area of public demand for such new systems. The advantages offered by these new system concepts, but with their attendant higher costs, may not necessarily be compatible with the notion of providing efficient public transportation system as a complementary mode to private transportation. The highly personalized and demand responsive features of the newer system concepts could be envisioned as more of a substitute for private transportation and hence, a lack of clear and positive demand for such system concepts for full regional application currently and in the foreseeable future.

For purposes of this comparative analysis, the factors used in judging the alternative concepts are based on the requirements to be met by each system in attaining the stated objectives. However, in the final analysis, certain factors must be considered as primary in selecting the concept or concepts such as system availability in meeting the operational date of 1980. It is concluded that the flexible bus and trunk line/feeder concepts are the only viable alternatives that can feasibly meet the public transportation objectives of the Island.

Table 5-1

COMPARATIVE ANALYSIS OF SYSTEM CONCEPTS

	Dual-Mode	PRT	Flexible Bus	Trunk Line/ Feeder
Demonstrated Hardware	-	-	+	+
Proven Operational Experience	-	-	-0-	+
Line Capacity	-0-	-	-0-	+
Scheduled Speed	-0-	+	-0-	-
Noise & Air Pollution	+	+	-	-0-
Visual Impact	-0-	-	-0-	+
User Convenience	+	+	+	-
Service Frequency	-	+	-	-0-
Cost	-0-	-	-0-	+

LEGEND:

\+ Best

-0- Neutral

\- Most Lacking

COMPARATIVE EVALUATION OF FLEXIBLE BUS & TRUNK LINE/FEEDER CONCEPTS

A detailed evaluation was conducted of the flexible bus or bus on busway concept as an alternative to the trunk line/feeder concept as presented in detail in the draft Environmental Impact Statement for this project. The basic bus on busway concept considered was a full 22-mile system comparable to route and station location of the trunk line/feeder concept. Furthermore, the busway system was assumed to attract the same volume of patronage as the trunk line-feeder concept by providing a comparable level of service as well as facilities[6]

The concepts were developed and optimized to provide a long-range, high level public transportation service to the Island. It should be pointed out that various interim solutions are available but the objective of this evaluation was to compare only the alternative concepts that would meet the long-range public transportation needs of the Island.

Based on the optimum operating criteria for each concept, system requirements were defined and design analysis conducted for fixed facilities and equipment. Right-of-way and relocation requirements, physical dimensions and features of facilities, performance characteristics of equipment, and other system features were established and used as the basis for cost analysis. Estimates of capital cost and operating and maintenance costs were developed for each concept.

Additionally, the design analysis permitted the development of data for making other comparisons. Air pollution emission, noise generation, system reliability, and community impacts were studied and comparisons made between the two system concepts.

The details of the trunk line/feeder concept as evaluated would be similar to the fixed guideway system as described in this report. The details of the bus on busway concept are described fully in the draft Environmental Impact Statement document and summarized herein.

Under the bus on busway concept, two types of buses were assumed, a standard 40-ft. bus and a 60-ft. articulated bus. Under one alternative all buses were assumed to be standard 40-ft. buses while the second alternative utilized standard 40-ft. buses on those routes where the buses operated on both the busway and surface streets and 60-ft. buses on routes that were limited to the busway only.

The busway system facilities basically coincided with the trunk line/feeder concept system to the extent that the routes and station locations were the same for both concepts. The detailed planning analysis indicated that to properly serve the population and employment concentrations with minimum physical and social impacts, the selected route with its stations would be the best of various alternative locations considered for both concepts.

The route configuration for the busway generally followed the same types of construction as the trunk line/feeder concept with most of the system on aerial structures and only 1.6 miles of the route through the downtown area placed underground. The busway structure was established at 34 feet in width to provide 2 moving lanes plus sufficient room for by-passing any disabled buses. Appropriate lengths of acceleration and deceleration lanes were provided at stations to permit efficient and smooth operation of all buses during the critical peak periods. The 6 turnbacks and 7 bus ramps were provided on the busways to provide maximum flexibility of operations.

Two types of busway stations were provided depending on the passenger volume and the number of buses stopping at the station. For stations up to a maximum of 6 berths, in each direction, the parallel saw-tooth configuration was used and for berths in excess of 6, the diagonal configuration was used. Six of the high volume stations are the diagonal type and the remaining 14 stations are of the saw-tooth type.

A detailed analysis of all costs necessary for concept evaluation was made. Costs were developed on comparable basis in terms of system feature, quality, and service, all based on 1972 prices. A 30-year period of analysis was selected and costs escalated at 5% per year and then discounted at 5% to obtain the present worth cost. For the full 22-mile system, the total present worth cost for the trunk line/feeder concept is $1.65 billion and for the busway concept, $1.78 billion and $1.71 billion for all 40-ft. buses and for combination of 40-ft. and 60-ft. buses, respectively. Therefore, the busway concept would cost between $60 and $130 million more than the trunk line/feeder concept on the 30-year period, present worth basis.

A supplemental analysis was made by reducing the system route from 22 miles to 19 miles by placing the ewa terminus at Halawa in lieu of Pearl City such that the route would run between Halawa and Hawaii Kai. Another variation of this analysis is that for the busway system, two-lanes of the proposed H-1 Freeway from Halawa to Middle Street would be assumed as being available for the exclusive use of buses. The results of this analysis was that the cost of the trunk line/feeder concept would be $1.60 billion and for the busway concept, $1.70 billion and $1.64 billion for all 40-ft. buses and for combination of 40-ft. and 60-ft. buses respectively.

In addition to the evaluation of costs, other major evaluative factors considered and analysed are summarized as follows:

- The flexible bus system would produce some 1500 tons more pollutants per year which would be particularly concentrated in the downtown area.
- The noise level would be approximately 10 dbA less for the trunk line/feeder concept.
- The aesthetic and visual impact of the system to the communities would be less for the trunk line/feeder concept due to less massiveness of its structure.
- The system reliability in terms of both service availability and schedule adherence would be better for the trunk line/feeder concept.
- The service convenience measured in terms of number of transfers required would be better for the flexible bus system concept.

Based on the foregoing it is concluded that the trunk line/feeder concept is superior to the flexible bus concept in meeting Honolulu's public transportation objectives and needs.

EVALUATION OF VEHICLE SYSTEMS

Since many types of transit vehicle systems can conform to the basic trunk line/feeder concept, an evaluation was carried out to determine the influence of availability and technological factors on the choice of a vehicle system. The equipment selections described herein have been made for preliminary design and cost estimating purposes and are construed to be a yardstick system. The basic concept may be accomplished in several alternative ways and with alternative equipment. In some cases, the equipment selected has been proved through actual revenue service. In other cases the equipment concept has undergone extensive testing and development sufficient to establish feasibility and cost characteristics adequate for preliminary engineering. Final selection in all cases will be based on additional detailed analyses utilizing the latest state-of-the-art technology, equipment, and subsystems which will improve system operation and/or reduce cost.

VEHICLE SYSTEM ALTERNATIVES

There are many vehicle system choices available within the trunk line/feeder concept. A wide spectrum is open for consideration, from small car to large car systems, and in the means of their support, i.e. steel wheels, rubber tires, air films, or magnetic levitation. There are basically 6 types of trunk line transit vehicle systems which are as follows:

- Conventional Steel-Wheel, Steel-Rail System
- Metro System
- Single-Axle, Pneumatic Tire, Tracked System
- Monorail Systems
- Tracked Air Cushion Vehicle and Linear Induction Motor
- Magnetic Levitation and Propulsion

The magnetic levitation and propulsion system is only in the research stage and estimated to be from 5 to 10 years away before prototypes suitable for urban application would be ready for testing. The tracked air cushioned vehicle system also requires a significant amount of research and development for urban application. Current research is limited to systems with station spacing from 5 to 10 miles apart. Therefore, these two vehicle systems are ruled out of further consideration for the Honolulu program on the basis that they would not be operationally ready by 1980.

The so-called monorail systems have been considered for use in a number of major U.S. cities. In general these systems have been found to be lacking in several respects when compared to conventional rail systems. They are more costly to build and operate plus having undesirable restrictions on passenger seating arrangement, vehicle size, speed, switching, and train operation. These facts are well documented in reports of studies by transit agencies in Los Angeles, San Francisco, and Washington, D.C. Therefore, monorails—as a category of transit vehicle type—are found to be lacking in service, performance and cost when compared with other vehicle types and are ruled out of further consideration as a trunk line vehicle system for the Honolulu program.

The conventional rail system is the oldest and most widely used type throughout the world. The Metro system, a pneumatic tire vehicle, is used in Paris, Montreal, and Mexico City. The single-axle pneumatic tire system has been recently adopted in Pittsburgh and a modified version in Sapporo, Japan. In addition, various manufacturers have prototype single-axle vehicles under varying stages of development, testing, and demonstration with full operational capability expected in the very near future. Therefore, these three basic vehicle types are all considered capable of trunk line operation on fixed guideway or track structure and available for the Honolulu rapid transit system within the desired time frame.

In analyzing the vehicle system requirements for the Honolulu rapid transit system, the long-range plans for the transit system, which envisages the crossing of the Koolau Range to the Windward side and extensions to or beyond Waianae and Wahiawa in the future to serve these outlying urbanized areas, should be considered. Also, in the urban core, the transit corridor traverses the most densely populated areas of the Island.

This implies that, unless the system is constructed mostly in subway, the route must penetrate highly developed areas where environmental impact would be a critical factor.

The vehicle system which will operate over this ultimate transit route directly affects cost, size and character of fixed facilities, level of service, and acceptability of the system by the public. In evaluating the systems, the three primary factors considered were:

- Technical features
- Service
- Public acceptance

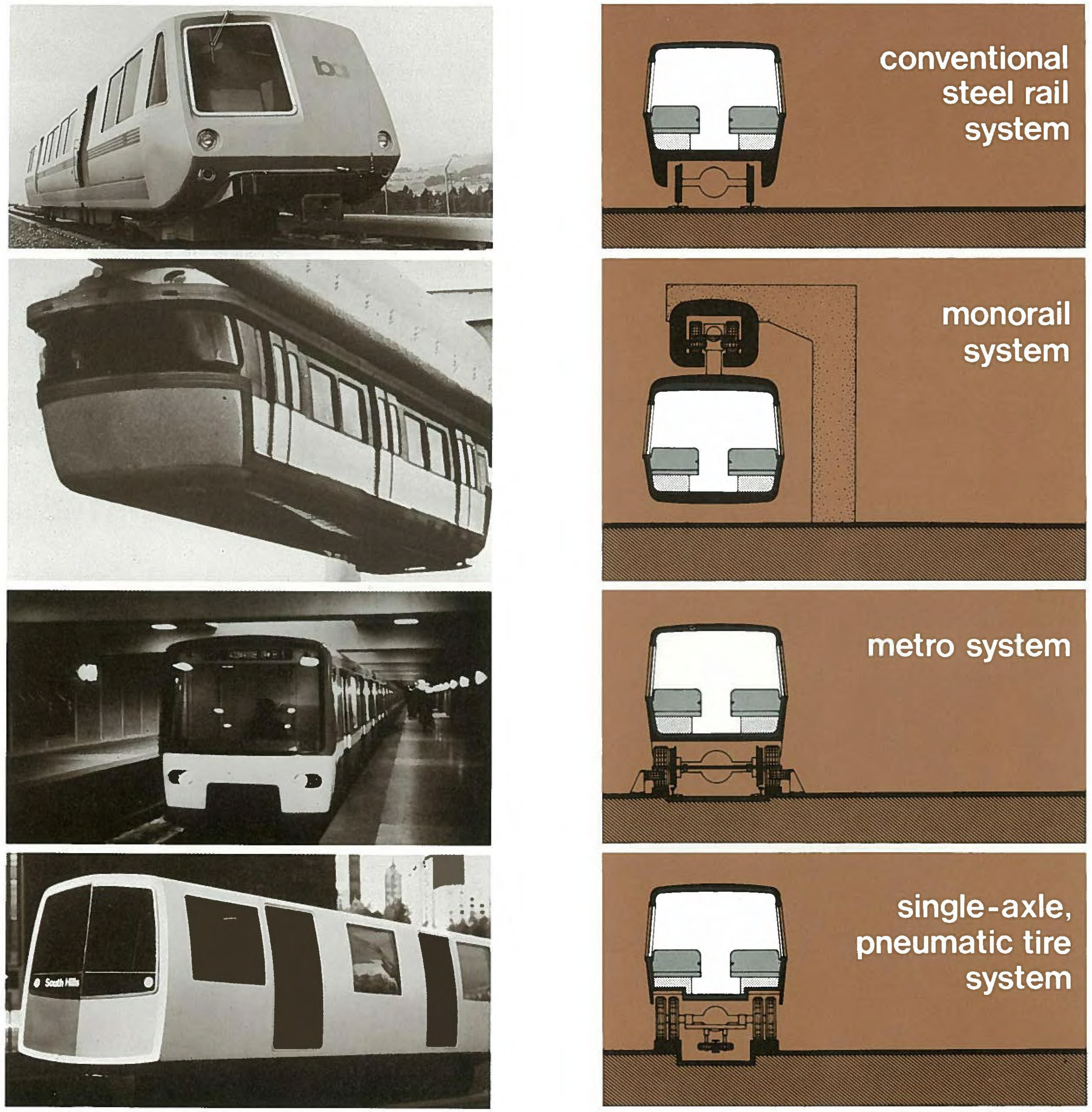


FIGURE 5-5 Trunk-Line Vehicle System Comparison

TECHNICAL FEATURES

A preliminary evaluation of potential vehicle systems which could serve the Honolulu rapid transit system must, because of the immediate plan to construct a system, draw from technology of demonstrated capability. Although new concepts of vehicle system components are under study and experimentation, major advances in such equipment usually require years of development before they are ready for use in revenue operation. The vehicle system chosen to meet the immediate need, however, should be capable of utilizing advances in technology as they become economically practical without major reconstruction of fixed way structures. As was stated before, the vehicle system types that has the capability of trunk line operation within the time frame of the program are conventional rail, Metro, and single-axle, pneumatic tire systems.

Each of these vehicle systems is capable of utilizing the most advanced system of propulsion and automatic train control. Therefore, propulsion, train control and similar items of hardware associated with, but not dependent on the type of vehicle system, are considered to be equal in quality and performance.

THE CONVENTIONAL RAIL utilizes steel flanged wheels running on steel rails, whereas the other two systems operate on pneumatic tires. Flanged steel wheels on steel rails have been used as an economical means of transportation for many years. The concept has advantages of simplicity and a high level of reliability. Steel wheels allow a higher axle loading than any other ground supported means and offers the simplest known solution to an otherwise complicated problem of guidance. Functional capability at speeds well in excess of 75 mph is also well established. The conventional rail system is well known as to both technical features and performance capabilities with a long history of successful operating experience.

THE METRO SYSTEM as installed in Paris, Montreal and Mexico City was developed by the French and initially installed in Paris. The system features a dual-axle bogie concept consisting of two types of wheel combined into one operating piece of equipment. Normal operation utilizes pneumatic tires for load bearing and guidance functions. In the event of tire failure or in switching conditions, the system relies totally on conventional steel flanged wheel-rail equipment. This double trackage requirement is present throughout the entire system and therefore significantly increases track construction costs. The duplication of wheel systems also increases gross vehicle weight when designed to equal standards of space for the passenger. This increase in weight must also be included in design of aerial way structures which would increase costs of fixed facilities over that of a conventional rail system or single-axle pneumatic tire system.

THE SINGLE-AXLE, PNEUMATIC TIRE SYSTEM is a medium capacity, lightweight vehicle system. The Milan-SSG and Transit Expressway systems have demonstrated this concept in test track operation at speeds up to 50 mph. Little detail is available at this time to properly appraise cost of constructing and operating a system utilizing the Milan-SSG. The system is known to have an operating switch which appears to be functionally compatible with requirements for rapid, safe, and reliable switching and vehicles may operate in either direction, as in conventional steel-wheel systems. The Transit Expressway does have an operating switch but does not permit reverse high-speed operation. The system, however, is capable of being designed for bi-directional operation and from its test track operations, well documented technical and operating data are available. The new system in Sapporo, Japan utilizes a combination single and dual rubber-tired, articulated vehicle system and has been in operation since 1971.

A further appraisal of pneumatic tires associated with the single-axle systems indicates that for a duty cycle of 65 mph maximum speed, 35 mph scheduled speed, U.S. tire manufacturer's maximum recommended load to ensure reasonable tire life and reliable service places the maximum vehicle weight at 50,000 lbs. This limits the vehicle size to approximately 36 to 40 seats which places it in the intermediate size category. The key feature which distinguishes this system from the Metro system is the single-axle, lightweight design for an intermediate size vehicle system.

One of the technical features that distinguishes each of the three alternative vehicle systems from the other is vehicle performance characteristics. The conventional rail system has the highest performance efficiency due to the combination of large cars with minimum rolling resistance, therefore requiring minimum power consumption per unit capacity of the vehicle. The Metro system with its combination of high unit vehicle weight and high rolling resistance of the rubber tires requires the highest power consumption per unit capacity of the vehicle. The single-axle, rubber tire system, although utilizing light-weight construction, has a relatively high rolling resistance and thus consumes more power than the conventional steel system but less than the Metro system.

Other key features worthy of comparison are the superiority of the steel rail switching mechanism over the switches currently developed for rubber tire systems. However, guid-

Table 5-2

COMPARISON MATRIX OF VEHICLE SYSTEMS

	Conventional Steel Rail System	Metro System	Single-Axle, Pneumatic Tire System
Capital Cost			X
Operating Cost	X		
Grade Capability		X	X
Switching	X		
Derailment Protection		X	X
Noise & Vibration			X
Visual Impact			X
Service Flexibility			X
Public Acceptance			X

FIGURE 5-7

ance system of the rubber tire systems provide protection against derailment and overturning. For Honolulu, the single most important requirement is the grade climbing capability of the vehicle system. Grades in excess of 6% are required which can be met by the rubber tire systems but not by the steel wheel vehicle.

Another important technical feature is the weight of the vehicles which has a direct bearing on system cost and environmental impact with 90% of the system route planned to have aerial structures. The light-weight, single-axle vehicle system requires the least costly way structure facility. The lightness also means more slender structural girders which will minimize the visual impact of the facility. It also means less noise and vibration from the lighter system.

In evaluating the technical features of the systems relative to cost, it can be summarized that the Metro system has the highest combined capital and operating costs of the alternative system. The single-axle system has the lowest capital cost while the conventional steel system has the lowest operating cost. The sum of capital and operating costs is assumed to be about equal with no measurable difference existing between the single axle system and the conventional steel system.

SERVICE

A modern system of rapid transit is expected to provide prompt, regular and expeditious means of movement about the more heavily populated areas of an urban community. If it does not perform the service desired by the potential rider, particularly the rider who may exercise a choice of mode, the service will not be utilized and the desired relief from traffic congestion will not occur.

The vehicle alternatives currently under study are equally capable of providing space, light, air conditioning, and other comfort factors. But the vehicle systems must also be capable of providing other desired service standards.

The vehicle characteristics should provide a high degree of utilization for the projected patronage while affording flexibility in train consist to meet changing demand for service. The ability to adjust to varying demand is particularly important because patronage will grow from year to year after operation is begun and the ability to adjust service to meet this changing demand will afford economy of operation while maintaining quality of service. Additional flexibility to provide varying train consists to match low off-peak demand is also an important feature to provide.

The vehicle system must be capable of running small trains for economy, yet at frequent headways for convenience. The most appropriate vehicle system needs to be feasibly and economically adaptable to these service requirements. With smaller vehicles, the capacity can be tailored much more efficiently to meet demand during any period of the day. The off-peak periods are best accommodated by the smaller vehicles since these vehicles could be operated economically such that the capacity could meet the low demand while operating at frequent headways for convenience. Also these smaller vehicles provide the greatest flexibility to efficiently balance demand and capacity during the period between peak and minimum demand. Of the three alternative vehicle systems under study, the single-axle, pneumatic tire system operates the smallest vehicle of the three and therefore, should best fit the desired service standards.

PUBLIC ACCEPTANCE

Recent developments on Oahu exemplified by increasing awareness of the environment indicate great attention is being given to beauty and aesthetics as the area builds for its ever expanding population. The rapid transit system must also be planned with equal care and attention to beauty and aesthetics in addition to providing a system of rapid, reliable and safe movement of people throughout the community. To provide such service, it must operate on exclusive rights-of-way to make it free from interference by other modes of transportation. The vehicle system has a direct bearing on the size and character of the way structure which provides the exclusive right-of-way which, in turn, bears heavily on the potential location of route.

The aerial way structures should be of a type which permit maximum flexibility in location of supports while presenting minimum visual obstruction to other surroundings. Noise associated with vehicle operation must be restricted to levels present in the adjacent community and not permitted to rise to levels which would become annoying. Noise of operation is therefore a significant factor of public acceptance in vehicle system evaluation.

Public acceptance therefore requires the establishment of standards of quality or quantity which, when applied equally to all potential vehicle systems, creates savings in cost, greater ridership appeal and least amount of detrimental impact on the community. Based on discussions with various private and public organizations and comments received at community meetings, it is the concensus that the medium-size, rubber-tired vehicle would be the most desirable system for Honolulu.[9]

FINDINGS AND CONCLUSIONS

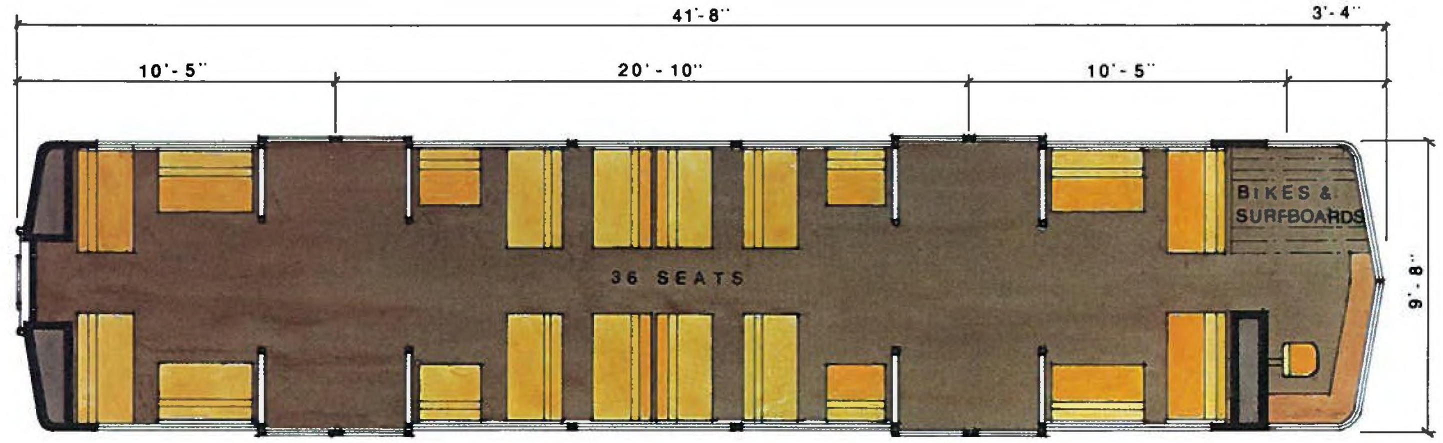
A review of available vehicle types and system needs for Honolulu can be summarized as shown in the comparison matrix (Table 5-2) and as follows:

- Of the various transit vehicle types reviewed, the conventional steel, Metro (pneumatic-tire), and single-axle, pneumatic tire systems were found to be potential candidate systems for Honolulu.
- The conventional steel and Metro systems are both large vehicles, ranging between 55′-80′ in length, and utilizes the double axle bogie construction. The conventional steel system has certain advantages over the Metro system in terms of less cost, simple switching, and less car weight. A primary advantage of the Metro system is its grade climbing capability.
- The single-axle, pneumatic tire system features the intermediate size car of lightweight construction which meets all performance criteria and offers positive advantages over the larger systems by providing less noise and vibration, lighter supporting structures, greater flexibility in meeting varying load demands, and can meet the grade climbing requirement.

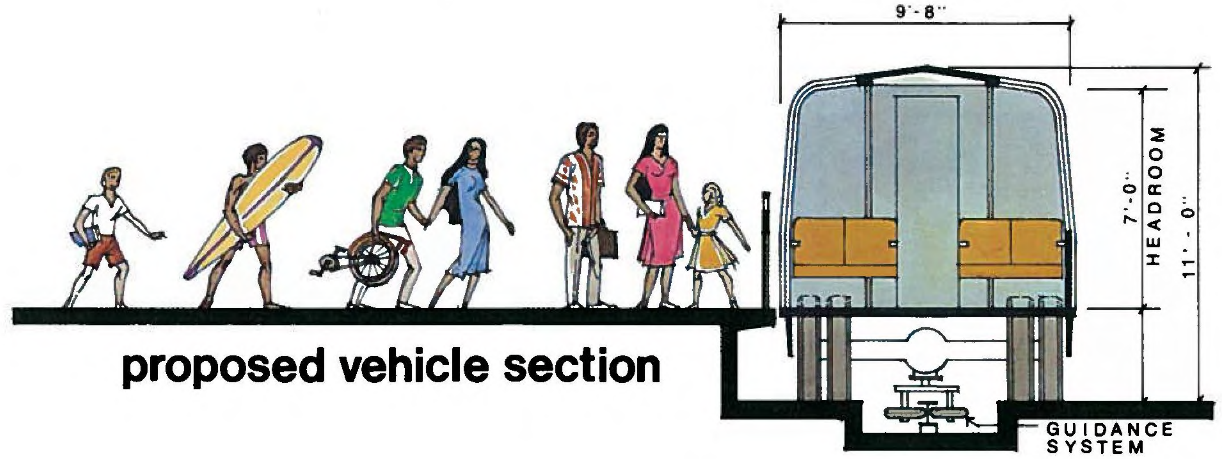
Based on the above findings, the following conclusions are drawn:

- A vehicle system with a car size which is less than the large (55′-80′) vehicle systems is more desirable to minimize environmental impact, provide greater flexibility in service, and gain public acceptance.
- A rubber-tired vehicle must be provided if the system is to negotiate grades of 6% or greater for the long-range regional system.
- An intermediate size (35′-40′) vehicle system with pneumatic tires would best fulfill the overall needs of the Honolulu system by providing more desired features required of a system at no greater cost than the other systems.

proposed vehicle interior



proposed vehicle plan



proposed vehicle section

VEHICLE SYSTEM DESIGN

In the vehicle system selection analysis, it was concluded that an intermediate size (35'-40') vehicle system with pneumatic tires could best fulfill the overall needs of the Honolulu system. In the design of the vehicle itself, there are certain design requirements for the proposed transit system that must be met. These are based on passenger safety, comfort and convenience as well as the need for optimum operational characteristics related to capacity, headways, speed, and economy. The more signficant requirements are as follows:

SYSTEM OPERATION

Minimum Operating Headways:	2 minutes for initial operation 90 seconds, ultimate
Station Dwell Time:	20 seconds, maximum
Vehicles Per Train:	10 maximum, 2 minimum

VEHICLE PERFORMANCE AND CAPACITY

Maximum Speed:	
Main Line:	65 mph
Scheduled Maximum Speed:	60 mph
Average Scheduled Speed: (total system, goal)	35 mph
Acceleration—Maximum:	3.3 mph/sec.
Normal:	3.0 mph/sec.
Deceleration—Maximum:	3.3 mph/sec.
Normal:	2.6 mph/sec.
Jerk, Maximum:	1.5 mph/sec./sec.
Vehicle Capacity—Design:	72 passengers (36 seated)

Fully Automatic Train Control (automatic line supervision, speed control, and train operation, including door operation)

VEHICLE DESIGN

The physical size of the vehicle was obtained through an analysis of characteristics which are related to vehicle size, such as, the projected ridership volumes, the desired peak hour and off-peak hour headways and the economics of construction and other system costs.

The 36-seat vehicle, with a maximum passenger load, produced a gross vehicle weight which coincided with the load carrying capacity, recommended by U.S. tire manufacturers for a pneumatic tire associated with the single-axle system and which was within the acceptable dimensions of wheel size.

After a careful evaluation of such items as an efficient seating arrangement, sufficient aisle space to permit passenger circulation, adequate headroom and space for structure and equipment, the tentative dimensions of the vehicle were determined to be:

Length:	41'-8"
Width:	9'-8"
Height (top of guideway to top of vehicle):	11'-0"
Ceiling Height:	7'-0"
Floor Height: (from top of guideway):	3'-0"

The vehicle will operate on four pairs of rubber tires on concrete guideways. The vehicle guidance system will be the center guiderail concept using steel "I" or wide flange section. Two sets of rubber-tired guidewheels per vehicle will run between the flanges of the guiderail to provide a positive lock-on feature that will prevent vehicles from overturning or leaving the guideway. To accommodate the switching mechanism, the guiderail has been placed below the running sur-

AR00053860

proposed vehicle

face of the way structure. The initial transit vehicles will be capable of attaining rapid acceleration and speeds up to 65 mph by means of an electric motor on each axle. The power source for these electric motors will come from a third rail pick up located between the concrete tracks and will be capable of carrying 600 volts, d-c. The vehicle braking system will use a combination of both dynamic braking and friction braking. The dynamic braking range is from 65 to 10 mph and then the friction brakes would take over and reduce the speed to 0.

The trains will be made up of two end cars (A cars), if more than two cars are required to carry the expected patronage, middle cars (B cars) would be added between the "A cars". The end cars will have a shaped end which will house the automatic train control equipment and space for the train attendant. The "A cars" (length = 45'-0") will be slightly longer than the "B cars" (length = 41'-8").

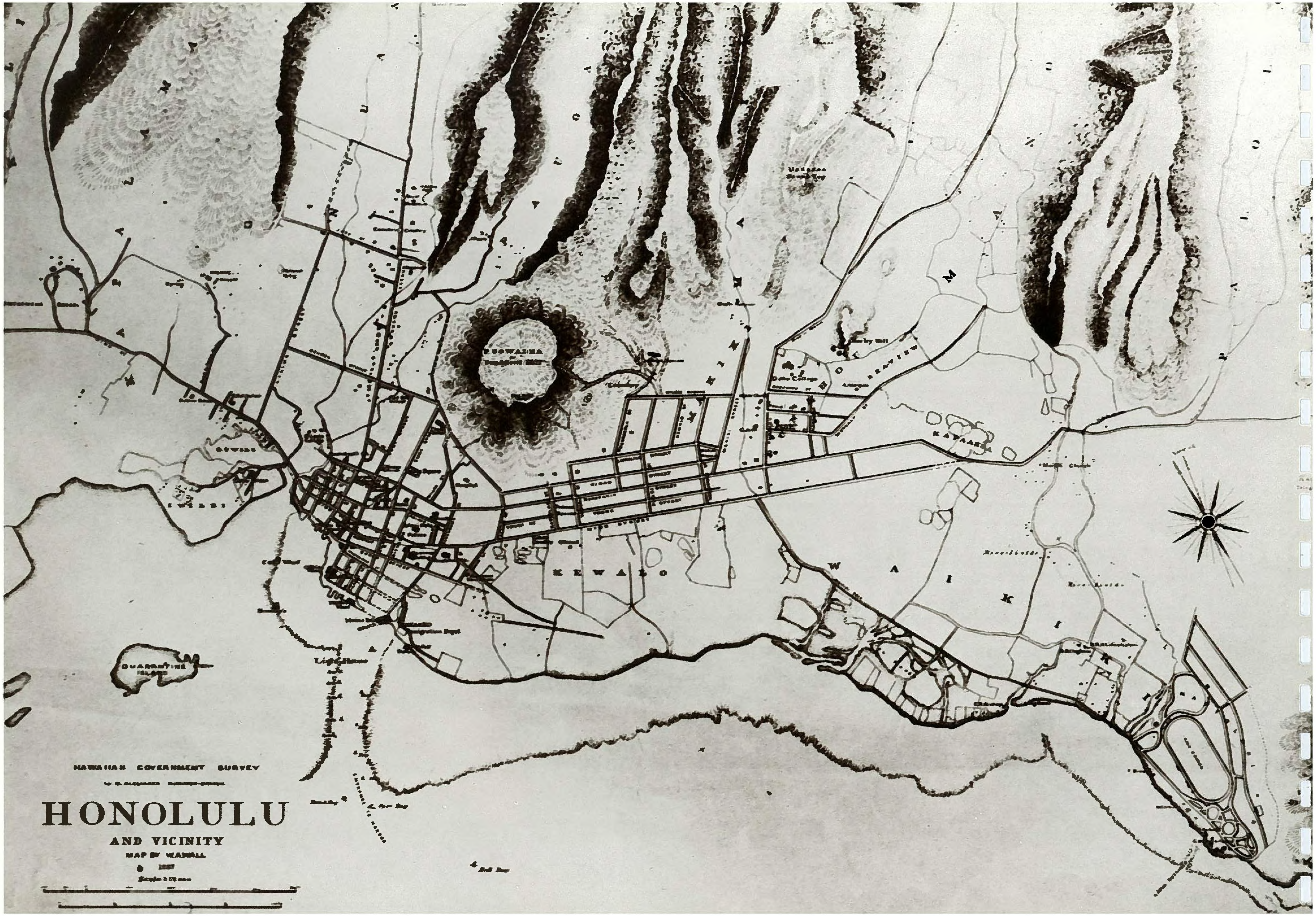
There will be two sets of doors on each side of the vehicle. The doors will be double-leaf, two-direction sliding doors spaced 20 feet apart on each side of the vehicle and will be interlocked with the train control system. The clear width of the door opening will be 4'-2" and the height will be 6'-6".

The interior of the rapid transit vehicles must provide superior features and accommodations if the transit system is to attract large numbers of choice riders from their automobiles. The car interior will have a two-and-two tranverse seating arrangement, except adjacent to the doors, in order to provide maximum comfort and convenience. There will be adequate seating to accommodate 36 passengers, with ample per passenger seat width of 20" or 22" and seat spacing of 31.5" to 35". There will also be convenient handholds to assure safety and comfort for standing passengers. The continuous aisles, approximately 27" wide, will allow easy passenger movement, and end doors in each vehicle will allow quick and safe passenger movement from one car to another in cases of emergency. The floor of the vehicle will be carpeted to enhance appearance, as well as reduce car interior noise. Special construction techniques such as resilient mountings for the floor structure and positive seals at the door, will further reduce interior noise. Fluorescent lighting will provide general illumination throughout the car, as well as adequate light for comfortable reading, about 30 ft.-candles at reading plane.

Wrap around windows with tinted safety glass will provide relief from sun glare and reduce the solar heat load on the air conditioning equipment, as well as permit transit riders to view the surrounding environment. Vehicle modules will also provide storage space for a limited number of personal articles particular to Island life such as surfboards and bicycles.

To further ensure the comfort of passengers, an air conditioning system will supply clean, fresh air at the proper temperature and in appropriate amounts. This air conditoning system will include both cooling and ventilating systems and will distribute air through overhead supply ducts uniformly throughout the car without uncomfortable drafts.

The vehicles will also be equipped with a communication system which includes a two-way voice transmitter on each train which permits voice communication between the train attendant and central control, and also a public address and intercom system on each car, for voice communication between the train attendant or central control and the passengers in the vehicle.


HAWAIIAN GOVERNMENT SURVEY
HONOLULU
AND VICINITY
MAP BY W.A.WALL
KEWALO
QUARANTINE ISLAND
Light House

the transit plan 6

INTRODUCTION

The movement of people and goods is not an end in itself, but rather a means to satisfy human needs. Therefore, a public transportation system must be designed in response to the existing and future needs of a particular region.

In order to properly determine transit needs on Oahu and as a result, define solutions twenty years or more into the future, five possible island-wide development patterns were identified and examined based on population and employment projections made by the State Department of Planning and Economic Development.[2] These planning studies examined variations in location and distribution of the Island's projected growth, and their impact on an island-wide transit system to effectively serve existing areas as well as provide flexibility to meet future demands. The result of these investigations indicated that, no matter which growth option were to be chosen for future island-wide development, the central Honolulu area from Pearl City to Hawaii Kai would remain the population, employment, and activity center of the region. This area will require a high capacity transportation system regardless of future population distribution over the remainder of Oahu and was therefore selected as the first phase of the rapid transit system. The development of this first phase rapid transit system would provide maximum flexibility for future extensions as the area from Pearl City to Hawaii Kai is common to all future growth patterns.

In addition, increasing demands for residential development in outlying areas such as the Windward, Central and Leeward districts, coupled with the continued employment concentration and residential intensification in central Honolulu will demand that major emphasis be placed on regional transit service to provide mobility between the places where people live and the places they want to go, such as offices, schools, shopping areas, and recreational facilities.

Consequently, a regional transit system plan was developed to provide efficient, high capacity service to major origin and destination areas within central Honolulu as well as fast and frequent service to outlying districts over the entire Island of Oahu.

LONG RANGE REGIONAL TRANSIT PLAN

The basic long-range regional transit plan identifies public transportation corridors over the entire Island to link the Windward, Central and Leeward districts with a high capacity corridor from Pearl City to Hawaii Kai.

The corridors crossing the Koolau Range would occur at the Koko Head end around Makapuu Point and on or paralleling either Likelike Highway or H-3 Freeway to serve the Windward district. The corridors serving the Central and Leeward districts would be an extension of the corridor through Pearl City. A future alternative corridor would cross the entrance to Pearl Harbor to provide a more direct link between the Leeward district and central Honolulu. Extensions to the corridors in these three outlying districts beyond Waianae, Wahiawa, and Kaneohe would be dependent on future population growth and distribution in these areas.

The central Honolulu corridor would serve the activity centers of the city which are located, for the most part, makai of Lunalilo Freeway. In the future, a rapid transit corridor along or in the proximity of Beretania Street would provide more direct service to existing and future high density areas mauka of the first phase corridor. This corridor could begin and interface at the University Station, connect to the downtown area, and then turn in the mauka direction and proceed in the ewa direction, mauka of the freeway. This line could then merge with the possible future Likelike route and also extend along Moanalua Road to the Halawa area where it can interconnect with the first phase line in the corridor traversing Pearl City. This "second" future rapid transit corridor through central Honolulu is considered as a relief line to the proposed first stage corridor to handle excess volumes in the future and also provide an alternative route for a more direct access to the downtown area from both ends of the system.

Due to the fact that this "second" line does not provide service to the major activity centers, a basic objective to be met by the system, it was identified for a second or future phase of development. Service on the "second" line would be oriented to existing and future population concentrations and destinations and would be properly located to achieve the most favorable service and development to the area.

Just as an effective total transportation system for Oahu requires an appropriate balance between public and private modes, a balance is also required within a public transportation system between the various forms of bus transit and rapid transit. This balance has been established on the basis of the various levels of transit service which can be provided. Factors which determine the level of service within a transit corridor and subsequently the system components required, include ridership volume, cost effectiveness, and availability and condition of existing facilities. Four levels of service, in addition to local feeder buses operating on local streets, can be provided with the following transit systems:

- Express bus operating in mixed traffic:
  Provides the lowest level of service due to slowness of speed and unreliability of maintaining schedule and is normally applicable to light volume corridors where large investments in fixed facilities are not warranted.
- Express bus operating on exclusive bus lanes in highways or freeways:
  Pre-empts the use of one lane (reversible) or two lanes for the exclusive use of buses. Generally this type of a system is provided in a corridor where ridership volumes exceed 2,500-5,000 passengers per hour during peak periods.
- Manually operated rapid transit utilizing buses operating on exclusive grade-separated busways:
  Provides the next level of service and is warranted where passenger volumes are in excess of 5,000 to 10,000 passengers per hour in the peak direction.
- Automated rapid transit (fixed guideway system) operating on exclusive, grade-separated rights-of-way:
  Provides the highest level of service and is generally warranted where corridor volumes are in excess of 5,000 to 10,000 passengers per hour in one direction to attain efficient, safe, and reliable service.

Based on anticipated population growth and distribution as well as preliminary estimates of corridor volumes, the following levels of service are proposed for the first phase de-

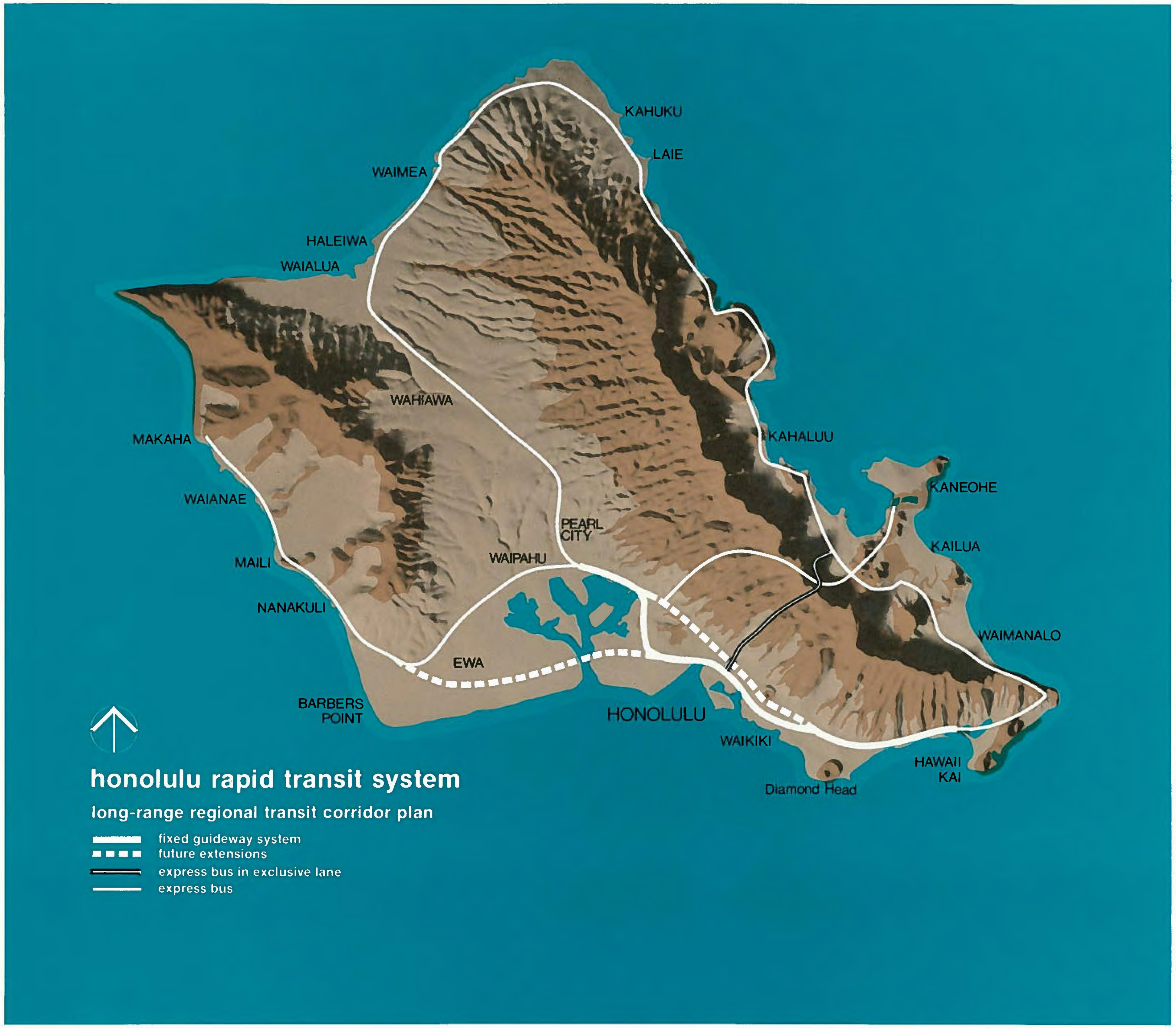


FIGURE 6-1 Island-Wide Transit Plan

velopment of the island-wide rapid transit system, illustrated in Figure 6-1.

- Automated fixed guideway system—the Honolulu corridor from Pearl City to Hawaii Kai.
- Express bus in exclusive lane—the trans-Koolau corridor serving the Windward district.
- Express bus serving Leeward and Central District, and the Waimanalo area around Makapuu Point.
- Local feeder buses.

The long range regional transit plan will therefore provide a high level integrated public transportation system combining the fixed guideway rapid transit with a broad coverage surface bus system to serve and connect outlying urbanized areas over the entire island.

Serving as the backbone for this island-wide network would be a high capacity fixed guideway system from Pearl City to Hawaii Kai. This system is a grade-separated, exclusive right-of-way system to provide safe, reliable and fast service which is attractive enough to capture a high volume of choice riders. It will also be capable of handling large volumes of riders such that when combined with both the highway and bus systems, the combined capacity of this balanced transportation system can meet the future mobility needs of the region.

THE ISLAND-WIDE BUS SYSTEM

The proposed bus network is representative of the type service required to supplement the regional rapid transit system. This network will not only provide improved accessibility and mobility for the region, but also serve as the basis for eventual expansion of the fixed guideway rapid transit system with appropriate modifications to reflect final selection and station locations in subsequent phases of the program.

Buses will serve the following functions within the regional transit system plan:

- Local and feeder service to stations
- Local service along rapid transit routes
- Express service in outlying areas not served by rapid transit
- Distribution service in major activity centers.

Buses will be an important adjunct of rapid transit, both along the transit system and over the entire island. The bus and rapid transit systems will be intricately coordinated and will operate as a unit. Schedule changes on one will

FIGURE 6-2 Rapid Transit Route and Station Location

affect schedule changes on the other.

Governing the specific layout of the bus routes were five major considerations.

1. Configurations of the rapid transit network. The linear form of the proposed rapid transit system, in conjunction with Honolulu's street pattern, established the basic network form for the bus service. In outlying areas existing streets and highways were utilized for the bus route planning.
2. Rapid transit station locations. Connection between bus and rapid transit must obviously occur at the station locations. In some cases, bus lines will terminate at stations, while in others, the stations will simply be one stop on a route. Some buses will serve more than one transit station. It was considered desirable that through-bus routes providing service to rapid transit stations deviate as little as possible from the principal streets on which they operate. This was, in turn, a consideration in station location.
3. Historical transit routing. It is not always possible or necessarily desirable to follow historical routing. It is necessary, however, to evaluate the service potential of existing routes and their ability to work with the proposed network.
4. Availability of suitable roadways. The physical dimensions of streets were considered in establishing the conceptual feeder bus network.
5. Special conditions. The locations of major traffic generators such as office complexes, shopping centers, hospitals, and schools were considered along with their particular requirements for transit service.

Headways for the bus network were set on the basis of existing practices, projected residential densities, the proximity to rapid transit, and anticipated operating policies. Speeds were assumed to correspond generally to existing service, with allowances for all special conditions that could be anticipated. The comprehensive plan of balanced public transit is shown in Figure 6-1. The bus network will need to be altered periodically as the rapid transit system is constructed, and/or as changes occur in population distribution served by rapid transit at that time.[6]

RAPID TRANSIT SYSTEM CONCEPT

The fixed guideway rapid transit system concept will be the most important segment of the regional transit system plan for Oahu. The system concept, which includes the basic route configuration and station spacing, will determine how well the system performs in providing transit service to the region. It will also have many implications relative to social, economic and environmental impact to the areas that the system traverses.

To establish the basis for defining the most desirable system concept, the basic objectives were outlined as follows:

- Develop a regional transit system interconnecting the existing and future urbanized areas of Windward, Central, Leeward, and Honolulu districts with appropriate levels of transit service.
- Provide a regional system that serves various land use activities and provides improved accessibility from major areas of residential concentration to major activity centers or traffic generators.

The City of Honolulu is uniquely suited to rapid transit. The natural boundaries of the ocean on one side and the Koolau mountains on the other have caused urban development to occur in a linear pattern from Pearl City to Hawaii Kai. Within this corridor of development are the City's major centers of activity or traffic generators including:

- Halawa Stadium
- Pearl Harbor—Hickam
- Honolulu International Airport
- The Central Business District
- Civic Center
- Honolulu International Center
- Ala Moana
- Waikiki
- The University of Hawaii

The rapid transit system concept chosen for Honolulu will serve all these major centers utilizing a basic "single line" system configuration, 22 miles long. (Figure 6-2) Appropriate station spacing will provide direct, reasonably fast, and convenient service at a scheduled average speed of 35 mph. This concept will not preclude extension of the fixed guideway facility to outlying areas as population growth and development occurs. While the basic "single line" configuration will adequately serve the city's major attraction centers, it must also provide convenient service to residential or trip origin centers.

The outlying communities located in the Leeward and Central districts will be served initially, by local and express buses interfacing with a first stage terminal station at Pearl City. Windward area patrons will also use express buses crossing the Koolau Range on Likelike Highway and/or H-3 Freeway and interfacing with stations located on Kalihi Street and at the Halawa Stadium site respectively. For communities beyond Hawaii Kai and on the Kalanianaole Highway corridor, patrons will use local and express buses interfacing at the Hawaii Kai terminal station.

The communities in the more urbanized area with Honolulu proper would either be directly served by the rapid transit system or by convenient feeder bus systems. In the higher density, inner city area generally bounded by Middle Street on the west and University Avenue on the east, maximum direct rapid transit services to residential concentrations would be provided by both the trunk line facility and feeder buses. In the Kalihi area, the residential population south of the Lunalilo Freeway would be generally well served while the area north of the freeway would be dependent on local and feeder bus service. The area east of downtown and south of King Street would also be well served by the proposed system configuration. The existing residential district of Makiki, Nuuanu Valley, Makiki Heights, and Manoa Valley would all be served by the local feeder bus system.

AIRPORT TO WAIKIKI TRANSIT SERVICE

Tourism has become a major island activity comprising visitors from predominantly mainland U.S. and from the Far East. The Honolulu International Airport is currently being expanded with a major new terminal facility under construction as well as a new off-shore runway to accommodate the anticipated increase in air passenger volume.

Of the total air passengers, it is estimated that approximately 65% are tourists and some 65% of all air passenger trips had their origins or destinations in Waikiki, the hotel center of Oahu.[6] This creates a relatively large travel movement between the Airport and Waikiki and it has been a major concern to the area due to increasing congestion on the highway access to the Airport.

The transportation facility linking these two activity centers is the Nimitz Highway/Ala Moana Boulevard, a 6 lane urban expressway traversing the most intensely developed area of the Island. It is also one of the major east-west arterials serving the downtown Honolulu and hence, carries a large volume of peak hour traffic. The distance is approximately 7 miles with the estimated travel time of 15-20 minutes during off-peak period and 30 minutes or more during peak period.

Various forms of transfer system have been studied and proposed. One is a hydrofoil service wherein the vessels would be used for dual purpose—inter-island service and Airport-Waikiki transfer service. Another proposed system was the use of express trains on exclusive, grade separated, aerial guideway.

The rapid transit system to serve commuter trips would necessarily serve both the Airport and the Waikiki area. Consequently, work and other trips to or from these two areas would be adequately served by the rapid transit system. The handling of air passengers, predominantly out-of-state visitors, with baggage poses special problems that can only be accommodated by providing special service.

As is the case in most regions, the most difficult and costly area for constructing transportation facilities is in the highly developed urban core area. It would be highly infeasible to construct a separate Airport to Waikiki system through the heart of Honolulu both from the cost standpoint and the highly disruptive effects of the facility.

In view of the economic and environmental consequences of implementing a separate system, consideration was given to ways and means of providing special airport express service utilizing the proposed rapid transit system facilities. The basic concept identified for this special service comprised of two special terminal facilities with special express trains operating nonstop between the two terminals. At the Waikiki end of the trip, special shuttle buses would be provided to collect and distribute passengers directly to major hotel complexes.

The Airport to Waikiki transit service is considered to be a special purpose system to be provided for the direct benefit of visitors to Hawaii and more specifically to tourists who would be staying in Waikiki. Although some local residents would be using the system, the predominant users would be out-of-state visitors. Therefore, the Airport transit service will be treated separately from the basic rapid transit commuter system oriented to primarily serve the local residents.

ROUTE PLANNING AND SELECTION

The primary function of the Route Planning activities in developing the proposed rapid transit system for the City and County of Honolulu was to identify potential routes to provide maximum service to the traveling public, and at the same time, would enhance the community. This enhancement may take many forms, but in general it must complement the indicated trends or stated goals of regional development. The routes selected and the configuration employed can and will play an important role in the future shape and structure of the areas traversed and the Island of Oahu as a whole.[3]

Historically, rapid transit has been considered applicable to lower income persons and indeed high level public transit service, both bus and fixed guideway, is vitally important to increased access to jobs, recreation, and social opportunities for these and other mobility restricted people. Transit will provide a mobility option for all segments of the population by offering a less costly alternative than can be provided by private automobiles. Such savings can be applied to improved living standards and conditions. Further, increased access to job opportunities can materially improve the economic level itself within the family structure. Transit route location can also constitute a catalyst for renewal and upgrading of blighted areas often associated with low income. For these reasons, service to such areas becomes extremely important from socio-economic standpoints.

However, congestion of street and highway facilities is also becoming a serious problem which imposes a constraint on *all* economic levels in terms of accessibility and increased costs in both time and money. Therefore, if the system is to be successful in making a maximum contribution to the region, it must attract more than those people who use the system out of necessity. This can only be accomplished by providing service to the largest centers of employment, as well as other major traffic generators or destinations. Such service must be competitive in terms of time, cost and convenience. The trend toward higher and higher concentrations of population and employment is clearly evident in the changing skyline of downtown Honolulu, Waikiki, Makiki, and several other similar areas. Projected developments are dependent upon access if they are to be realized. Even if adequate traffic arteries could be developed to serve these areas, the cost of providing sufficient terminal space for automobiles is rapidly becoming prohibitive. The factors of traffic congestion, parking space, restraint to development potential, and increasing cost in time and money for commuter movements are also major considerations of route planning.

Transit must be related to satisfying both existing and long range future needs for mobility. Because of the locational influence on development exercised by transit, the route and station locations must also reflect the desired development pattern of the communities traversed. While transit can be a catalyst for change in land use and intensity, it can also promote stability.

The route planning and evaluation process was therefore based on a total urban design strategy wherein all factors relating to transit and the community were examined to insure that the system would not only provide the best service with the least amount of disruption, but also provide a positive force to aid in shaping future urban development.

DATA COLLECTION AND DEFINITION OF ROUTE ALTERNATIVES

The first step of the route planning process consisted of a data gathering effort in order to gain the maximum insight into factors of economic need, traffic patterns, development plans, and community desires. Various City, State and other public and private agencies were contacted and the necessary land use plans, zoning ordinances and maps, traffic data, master plans and studies, economic data, population and demographic data as well as other pertinent data were collected and reviewed. Based upon this general information, and the physical features of the entire Island of Oahu, a long-range public transportation plan was developed, within which the Honolulu corridor was defined as the first area of planning concentration.

The basic routes established in the Oahu Transportation Study of 1966 as well as subsequent studies by the Oahu Development Conference were included and used as a point of departure. Thirty-six alternative routes were then defined within this established corridor, ten of which, after initial examination, were discarded on the basis of their relatively poor and unacceptable characteristics in terms of environmental impact, economic feasibility or service characteristics. The corridor was then divided into segments, each of which contained the most viable alternatives. These routes were then refined in terms of alignment and station location and analyzed in a detailed evaluation.

CONFIGURATION CONSIDERATIONS

As the alternative routes were being developed, various configurations of way structure were analyzed for each route alternative. Each potential configuration had advantages and disadvantages under specific application. Factors of light and air intrusion by aerial structure, street and business disruption by subway construction, visual and physical barriers, landscaping, noise, and vibration were among the items considered in developing a set of guidelines for applying various route configurations to the alternate route locations.

ROUTE EVALUATION AND SELECTION

The route evaluation process for the Honolulu program was predicated upon an urban design concept wherein an interdisciplinary team was established to assure sensitivity to community values in planning an efficient transportation system. To provide a balance of both the tangible elements of cost and service as well as the intangible elements of community disruption, aesthetics, development potential and environmental impact, an evaluation system was developed which assigned a relative value or weight to these elements for each of the alternative routes.

Cost estimates were based upon the preliminary plan and profile, station location and other factors which varied with route location. These comparative costs did not include common system costs such as electrification, rolling stock, fare collection or control and communications systems. These common system costs remained constant regardless of which route was selected and were, therefore, excluded from the comparative cost calculations for route evaluation. In addition, land acquisition costs were estimated as well tax loss on lands required for the transit facilities.

Using the economic and demographic data and the master plan, zoning maps, land use plans, physical features, existing and planned transportation networks, the intangible factors were evaluated. Combined with the comparative costs, these factors were prepared for each possible alternative route and subsequently compared to other routes within each segment.

After this initial ranking of alternate routes, a weighted rating system was developed which assigned relative values to the tangible and intangible elements. This rating system was intended to provide a balance between the purely economic factors of cost and the more intrinsic elements of community value, which may be associated with transportation and accessibility. In order to further test the alternate routes, a computer program was utilized which measured the sensitivity of each factor in the evaluation methodology to changes in their relative values or weights. This was important in an evaluation procedure where numerous intangible items were being analyzed, in that it tested a wide range of weights to determine the sensitivity of each element to all remaining elements.

The various factors examined in the analysis are as follows:

- **TANGIBLE FACTORS**
  - COSTS
    - Construction
    - Right-of-Way Acquisition Costs
    - Tax Losses
- **INTANGIBLE FACTORS**
  - SERVICE
    - Service to Origin
    - Service to Destinations
  - IMPACT
    - Local
    - Regional
    - Environmental
  - DESIGN
  - CONSTRAINTS

The final route in each segment was determined by the consulting team only after careful consideration of not only the evaluation scoring results and the computer sensitivity analysis, but also pertinent feedback received from over 300 meetings with local community organizations, businessmen, citizen groups and governmental agencies.

FIGURE 6-3 Rapid Transit Route Pearl City

PEARL CITY

The Pearl City community extends from the northern edge of Pearl Harbor well up into the valleys above Kamehameha Highway. The area is bisected by two major traffic arteries; Kamehameha Highway and the recently completed section of the H-1 Freeway.

The community is made up primarily of single family residential areas with most of the commercial, business, and industrial activities located along Kamehameha Highway. The bulk of the community, mauka of this spine of activities, is low density detached housing, generally owner-occupied and in good repair. There is currently a large proportion of housing in the low and moderate income category and State projections indicate that these demographic characteristics will tend to remain constant for the next 25 years.

ROUTE DESCRIPTION

The transit route in the Pearl City segment begins at a terminal station, ewa of Pearl City at Lehua Avenue, and proceeds easterly, in an aerial configuration above a widened and landscaped median of Kamehameha Highway.

The location of the transit route will minimize detrimental impacts while at the same time provide improved mobility and accessibility and as a result tend to solidify potential for coordinated development.

STATIONS

PEARL CITY—The terminal station in Pearl City will be located above the median of Kamehameha Highway ewa of Lehua Avenue. Transit service characteristics in suburban areas, where population densities are low must rely heavily on feeder bus service to bring patrons to the trunk line. The Pearl City Station has been located to maximize interface with these bus feeders. A park and ride facility for approximately 250 cars will also be provided to allow patrons from outlying areas such as Wahiawa and Waianae to park their automobiles and ride the rapid transit system.

While the Pearl City Station will be a terminal station in the first phase of the rapid transit system, it has been designed to become an on-line station when future extensions are required.

FIGURE 6-4 Rapid Transit Route Pearl Ridge

PEARL RIDGE

This area is similar to Pearl City in land use and composition. It is basically a low density residential community with most commercial, industrial, and business activities located in strip development along Kamehameha Highway. The new Pearl Ridge Shopping Center, when completed, will contain 900,000 square feet of retail space and draw customers from the entire region.

New residential growth within this community is occurring in the valleys above the H-1 Freeway. Predictions are for heavy increases in middle income residents, a somewhat lesser increase in low income residents and virtually no increase in high income residents.

ROUTE DESCRIPTION

The transit route will proceed in an aerial configuration above the widened median of Kamehameha Highway through this segment. There will be little impact upon adjacent properties along Kamehameha Highway, as the line will be located in the median of an existing arterial and the adjacent commercial and industrial properties would be relatively compatible with a transit system. Although portions of Kamehameha Highway will be widened approximately 10' to accommodate the transit line, this will have little effect on adjacent properties due to existing setbacks which are quite ample.

STATIONS

PEARL RIDGE—An aerial station will be located at the intersection of Moanalua Road and Kamehameha Highway to serve both the surrounding residential communities and the new Pearl Ridge Shopping Center. Adequate bus interface and "kiss and ride" facilities will provide good station access.

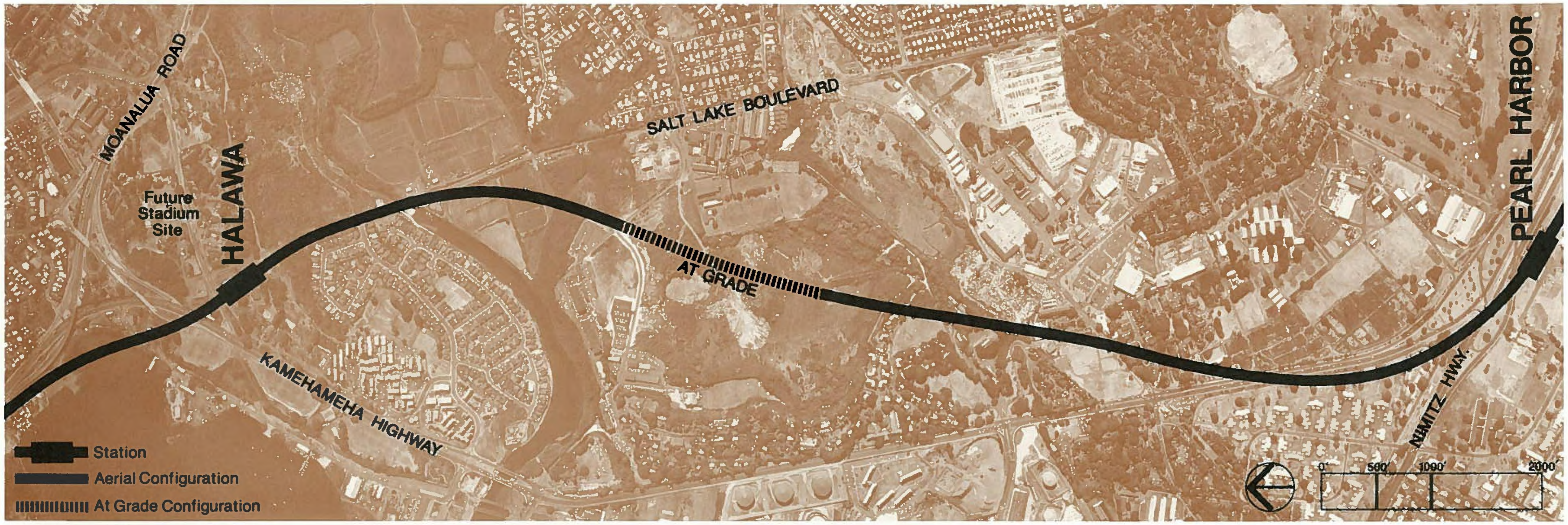


FIGURE 6-5 Rapid Transit Route Halawa

HALAWA

This segment includes the entire eastern rim of Pearl Harbor from the Halawa Stadium site to the International Airport. Within this area are two major military installations, Pearl Harbor Naval Base and Hickam Air Force Base, as well as a large residential community in the Salt Lake Area. Kamehameha Highway is the major traffic artery which runs through both segments and provides access to all of the aforementioned sub-areas.

Two major public projects are planned for the area and will introduce significant changes in development patterns when completed. The proposed H-1 Freeway, to be completed in 1977, will cut an inland corridor from the Halawa Interchange, across the Halawa Stream and through the Makalapa Crater. The increased automobile accessibility which will result from this facility will play an important role in the future development of the surrounding communities. The second major public investment planned for this area is the new Halawa Stadium, which will seat approximately 50,000. This facility will also play an important role in future growth as it will become a regional focal point for recreation and, therefore, affect the surrounding community. The existing community is made up of military and civilian low-density housing. While these areas will remain relatively stable, 1995 Land Use predictions indicate that the diamondhead portion of the Salt Lake Area and the area mauka of Moanalua Road will show large increases in population over the next 25 years.

ROUTE DESCRIPTION

The transit route in this segment will cross Aiea Bay from Kamehameha Highway in an aerial configuration and pass through the new Halawa Stadium parking lot. The line will then proceed on the ewa side of the new H-1 Freeway sharing the right-of-way with that facility. The line would be in an aerial configuration to Makalapa Crater then drop to an at-grade configuration to Plantation Boulevard where it would rise to an aerial configuration again and proceed across Kamehameha Highway. The line would then cross Kamehameha and Nimitz Highway and proceed diamondhead to the International Airport.

STATIONS

HALAWA—An aerial station would be located above the parking lot of the new Halawa Stadium. Facilities would be provided for connection with feeder buses and "kiss and ride" patrons as well as express buses on the H-3 Freeway when completed. The station is also planned to make use of the stadium parking facilities when not required for sporting events. The Halawa Station will provide excellent service and regional access to what will become a major recreational center, the Halawa Stadium.

FIGURE 6-6 Rapid Transit Route Pearl Harbor/Airport

PEARL HARBOR/AIRPORT

This segment covers the area from Hickam Air Force Base to Keehi Lagoon and includes the International Airport, the Damon Industrial Tract, Keehi Lagoon Park, the Moanalua Industrial Area and portions of the Salt Lake residential area. The area is presently bisected by Kamehameha Highway and Nimitz Highway, and in the future, the proposed H-1 Freeway which will be in an aerial viaduct.

The area makai of the highways is devoted primarily to industrial type land uses, the major portion being the airport facilities. Commercial activities are located along Kamehameha and Nimitz Highways and at the Gibson Shopping Center, makai of Moanalua Road. Although there is virtually no resident population makai of Nimitz Highway, the Airport generates an enormous amount of "origin" traffic in the form of arriving air travelers, which will approach a rate of 8,000,000 Oahu bound travelers per year by 1985. The airport area is also an important employment destination in that 15,000 people are now employed in the airport and the Damon Tract industrial area makai of the future H-1 alignment. In addition, two other major areas of employment will be served by rapid transit in this segment. The Pearl Harbor area has a present employment population of 28,900 with projections for 1995 at 32,100. Hickam Air Force Base employs 10,200 at present, and is projected to grow to 11,200 by 1995. While these are military areas, a large portion of those working in Pearl Harbor are civilian employees who live in other areas on Oahu.

ROUTE DESCRIPTION

The transit route would proceed makai of Nimitz Highway in an aerial configuration to Elliott Street where it would turn makai to the International Airport. The line would then continue in an aerial configuration along Aolele Street to Keehi Lagoon where it would pass along the mauka edge of the park into Kalihi.

STATIONS

PEARL HARBOR—This aerial station would be located near the Nimitz Elementary School to serve the Pearl Harbor Naval Base and Hickam Air Force Base as well as the residential areas in Salt Lake. Bus interface and "kiss and ride" facilities will provide good station access.

AIRPORT—The station to serve the Honolulu International Airport would be located adjacent to the existing parking garage and will connect directly to the terminal facilities. The station has also been designed to allow connection with the future airport people mover system.

FIGURE 6-7 Rapid Transit Route Keehi Lagoon/Kalihi

KEEHI LAGOON/KALIHI

This segment includes the area from Keehi Lagoon to River Street and extends from the ocean well up into the valleys of Koolau Range. Approximately 33% of the land in Kalihi-Palama is currently being used for some type of residential purpose. Industrial properties are generally concentrated makai of Dillingham Boulevard, with some small industries spotted throughout the area. Most commercial establishments are located along the major thoroughfares intersecting the area with several shopping centers, as well as a number of small family stores distributed throughout the neighborhoods. The Keehi Lagoon area is primarily industrial, with the exception of the Keehi Lagoon Park and Playground.

The present population in Kalihi-Palama is 24,400; this is projected to increase by 45% to approximately 35,300 by 1995. For the most part the increase will occur in the redevelopment areas near downtown Honolulu. Residential uses makai of Dillingham will continue to be supplanted by industry. The resident population in Kalihi-Palama has a very low median income ($6,120) which partially explains the prevalent overcrowding in the area as well as the high percentage of persons relying on welfare payments as a source of income. The transit system would offer a higher degree of resident mobility which would increase job opportunities by making other areas more accessible.

ROUTE DESCRIPTION

The transit route would proceed from Aolele Street in an aerial configuration through the Keehi Lagoon Park. The aerial structure would be on the mauka edge of the park. The line would then parallel Nimitz Highway and cross into Kalihi-Palama makai of Dillingham Boulevard. It would then continue through Kalihi in an aerial configuration on the makai side of Dillingham Boulevard. The transit route in this segment would offer good service and, at the same time, would require relatively little residential and commercial displacement.

STATIONS

KEEHI LAGOON—This aerial station would be located diamondhead of the intersection of Keehi Lagoon Drive and Aolele Street. Access would be provided primarily by feeder buses from the Salt Lake Area and kiss and ride facilities.

KALIHI—This would also be an aerial station located makai of Dillingham Boulevard diamondhead of Kalihi Street. It is located to allow good pedestrian and feeder bus access from the surrounding residential areas as well as good access for express buses over Likelike Highway.

YARDS AND SHOPS

The maintenance shops and storage yards for the rapid transit system will be located in the Kalihi-Kai Industrial area, makai of Nimitz Highway. The site was selected due to its central location in terms of the proposed 22-mile fixed guideway system. Placement of the maintenance and storage facilities in a central location aids not only in reducing initial daily start up and running times, but also average daily trip length by making initial system runs approximately equidistance.

The complex utilizes a 21 acre site and will contain storage tracks for approximately 300 rapid transit cars in addition to washing and repair facilities.

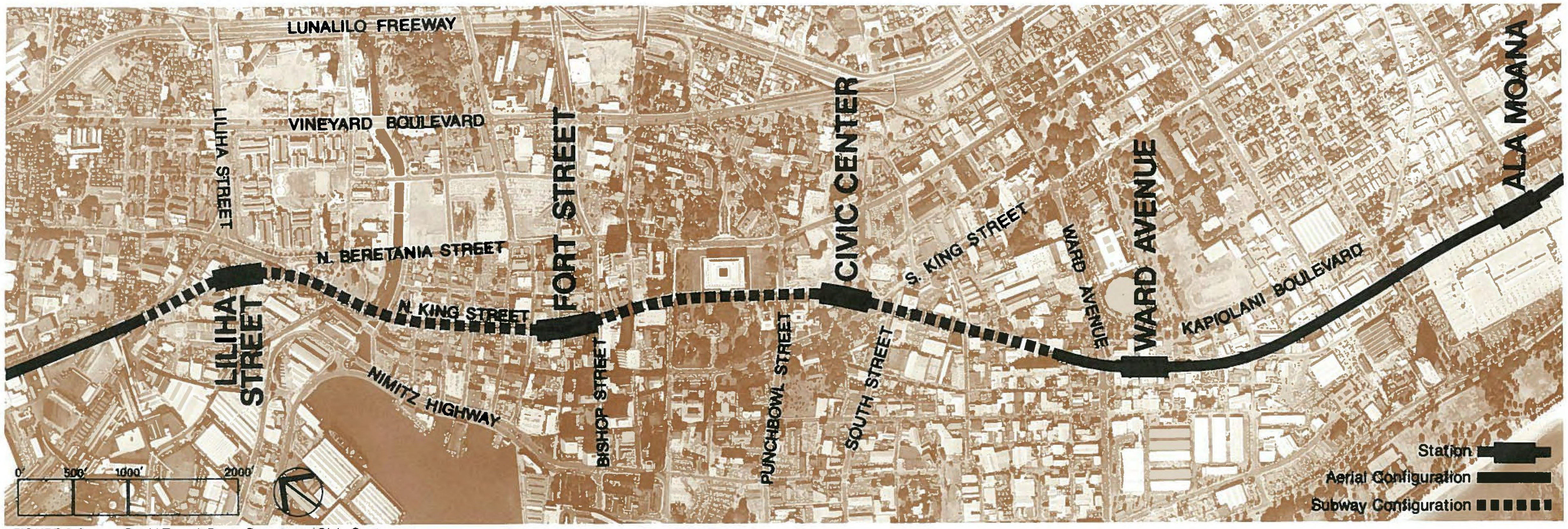


FIGURE 6-8 Rapid Transit Route Downtown/Civic Center

DOWNTOWN/CIVIC CENTER

The central area of Honolulu from Liliha Street to Pensacola Street encompasses most of the important financial, governmental and historical elements in the State. Within this area are several distinct sub-areas: Chinatown, the Central Business District, the Civic or Governmental Center and the Honolulu International Center.

Numerous planning studies and renewal programs have been undertaken over the last several years to shape the future development of these areas; the Chinatown Renewal Program, Block G and F Redevelopments, the downtown plan and the Civic Center Study.

The "Program for the Revitalization of the CBD of Downtown Honolulu" by Victor Gruen and Associates for the City Planning Department recommended, among other things, that Hotel Street be converted to a pedestrian mall and that a system of traffic couplets be adopted to ease circulation.

John Carl Warnecke's "Oahu Civic Centers Study" outlined a master plan for the future development of the governmental sub-center within the downtown area. It recommended traffic re-routing and street closings in order to create a "governmental campus" within which the expansion of facilities could take place.

Careful coordination of transit planning with these previous studies resulted in the integration of rapid transit into the heart of the city with minimal disruption and maximum development potential.

ROUTE DESCRIPTION

The transit route in this segment will proceed makai of Dillingham Boulevard in an aerial configuration to a point ewa of Kaaahi Street where it will portal to a subway configuration. The line will then continue under Aala Park and into the downtown area in subway under Hotel Street. Proceeding through the Civic Center in subway, the route will then turn makai under Kapiolani Boulevard and rise to an aerial configuration diamondhead of Cooke Street and proceed past Ward Avenue one block makai of Kapiolani Boulevard in the direction of Ala Moana.

STATIONS

LILIHA—This station would be in a subway configuration makai of the intersection of King Street and Dillingham Boulevard. It has been positioned to allow good pedestrian access from the surrounding residential developments of Kukui Gardens and Mayor Wright Housing as well as good access for local feeder buses.

FORT STREET—This underground station is located at the intersection of Fort Street and Hotel Street. By providing an entrance at Fort Street, Nuuanu Avenue, and Bishop Street, this station would serve both the downtown office and commercial areas and the Chinatown area. Good feeder bus interface facilities will also be provided.

CIVIC CENTER—This station would also be underground, located in the heart of the Civic Center campus ewa of the intersection of King Street and Kapiolani Boulevard. It will provide excellent pedestrian access to all governmental facilities and will interface with feeder buses from nearby areas.

WARD AVENUE—The Ward Avenue Station would be in an aerial configuration located diamondhead of Ward Avenue one block makai of Kapiolani Boulevard. It will provide good pedestrian access to the Honolulu International Center and surrounding areas as well as good interface with local buses.

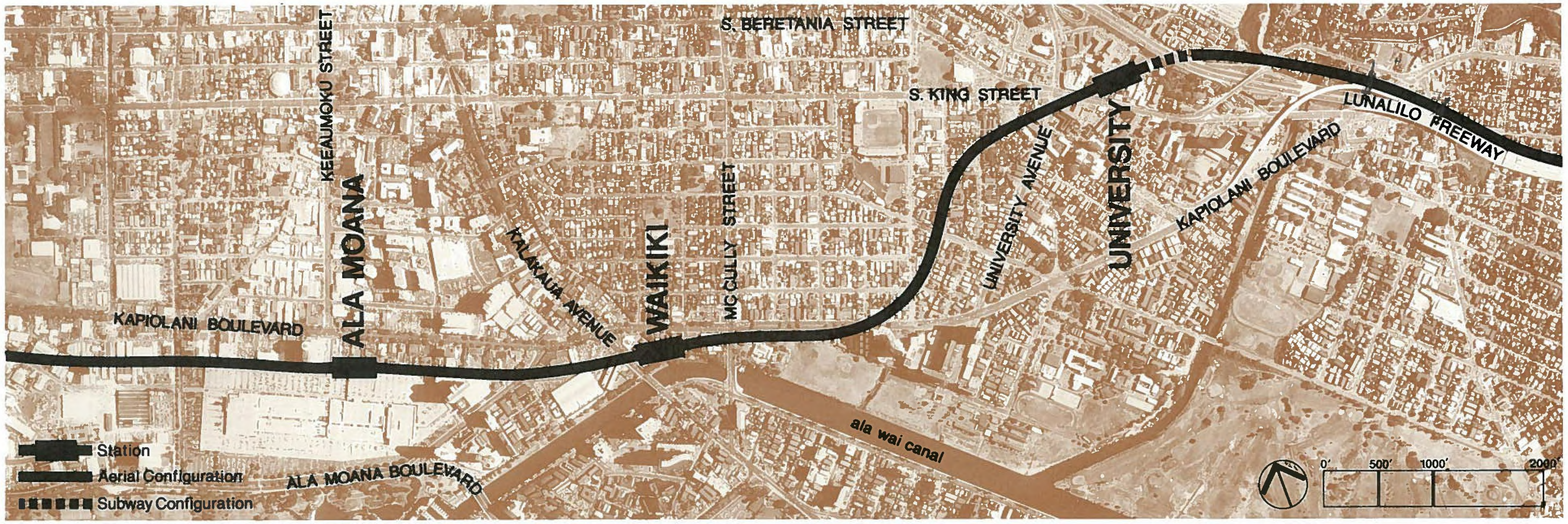


FIGURE 6-9 Rapid Transit Route Ala Moana/Waikiki/University

ALA MOANA/WAIKIKI/ UNIVERSITY

This segment includes the Ala Moana area, Waikiki, McCully, Moiliili and the University of Hawaii.

The Ala Moana Shopping Center is the main retail trade center of the entire Island of Oahu, and indications are that it will continue to capture a large number of customers.

Waikiki is one of the world's largest tourist centers with over 1,800,000 visitors per year. With continued growth predicted, those figures will increase dramatically by 1995. The area is structured in a linear fashion by three major arterial streets; Ala Wai Boulevard, Kuhio Avenue, and Kalakaua Avenue.

The University Area is, at present, primarily residential in nature with some commercial services along King Street and University Avenue. The University triangle, already developed with some high-rise, will show a 50-55% growth rate over the next two and a half decades. The Moiliili Area, zoned for high density residential development, is also predicted to grow dramatically in the future.

The University of Hawaii has indicated that a ceiling on the number of students at the Manoa campus will become necessary at approximately 26,000.

ROUTE DESCRIPTION

The transit route will proceed in an aerial configuration through the Kakaako Industrial area one block makai of Kapiolani Boulevard. After crossing Piikoi Street the line will continue in an aerial configuration above Kona Street to a station at Ala Moana Center.

The line would then pass over Atkinson Drive and Kalakaua Avenue to the Waikiki Station mauka of the Ala Wai Canal. Crossing McCully Street, the line would continue in an aerial configuration makai of Kapiolani Boulevard, then turn mauka near Coolidge Street. Proceeding through Moiliili in a landscaped right-of-way, the line would cross University Avenue and King Street and proceed to the University Station. The transit route would then continue under the Lunalilo Freeway, turn diamondhead and proceed into Kaimuki on the mauka side of H-1.

STATIONS

ALA MOANA—This would be an aerial station located above the intersection of Kona Street and Keeaumoku Street. It has been designed schematically to become an integral part of the Ala Moana parking structure providing good pedestrian access and bus interface.

WAIKIKI—This aerial station is located between Kalakaua Avenue and McCully Street mauka of the Ala Wai Canal. In addition to bus interface facilities at the Station, a pedestrian people-mover crossing of the Ala Wai Canal would be provided to connect with a subsystem, interial to Waikiki, for distribution of patrons to their varied destinations. The subsystem would be flexible and fine grained in serving the entire Waikiki area, responding to the many different service needs for employment, business/shopping and recreation.[14]

UNIVERSITY—The aerial station is located kokohead of University Avenue on the mauka side of King Street. Its location would allow good pedestrian access to and from surrounding commercial and residential areas as well as the Manoa Campus of the University of Hawaii. Adequate facilities for interface with local feeder buses would also be provided.

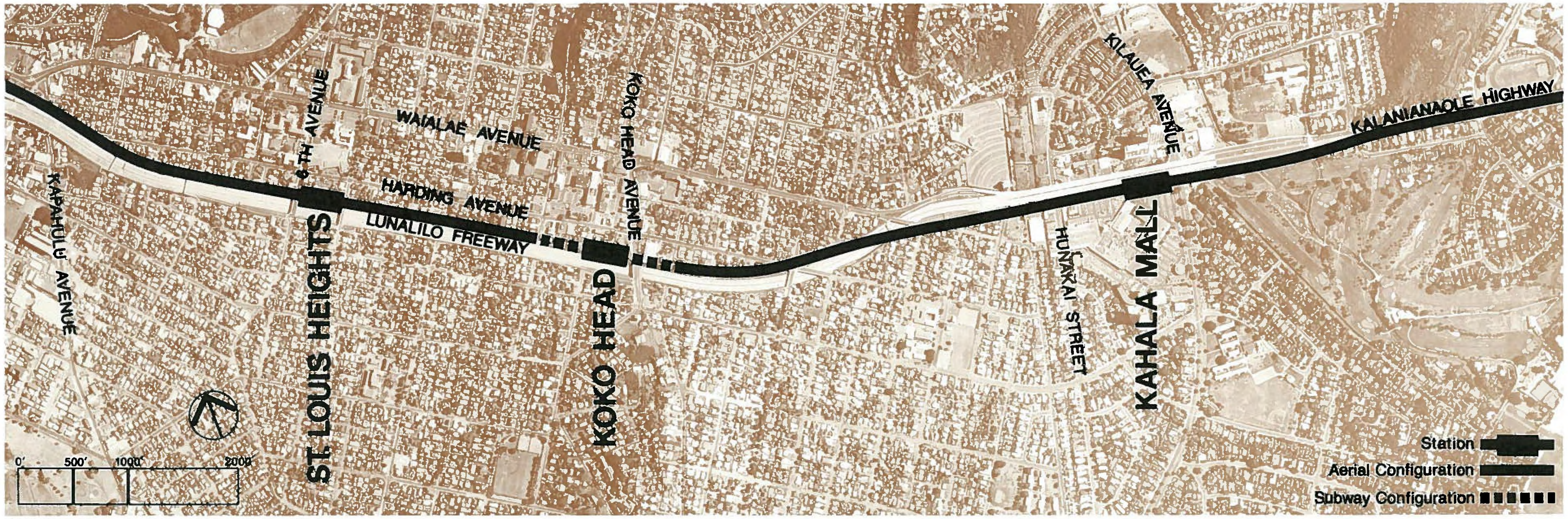


FIGURE 6-10 Rapid Transit Route Kaimuki/Kahala

KAIMUKI/KAHALA

Covered in this segment are the areas from the intersection of Kapiolani Boulevard and Kapahulu Avenue to the Kahala Mall. In 1970, the resident population in this segment was 41,858. Forecasts for 1995 show a slight decline to 39,214 due primarily to an aging population. It is traversed horizontally by two major arterials, Waialae Avenue and the Lunalilo Freeway.

The Kaimuki area is essentially a stable, low density residential community with strip commercial development along Waialae Avenue. The Kahala Shopping Center has, at present, approximately 545,000 square feet of retail space and is predicted to grow to 700,000 square feet by 1995. This growth will occur as a result of its good accessibility and the fact that the resident population in areas koko head will increase.

There are a large number of educational facilities within this segment; St. Louis High School, Chaminade College, Academy of the Sacred Hearts, Aliiolani School, St. Patrick's School, Church of the Epiphany School, Liliuokalani Public School and the Star of the Sea School. There is also a large branch library located at Koko Head Avenue and Harding Avenue.

ROUTE DESCRIPTION

The transit route in this segment will be in an aerial configuration along the mauka edge of the Lunalilo Freeway. As the line reaches the crest of the Diamond Head Saddle, it will be in an open cut configuration. After crossing Koko Head Avenue, the line will cross the freeway in an aerial configuration and continue to Kahala Mall on the makai side of the freeway viaduct. The route will then proceed koko head past the on-ramp to Kalanianaole Highway then cross to the median where it will continue in an aerial configuration to Aina Haina.

STATIONS

ST. LOUIS HEIGHTS—This aerial station is located between 6th and 7th Avenues mauka of Lunalilo Freeway. It will provide good pedestrian access to surrounding residential areas as well as adequate local bus interface facilities.

KOKO HEAD—This station would be in an open cut configuration with the concourse area at grade level. It is located ewa of Koko Head Avenue, mauka of the freeway and would provide excellent pedestrian access to both the Waialae commercial area and adjacent residential areas. Interface facilities for local feeder buses will also be provided.

KAHALA—This station would be in an aerial configuration makai of the freeway viaduct, above the parking area of the Kahala Shopping Center. It is located to provide excellent pedestrian access to both the shopping center and the surrounding housing areas. It will also provide smooth connection with local buses and "kiss and ride patrons."

FIGURE 6-11 Rapid Transit Route Aina Haina/Niu

AINA HAINA/NIU

This segment extends from Kahala to Kuliouou Street and includes Aina Haina and Niu. The area is unique in that it is a narrow corridor between the mountains and the sea with the exception of several valleys and rises which contain residential development.

The Aina Haina community is located almost exclusively in one large valley mauka of Kalanianaole Highway at the intersection of West Hind Drive. The community is composed of single family residences and a neighborhood retail shopping center. The population in 1970 was 6,485 and is projected to grow to approximately 9,042 by 1995. Commercial growth will be correspondingly small and will remain concentrated within the present business zone mauka of Kalanianaole Highway at the intersection of West Hind Drive.

The Niu community is composed of three valleys, Niu, Kupaua and Kuliouou which are almost exclusively developed with single family residences. The population in 1970 was 5,123 and is projected to increase slightly to approximately 6,025 by 1995.

The Niu Shopping Center is located directly mauka of Kalanianaole Highway at the intersection of Halemaumau Street. This commercial area is primarily local in nature and consequently growth is projected as being relatively small.

ROUTE DESCRIPTION

The transit route in this segment will be in an aerial configuration above the median of Kalanianaole Highway. This median will be widened to accommodate the aerial structure as well as provide space for a heavily landscaped linear park the entire length of Kalanianaole Highway. A bikeway would also be included within this park median.

STATIONS

AINA HAINA—This aerial station would be located koko head of West Hind Drive above the median of Kalanianaole Highway. Bus interface facilities would be provided on both sides of the highway with a pedestrian underpass to the concourse area in the median. This station will provide good pedestrian access to the Aina Haina Shopping Center and the adjacent residential areas.

NIU—The Niu Station would be similar to the station at Aina Haina in service facilities, configuration, and location above the median of Kalanianaole Highway. Good pedestrian access would again be provided by an underpass to the concourse area.

FIGURE 6-12 Rapid Transit Route Hawaii Kai

HAWAII KAI

Over the past fifteen years, the Kaiser Aetna Company has developed a residential community of significant size at the koko head end of Kalanianaole Highway. This pre-planned community contains, in addition to a variety of residential land use types, a certain amount of mixed land uses for support of the resident population such as commercial, educational, recreational and some industrial. In 1970 the resident population of Hawaii Kai was 12,500. By 1995 this population is expected to grow to approximately 37,900. Development plans call for more construction within the Hawaii Kai area. Additional plans call for resort and residential development in the Queen's Beach area.

Kaiser Aetna has included within their overall planning an easement for a grade-separated expressway through Hawaii Kai to the Kalama Valley where it will connect with an improved Kalanianaole Highway to Waimanalo and the Windward side of the island. Their zoning and land use plans have been adjusted to reflect sound land use planning around this expressway.

There are several commercial areas within Hawaii Kai; the largest is the Koko Marina Trade Center at the intersection of Lunalilo Home Road and Kalanianaole Highway.

ROUTE DESCRIPTION

The transit route in this community will be located in an aerial configuration above the median of Kalanianaole Highway. At the intersection of Hawaii Kai Drive and Kalanianaole Highway the line will turn mauka to share the median with the proposed grade-separated expressway through the area. The Kalanianaole Highway median will be widened in conjunction with State plans to provide more traffic capacity in this corridor.

STATIONS

HAWAII KAI—This station will be in an aerial configuration above the median of the proposed extension of Kalanianaole Highway. It would be located ewa of the second intersection of Hawaii Kai Drive with the new Kalanianaole Highway thru Hawaii Kai. This station is the koko head terminal station in the first phase and has been designed to provide good interface for express and local buses as well as kiss and ride drop off areas. Due to the unavailability of land and the high property values in this area, an underground parking structure for 350 cars under the station area will also be provided. This will allow patrons in outlying areas beyond Hawaii Kai to park their cars and ride the rapid transit system.


1 KALIHI UMI ST.
VIA-UPPER AINA HAINA
673

passengers, revenues and operations 7

INTRODUCTION

A key element of regional transit system planning is the travel forecast or estimate of passengers that will use the system when it is operational. Preliminary results of this passenger estimate or travel forecast provided the basic data for system definition as described in Section 6 "The Transit Plan." At the same time, a reasonable fare plan was devised and checked against the passenger estimates to ensure compatibility. The validated passenger estimate and the fare plan were then utilized to estimate revenues, which, in turn, provided a measure of the system's ability to meet operating and maintenance costs. In addition, the passenger estimate was used to formulate an operating plan suitable for the selected vehicle system and route, as well as in the design of stations, to determine the extent of fare collection, equipment, escalator installation and space requirements.

Therefore, the forecast of passengers and the resulting revenue and operating cost estimates provided, not only a basic source of data for the formulation of the operating plan, the financing plan, and station design criteria but also a test of the feasibility of the proposed rapid transit system.

TRANSIT TRAVEL FORECAST

ASSUMPTIONS

Since this study was directed only at the proposed mass-transit element of a balanced regional transportation system, certain basic assumptions were necessary, particularly in reference to the highway and street network. This study assumed that current highway plans would be completed and in operation by the design year, 1995, including Interstate Routes H-1, H-2, and H-3. It was further assumed that no additional traffic lanes would be constructed on Kalanianaole Highway, in the section between Kahala Mall and Hawaii Kai Drive, thereby limiting the capacity of that route to a definable value.

In addition, the patronage estimates were based on certain assumptions and forecasts regarding population, employment, propensity to travel, spatial distribution of jobs, people, economic activities, recreation areas, schools, and the characteristics of the population. In this study the forecasts of population and jobs were prepared by the Hawaii State Department of Planning and Economic Development (DPED). These forecasts formed the principal inputs to a series of models which distributed economic activities in conformance with the City's General Plan. The 1995 population on Oahu was forecast to be 924,000 and the number of jobs was forecast to be 518,140. By the year 2010, the population was forecast to be 1,132,000. Finally, it was assumed that the Manoa Campus of the University of Hawaii would be limited to an enrollment of 26,000 and that Waikiki would be limited to a total of 27,000 hotel rooms. These assumptions on enrollment and hotel room ceilings placed limits on certain types of trips which were analyzed in this patronage study.

METHODOLOGY

The techniques involved in forecasting future travel patterns required that a series of travel forecast models be developed. These models are essentially mathematical expressions of the relationship between travel patterns on the island and:

- Socio-economic and land-use characteristics
- Features of the transportation networks.

The observed regularity of travel behavior in response to these factors is the phenomenon that permits the use of the predictive models. Simply stated, the models are developed through an analysis of what happens in the present time, so that when forecasts of certain key characteristics and features have been made, they may be used to predict future travel activity.

The basic models used in the patronage estimate were developed by the Oahu Transportation Study (OTS). The Advanced Transportation Planning Office (ATPO) of the Hawaii State Department of Transportation (as successor to OTS) made the models available and provided much of the input information. ATPO also provided the data processing necessary to complete the patronage estimates and performed many of the early steps necessary to convert population and land-use forecasts into travel estimates. In addition, ATPO provided the 1995 highway network coded in machine processing form.

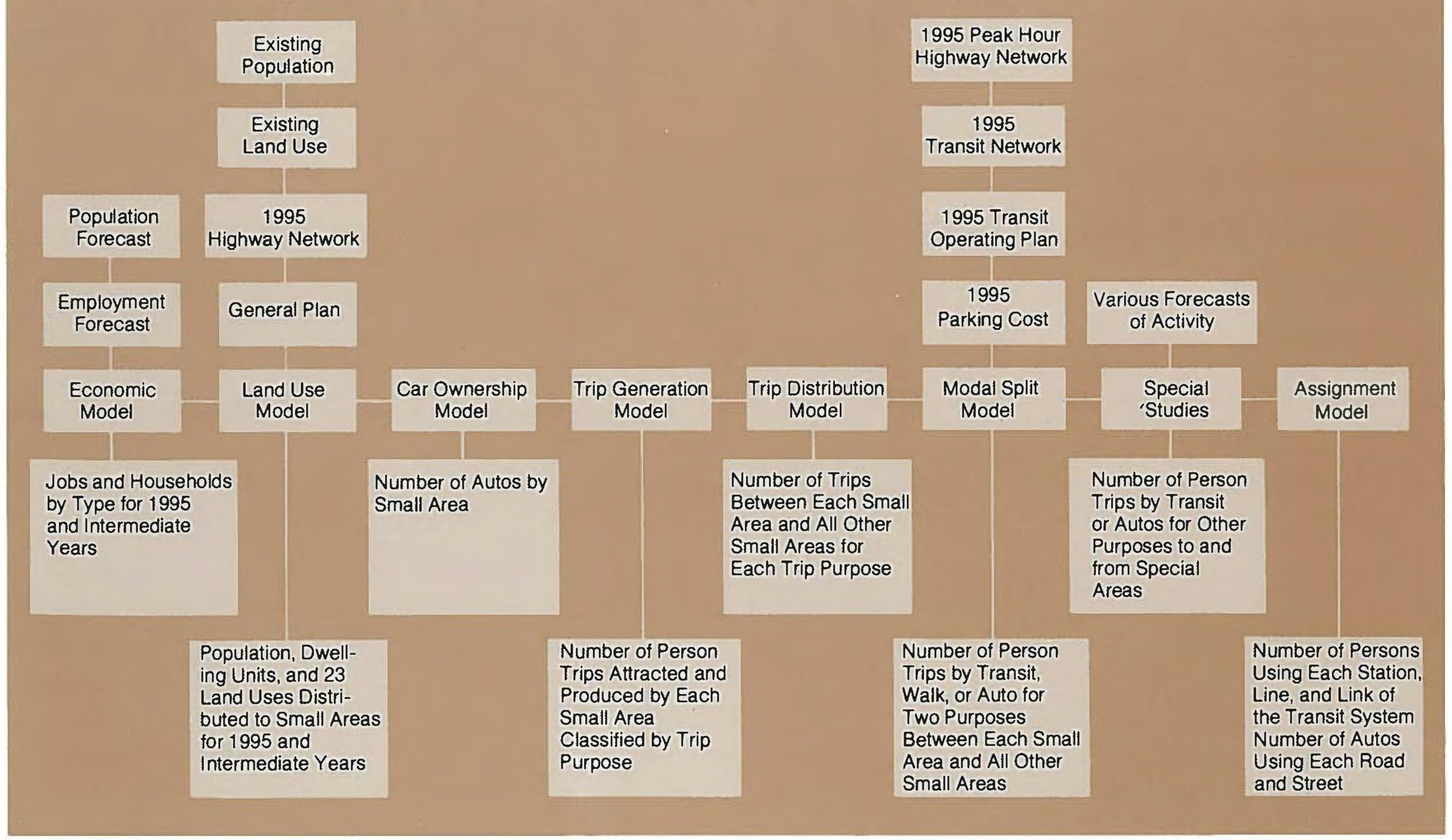
Estimation of future travel was made in two steps.

1. THE TRAVEL FORECAST AND THE TRAVEL PATTERN FORECAST, which indicated the total travel by all modes. This step involved the forecast of the number of the total daily trips attracted and produced by each census tract and the distribution of these trips by traffic analysis zones.
2. THE TRANSIT TRAVEL FORECAST which estimates that part of total travel to be made by transit, both rapid and bus. This step involved: the Transit Travel Assignment Procedure and the Modal Split, which distributes total travel according to the mode of transportation used.

The second step, was to identify 1995 travel on the proposed transit system, which provided the basis for:

- The identification of service requirements and determination of design requirements for the system
- Estimation of passenger revenues from operation of the system
- Estimation of the expenses of operation of the system.

Figure 7-1—Generalized Model Relationships for Transit Patronage Forecasts



The general process is illustrated in Figure 7-1 and shows the seven major models involved: economic, land use, car ownership, trip generation, trip destination, modal split, and assignment.

THE ECONOMIC MODEL predicts the future size of employment in the region and was operated by DPED. The 1995 population was estimated to be 924,000, as compared to 630,000 for 1970 and 505,000 for 1960. It estimated that there will be 518,140 jobs on Oahu in 1995, or 52 jobs per 100 persons. Family size was forecasted to go down slightly. These forecasts contrast sharply with those made by OTS for 1985 which had anticipated larger family sizes and fewer jobs per 100 persons. However, the new forecasts reflect trends over the last decade, conform to forecasts made by the U.S. Census Bureau.

THE LAND-USE MODEL distributed the outputs of the Economic Model to census tracts throughout the region. Employment was allocated to census tracts depending on the type of employment (e.g., industrial, commercial, and agricultural), and the type of land use allowed under the General Plan for the City and County of Honolulu. Thus, allocations were made to census tracts which have land available for the specific purpose. Dwelling units and population were also estimated by the Land-Use Model. The model provided 29 items of information for each census tract in five-year increments. The results of the model were reviewed, errors were corrected, and small adjustments made. These adjustments affected about one per cent of the population and jobs.

AUTO OWNERSHIP in 1995, was calculated for each census tract based on the number of households in each of three income ranges forecasted by the Land-Use Model. This information was required for subsequent work on both the trip generaion model and the Modal Split Model.

THE TRIP GENERATION MODEL is a set of mathematical equations which was used to determine the number of daily trips attracted and produced by each census tract. Different work trips, home-based shopping, home-based social-recreation, home-based school, home-based other, and non-home-based trips were each calculated separately. The outputs of this model were analyzed for conformance to results of recent home interview studies on Oahu and to results of similar studies on the Mainland. In the OTS study and in the recent home interview the ratio of 1.30 trips per job was found, a ratio which conforms to findings of mainland studies. This consistent ratio of trips to jobs thus enabled the results of the Trip Generation Model to be checked.

THE TRIP DISTRIBUTION MODEL is a process by which trip ends are connected using the results of the Trip Generation Model as input data. The basic tool used to accomplish this is the Gravity Model. As its name implies, the principles governing the way in which trip ends are matched are similar to the basic laws of gravity. In operation, the model connected the trip productions at the home-end with the attractions at the non-home-end. It also links the non-home-based trip ends. The number of work trips between any two zones, for example, is directly proportional to the number of resident workers and the number of jobs in each zone; and inversely proportional to a measure of the distance separating the zones. The measure of distance is normally expressed as a function of the travel time between the areas.

Prior to using the trip distribution model, census tract trip totals were refined to traffic zones. These are subdivisions of census tracts and were used to provide more precise allocations of trips to the highway and transit networks. There are 159 such zones. Since it is possible for trips from any zone to go to all other zones, there were more than 25,000 combinations. The model distributed the trips to these zonal pairs keeping each trip purpose separate. The model worked with persons trips and produced what is called a person trip table, one for each trip purpose.

THE MODAL SPLIT MODEL determines the percentage of persons who will use rapid transit based on the volume and distribution of total regional travel. The model used the estimated travel time by auto and transit, parking costs, and auto ownership to calculate trips made by transit. It calculated the modal split for (1) home-based work trips and (2) home-based other trips; viz, the aggregate of home-based shopping, social-recreation, and other trips. Thus the model produced four trip tables—two for transit trips and two for auto trips. The model was able to deal effectively with nearly all trips, however, certain kinds of trips and certain areas are substantially different and special studies were required. Special analyses were made for school trips, trips to and from the Manoa Campus of the University of Hawaii, and trips to and from the Honolulu International Airport. Additionally, commercial trips, although not assignable to the transit system, were separately estimated and converted to "equivalent" automobiles.

NETWORK CODING

The highway and transit systems determine to a large extent, how trips are made and what routes are taken. Therefore, it was necessary to develop the 1995 highway and transit systems and describe their operating characteristics. The 1995 highway system was prepared by ATPO. It was assumed to be the same for all of the transit alternatives.

The total transit network was then mapped in a specific manner which permitted it to be digitized for the computer. The system was represented as a series of lines called links, points denoting intersections or stations, and centroids denoting the approximate center of activity for each traffic analysis zone. Each link was described by its length, travel time or speed, and certain other characteristics. In the transit network, time spent walking, waiting, or transferring was kept separate from running time and multiplied by 2.5 for use in the Modal Choice Model. The reason for this is that people weight this time in their choice of travel mode. After the network description was encoded for machine processing, the computer made all necessary calculations to determine the travel time by transit and highway for the over 25,000 zone-to-zone movements.

SUMMARY

By 1995 it was estimated that there will be 3,362,000 person trips per day for all purposes and by all modes. This translated to 3.64 trips per person per day. Table 7-1 illustrates the distribution of total trips and transit trips by purpose.

The transit system is expected to serve 29% of all home-based work and 11% of home-based trips for other purposes. Whether school trips, which were projected to be 289,000 per day, will use transit is largely a matter of public policy. Only 11% were assigned to the transit system. Other special trips represent trips to and from the Manoa Campus of the University of Hawaii, trips between Honolulu International Airport, and trips to and from Halawa Stadium were projected to be some 86,000 total trips with approximately 30% expected to use the transit system.

RAPID TRANSIT PATRONAGE FOR THE RECOMMENDED SYSTEM

The final step was the assignment of the 1995 Transit Travel Pattern Forecast of 24-hour trips to the regional transit network for both the bus and rapid transit lines.

The total patronage on the recommended system in 1995 was estimated to be 484,000 riders per day. Of this total, 349,050 trips or 72 per cent are expected to use rapid transit for all or part of the journey. The feeder and local buses are expected to carry 510,000 daily passengers while express buses would carry 123,000 passengers per day. The total is greater than the 484,000 trips mentioned earlier due to transfers from one mode to another.

These trips, when assigned to the system, are manifested as passengers entering and leaving each rapid transit station and traveling between stations. Due to varying conditions, the 20 stations show a wide range in usage, from a low of 5,400 at Niu to a high of 106,600 on and off movements at the Central Business District (CBD) station. The stations at the ends of the line—Pearl City and Hawaii Kai—are expected to have about the same usage. Both are served by express and feeder buses. An important station is the one at Kalihi which serves as the transfer station for the Trans-Koolau express buses. It also is served by local feeders from Kalihi Valley. The station with the second highest usage is Waikiki. This station will be served by an extensive system of local Waikiki buses, taxis, and jitneys.

The average daily passenger volumes on the system are about 45,000 persons per day at the ends of the line and build to over 100,000 between Kalihi and the University of Hawaii. (See Table 7-2) The highest volume is 172,000 between the CBD and Civic Center Stations with the average volume between the CBD and Ala Moana being approximately 170,000 persons per day. (Figure 7-2)

Peak-hour volumes were estimated from average daily volumes on the basis of observed patterns of travel for each trip purpose. These peak-hour trips were assigned to the system to determine station and line volumes and show that the principal destinations of morning transit trips are downtown, the Civic Center, Waikiki, and University stations.

Directional morning peak-hour volumes between rapid transit stations is shown in Table 7-3. The trips in the koko head direction drop abruptly at the Waikiki and University stations to only a few hundred persons per hour. In the Ewa direction the big drop occurs at CBD station but line volumes beyond the CBD station remain above 1,000 persons per

Table 7-1

1995 TOTAL TRIPS AND TRANSIT TRIPS

Purpose	Total Trips	Transit Trips	Percent by Transit
Home-Based Work	674,000	193,000	29
Home-Based Nonwork	1,697,000	193,000	11
School	289,000	32,000	11
Non-Home Based	616,000	40,000	7
Other Special Trips	86,000	26,000	30
TOTAL	3,362,000	484,000	14

Table 7-2 **AVERAGE DAILY PASSENGER VOLUME BETWEEN RAPID TRANSIT STATIONS—1995**	
Station	
Pearl City	
Pearl Ridge	45,000
Halawa Stadium	53,000
Pearl Harbor	62,200
International Airport	71,600
Keehi Lagoon	81,600
Kalihi	91,500
Liliha	135,800
CBD	150,000
Civic Center	172,000
Ward Avenue	169,600
Ala Moana	170,300
Waikiki	155,400
University	120,900
Sixth Avenue	95,800
Koko Head	79,100
Kahala	68,800
Aina Haina	60,200
Niu	53,100
Hawaii Kai	49,000

Table 7-3

PEAK HOUR PASSENGER VOLUMES BETWEEN RAPID TRANSIT STATIONS BY DIRECTION—1995

Station	Koko Head Bound	Ewa Bound
Pearl City		
Pearl Ridge	7,400	1,300
Halawa Stadium	8,900	1,400
Pearl Harbor	10,500	1,000
International Airport	11,200	2,000
Keehi Lagoon	10,500	3,000
Kalihi	11,600	3,500
Liliha	17,900	4,900
CBD	19,000	6,200
Civic Center	14,600	13,800
Ward Avenue	10,500	17,500
Ala Moana	9,400	18,800
Waikiki	8,700	16,800
University	4,300	17,600
Sixth Avenue	1,100	16,500
Koko Head	690	14,100
Kahala	570	12,600
Aina Haina	170	11,500
Niu	150	10,000
Hawaii Kai	190	9,100

hour, reflecting the large availability of jobs Ewa of downtown. The peak hourly volume is 19,000 persons and 18 links (eight in the koko head direction, ten in the Ewa direction) have volumes in excess of 10,000 persons. (Figure 7-3)

BUS FEEDER SYSTEM

To carry people to and from the stations and also to provide public transportation in corridors and areas not served by the fixed guideway system, a feeder system consisting of express, local, and shuttle buses was provided. Each bus route was laid out on a map of the area, given a service level, and coded as part of the Island-wide network. After assignments were made, the capacity of each route was checked against the assigned volume to be sure that enough buses were available to carry the anticipated volume and that there was enough patronage to warrant the level of service assumed in the original route planning. The bus routes included in the final assignments to the recommended system include all of the improvements in routing and service levels. It consists of 13 express routes, 47 local and feeder routes and four shuttle routes.

REQUIRED BUSES[1] FOR RECOMMENDED SYSTEM

	1980	1995	2010
Express	120	172	234
Feeder	166	260	316
	286	432	550

[1]plus 10% spares

FARE STRUCTURE AND REVENUE ESTIMATES

The optimum fare schedule for a rapid transit system is one which will maximize patronage and at the same time will produce sufficient revenues to meet operating and maintenance expenses. It must also be related to the existing fare structure of the City's bus system as both the rapid transit and bus systems will operate as an integrated system.

There are many possible fare structures applicable for the proposed system such as flat fares, zone fares, and graduated fares. In considering the fare structure for the Honolulu system, the primary considerations were:

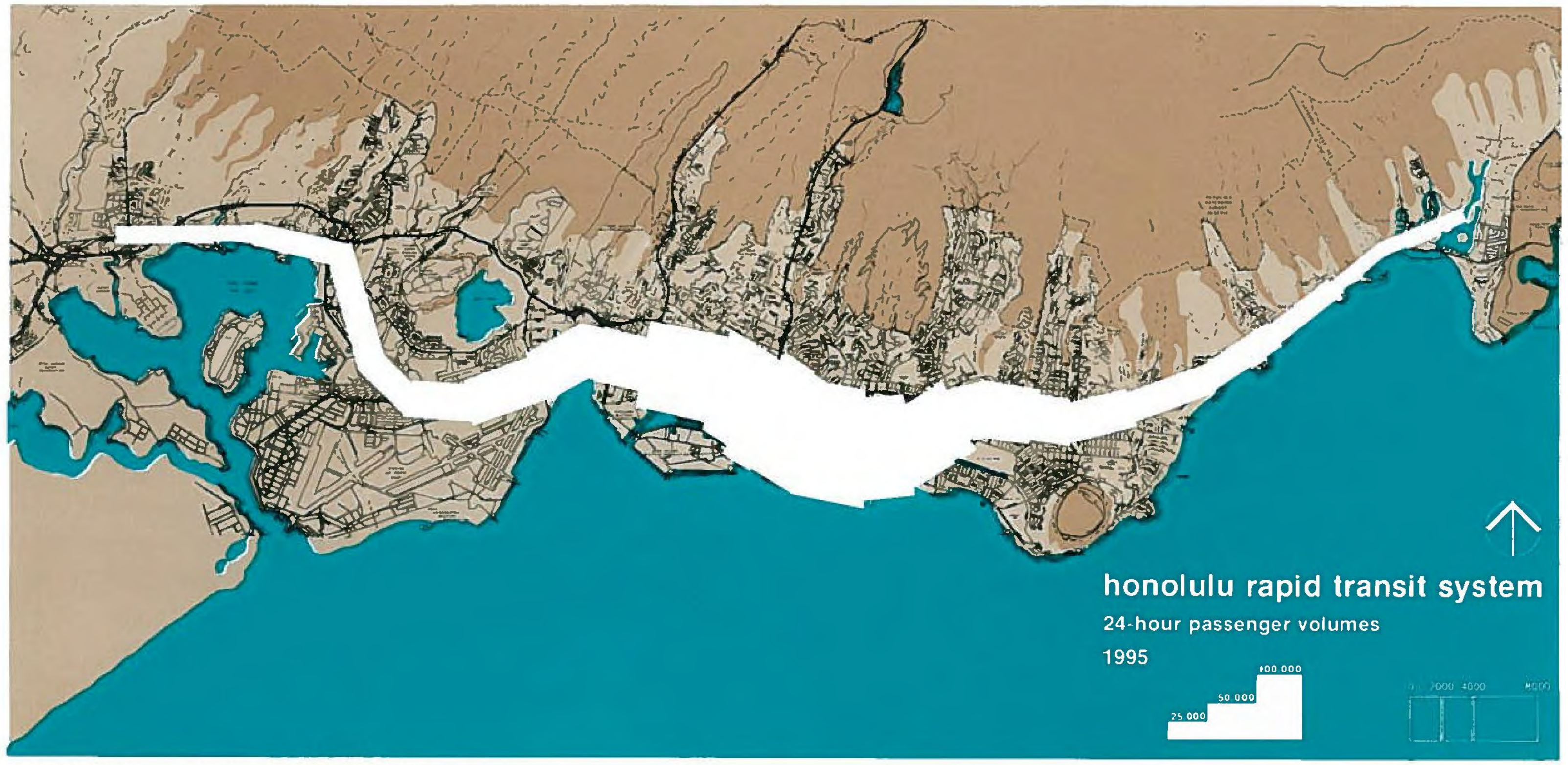


FIGURE 7-2 *24 Hour Passenger Volumes*

FIGURE 7-3 *Peak Hour Passenger Volumes*

- The existing fare structure of the City's bus system is a flat 25¢ per ride in urbanized Honolulu and 50¢ per ride from the outlying suburban areas to Honolulu
- One of the goals of the City is to ultimately provide for free transit service
- A full 60% of all transit trips are less than 5 miles in length

The relatively short trip length for most trips on Oahu suggests that graduated fares might not be as desirable as in the case of regions where trip lengths are distributed over a large range of values. In such cases flat fares would result in a clear inequity for those making very short trips.

Graduated and zone fares furthermore require more expenses for revenue collection. Both the Bay Area Rapid Transit (BART) and Washington Metro systems have selected expensive systems to collect graduated fares. However, both of these transit systems are distinctly different from the proposed Honolulu system in terms of system layout, trip length, and average fare.

After analyzing the proposed system and its users, it was concluded that the fare structure should have the following characteristics:

1. A Flat Fare for Each of the Major System Components
   - Feeder and Local Bus
   - Express Bus
   - Rapid Transit
2. No Transfer Privileges
   This characteristic implies a partial graduation in that persons using an express bus plus rapid transit, who generally would be making longer trips, would pay more for the ride than would those who only used one or the other mode.
3. Charges Should Reflect the Quality of Service
   This means that those using rapid transit and express buses should pay more than those using local and feeder buses.
4. Revenue Collection Equipment
   The equipment should be simple and economical in operation.
5. Fares
   Fares should be kept at a level approximately equal to that of the existing bus system.

These characteristics were employed in developing two basic fare structures with variations in the fare schedule for each (Table 7-4). Type I established fares for each of the transit system components with the local bus fare remaining constant at 10¢ for all alternatives. The rapid transit and express bus fares remain the same within each alternative.

Type II fare structure differs from Type I in that the local bus has free fare under all alternatives. The rapid transit and express bus fares remain the same within each alternative.

All of the alternative structures have a simple set of fares to eliminate transfers and their attendant costs and delays. Each includes either a small charge or no charge for local and feeder buses. This feature was designed to accommodate the realization of a free or at least a low-fare bus system by the time a rapid transit system is open to use.

The principle effect of the basic plan is to charge in accordance with the amount of service used. Thus a person using rapid transit plus express bus would pay more than one using, say, only the rapid transit. Similarly, long trips would cost more than short ones. To offset this in actual operation, short express bus routes could have lower rates and long local routes could have higher charges. The fares of the variour alternatives do not differ significantly from those existing today.

Both Type I and Type II fare structures would produce revenues to meet the estimated total operating and maintenance cost based on 1972 costs. Based on the transit patronage projections, either fare structure would generate approximately $27 million and $50 million in revenues for 1980 and 1995, respectively. The total annual operating and maintenance costs are estimated at $26 million and $36 million for 1980 and 1995, respectively.

These fare structures would provide some excess to cover possible over-estimates in the patronage. For example, in 1995, sufficient revenues would be produced with only slightly more than 70 per cent of the estimated patronage to cover the operating and maintenance costs. The outlook for 1980 is not so favorable. Practically the full estimated patronage is needed to cover operating and maintenance costs. However, in the event that patronage were to be well below the estimate, operating costs could be reduced to partly offset losses.

The revenue estimates do not explicity allow for reduced rates or free fares to students or senior citizens. However, the majority of school trips would be on local or feeder buses which are fare-free in Type II and only ten cents in Type I. Therefore, the estimates are deemed reasonable for planning purposes at this time. Under either fare structure, a patron utilizing the feeder bus once and the rapid transit for a particular trip would be paying 35¢. This compares favorably to the current 25¢ fare for a similar type when one considers the improved service obtained on the rapid transit portion of the trip which would be faster and more comfortable.

Table 7-4

ALTERNATIVE FARE STRUCTURES
(Based on 1972 Dollars)

	Rapid Transit	Express Bus	Local Bus
Type I	25¢	25¢	10¢
Type II	35¢	35¢	-0-

PLAN OF OPERATION AND OPERATING AND MAINTENANCE COSTS

The annual operating and maintenance (O&M) expenses were estimated for the proposed transit system by setting forth the principal operating and maintenance functions to be performed on both the rapid transit and bus systems. The required manpower and materials were estimated for these functions, giving consideration to the physical characteristics of the planned system, the number of passengers to be carried, and the plan of operation developed for the system.

The wage rates used in calculating labor costs were those in effect in 1972 for comparable job position within the City and present work force. Working rules and conditions and employee benefits which affect expenses were assumed to be similar to those contained in the City's present labor agreements.

RAPID TRANSIT PLAN OF OPERATION

A plan of operation was prepared to serve as a basis for estimating expenses. The plan provides for through routing of trains between the terminal at Pearl City and Hawaii Kai. Operational turnback points were provided at the University Station and the Pearl Harbor Station, but under normal service operations, the trains will all continue to the terminal stations. This would provide sufficient seats for boarding patrons at the outlying stations.

The hours of operation would be from 5:00 a.m. to 1:00 a.m., seven days a week. Train schedules were prepared based on estimated passenger volume, the physical characteristics of the transit cars, and the plan of operation. Car loading was assumed to be 72 passengers per car with a maximum of 720 passengers per train for a 10-car consist. The maximum frequency of service during off-peak periods was assumed to be 4 minutes or 15 trains per hour. (See Table 7-5)

Table 7-5

RAPID TRANSIT OPERATIONS

1995
Peak Hour: 9-car consists @ 2 minute headway
Base Period: 6-car consists @ 4 minute headway
Evening Period: 2-car consists @ 4 minute headway

1980
Peak Hour: 7-car consist @ 3 minute headway
Base Period: 5-car consist @ 6 minute headway
Evening Period: 2-car consist @ 6 minute headway

Based on the projected 1995 volume, it was estimated that 360 cars are required for peak period service or a total fleet of 405 cars including spares. In 1995, ti was estimated that 31.3 million car miles would be operated.

ESTIMATED EXPENSES

The estimated annual operating and maintenance expenses and the expenses per car mile are listed in Table 7-6. These estimates are for 1995 service levels but at wage and cost levels in effect in 1972 for the rapid transit portion of the system.

The items of expense included in each category are described briefly as follows:

MAINTENANCE OF WAY AND STRUCTURE
Costs in this category include the labor and material expenses of maintaining fixed facilities such as subways, aerial structures, guiderail and switches, stations, power systems, control and communications equipment, fare collection equipment, escalators, fencing and parking lots.

TRANSPORTATION
This category includes the wages of the train attendants, station attendants, porters, and other operating personnel and the cost of materials directly associated with train operation.

MAINTENANCE OF EQUIPMENT
Includes the labor and material expenses of maintaining, inspecting, repairing and cleaning the rolling stock.

GENERAL AND ADMINISTRATION
This category includes the administrative personnel required in such functions as accounting, purchasing,

scheduling, personnel, etc., that will be required; insurance expenses including liability and property damage insurance; and other administrative expenses.

POWER
Included in this category are the costs of providing traction power for the propulsion of the cars and auxiliary power for station illumination and operation of machinery, such as escalators, fans, pumps, and other power equipment.

BUS SYSTEM

The proposed rapid transit system will bring about changes in the existing bus system by attracting a substantial number of new passengers to the proposed feeder bus network and by diverting to the rapid transit system those bus passengers whose journeys will be more satisfactorily made by that mode. It is estimated that on an average weekday in 1995, there will be 349,000 boarding and alighting trips in and out of the rapid transit stations, of which some 60% will be carried by feeder buses. The bus network required to serve this volume will consist, in part, of present bus lines which directly serve the proposed station locations or which can do so with minor modifications in routing. These lines will need to be augmented with a substantially higher level of service than is now operated. Entirely new routes will be required for areas not now served by the City bus lines.[6]

FEEDER BUS SYSTEM

To accommodate the estimated number of passengers who will require transportation by buses, a network of 64 bus lines operating over some 500 line miles is proposed. Of this, there will be 47 feeder bus lines, 4 shuttle bus lines, and 13 express bus lines. In 1995, a total of 432 buses are required for peak period operation plus 43 spares for a total fleet of 475 buses.

OPERATING AND MAINTENANCE COST

To determine the operating and maintenance (O&M) cost of the bus system, the number of buses required during the peak hour was calculated route-by-route to ensure that the prescribed level of service was met. The peak hour required vehicles were then converted to bus hours covered per day based on a utilization factor, i.e. the effective hours the buses are in operation for an average weekday. The utilization factors used were 8.58 hours per day for express buses and 11.735 hours per day for feeder buses.

For 1995, the bus hours estimated were 1,480 express bus hours and 3,050 feeder bus hours per average week day. Bus-miles operated per day were then calculated based on assumed speeds of 25 mph and 9 mph for express and feeder buses, respectively. The bus miles were 37,000 and 27,450 for express and feeder bus, respectively, for a total of 64,450 bus miles per average weekday.

Based on the above plan of operation for the bus system, a unit O&M cost of $13.50 for feeder and $15.00 for express bus as the cost per bus-hour, the total cost on a daily basis was determined. These unit costs were derived from the City's operating experience and utilizing wage and cost levels for 1972. The annual O&M cost, for 1995, is estimated to be $19.0 million based on 1972 prices.

CONSOLIDATED OPERATING AND MAINTENANCE COST

The bus and rapid transit systems will be operated as an integrated system by the City and therefore the O&M expense estimates are consolidated on a system-wide basis. The estimates set forth heretofore have been for the full 22-mile rapid transit system with complementary feeder bus system and based on the level of service to handle the 1995 patronage.

Operating and maintenance costs were developed in a similar manner on the system-wide basis for the 1980 and 2010 patronage estimates. In Table 7-7 the bus and rapid transit expenses are presented for the proposed 22-mile system for the year 1980, 1995, and 2010.

In addition to the full 22-mile system, studies were conducted to determine O&M costs for a shortened system. Two different system lengths were considered, the first comprising a 12-mile system from the Halawa Station to the University Station and the second comprising a 14-mile system from Halawa Station to the Kahala Station. Express and feeder bus routes were extended and supplemented to provide service and interface at these terminal stations. Additional buses were required with corresponding increase in bus O&M costs. The O&M expeses for the two alternative system lengths for the three time periods are shown in Table 7-8.

Table 7-6

RAPID TRANSIT OPERATING & MAINTENANCE COST

Expense Categories	Annual Expense	Expense per Car-Mile
• Maintenance of Way & Structure	$ 3,300,000	10.5
• Transportation	5,800,000	18.5
• Maintenance of Equipment	2,300,000	7.4
• General & Administration	2,850,000	9.1
• Power	2,700,000	8.6
TOTAL	$16,950,000	54.1¢

Table 7-7

CONSOLIDATED OPERATING & MAINTENANCE COSTS
(In $ Millions)

	1980	1995	2010
Rapid Transit	13.0	17.0	21.3
Express Bus	4.6	6.6	9.0
Feeder Bus	7.9	12.4	15.0
TOTAL	25.5	36.0	45.3

Table 7-8

12-MILE INCREMENT

	1980	1995	2010
Rapid Transit	9.8	12.6	14.5
Express Bus	5.1	7.8	10.6
Feeder Bus	9.7	16.7	20.5
TOTAL	24.6	37.1	45.6

14-MILE INCREMENT

	1980	1995	2010
Rapid Transit	10.5	13.5	16.3
Express Bus	4.9	7.4	10.0
Feeder Bus	9.3	15.5	19.2
TOTAL	24.7	36.4	45.6

PROJECTED TRAVEL TIMES: 1980

+50 min. to Waianae
+62 min. to Kahuku
+32 min. to Haleiwa
+12 min. to Wahiawa
+10 min. to Waipahu

+32 min. to Kailua
+30 min. to Kaneohe

+24 min. to Waimanalo
+39 min. to Kailua
+53 min. to Kaneohe

Transit Travel Time in Minutes

	PEARL CITY	PEARL HARBOR	AIRPORT	CBD	WAIKIKI	UNIVERSITY	KAHALA	HAWAII KAI
PEARL CITY	0	7:25	9:25	16:43	22:15	24:07	29:01	39:19
PEARL HARBOR		0	1:55	9:18	14:50	16:42	21:36	31:54
AIRPORT			0	7:23	12:55	14:47	19:41	29:59
CBD (FORT)				0	5:32	7:24	12:18	22:13
WAIKIKI					0	1:52	6:46	17:04
UNIVERSITY						0	4:54	15:12
KAHALA							0	10:18
HAWAII KAI								0

FIGURE 7-4 Rapid Transit Travel Times

HONOLULU INTERNATIONAL AIRPORT (HIA)—WAIKIKI TRANSIT SERVICE

The HIA—Waikiki transit service has previously been identified as a special purpose service in that it would be provided to predominantly serve out-of-state visitors and consequently should be treated separately from the basic transit system. Based on forecasts of air passenger volume at the HIA and past studies conducted of travel characteristics of air passengers, a preliminary study of potential patronage for special transit service was conducted.

HIA PASSENGER FORECAST & TRAVEL CHARACTERISTICS

Forecasts of HIA enplaned and deplaned passenger volumes have been developed by the State Department of Transportation (DOT) using their airport computer model. A significant increase in annual passenger volume is forecasted as follows:

1972	7,000,000
1980	12,800,000
1985	15,800,000
1990	28,800,000

Previous surveys conducted by the State DOT indicated that 65 % of enplaned passengers designated Waikiki as their trip origin and approximately 65% of all air passengers were tourists.

The survey also indicated that the mode of travel used between HIA and Waikiki were distributed as follows:

Mode	Percent Use
Private Car	9
Rental Car	16
Taxi	39
Airport Bus & Limousine	13
Tour Bus & Limousine	19
Other	4
	100

DIVERSION ANALYSIS

A diversion analysis was made based on fare and travel time differentials between current modes and the rapid transit system. A rapid transit fare of $1.50 and travel time of 30 minutes were used in analyzing the potential market diversion from private and rental cars, taxis and airport buses and limousines. The tour bus and limousine mode was not considered since the choice of mode is determined by the tour companies and not left to individual's choice.

Based on diversion curves developed in previous studies,* and data obtained from the Cleveland Hopkins Airport Access Study, it was estimated that diversions could be made as illustrated in Table 7-9.

PATRONAGE AND REVENUE FORECASTS AND ESTIMATES OF COSTS

In 1995, it was estimated that approximately 60,000 person trips per day would be generated from the Honolulu International Airport. Of this, 50% has been assumed to be trips generated by visitors staying in Waikiki. A 25% diversion of the total HIA—Waikiki trips to rapid transit would provide a daily patronage volume of some 7,500 passengers per day. Applying the rapid transit fare of $1.50 per ride used in the diversion analysis, this would generate an annual revenue of approximately $4.0 million in 1995.

Through maximum utilization of the rapid transit facilities provided for the commuter service, the added facilities and equipment required for the special HIA—Waikiki service is estimated to cost $33 million. This estimated amount includes appropriate contingency and escalation provisions and the required rapid transit vehicles and shuttle buses in Waikiki. The escalation amount is based on the construction schedule as developed for the basic commuter service system

*Honolulu International Airport Transfer Study; Peat, Marwick, Livingston & Co., Feb. 1970 with the initial revenue operations scheduled to begin in late 1978.

For purposes of this analysis, it is assumed that two-thirds of the capital cost would be funded by UMTA. The remaining one-third to be locally funded would then amount to $11 million. It is assumed that this amount would be financed by revenue bonds at 25-year maturity and an interest rate of 6%. The annual debt service, assuming level payment, would be $860,000 with the required revenue based on 1.5 debt service coverage amounting to $1.29 million.

The annual operating and maintenance cost for providing the HIA—Waikiki service would include both the rapid transit and shuttle bus operations. The rapid transit portion of the O&M cost includes the pro-rata share of the total cost of operating and maintaining the commuter rapid transit system and the added cost of manning the two terminal stations at Waikiki and the airport. The bus portion of the O&M cost is based on the actual operating hours of the Waikiki shuttle buses using the same unit cost as developed for the regular commuter service bus operations.

Table 7-10 presents a comparison of revenues to cost based on 25% diversion of the projected total HIA—Waikiki trips for the indicated years. Based on these figures, it can be seen that annual cost exceeds revenue for the initial 10 years or more of operations with subsequent years beginning to show a small surplus. Both the revenue and cost estimates are based on 1972 price levels.

SUMMARY OF FINDINGS AND CONCLUSIONS

The study pointed out several critical factors that would influence the feasibility of providing special transit service for the HIA—Waikiki movement. To provide this service would require a relatively high capital investment for a ridership market characterized as modest in potential volume and predominantly non-resident tourists. Tourism has grown at a rapid pace and is expected to continue growing for the State of Hawaii. However, like most industries, tourism is also subject to economic cycles such as the year 1971 when the total visitor count fell substantially below the anticipated increase over the previous year.

The projected HIA—Waikiki movement is based on the assumption that visitor accommodations would continue to increase in Waikiki. However, there have been objections raised to the uncontrolled growth of hotels in Waikiki with emphasis voiced for more quality than quantity growth. Such a growth would ensure the continued viability of the tourist industry in Waikiki but would constrain the growth realized in the past decade. Since the HIA—Waikiki service is highly dependent on the tourist market, it is necessary to redefine the future development and growth of Waikiki in order to reliably estimate the potential transit patronage volume.

The second important factor in determining the patronage volume is the relationship of the proposed service to the existing service presently provided by automobiles and buses on streets and highways. The potential diversion of travelers from present modes is highly dependent on the highway facilities in the future. Consequently future improvements such as the widening of Lunalilo Freeway and Nimitz Highway/Ala Moana Boulevard would have an impact on the competiveness of the rapid transit service. These highway widening programs may not provide a long-range solution to the airport access problem but could have a significant effect on the diversion to rapid transit in the early years of operation. A determination of the level of highway improvements contemplated is necessary to more reliably estimate the transit patronage, especially in the early years of operations where the financial requirements are most critical.

There are additional considerations which will have both direct and indirect impact on the feasibility of providing the HIA—Waikiki transit service. The proper location of the transit facilities relative to the airport terminal must be fully coordinated with the current improvement program. A simple and readily identifiable flow through the airport facilities must be provided together with appropriate accommodations for baggage transfer, customs and agricultural inspection, and coordination with the intra-airport transport system. The attitude of tour operators would also have an important influence on the feasibility of the system. Approximately 20% of the total passenger movement between HIA and Waikiki is handled through pre-arranged tour buses and limousines. A substantial capture of this market would enhance the feasibility of providing rapid transit service.

The results of this study confirm the basic conclusions drawn in various other studies that user revenue production under a free market situation would not be sufficient to cover both capital and operating costs of any new mode of transportation to serve this special purpose travel. The study shows that even under a very favorable basis of utilizing the common facilities of the proposed rapid transit system, the financial feasibility of providing the special HIA—Waikiki transit service is marginal at best, again assuming that the system would be operated in a free market. Accordingly, before any final conclusions can be drawn, the previously discussed factors stated to have a major bearing on the system feasibility must be considered further and resolved by various involved agencies and groups.

Table 7-9

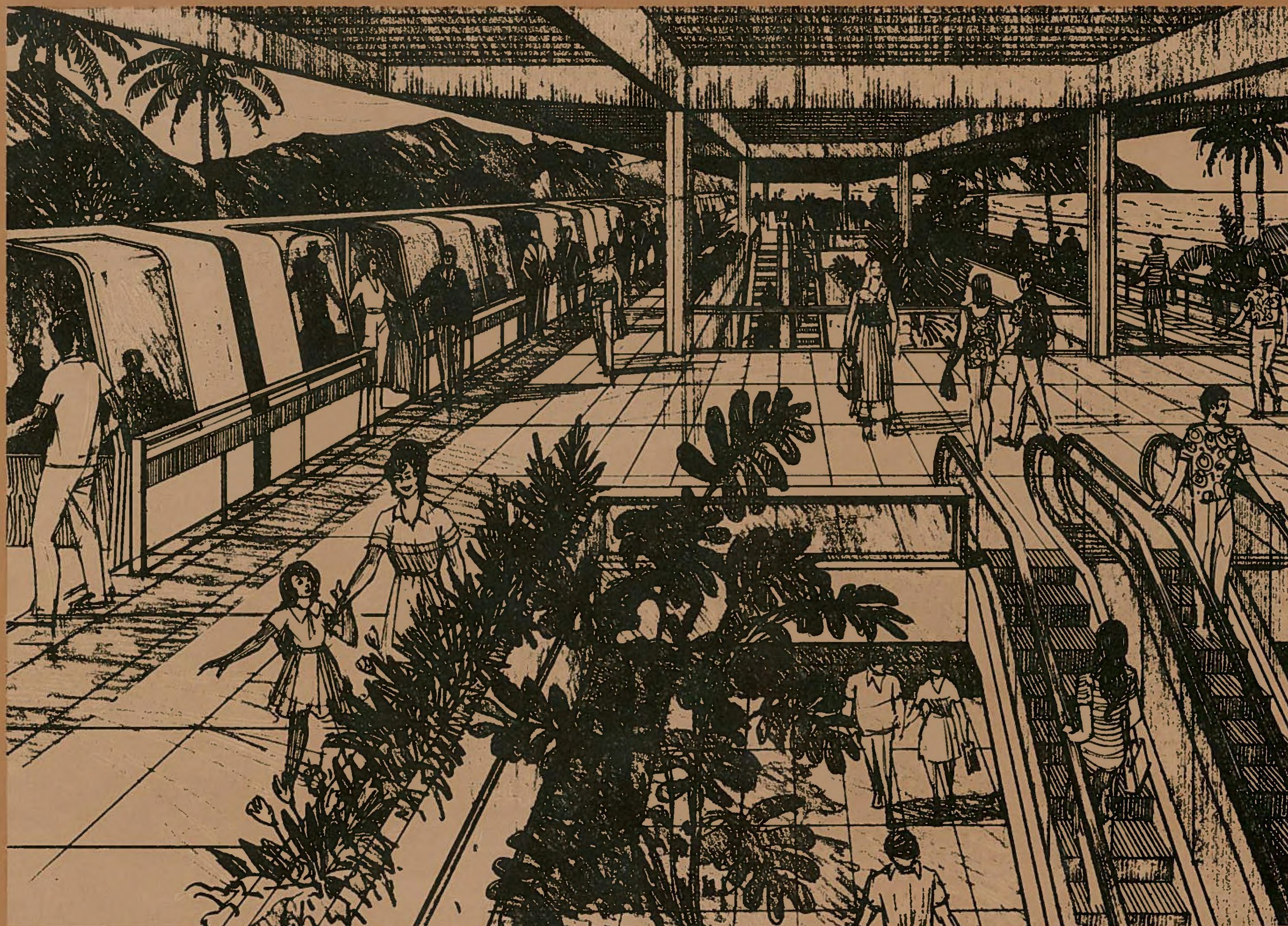
AIRPORT DIVERSIONS

Mode	Current % Use	% Diversion	% Rapid Transit Use
Private Car	9	20	2
Rental Car	16	18	3
Taxi	39	35	14
Airport Bus & Limousine	13	45	6
Tour Bus & Limousine	19	—	—
Other	4	—	—
	100		25

Table 7-10

PROJECTED REVENUE & COSTS

	1980	1985	1990	1995
Total Annual Diverted Trips (in millions)	1.28	1.55	2.14	2.74
Total Annual Revenue $1.50 Fare (in $ millions)	$1.92	$2.32	$3.21	$4.11
Annual Costs				
• Debt Service including 1.5 coverage (in $ millions)	1.29	1.29	1.29	1.29
• Operating Cost	1.75	1.95	2.12	2.49
• Total Annual Cost	3.04	3.24	3.41	3.78
Difference between Revenue & Cost	(-1.12)	(-0.92)	(-0.20)	+0.33



facilities design 8

INTRODUCTION

Good design of stations and way structures is extremely important if a transit system is to win public acceptance and attract patrons from other modes of travel. The basic design objective has been to create a total transportation environment that will not only provide fast, safe and convenient service, but one which will satisfy human needs as well.

The people of Hawaii have, over the years, developed a unique way of life in response to the inherent characteristics of their environment. This life style incorporates not only a relaxed informality as a response to climatic conditions, but also a sophisticated sense of graphics and color which results from an appreciation of the surrounding beauty. In addition, the richness and variety of the Island's cultural and racial heritage has created an historical awareness found in few other places. All of these factors have been recognized and have influenced the preliminary design of way structures and stations for Honolulu's proposed rapid transit system.

New rapid transit systems in San Francisco, Montreal, and Mexico City have demonstrated that design excellence can and must be incorporated in public transit systems. For Honolulu, the transit structures have been schematically designed and proportioned to contribute to the architecture of the community and provide rich variety and local identity throughout the system. Subsequent design phases must provide a rapid transit system which will become not only an integral part of the urban environment, but also an attractive environment in itself.

Together with the sensitive design of guideway and station facilities, the most technologically advanced operating systems would be incorporated to provide a modern, attractive rapid transit system. Fully automatic train operation is within the state-of-the-art and is necessary to ensure safe operation of a high speed, high capacity system as proposed for Honolulu. Modern techniques of supervisory control and voice and video communications provide safety to the patrons as well as important overall system operational efficiency. Comfort, convenience and dependability of the service to be provided are primary system design features to attract a high volume of patrons.

DESIGN REQUIREMENTS

The design parameters established for the proposed rapid transit system should and will impose stringent requirements on the design of various elements of the system. They are required to ensure passenger safety, comfort, and convenience as well as operational requirements for capacity, headways, speed and economy. The primary design parameters used as the basis of design include the following:

SYSTEM CAPACITY

Capacity of the system is based on anticipated patronage demand in the year 1995 including appropriate allowance for increased patronage beyond the present estimates. Additional capacity to meet growth and contingency demands beyond 1995 is provided by increasing the capacity by one-third of the 1995 demand. The maximum link volume, in one direction, occurring on the proposed system in 1995 is estimated to be 20,000 passengers per hour. A one-third increase of the volume would be 27,000 passengers per hour which would require a 10-car train operating at 90-second headway.

SYSTEM OPERATION

Minimum Operating Headways:	2 minutes and 90 seconds ultimately
Station Dwell Time:	20 seconds, maximum
Vehicles per Train:	10 maximum, 2 minimum
Vehicle Capacity-Design:	72 passengers (36 seated)

GUIDEWAY ALIGNMENT

HORIZONTAL ALIGNMENT

Curvature—Minimum:	500 ft.
Superelevation—Maximum:	9 inches
Transition:	Spiral

VERTICAL ALIGNMENT

Gradient—Design Maximum:	6%—sustained 10%—short distance 1%—through station
Vertical Curves—Maximum rate of change:	1.5% per 100 ft.

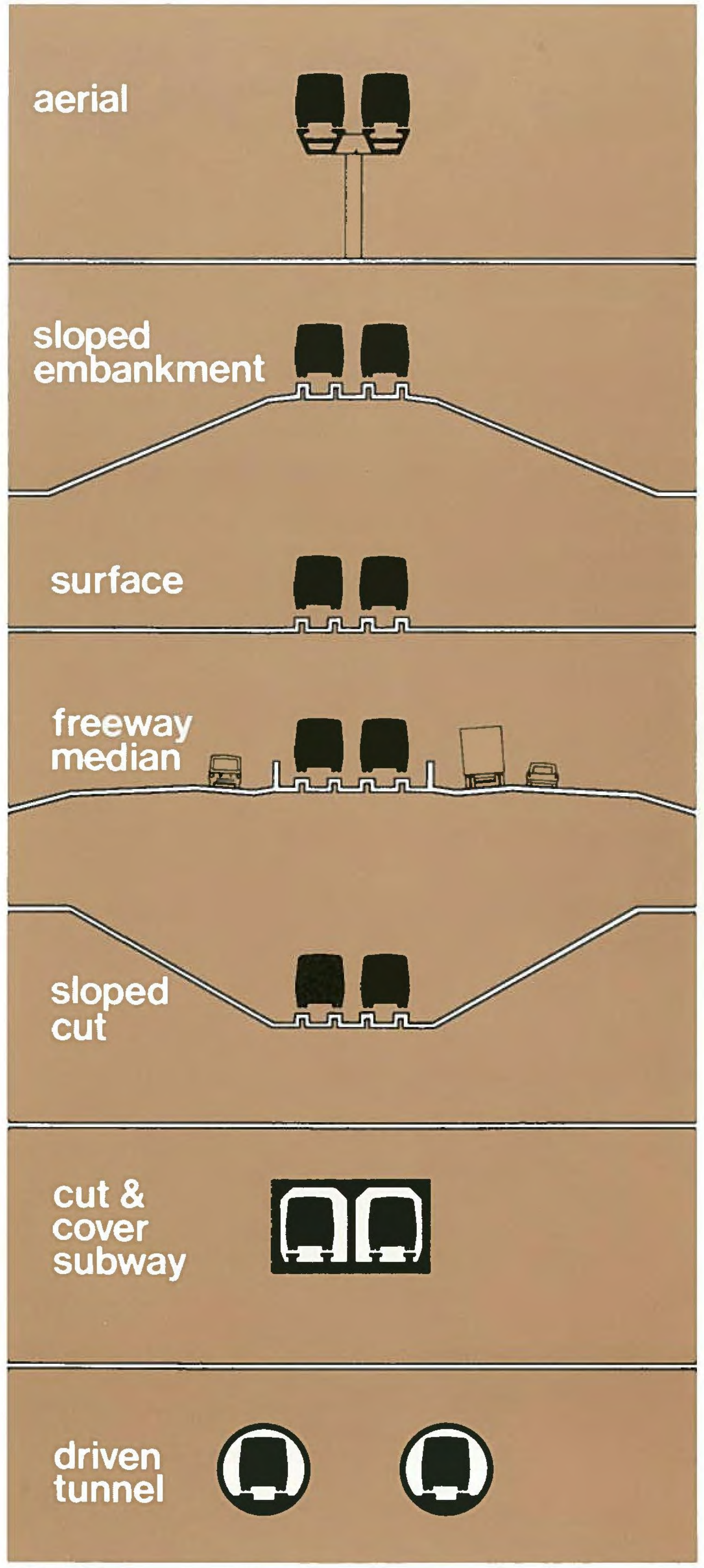


FIGURE 8-1 Rapid Transit Configurations

WAY STRUCTURE

Clearances—Minimum over Highway:	16′-6″
Aerial Structure—Maximum Deflection:	1/1000 span length for 80% of maximum line load
Seismic Load:	10% of dead load
Wind Load:	Per A.A.S.H.O.

FACILITIES

STATIONS	
Platform Length:	420 ft.
Vertical Circulation:	Escalators and Elevators
Fare Collection:	Automatic
SUBWAY	
Ventilation:	Piston action and emergency fan.
ELECTRICAL	
Traction Power:	600 volt, d.c.

WAY STRUCTURES

Way structures represent one of the largest capital investment items of the entire system and together with stations, will become the most visible feature. These structures must therefore be aesthetically pleasing in all respects. As a structural system, they must be capable of supporting high speed trains in complete safety. They must also be economical to build and maintain, and their construction must involve minimum disruption to local communities and neighborhoods.

The configuration used in traversing any given section of the proposed rapid transit route will be one of the dominant items influencing community acceptance. To make such selections involves a range of considerations such as aesthetics, noise, and community goals, as well as economic factors of land value and construction costs. The route planning process established criteria for planning and investigated various configurations and their application.

There are three basic way structure configurations which provide the necessary separation of rapid transit operation from other traffic and community activities as well as permit the rapid transit system to be superimposed on an urban area with minimum interference and disruption. These are classified as at-grade, aerial, and subway, with certain significant variations. (See Figure 8-1)

AT-GRADE CONFIGURATION

The at-grade configuration is the least expensive. The guideway is placed on a shallow supporting foundation which, in turn, is placed directly on the earth. This configuration is used where grade separation already exists, such as a freeway median, or where it is not required such as along a river or waterway. Any other use of at-grade construction requires variation to achieve the necessary grade separation. Such variations include cut (on depressed sections) or fill (or embanked sections). Both cut and fill sections may be either retained or sloped depending on right-of-way width.

AERIAL CONFIGURATION

The aerial configuration is more expensive than at-grade construction, but provides integral grade separation and at the same time permits the use of the ground below for other purposes. In this configuration, the transit guideway is placed on elevated beams supported by columns. The supporting structure may be constructed of either steel or concrete.

SUBWAY CONFIGURATION

The subway configuration is the most expensive to construct, however, it permits complete freedom for existing and future land use. The guideway is placed entirely underground within a tube or box section. Subways may be either driven tunnels or constructed by cut and cover methods in concrete box sections.

WAY STRUCTURE CONFIGURATION SELECTION

ALIGNMENT CONSIDERATIONS

Much of the decision on configuration selection is governed by the location of a particular route segment. For example, while an at-grade configuration is the least costly and easiest to construct of all transit way structures, it is limited in its application by requirements for complete grade separation of transit and other traffic. Therefore, this configuration is applicable only where grade separation already exists, as in the case of a freeway median.

The open cut or depressed configuration provides grade separation but encounters serious problems with existing utilities, particularly gravity systems such as sewers and storm drains, which must cross the system. This configuration is, therefore, most applicable where the route parallels the natural slope of the surrounding terrain and utility crossings are minimal.

The aerial structure, on the other hand, is not appreciably constrained by utilities or topography. It also has the added advantage of allowing community use of the land below for parks, streets or other activities and with Oahu's limited land resource, this is particularly important. The aerial configuration is also the most favorable for the transit rider since the elevated view point will afford incomparable vistas of the Island's scenery. With good structural design and careful landscaping, the aerial structure can become an aesthetically pleasing addition to the urban environment.

The subway configuration is the least influenced by physical surroundings and topography. However, the high cost of construction limits the use of this configuration to those areas where physical disruption must be kept to an absolute minimum such as the historic downtown area of Honolulu.

ACOUSTICAL CONSIDERATIONS

The constantly increasing sound level in urban areas has become a serious concern to urban planners and residents alike. On Oahu, this concern has been manifested in the "Vehicle Noise Control Regulations" enacted by the State Legislature. The preliminary design studies therefore have included in-depth study and analysis of sound and vibration control throughout the system. These studies have included a determination of sound levels and vibrations which would be produced by the transit trains in various configurations; measurements of existing sound levels in the areas traversed by the proposed routes; evaluation of acceptable sound levels for Honolulu; and a determination of sound control techniques which will produce acceptable conditions.

The results of these studies have clearly shown that the sound level produced by a 10-car transit train traveling at 60 mph will be less than the limits defined in the Oahu Vehicle Noise Regulations. In addition, a further reduction in noise levels can be accomplished by incorporating a sound barrier into the way structure. All technological advances and control techniques will continue to be reviewed for incorporation into final design in an effort to reduce noise even further.

AESTHETIC CONSIDERATIONS

The aesthetic considerations connected with route configurations involve architectural design and landscape treatment of the transit way and stations. The basic considerations in the aerial guideway concepts include:

- structural simplicity
- proper proportion of mass to height and span
- landscape treatment
- acoustical considerations
- harmonious color and texture

On this basis, structures can be aesthetically pleasant, integral with their surroundings and provide a strong design element which can be a positive force in creating an aesthetic urban environment.

Whether the transit facility is visually appealing will often depend upon the quality of right-of-way landscaping. The abundance of natural beauty in Honolulu requires that a high standard of landscape design be employed to gain community acceptance.

Through careful design of both way structures and stations, combined with a high standard of landscape treatment, attractive green spaces will be created within the urban area. Where the transit guideway is in an aerial configuration, the landscaped linear park below will be completely open and accessible to residents of the area providing maximum aesthetically acceptable facilities.

SELECTED CONFIGURATIONS

AT-GRADE STRUCTURES

Only a small portion of the 22-mile fixed guideway system will be in an at-grade configuration, approximately 30 miles. This will occur in the line segment between Halawa Stadium and Plantation Boulevard as the transit route parallels the new H-1 Freeway.

In order to make full structural use of the track beams, a spread footing support on 20-foot centers has been chosen. Where unusual soil conditions exist, pile or caisson foundations are recommended.

AERIAL STRUCTURE

To minimize the amount of land required for the transit structure and at the same time provide complete grade separation, an aerial configuration has been utilized for over 90% of the 22-mile route. The aerial structure has been placed on public rights-of-way, such as streets, wherever possible in order to reduce the required land taking.

Aesthetic considerations dictate a simple, gracefully proportioned structure of minimum depth. This is accomplished by placing guide beams, contact rail, and control equipment between the trackways and by using a continuous girder of uniform depth with no interruption of structure at supports to break the continuous girder line. The lighter weight vehicle system will require a girder depth of only 4'-6". Using this construction depth, an economical, standard span of 80' was selected.

To allow for fabrication and erection tolerances in the girders, the running surface will be adjustable by grouting the concrete track slab in place to exact profiles and by providing adjustable steel connection plates. Provisions are also made to horizontally align the beams. Elastomeric bearings are used throughout to provide a maintenance-free unit and to dampen vibrations transmitted from the vehicles.

The aerial structure will employ spread footings except where unusual soil conditions exist. For these locations, steel on precast concrete piles are recommended.

SUBWAY STRUCTURES

Due to the high cost of construction, the use of a subway configuration has been minimized. A 1.6 mile segment through the historical, financial, and governmental heart of the city has been placed underground in order to minimize disruption. This segment will be constructed under Hotel Street by the cut and cover method rather than more expensive tunneling:

- where there is relatively little interference with utilities
- where depth is not excessive
- where construction is on transit owned or public right-of-way
- where traffic and other surface activities permit

The cut and cover method of subway construction consists of excavating a trench, within which a concrete box section is constructed for the rapid transit guideway. The trench is then re-covered.

LANDSCAPE DESIGN

An extensive landscaping program has been developed for implementation in conjunction with the construction of the transit facilities. This program will call for, not only replacement or replanting of those trees which require removal, but also the addition of considerable plant material in and around the transit facilities. This landscaping is seen as extremely important in softening the visual and aesthetic impact of the system on the surrounding environment and the subsequent compatibility of the system with that environment.

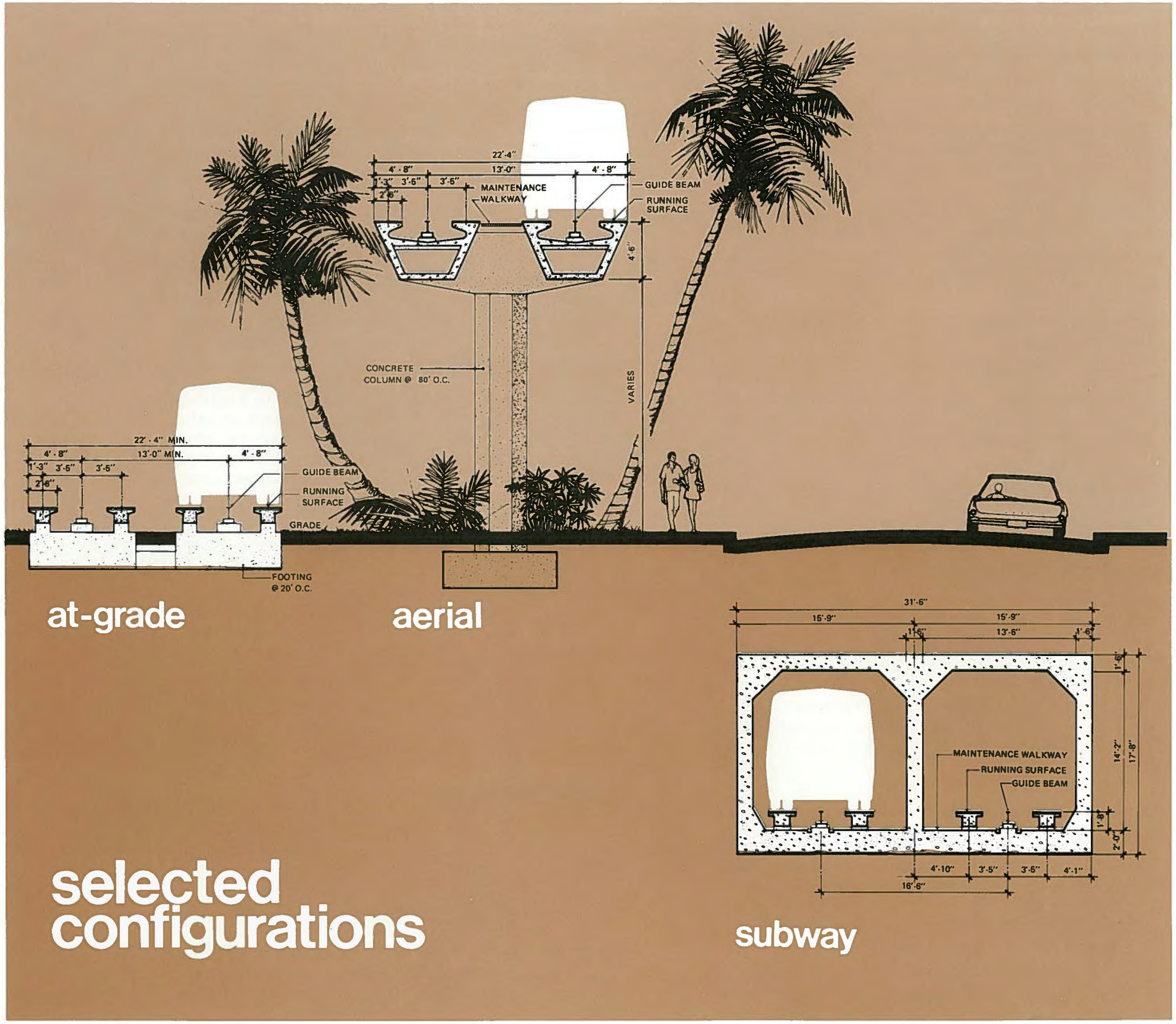


FIGURE 8-2 Selected Configurations

To insure that sufficient plant material will be available at the required time, the consultants have recommended that additional tree nurseries be established to provide adequate plant life resources of sufficient maturity and quantity. Major considerations in realizing an overall landscaping concept include: the natural identity of the areas in which the rapid transit system is planned; present and potential land uses; climatic and geographic elements; noise levels; and views.

With these considerations in mind, the following objectives evolved:

- Landscaping of both stations and the corridor will be an effort to blend the transit system with the surrounding areas, to enhance the visual quality as much as possible.
- Vegetatively barren areas will be relieved with an abundant use of greenery.
- Privacy of adjacent areas will be maintained with landscaping.
- Where noise from station circulation or the transit line itself is a disturbance, heavily-landscaped buffers will be planted to aid in reduction of aural pollution.
- Station landscaping will provide a refreshing atmosphere for the patrons and an attractive asset to the community.
- Berming around station structures and along corridors will be done to further enhance and provide sound barriers for the transit operations.
- Paved areas will be shaded with trees and will have plots of groundcover and shrubs to break up the hard surfaced patterns.
- Planter boxes designed as integral part of stations will contain flowering vines to soften the appearance of the structure.
- Vines will also be planted at the base of walls, fences, and columns to break up solid masses, provide barriers and contribute to the overall landscape appearance.
- The landscape design of each station will be orderly and abundant without a wide variation in kinds of plant material. The end result will be an asset to the overall beauty of each community.
- The transit corridor will be landscaped with groundcover, rows of shrubs, and groupings of trees. Views from the transit line will be considered carefully in the placement of trees. Small trees and shrubs will be planted in the median beneath the transit structure to enhance views from automobiles and adjacent property and to provide a barrier between traffic lanes.
- An irrigation system will be installed to maintain the plant material.

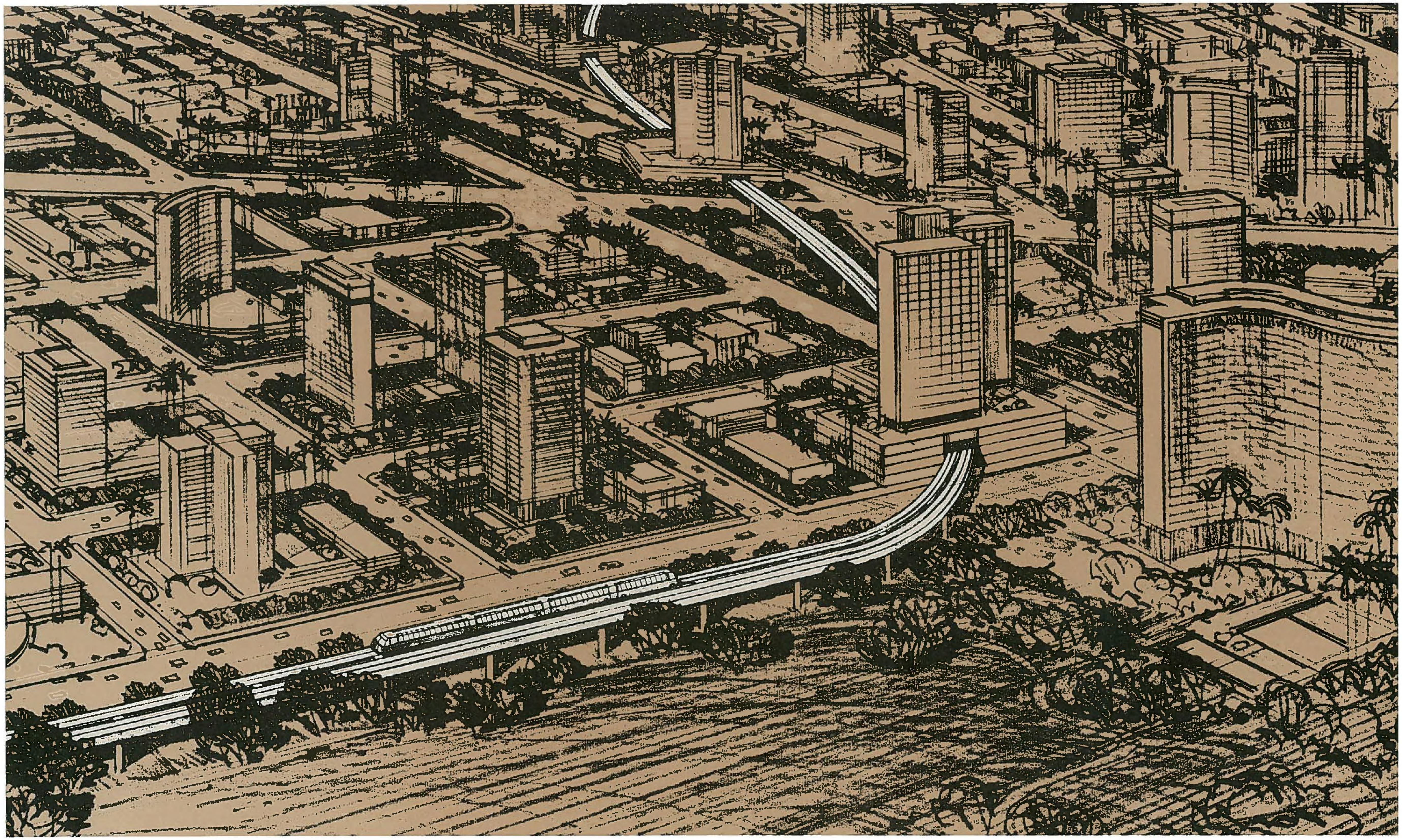


FIGURE 8-3 Way Structure in Urban Context

STATION FLOW DIAGRAM

ENTERING PASSENGER FLOW

EXITING PASSENGER FLOW

1. TICKET VENDING AND MONEY CHANGING EQUIPMENT
2. STATION AGENT
3. FAREGATE TURNSTILES
4. ELEVATOR
5. ESCALATOR/STAIR

STATION SITE ELEMENTS

BUS FLOW

KISS AND RIDE FLOW

1. BUS LOADING AREA
2. AUTOMOBILE DROP-OFF AREA
3. LANDSCAPED PARK AND RIDE AREA

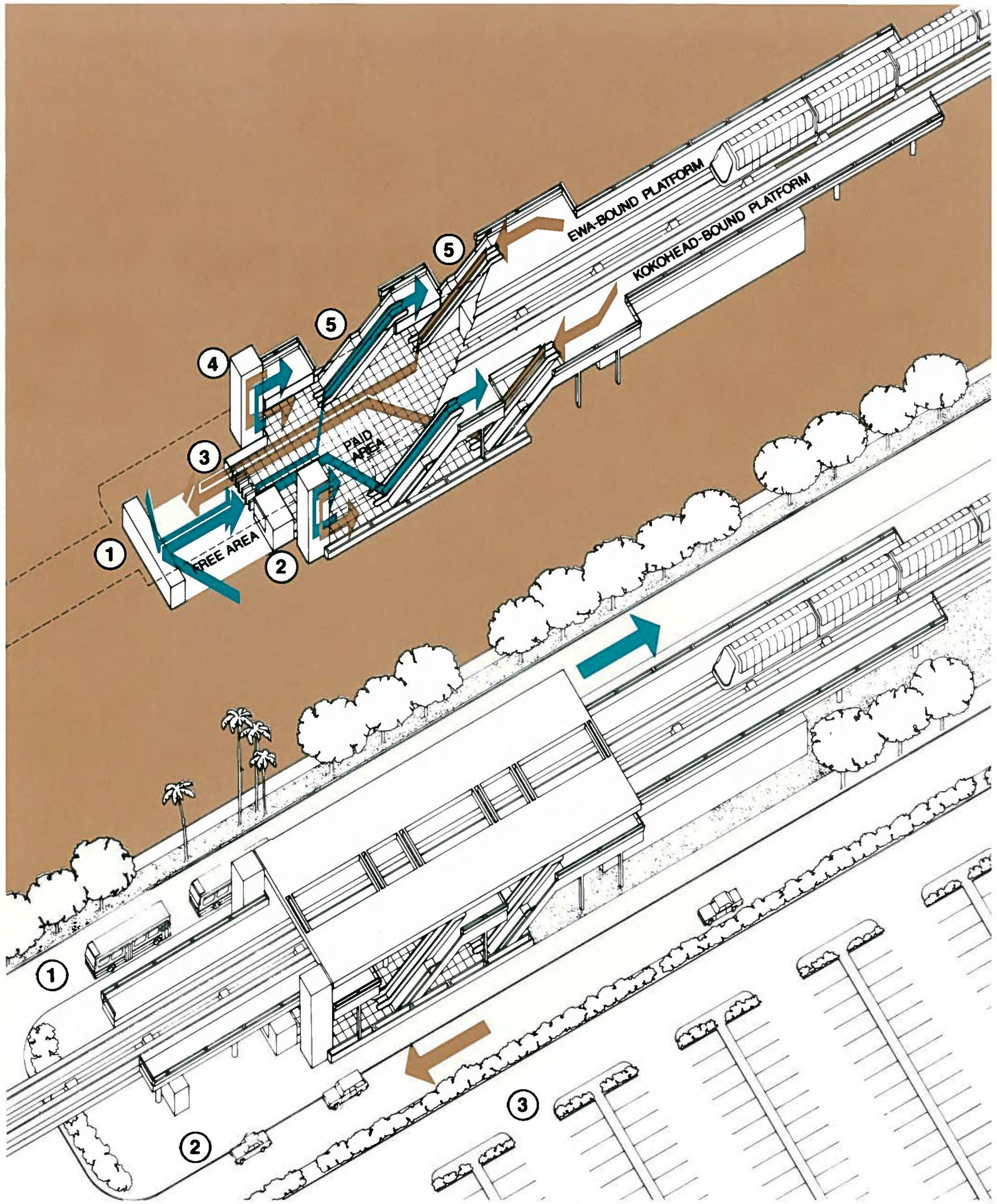


FIGURE 8-4 Transit Station Site Elements & Circulation

STATION DESIGN

The basic function of a transit station is to provide access to and from the rapid transit line. Each station must be able to accommodate large volumes of people and facilitate transfers of patrons from other modes of travel such as buses and automobiles. This must be accomplished in an efficient manner with minimum confusion and congestion within a pleasant architectural environment.

In addition, each station must be designed to complement the community and surrounding neighborhoods in a positive manner, providing a distinctive focal point without being obtrusive, both initially and in the future.

Standardization of certain elements throughout all stations is necessary to achieve economy in both initial and maintenance costs. This will establish an identity for the transit system as a whole and enable patrons to find their way easily, even in stations unfamiliar to them. Continuity is achieved through the use of specific materials, certain standard items of equipment and prefabricated units as well as similar orientation of spaces and their relationships in all stations. The best solutions are repeated where applicable and form the basis of the system.

Variations in the stations occur within this framework of established standards due to site conditions, location, way structure type, and passenger volumes. In addition, unique station design, color, lighting, and graphic identification will give rich variety to the rapid system travel experience.

STATION ELEMENTS

All station design is based on projected passenger volumes which govern the extent of fare collection equipment and escalator installation as well as all space requirements. For Honolulu, a "kit-of-parts" system concept (Figure 8-5) has been developed to provide not only the necessary station elements but also expansion capability to meet possible future increases in passenger volumes.

There are major functional elements common to all stations regardless of configuration or passenger volume. Two major areas common to all stations are the "free area" which is open to the general public and the "paid area" which is reached only after passing through the fare gates, or turnstiles. (Figure 8-4) Relating to one or both of these areas are the following common elements:

- Station access areas are designed and located for public convenience. Distinctive treatment of entry points permits easy identification and good circulation planning will avoid congestion.

SITE PLANNING

In developing station sites, care has been exercised to assure proper integration with the community's desires and its future goals. The location of each station's structure and its parking and bus interface facilities has been carefully selected, taking into consideration, existing and future land use, street patterns and capacity, and existing land and improvement values.

All stations will have off-street bus loading and unloading areas specifically designed to facilitate transfer from surface transportation to the rapid transit system. Feeder buses will therefore have convenient access to stations for pick-up and discharge of passengers. At those stations which are primarily origin points or terminal facilities, adequate automobile parking will be provided for transit patrons. Separate from the long term parking areas, there will be special "kiss and ride" short-term parking and drop-off areas. All sites will be pleasantly landscaped as well as properly and aesthetically screened where necessary. This will not only provide each station with its own visual character and identity but will also aid in passenger orientation.

The preliminary concept designs illustrated on the following pages are based on the most typical conditions. Some variations are required due to projected passenger volumes, individual site conditions and operational requirements.

- The concourse area will be designed to receive patrons into the free area of the station and control admission into the paid areas through the fare gates. Passengers will then proceed via escalators to the train loading platforms.
- Vertical circulation within the station will be accomplished by heavy duty reversible escalators and stairs. Elevators will also be provided to permit use of the system by the handicapped.
- The platform area will provide for the transfer of passengers between the station and transit vehicles. The platform length is determined by the maximum train length (420') and adequate width is provided to facilitate distribution and circulation of patrons.
- Support facilities required to operate the system will be located in non-public spaces in all stations. These include the power substation, mechanical, control and communications, storage and maintenance rooms, attendant's office, toilet facilities, a vault for fare vending equipment, and additional storage areas for possible mail and package handling.

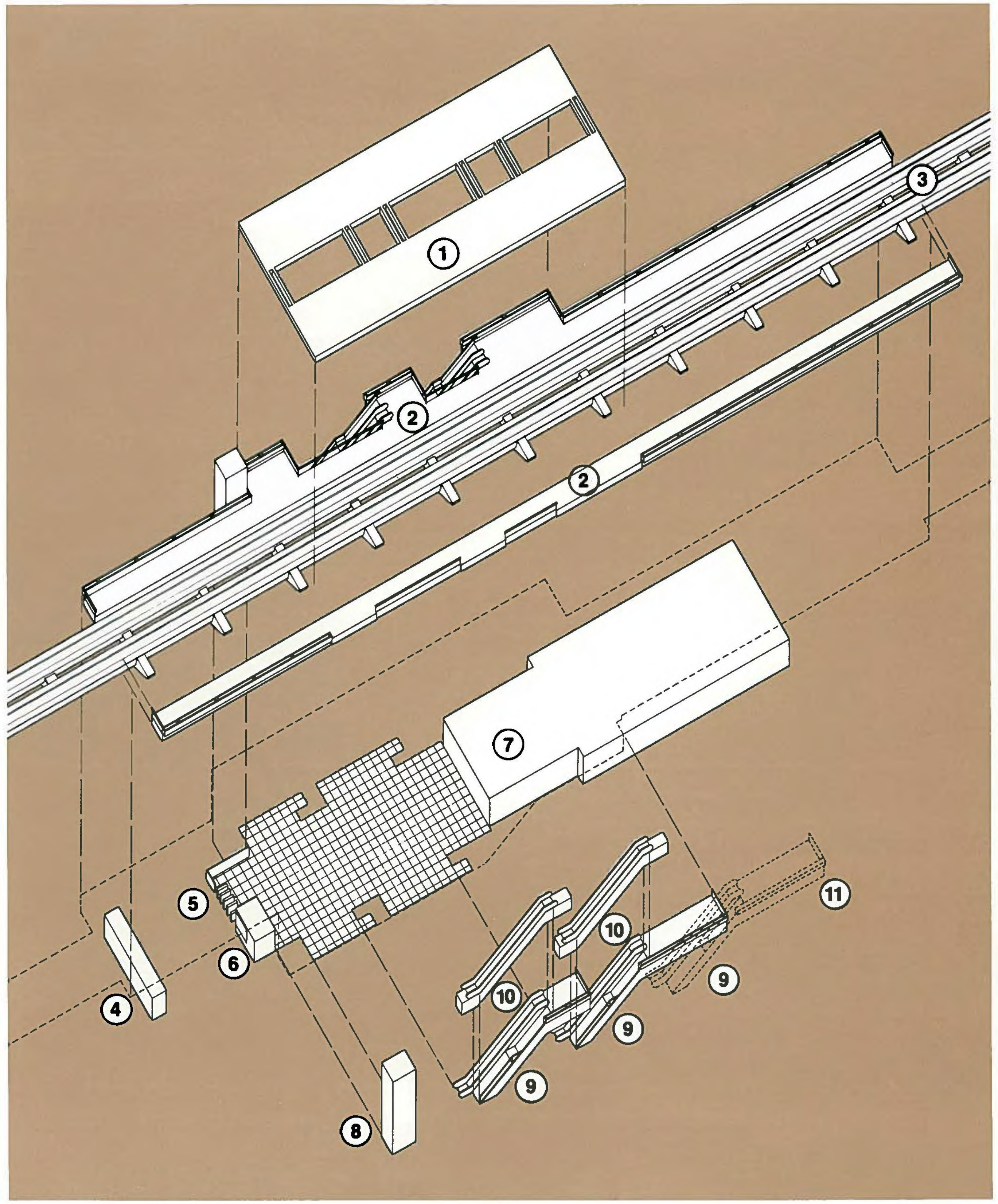


FIGURE 8-5 *Transit Station Elements*

STATION KIT-OF-PARTS

1. PLATFORM COVER STRUCTURE
2. PLATFORM
3. TRAIN GUIDEWAY
4. TICKET VENDING AND MONEY CHANGING EQUIPMENT
5. FAREGATE TURNSTILES
6. STATION AGENT AND SERVICE GATE
7. ANCILLIARY SPACES AND POWER SUBSTATIONS
8. ELEVATOR
9. ESCALATOR/STAIR

ADDITIONAL ELEMENTS

10. FUTURE ESCALATOR FOR INCREASED CAPACITY
11. ESCALATOR/STAIR FOR HIGH-VOLUME STATIONS OR FUTURE EXPANSION

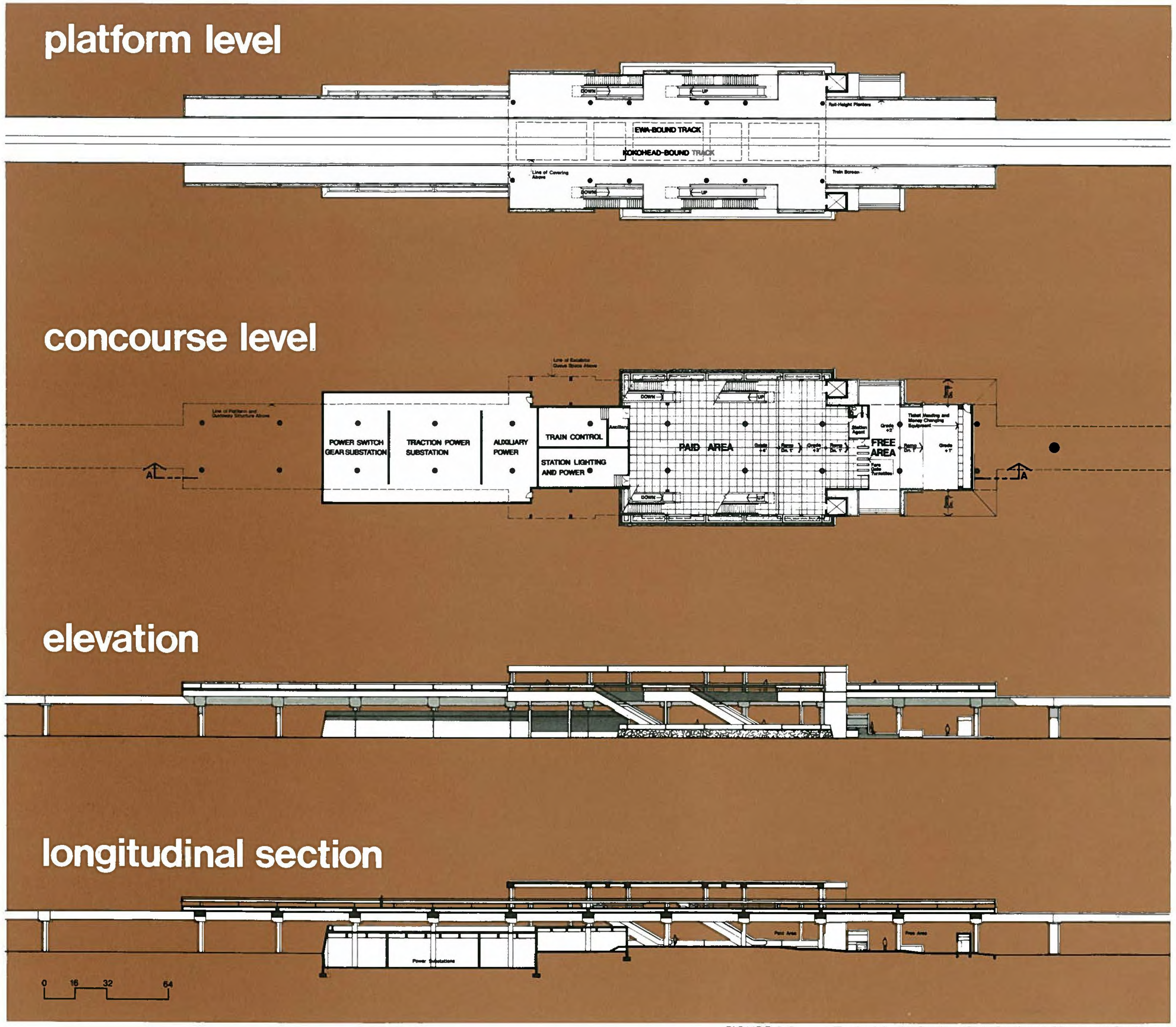


FIGURE 8-6 *Typical Aerial Station (Side Platform) Plans and Sections*

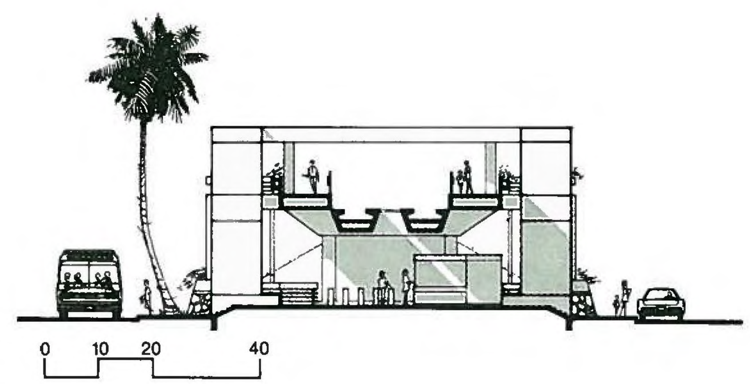
TYPICAL AERIAL STATION (SIDE PLATFORM)

An aerial guideway structure will provide the necessary grade separation to allow surface traffic to continue unimpeded under the transit route. On those segments of aerial alignment where private right-of-way will be obtained, the station site is located between cross streets maintaining the 16′-6″ clearance required by those cross streets under the guideway structure. Side platforms are utilized in these stations to permit the two guideways to continue through the station at a constant width, minimizing alignment changes and providing savings in construction costs and operational efficiency. The ticketing concourse is built at-grade under the platform structure and will permit direct access to the station entrance by pedestrians, and by patrons using the bus, kiss and ride, and parking facilities.

The escalators, stairs and elevators, on the outside of platforms, discharge passengers at approximately the center of each platform to achieve efficient passenger distribution.

Aerial stations designed with side platforms are as follows:

- Halawa
- Pearl Harbor
- Keehi Lagoon
- Kalihi Street
- Ward Avenue
- University
- St. Louis Heights
- Koko Head



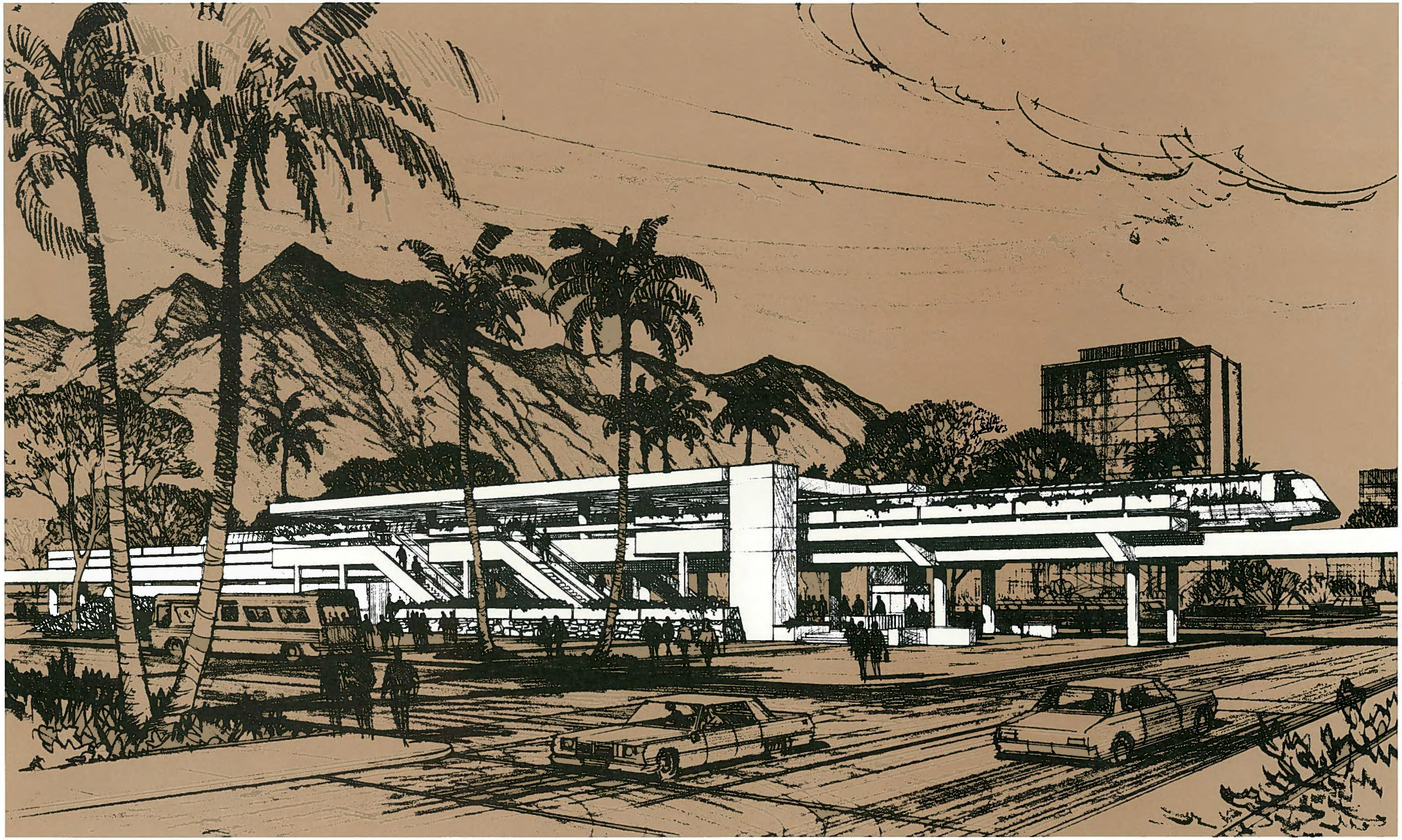


FIGURE 8-7 Typical Aerial Station (Side Platform)

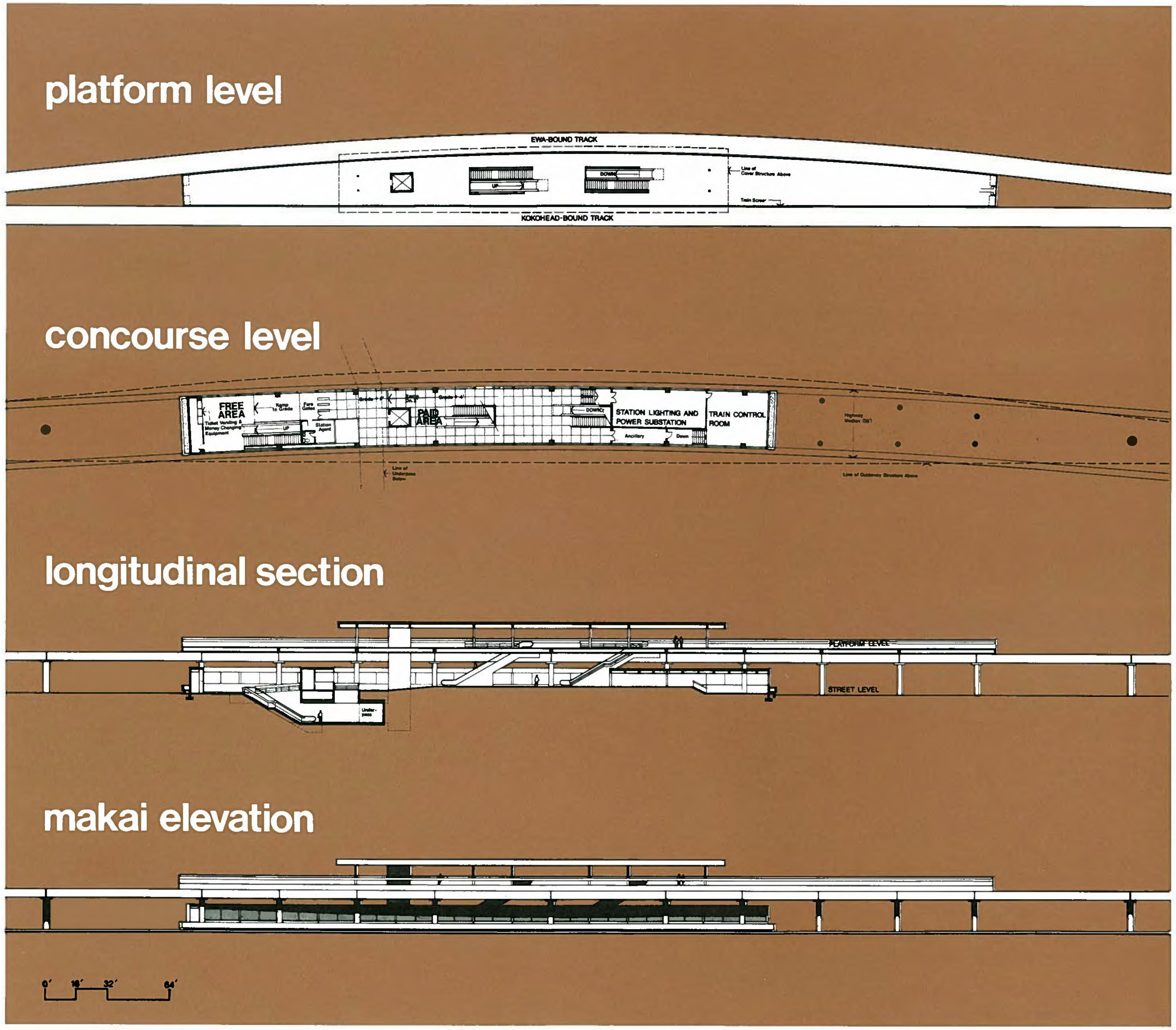


FIGURE 8-8 Typical Aerial Station (Center Platform) Plans and Sections

TYPICAL AERIAL STATION (CENTER PLATFORM)

A variation of the aerial transit station occurs when the guideway structure is located in a street or highway median. In this case the two guideway beams are separated at the station to permit a center loaded, center platform to be built between them.

The location of the concourse will vary, depending upon the site conditions. Where the aerial alignment will be above a major highway median such as Pearl City or Pearl Ridge, the concourse will be underslung below the raised guideway and platform level. Access to the concourse will be provided by elevated pedestrian overcrossings into the free area. Where the transit structure will be in the median of more local arterials such as Aina Haina or Niu, the concourse is placed at-grade, under the guideway structure and pedestrian access provided by underground passageways under the traffic lanes to the free areas.

Aerial stations designed with center platforms are:

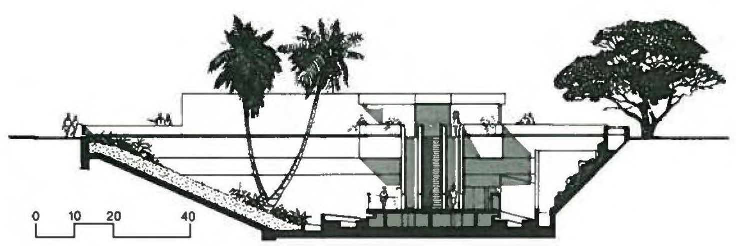
- Pearl City
- Pearl Ridge
- Ala Moana
- Kahala
- Aina Haina
- Niu
- Hawaii Kai

CIVIC CENTER

All underground construction for the rapid transit system in Honolulu will be carried out by the cut and cover method. This is due to varying subsoil conditions and the subsequent need to keep the transit line as shallow as possible. The subway stations have been located such that they can be as open as possible without disrupting surface activities such as vehicular traffic.

The Civic Center Station is located in the heart of the park-like governmental campus and has been designed as a sunken garden within which the rapid transit line will be accommodated.

The two guideways will be separated as they enter the station to allow a center loaded, center platform between them. The center platform will be entered from each end through separate ticketing concourses which are at the surface level. This allowed the platform levels to be opened to natural light and air. Gently sloping embankments will be carefully landscaped to create a uniquely beautiful Hawaiian environment.



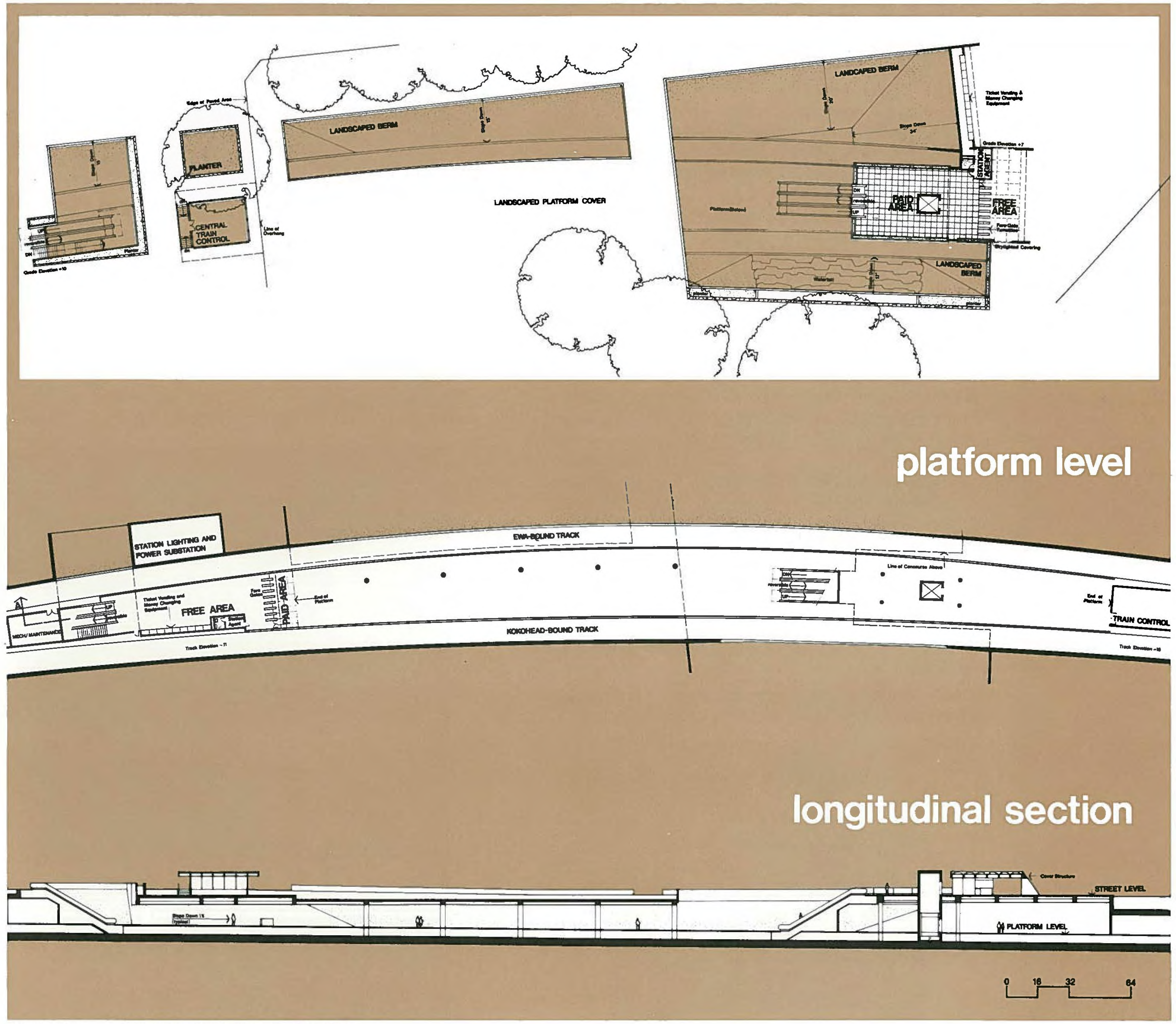


FIGURE 8-9 Civic Center Station Plans and Sections

FORT STREET STATION

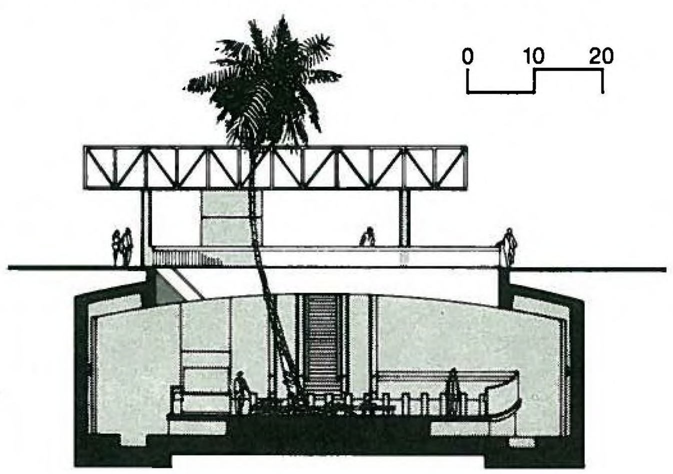
The design and planning of this station has been carefully coordinated with the Chinatown Renewal Project and the Downtown Improvement Association, as well as the Victor Gruen Plan for downtown Honolulu which calls for Hotel Street to become a pedestrian mall. While this latter study has not been fully adopted by the City, the recommendation for the Hotel Street mall has been incorporated in the Development Plan for the area.

The downtown or Central Business District Station has been located at the intersection of Hotel Street and the Fort Street Mall. By providing an entrance at Fort Street, at Nuuanu Avenue, and at Bishop Street, this station would serve both the Chinatown area and the downtown office and commercial areas. Locating both the line and station under the future Hotel Street Mall permitted the station to be kept as close to the surface as possible. This allowed visual and spacial interconnections to be made between the platform and the pedestrian mall through the use of light wells and openings. Trees planted at the platform level would grow up through these openings to further enhance both the station and mall area.

The center platform will be end loaded from two ticketing concourses at Fort Street and Nuuanu Avenue. These two entrance pavilions are at mall level and will be designed to provide smooth and easy access to the platform areas.

Although a center platform scheme has been suggested for this station to minimize land taking requirements, a side platform scheme which would offer potentials for integration of adjacent commercial areas into the station area will be explored in subsequent final design of the station. (See Figure 8-11)

The Liliha Street Station would also be in an underground configuration similar to the one described here.



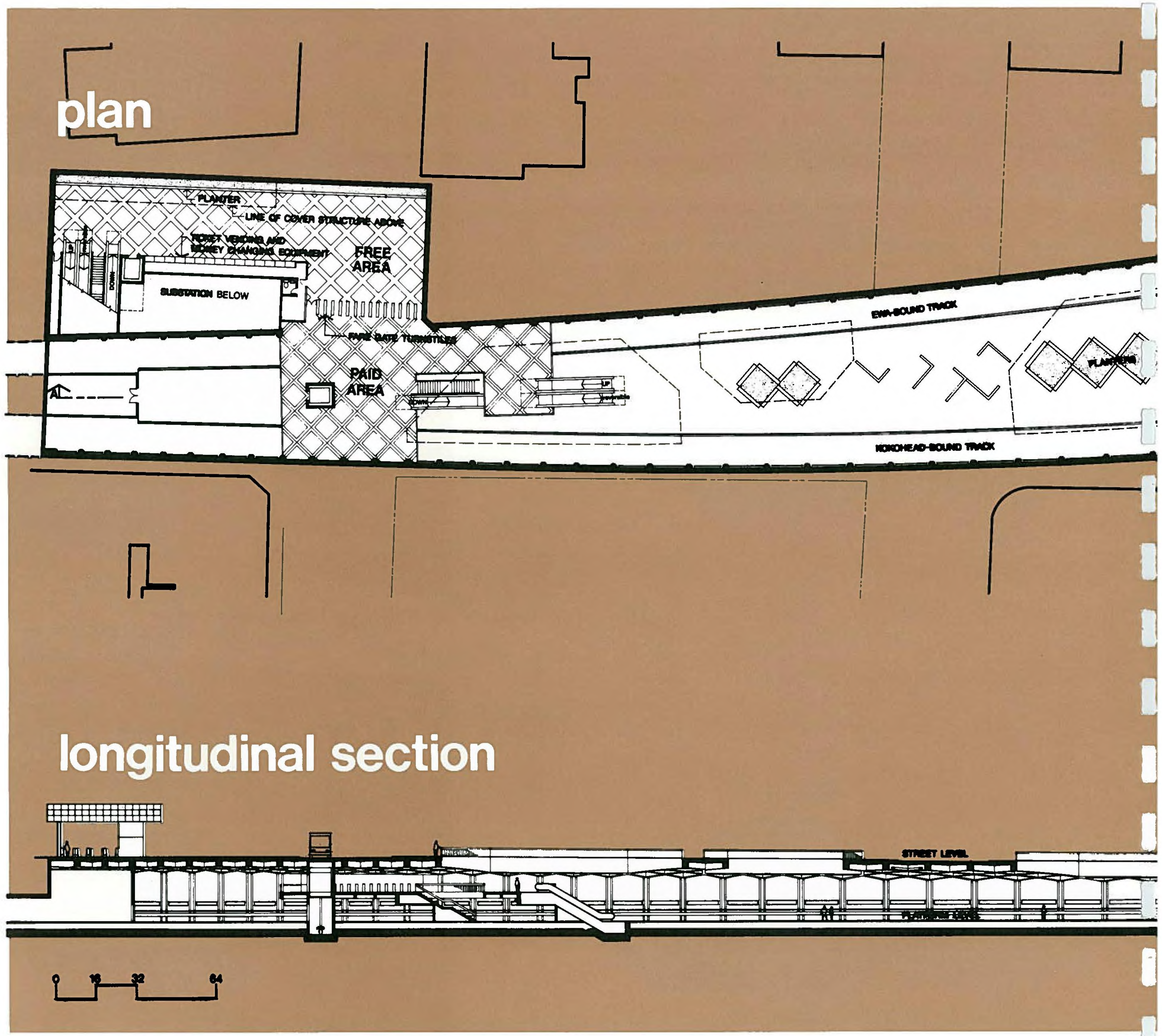
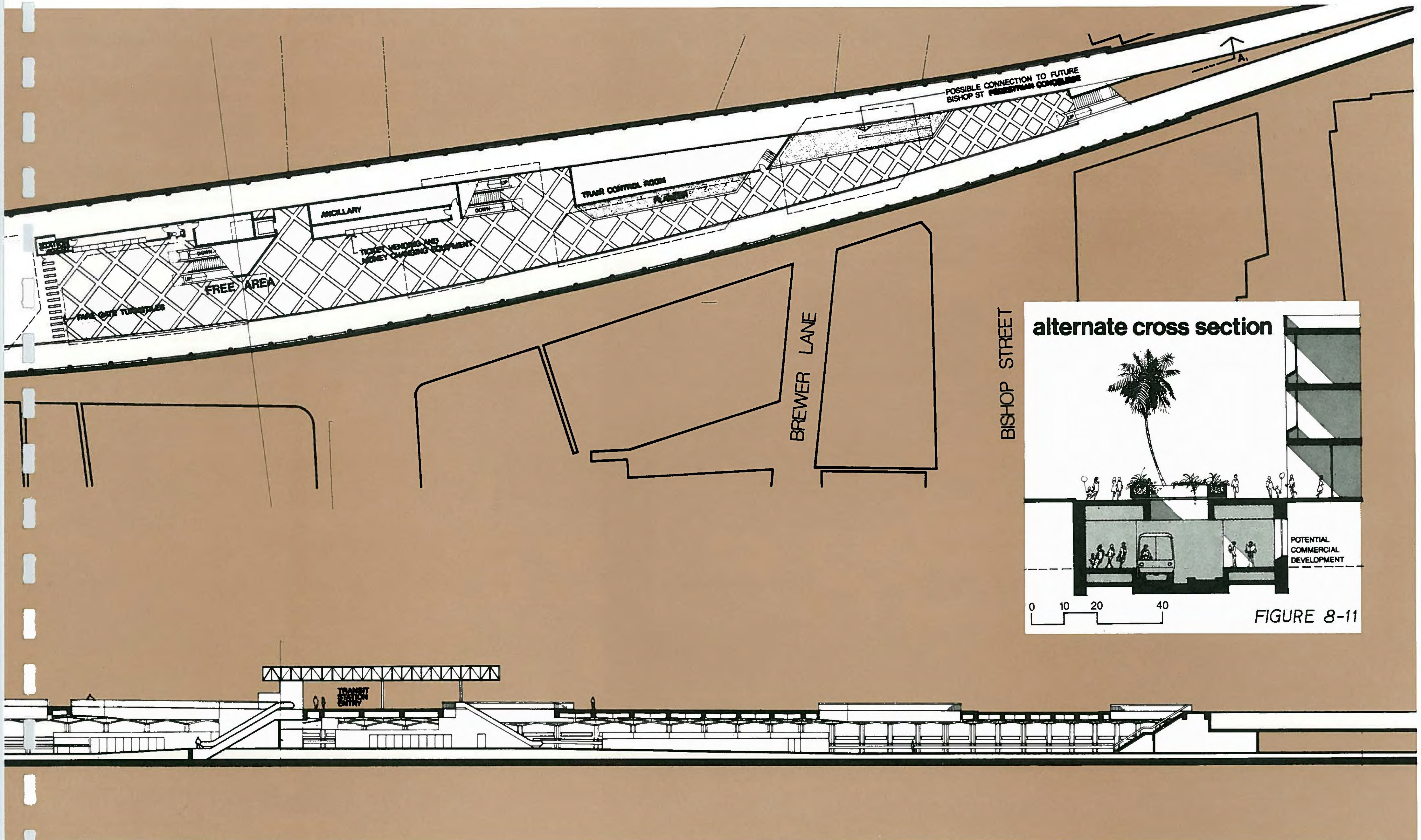


FIGURE 8-10 Fort Street Station Plans and Sections



alternate cross section

FIGURE 8-11

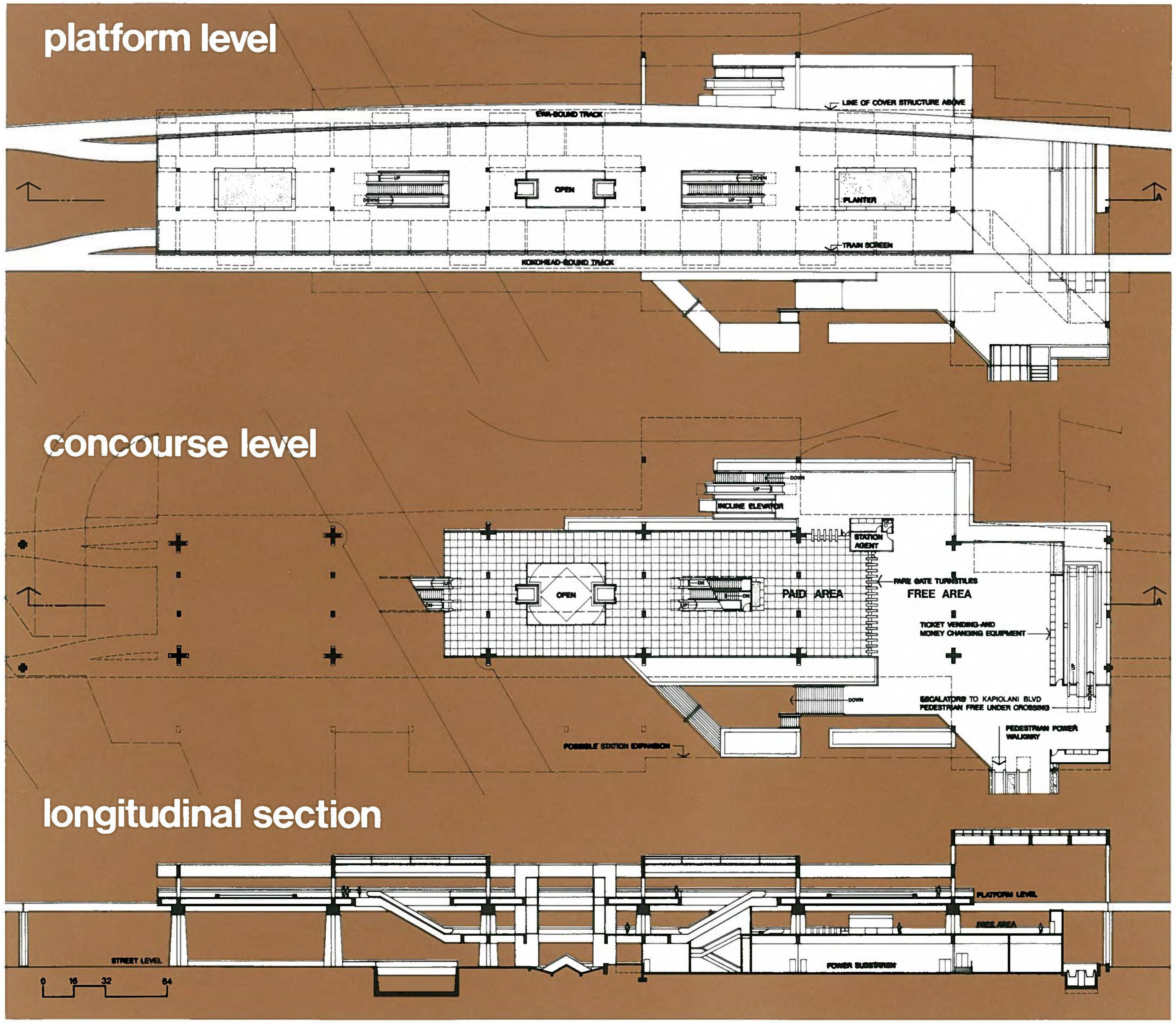


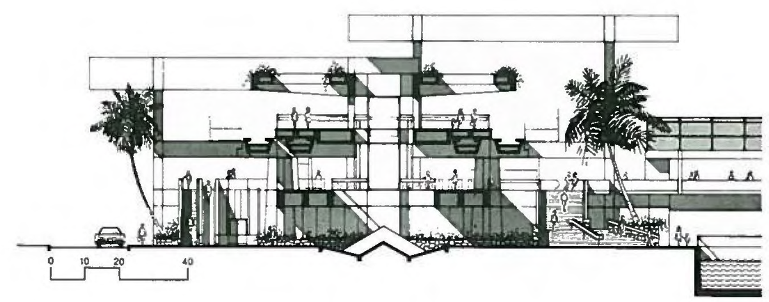
FIGURE 8-12 *Waikiki Station Plans and Sections*

WAIKIKI STATION

The station at Waikiki has been designed as a portal or entry station to the Island's tourist center. It has been planned as an on-line station initially with expansion capabilities to accommodate a possible Airport—Waikiki express terminal in the future. Carefully organized interconnection between buses and a sub-system to serve the Waikiki area will provide efficient and convenient service.

The aerial station will have a center loaded, center platform with an underslung concourse. Patrons will enter the station from either an elevated bus ramp which feeds directly into the concourse or from the elevated pedestrian walkway and moving sidewalk across the Ala Wai Canal. This overcrossing will link the on-line station with the sub-system terminal facilities located on the Waikiki side of the canal. By bringing passengers to the station rather than the vehicles, traffic congestion can be minimized on the already overcrowded Kalakaua and McCully Bridges.

Future expansion of this station would provide additional guideways for the airport express trains as well as facilities for baggage handling to create a total Waikiki-Airport Express service for residents and visitors alike.



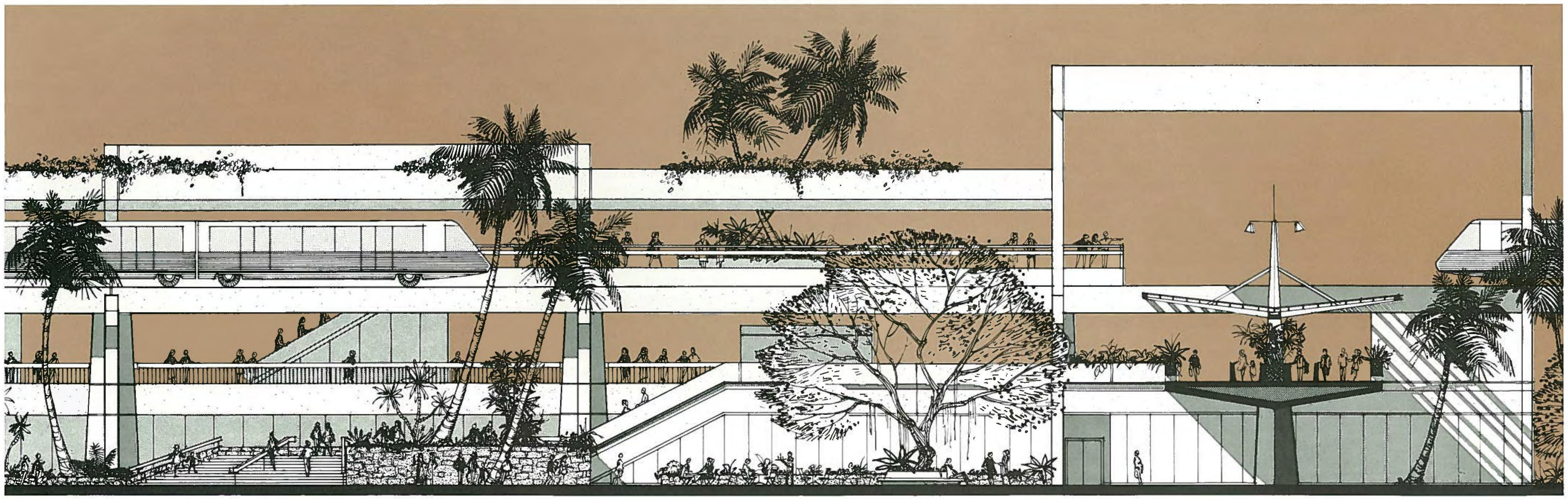


FIGURE 8-13 *Waikiki Station Elevation*

YARDS AND SHOPS

A fundamental principle of a modern rapid transit system is first class maintenance to ensure the operational integrity and visual appearance of operating units. Maximum attainable safety, dependability, and comfort are required to provide the high level of service demanded by today's transit patron. The proposed yard and shop facilities have been provided with the functional elements to satisfactorily meet these requirements.

YARD OPERATIONS

The major task of the yard operation is to vary the train make-up to meet peak and off-peak demands, put the units into the system and transfer units from service into storage provided in the yard areas. Cars are stored near the transfer area and brought to position under manual control. Transfer from manual to automatic train operation is made before entering the mainline tracks and is accomplished at a specific section of the transfer track.

When trains must be dispatched in each direction on the adjacent mainline, the use of an additional staging area, or dispatch track, is required. The dispatch track is under surveillance of the automatic train control. Movements of vehicles within the yard could be performed under automatic control; however, the present plan is to use manual control.

MISCELLANEOUS SERVICE FACILITIES

The miscellaneous service facilities include interior and exterior washing of cars, changing filters, hand cleaning, and any light work that can be done above the car floor from platforms at car floor height. The miscellaneous service shop will have two tangent tracks long enough to work two cars each; one track to have roof and side washing brushes with pre-wet and final rinse arches all enclosed by masonry, followed by access platforms from which the car ends can be cleaned manually. The other tracks to have platform access at car floor height to service car interiors. Minimum building length will be 100 feet.

INSPECTION AND SERVICE SHOP

Inspection and service includes scheduled diagnostic testing of cars and train lines, preventive maintenance, and unscheduled troubleshooting of train malfunction. The shop will have 3 train support structures with the top of the track 4'-6" above the shop floor. One structure will accommodate a 10-car train, one will accommodate an 8-car train and one will accommodate two 2-car trains all under roof and with a safe operation distance. Track structures will be located 20 feet on centers with 20 feet from the center of track to adjacent walk or other bays.

HEAVY REPAIR SHOP

Heavy repair will include removal of faulty sub-assemblies, mostly below car floor and replacement by new or re-built sub-assemblies, body work, retrofitting, car modifications, car overhaul and renovation. Work will be scheduled on time and/or mileage basis, or will be due to a major malfunction such as out-of-tolerance details by inspection, failure of a sub-assembly, and tire or brake damage. The heavy repair shop will have 2 train support structures, 20 feet on centers, with the track surface 4'-6" above the shop floor. Both support structures will be 2-car lengths long inside the shop with transporter which will move one car at a time to a work station.

ELECTRIFICATION

Of the various methods available to propel fixed guideway vehicles, the one most widely used in rapid transit systems consists of vehicle mounted electrical motors supplied from an electrical conductor (contact rail) running parallel to the tracks. The most important reasons advanced for using this method for rapid transit are safety, reliability, and economy of operation.

The primary objective of a rapid transit system is to provide reliable transportation under any of the varying conditions which may be encountered. To meet this objective the propulsion power system must provide enough power for satisfactory rapid transit operation even when the power system is not fully operational. Rapid transit propulsion systems consist of several elements including a power source, transmission capability, power conversion equipment, a contact rail system, and vehicle propulsion and braking equipment. Total failure of any one of these elements would prohibit further train movement. Therefore, the components making up these elements must be arranged so that a component failure will not result in total element outage. For all elements except the contact rail system, this can be accomplished economically by providing multiple components. The contact rail system cannot be readily protected from outage by an alternate or spare installation and therefore must be constructed as ruggedly and reliably as is feasible. If component failure results in insufficient power, the trains will have to operate at reduced speed in the vicinity of the failure. If the power deficiency persists for more than a few minutes the transit system capacity will be reduced.

The propulsion power demand varies considerably throughout the operating day. During the commute periods it is four times the midday demand. Assuming the commute periods total only 20 hours out of a total of 140 operating hours per week, the full capacity of the propulsion system is required less than fifteen percent of the time, even though this is during the most important period. Since the probability of a prolonged component failure during the commute period is remote, the risk of reduced speed operation is low enough to permit the propulsion system design to be based on the following provisions:

- Normal operation at maximum demand for fully operational power system.
- Reduced speed operation at maximum demand with one component failure, which is defined as a condition where one component of an element such as primary feeders or one of the rectifier units in a substation becomes inoperative.
- Normal operation at off-peak demand with one component failure.

The power source selected is the Hawaiian Electric Company, Inc. (HECO). Its rates for the transit system demands and energy requirements suggest the infeasibility of owning and operating a separate power generating facilities. It is planned to obtain power from HECO at 14 points, each point served by 2 underground 46-kilowatt transmission lines, the backbone of the HECO system.

Each service point or traction power station is equipped with an automatic throwover circuit breaker that will accept power from whichever 46-KV feeder that is energized; although normally both 46-KV lines will be energized. The dual service will ensure maximum system reliability.

Each power station will be equipped with 2 power conversion units which transform and rectify the 46-KV, 3-phase supply voltage to 600 volt d.c., which is the contact rail voltage. The contact rail system will consist of 2 rigid conductors, one positive and one negative, running continuously on each side of the guiderail. Both contact rails are insulated from ground and supported every 10 feet.

CONTROL AND COMMUNICATIONS

A tested and proven control and communication system will provide total safety and dependability for the transit system and enable trains to operate smoothly at high speeds and close headways. Modern systems employ advanced computerized control and communication equipment with improved versions of traditional train-safety equipment.

A compact electronic computer on each train will regulate its operation according to continuous safety and control intelligence input from wayside transmitters. High speed data channels will deliver train performance data to the central control system where a sophisticated digital computer system will permit dispatchers and supervisors to manage and coordinate movement of trains and buses throughout their entire route. The integrated control and communication system will compare moment-to-moment position and movements with schedules, conditions, and requirements.

A fully automatic train operation is proposed for the Honolulu system and it is the only method that will safely fulfill the requirements for speeds in excess of 60 mph with 90 second headway.

AUTOMATIC TRAIN CONTROL

The newer methods of track circuitry vital to a successful train-protection scheme lend themselves well to cab signaling. Once all the train-operation information is on the train in the form of electrical signals, it is natural to close the loop to the electrically controlled propulsion and braking system with an electrical controller. Such an electrical controller performs three main functions:

- Regulates speed in response to wayside speed commands by modulating power and braking force.
- Regulates deceleration to berth the train in stations accurately through a wayside-triggered station-stop program.
- Regulates station dwell time and controls train door movements.

In practice, the controller is a special-purpose digital computer with subroutines for programmed stop and station-dwell control. It is planned that one controller would be placed in each end car of each train. In all cases, control would be in the lead car, and in reversing direction, control would be switched to the appropriate end car.

Several separate speed control commands will be used in normal operation and an absence of a speed command signal will automatically initiate braking to provide fail-safe operation. Computer comparison of actual versus desired speed at various reference points in the station approach zone will adjust deceleration and improve berthing accuracy.

Train protection includes a subsystem which divides the route into individual zones, or blocks, which are equal in length to at least the train's maximum stopping distance plus a margin of safety. Presence of a train in an adjacent zone will be automatically detected and transmitted to the following train. If the safe separation distance is approached, the overtaking train automatically slows, and if it enters the safe separation distance, it automatically stops.

SUPERVISORY SYSTEMS

Supervisory systems relay information to a central control room via a data communication system. In Honolulu, central supervision will be maintained over train operation, propulsion power supply, and station support facilities.

A computer in the control center will monitor train operation, make routine adjustments to compensate for schedule deviations, and control the entrance and exit of trains in service in accordance with the daily operational plan. It is proposed that the control center be located near the Civic Center transit station.

The propulsion power supply will be controlled and monitored in the control center, and all controls necessary to the routing of power to maintain continuous transit system operation will be available to personnel in the control center. Station and support facility status will also be monitored, although control of pumps, fans, and other station auxiliary equipment will be under the supervision of the attendant at each station. Alarms of abnormal requirements such as power failure or fire, police, or other station emergencies will register in the control center, but the primary responsibility for corrective action or obtaining assistance will remain with the station personnel. Central control acknowledgement and follow-up of alarms come through the voice communication system.

VOICE COMMUNICATION SYSTEM

A voice communication system which blankets the entire transit system will enable performance of important functions in the rapid transit system under voice control. Supervisors will have equipment and channels available for them to talk to any station, yard, train, or shop without delay.

Information important to the passenger's travel and comfort will be transmitted to them by voice messages in all trains and stations. Facilities will be provided for patrons and employees to ask questions or report conditions from all cars, stations, and wayside locations.

A dial telephone system will interconnect all stations, yards, shops, and the control center by a network of shield multi-conductor cable. Every conductor-pair will be conditioned to high quality transmission standards by the insertion of inductive loading coils and amplifying elements at optimum locations. These main communication cables will be pressurized with dehumidified air to protect against moisture. Quality characteristics of the voice communication channels will equal or exceed recognized transmission standards.

Voice communications will be transmitted by radio to and from passenger trains. Main and standby antennas at central, high locations will handle messages to and from widely separated points throughout the transit system. Any locations that would be out of reach or shielded from the main station will be reached by separate radio repeater stations.

FARE COLLECTION SYSTEM

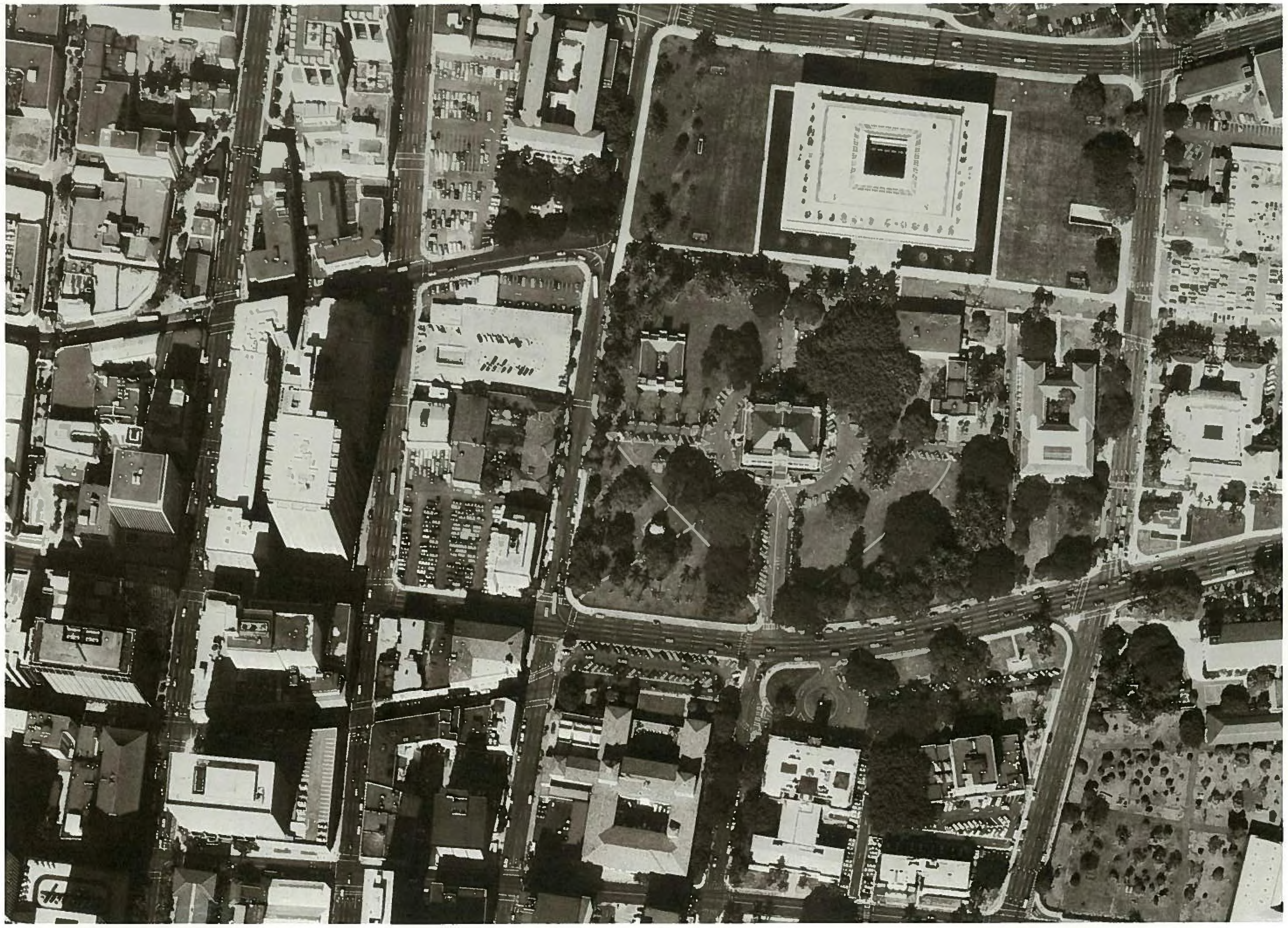
An automatic fare collection system ensures an economical and efficient operation, and concurrently facilitates passenger speed and convenience in entering and departing from the transit system. The flat fare structure considered, with no transfer, requires a relatively simple collection system comprising ticket vendor, turnstiles, and money changer equipment.

The ticket vendor accepts coinage and bills up to the amount of maximum number of tickets determined to be handled by the equipment. The vendors do not accept pennies nor will they dispense change. Therefore, for the convenience of the passengers, change makers will be provided adjacent to the ticket vendors.

Turnstiles are designed for use as entrance and exit gates. They are normally programmed by the station agent to operate in only one direction, but are easily reversed for changes in peak traffic direction. In entrance mode, the gate accepts a ticket, ascertains its validity, and releases the gate for entrance. The turnstiles will also be provided with an automatic counter to provide ready passenger information.

SYSTEM SECURITY

Each passenger station will have an attendant on duty whenever the station is open. He will normally be in the ticketing area. From there he can monitor the status of air conditioning systems, tunnel ventilation systems, train screens, fire and police alarms, escalators, and fare-collection equipment. He can also communicate with central control through a voice link, with passengers in the station through a public address system, and with local fire and police stations through established alarm systems. Certain sections of the station, primarily the platforms, cannot be seen directly by the attendant. Closed circuit television will let him observe these areas on monitors in the attendant's station. Cameras will scan the platform area at all times. Controls for the remote cameras will be in the attendant's station.



planning impact and urban design studies 9

INTRODUCTION

The success of any large scale planning project depends, to a great extent, upon the correct appraisal of the future implications of that project on the surrounding environment. The increasing size and complexity of human settlements make it more and more essential to evaluate and predict, with reasonable accuracy, the physical, economic, and social reactions to any policy of action. Planning impact and urban design studies when coupled with environmental impact information (Section 10) and cost-benefit analyses (Section 13) provide the basis for decision making which will yield the greatest possible benefits while minimizing the disadvantages.

The imposition of a new, major, public transit facility in the urbanized and outlying areas of Honolulu will have profound effect on the travel habits of residents and visitors, as well as significant impact on the general development within the corridor and zones of influence of the rapid transit system.[3] Recognizing that these effects and impacts will tend to occur, the City must be prepared to provide guidance and control such that the results fit within an orderly plan. The purpose of these studies is therefore to provide concurrent urban planning and design inputs to the route location studies and preliminary engineering design which will complement transportation considerations and produce a plan which is well balanced in all respects.

All pertinent data for growth conditions in the region was collected and reviewed in conjunction with the route planning process. Land use plans, zoning ordinances and maps, traffic data, master planning studies, economic information, as well as population and demographic data were synthesized to form the background for planning analysis.

In addition to land use impact and urban design studies, examinations were made of potential social and economic improvement opportunities which would be created by implementation of the plan. Concepts were outlined as to how the City and community might benefit from these associated effects. Right-of-way requirements for development of the system were established and the related need for relocation of households and businesses was defined. The potential future relocation problems are of particular concern on Oahu and have been dealt with in a sensitive manner to avoid or resolve disruption as much as possible. Special consideration was also given to system access for senior citizens and handicapped.

The results of the broad land use and planning impact studies and the more fine grained urban design potentials studies have been used to develop a rapid transit system which will serve both as a catalyst and a structuring element for the city's economic and physical growth.

LAND USE IMPACT

One of the most significant characteristics of rapid transit is its ability to shape and direct the growth of urban areas. The introduction of a well-defined transit corridor into the fabric of an existing city causes, in most cases, pressures to be created for the intensification of land uses around stations. This results from the increased accessibility afforded those areas and the corresponding increase in land values which normally occurs. In many cases these pressures can be seen as beneficial since they tend to consolidate and structure growth in an organized manner. In other cases, increased growth may not be desirable or compatible with the surrounding community, and constraints may need to be formulated by the public sector to counter these development pressures.

In order to determine the best direction which should be taken in terms of land use planning for each particular area, the land use impact of the transit system was investigated, both station by station, as well as along the entire line.[10] To form a basis for understanding future land use changes, a Preliminary Market Study was completed,[11] indicating economic growth trends within the sphere of influence of the rapid transit system.[17] This work when coupled with the population and employment projections from the DPED "Land Use Inventory Model" offered a relatively clear framework within which the impact of the rapid transit system could be evaluated. Any tendencies to change usage or to accelerate trends toward more intense or dense usage of various types were then identified. In addition, the line sections of the system extending between stations were examined and assessments were made of the impact of such development on circulation, neighborhood access, aesthetics, and environmental quality.

Careful coordination of land use impact studies and route planning provided maximum service to the traveling public and at the same time located the system to complement indicated trends or stated goals of regional development. As a result, stations in many areas will not create major changes in land use designations or controls such as the Halawa Stadium Station, the downtown area, Civic Center, Kahala, and the airport. Others will require some modifications to either encourage or control growth such as Pearl City, Liliha, and Ward Avenue. In addition, the radial impact of a station will not be uniform in all instances and may be altered because of land ownership or existing physical barriers, both man-made and natural.

The information contained in those studies was intended to provide a framework with which the City and County of Honolulu could begin a detailed investigation and analysis of public policy along the transit corridor, and particularly around the stations, to establish objectives for future growth. Actual changes in land use and zoning around the stations should receive the same meticulous review as any land use and zoning change. The land use impact studies undertaken in this preliminary engineering evaluation program examined each station site to formulate the following informational base:

1. STATION SERVICE PARAMETERS—The projected patronage for each trunk line station was examined, based upon the OTS Land Use Model of population and employment distribution for 1995. The model had as its foundation the City and County of Honolulu's General Plan adopted in 1964 with subsequent amendments in various localities throughout the Island.
2. COMMUNITY PLANNING DESCRIPTION—All pertinent physical and social characteristics of the population and development within the communities surrounding the stations was examined and quantified.
3. PRESENT PLANNING GOALS—A summary was prepared of known planning goals which are either reflected in the General Plan for the City and County of

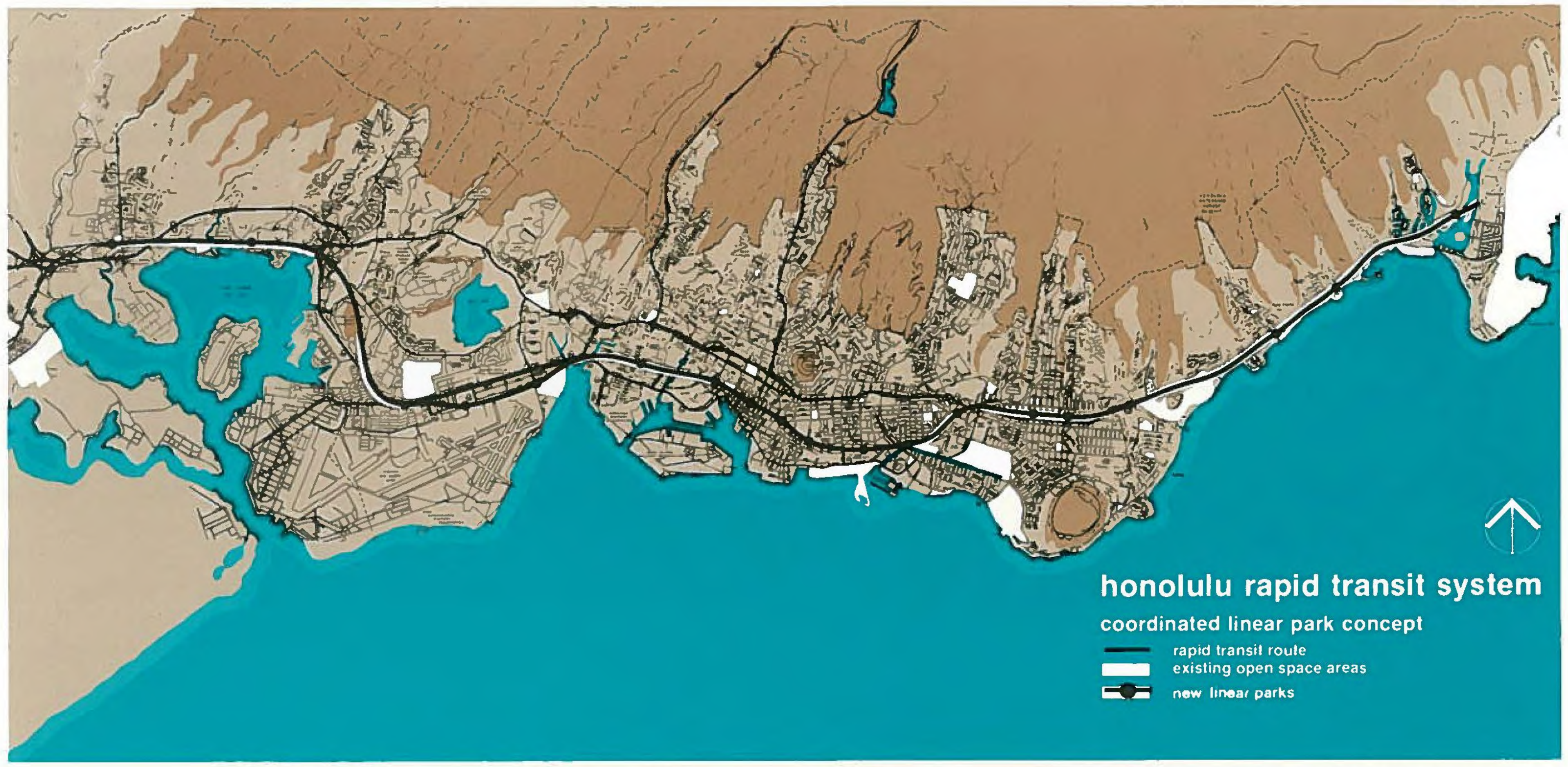


FIGURE 9-1 Coordinated Linear Park Concept

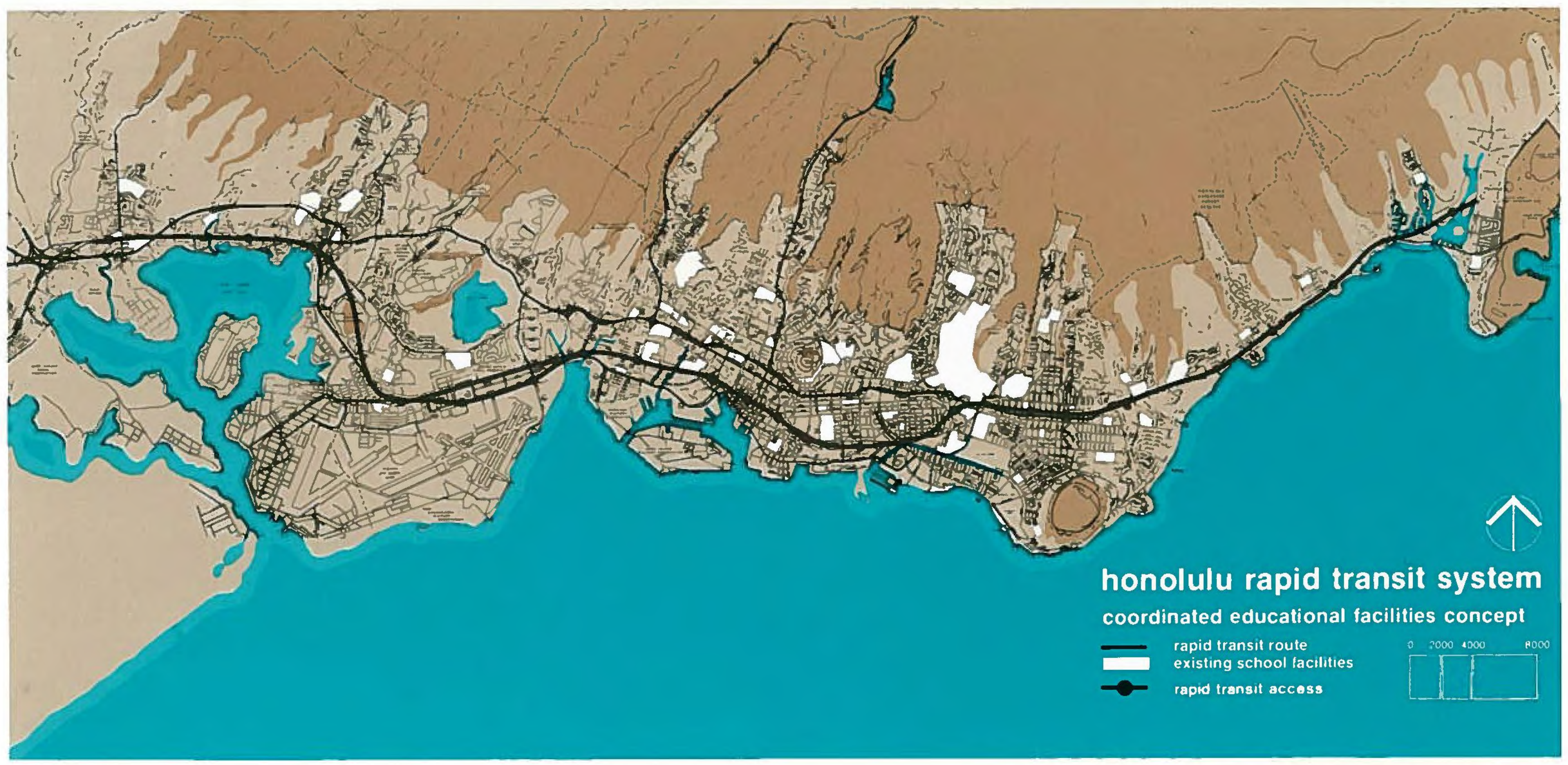


FIGURE 9-2 Coordinated Educational Facilities Concept

Honolulu, the Comprehensive Zoning Code, or those developed by other public and private agencies which augment adopted public goals.

4. DEVELOPMENT POTENTIAL—Based on community planning data and transit patronage, suggestions for integrated development programs between the transit system and the adjoining property were outlined.
5. DEVELOPMENT PROGRAMS—All existing or projected programs under the authority of the City and County of Honolulu, the State of Hawaii, or private institutions were examined for possible coordination with rapid transit.
6. ASSOCIATED SOCIAL AND ECONOMIC IMPROVEMENT OPPORTUNITIES—The ancillary benefits which can accrue to adjoining property and to the Urban Environment as a whole were reviewed.
7. RELOCATION—The number of businesses and residences to be relocated because of the development of the transit system was quantified and the resulting implications examined.
8. EXISTING AND PROJECTED LAND USE—Based on all of the aforementioned factors any suggested changes to the existing General Plan and Comprehensive Zoning Code were outlined.

TRANSIT FACILITIES AND COMMUNITY SYSTEMS

While careful integration of the system into the existing community environment is a primary concern, it is also important to coordinate future planning of various urban systems with the transit network. Understanding and making use of transit as a resource in planning other urban developments can result in new and imaginative concepts for integrated city planning.

As an extension of the land use and planning impact studies, investigations were made to identify potential socio-economic improvements which would be afforded the City as a whole with the creation of the rapid transit system. There are many possibilities for the coordinated planning of physical and human resources with rapid transit such as joint use of rights-of-way, air rights development, land assembly and consolidation, development of low-income housing sites, and the development of neighborhood parks, bikeways and other amenities. Many of these elements have been incorporated in the prototypical urban design studies for specific station sites. There are in addition, potentials for coordination of large scale urban systems with transit such as education, parks, and health care; two of these have been examined here to illustrate the potential benefits to be derived.

COORDINATED LINEAR PARK CONCEPT

In order to minimize the amount of property utilized by the rapid transit system while at the same time maintaining grade separation, much of the guideway was placed in an aerial configuration. This would not only allow free movement of pedestrians and vehicles on the ground below, but it would also provide valuable space for public parks. In Honolulu where land costs are prohibitive and residential densities are high, efficient use of land in public ownership is of prime concern. Therefore, multiple use of the transit corridor as both a transportation right-of-way and recreational park land would make for efficient and productive land use planning.

The aerial structure, with two nine-foot guideways, would be slender and graceful in design allowing ample sunlight and air to circulate through the landscaped areas below thereby creating a pleasant public environment. In addition, the location of the transit route is such that these linear parks would be placed within communities where more open space is needed.

This linear park system when coordinated with the City's existing public park areas could form an interconnected network of green spaces from Pearl City to Hawaii Kai. Carefully landscaped and planned with play areas, places to sit and relax, walkways and bikeways, these green areas could help return the City to a more pleasant pedestrian environment.

COORDINATED EDUCATIONAL FACILITIES CONCEPT

In addition to transporting students to school; fast, safe, and efficient public transit offers significant opportunities for expanding the present concept of the City's educational system. Specialized centers for science, languages, or the arts could be created at major schools along the corridor such as McKinley, Kaimuki, Kaiser, Radford, or the University of Hawaii and linked together by high speed rapid transit. Expanded educational programs could be formulated utilizing transit as the central backbone of a new educational system to exploit the City's underused physical and human resources. The area around each station would provide an "instant resource" of offices, arenas, cinemas, shops, restaurants, computing centers, bookstores, government facilities and the community as a whole. Making the City observable or learning from the environment can be important in providing young people with a viable context for education. A quick, safe, inexpensive and convenient means of moving about in the City could be a significant ingredient in expanding a child's perception of his environment.

Rapid transit is a potentially valuable resource around which new planning concepts could be structured. The interconnection afforded by good public transportation can be extremely useful, not only in the design of educational systems, but also in the planning of community service programs such as health care, child care, or programs for the handicapped and senior citizens.

URBAN DESIGN POTENTIAL STUDIES

Within the broad framework of land use planning, specific micro design problems have been examined. These urban design studies are prototypical in nature and are meant to provide a conceptual approach to the integration of rapid transit into an urban context. Their intrinsic value lies in providing those responsible for planning and/or controlling future growth in Honolulu with new concepts and ideas for coordinated development with rapid transit.

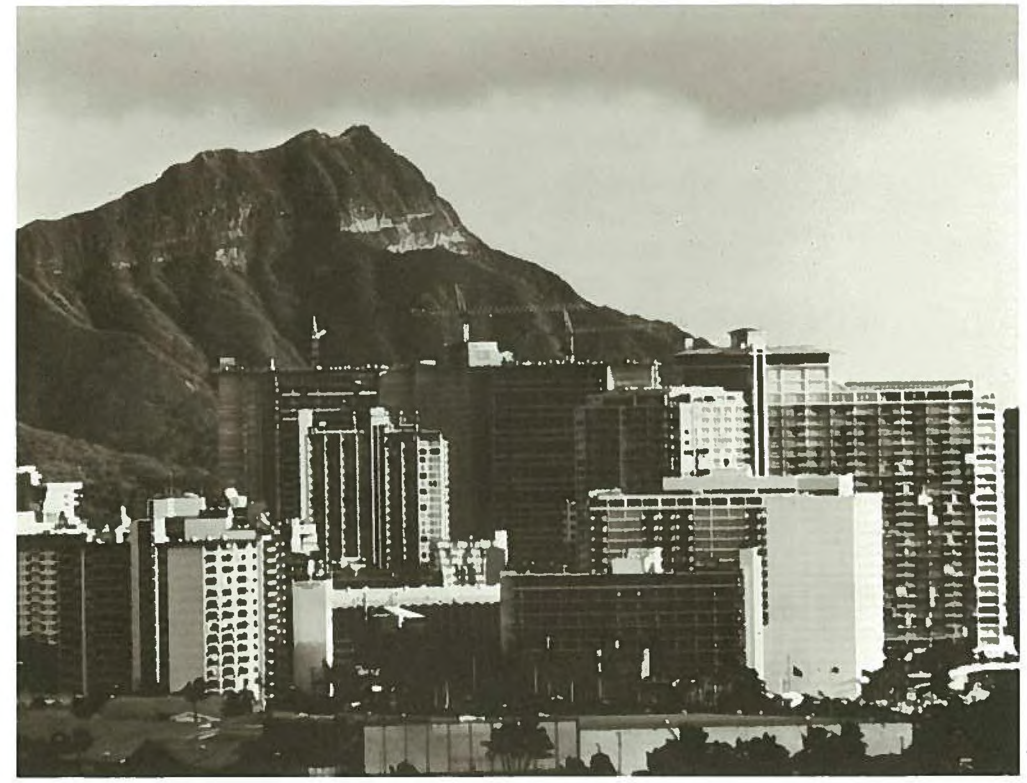
While transit way structures have been designed and located to minimize the impact upon the communities through which they will pass; transit stations, on the other hand, have been located to maximize future development potentials. Station environments have been examined to make the best use of the commercial, cultural, recreational or community opportunities resulting from the daily flow of large volumes of transit patrons.

Specialized urban design studies were carried out to illustrate generic problems involved in developmental response to the proposed system. Selection of these sites was based on economic growth trends, community character and sensitivity and relative importance to the City as a whole. The following stations were examined in some detail to produce a conceptual plan for their future development around rapid transit:

- Ward Avenue (H.I.C.)
- Fort Street (CBD)
- Civic Center
- Waikiki
- Airport
- Kalihi

AN URBAN DESIGN METHODOLOGY

In developing conceptual design studies for specific areas of potential growth in the vicinity of rapid transit stations, it became apparent that a wealth of information and responsibilities required definition. Creative approaches necessitate



a framework within which they can be formulated and, as a result, an urban design strategy or methodology was synthesized to establish that framework. This process attempts to identify in a step-by-step manner each task which will need examination.

In general, the process follows normal planning procedures of data collection and synthesis, goal formulation, development economics, and implementation. In an attempt to allow as much flexibility within the framework as possible, broad areas of responsibility were outlined. This would make the process applicable to not only the varied conditions to be encountered at particular station locations, but also varied governmental procedures which now exist to control public and private development.

Ultimately, some process will need to be formulated to insure coordination of public and private goals to this end. While this is primarily a public policy decision, the following outline is a preliminary step in providing an approach:

RAPID TRANSIT SERVICE CONDITIONS
- Expected Patronage

EXISTING CONDITIONS
- Land Use
- Area Goals
- Infrastructure

PROJECT DEFINITION
- Determination of Need
- Problem Definition
- Goal Formulation
- Evaluation of Existing Situation and Potential

URBAN LAND ECONOMICS
- Potentials and Objectives
- Define Market Potentials
- Identify Highest and Best Use (Density)
- Conflicts with Present CZO, OGP
- Transit Facility Impact

DETERMINE GOALS
- Physical/Aesthetic Goals
- Land Use Goals
- Community Needs that Could Be Fulfilled in Conjunction with Transit Facilities

INTEGRATED GOAL CONCEPT

IMPACT ASSESSMENT, PROGRAMMING
- Dislocation, Relocation, and Redevelopment
- Physical Design

FORMULATION OF PHYSICAL OBJECTIVES

IMPLEMENTATION
- Economic
- Control and Responsibility
- Coordinating Element

WARD AVENUE

The proposed Ward Avenue Station will serve two distinct areas. Mauka of Kapiolani Boulevard, the land is primarily devoted to recreational, institutional, and cultural facilities such as the Honolulu International Center, McKinley High School, and the Symphony Hall. The Kakaako area makai of Kapiolani Boulevard, on the other hand, is a mixture of industrial, residential and commercial land uses of a relatively underdeveloped nature.

Located between Waikiki and the Downtown area, the service industries located in the Kakaako area provide needed support facilities for financial, commercial and industrial activities throughout the City. Increased land values and resulting higher taxes in this area, however, will increase pressure for redevelopment to higher densities, thus making it difficult to maintain these service type industries. In order to accommodate both the desire of the City to retain these service industries within the urban core and at the same time permit redevelopment to occur, a concept for the vertical mixture of land uses is suggested. This concept would allow industrial, service industries or warehousing and commercial activities to occur on the lowest levels, parking on the next levels and residential uses and local commercial uses to serve such residential development on the upper levels. This would in effect raise the ground level for residential purposes three or four floors depending upon final design. These upper levels could then be connected with pedestrian walkways to provide second level circulation throughout the entire area.

A major objection to new development in areas along the shoreline of Honolulu is the possible disruption of views. Careful design and arrangement of building complexes can maintain these view opportunities as well as provide generous open space at a density which recognizes the central location of the Kakaako area.

At present, neither the General Plan nor the Comprehensive Zoning Code contain the appropriate provisions for this type of development. It is suggested that due to the special conditions which exist in this area, and the anticipated developmental pressures which will result from the introduction of a rapid transit station, a special district in the CZO be established. There are a number of precedents for this type action in the Honolulu code such as the "Central Business" district and the B-5 Resort—Commercial District which only apply to specific areas. A special mixed land use district could therefore respond to the particular conditions by density, massing, and design.

The schematic design studies on the following pages illustrate potential development around the Ward Avenue Station.

ward avenue station

WARD AVENUE

SITE DEVELOPMENT PRINCIPLES

- **AIR RIGHTS DEVELOPMENT:** utilization of air space above portal, way structure, and transit station for development.
- **MIXED USE DEVELOPMENT:** development of residual and "soft" sites with multiple uses: compatible mixed uses can be structured to occur in adjacent or vertically "stacked" configurations.
  - Establishment of economic viability while maintaining needed regional light and service industry space
  - Non-compatible uses can be separated by "buffer-use" layers (parking, landscaping, etc.)
- **PEDESTRIAN ACCESS SYSTEM:** provided grade-separated pedestrian crossing of Kapiolani Boulevard directly linking transit station and H.I.C. as first step in an integrated, second-level pedestrian system for the entire area
  - Pedestrian access from all new developments to transit station
- **PLANNED DEVELOPMENT STAGES:** structuring of pedestrian system and mixed-use/air rights developments to allow integration of various elements in separate stages.
- **VEHICULAR MOVEMENT:** clarification and simplification of auto movement, parking, bus routes, and bus stops.
- **"TREE-LINED BOULEVARD":** preservation and enhancement of Kapiolani as Honolulu's primary "tree-lined boulevard" in design and planning of any new development.
- **PRESERVATION OF VISTAS:** placement and orientation of commercial/office and/or housing tower structures to allow views from hills to sea and from Ala Moana Boulevard across Kakaako area to hills.

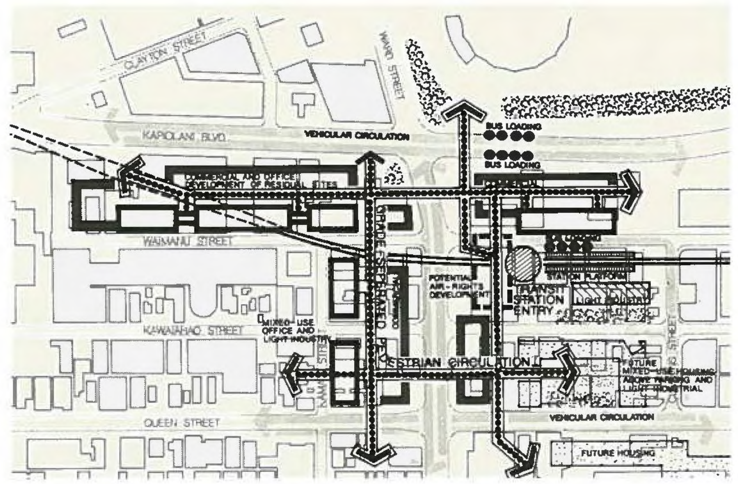


FIGURE 9-4 Ward Avenue Urban Design Diagram

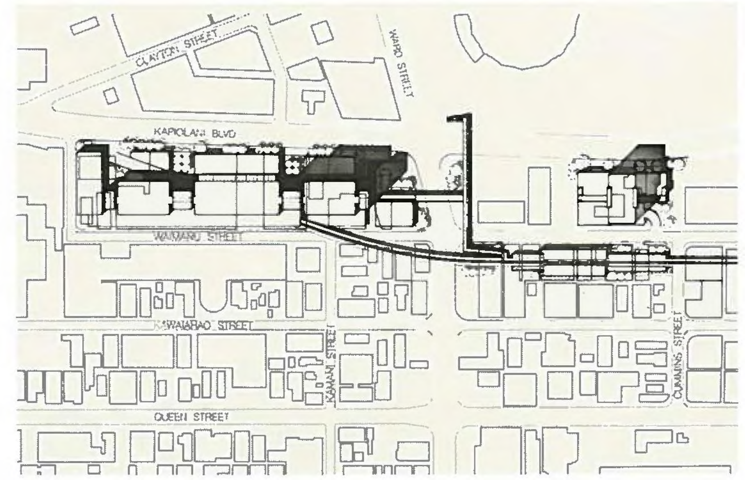
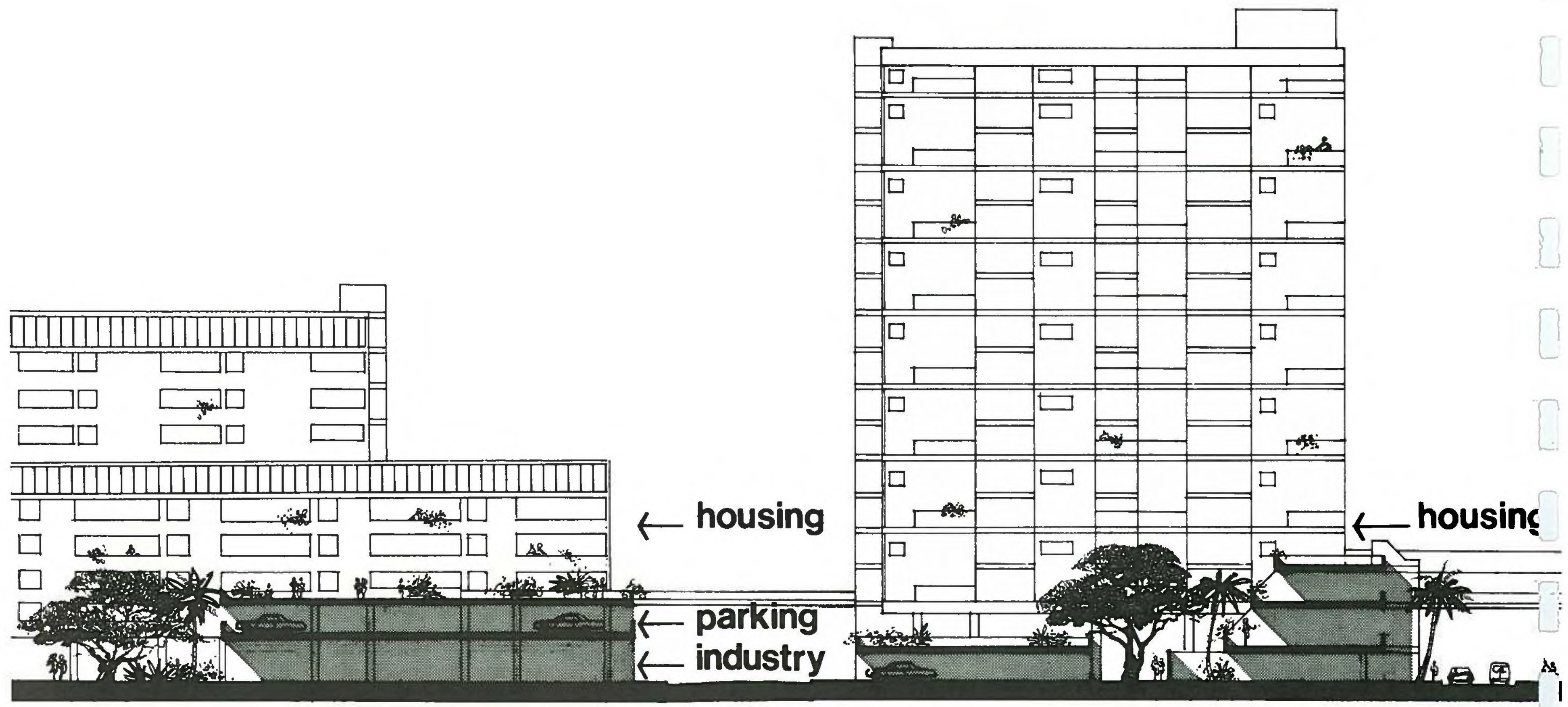


FIGURE 9-5 Ward Avenue Transit Development



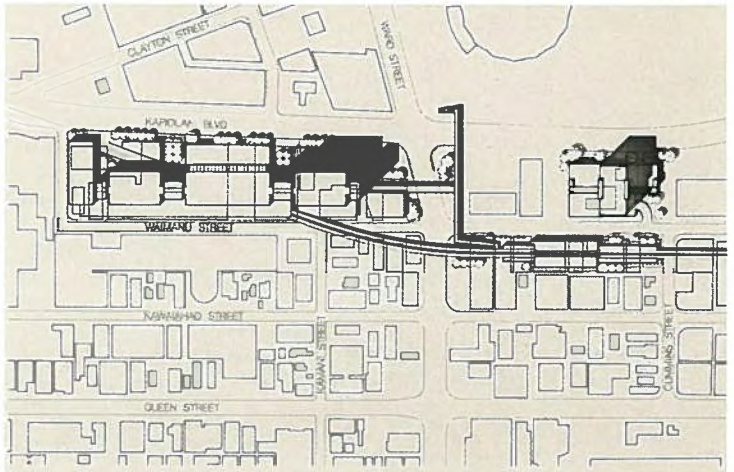


FIGURE 9-6 *Ward Avenue 1st Phase Urban Design Development*

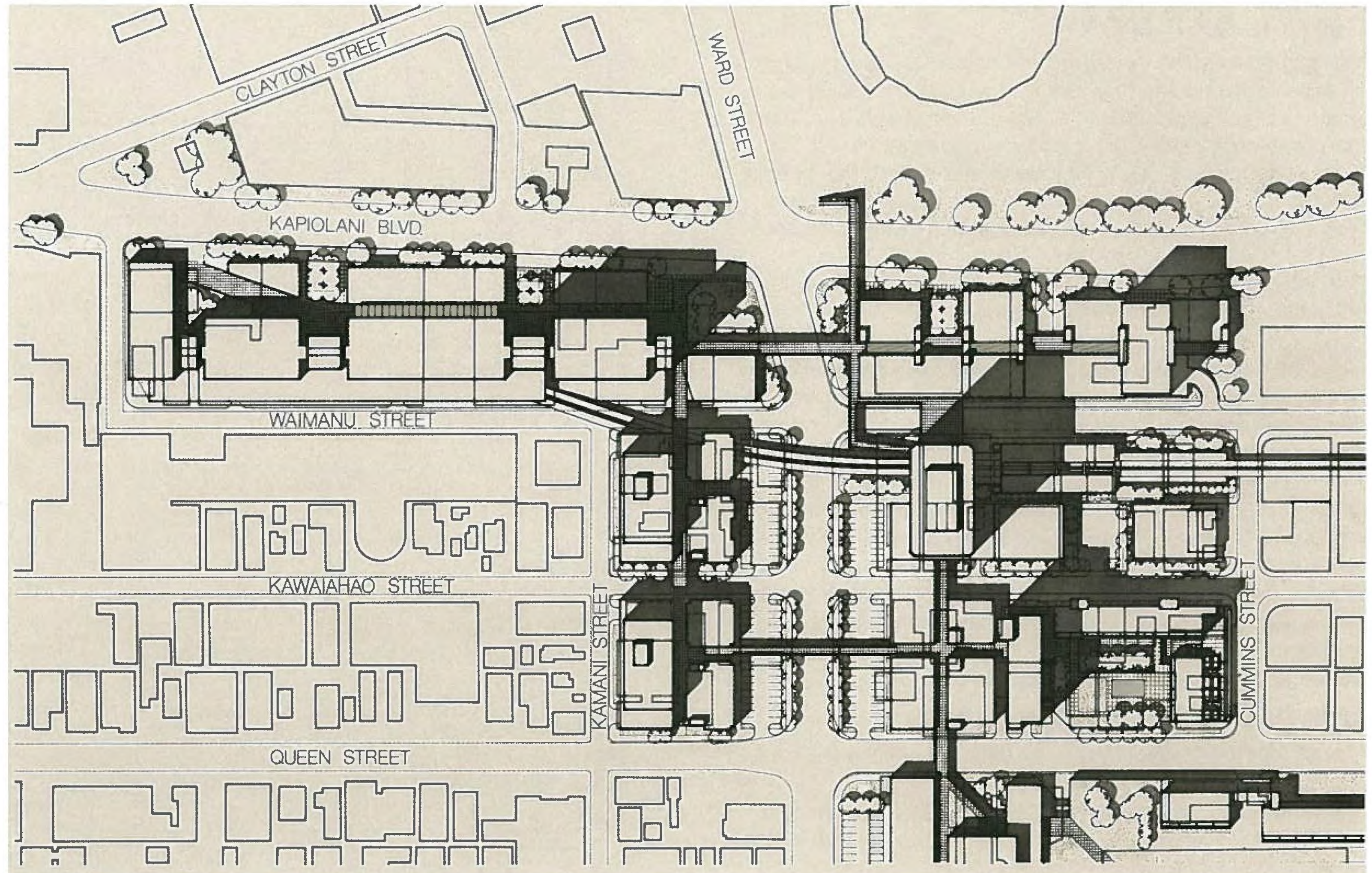


FIGURE 9-7 *Ward Avenue Site Plan of Urban Design Concept*

FIGURE 9-8 *Ward Avenue Cross Section*

FORT STREET

The downtown area is presently the center of business and and financial activity within the City as well as the largest center of employment. Over the last ten years, however, the downtown has declined as a major commercial center due to several factors: 1) most new residential growth has been suburban, 2) new and more convenient shopping centers have captured most of the retail trade, and 3) increased automobile ownership has overtaxed the outmoded structure of the historical center of the City with pressing demands for circulation, parking, and traffic facilities.

Coordination of transit planning with the numerous planning studies and renewal programs which have been undertaken over the last several years to plan for future development in the downtown area led to the selection of an underground transit route under the proposed Hotel Street Mall.[12] This route and station location would offer excellent service to both Chinatown and the Central Business District as well as provide needed stimulus for continued growth and commercial revitalization.

Integration of the pedestrian malls on Fort Street and Hotel Street with pedestrian circulation within the transit station will permit easy and convenient access to shopping facilities, offices, restaurants, and landscaped areas.

SITE DEVELOPMENT PRINCIPLES

- **SYSTEM VISIBILITY:** highly visible, open transit station, grade-separated, subway.
- **MINIMUM CHINATOWN DISRUPTION:** design and placement of station to minimize disruption and relocation in Chinatown.
- **CONSOLIDATED PROPERTY TAKING:** limit all necessary property taking to one (mauka) side of Hotel Street.
- **VEHICULAR MOVEMENT:** clarification and simplification of auto movements, bus routes, and bus stops.
- **INTEGRATED PEDESTRIAN SYSTEM:** improved pedestrian movement and safety, increased pedestrian areas, and ease of transit access.
- **NEW DEVELOPMENT:** development of residual or "soft" sites with mixed commercial and office uses to enhance shopping character and life of CBD and its economic viability.
- **"FOCAL POINTS":** creation of identifiable pedestrian/shopper "focal point" at Fort and Hotel Streets, with smaller "places" interspersed throughout the pedestrian system.
- **TOWER SETBACKS:** Establish tower setbacks for new development to maintain 2 to 4 story scale of Fort and Hotel Streets and Chinatown.

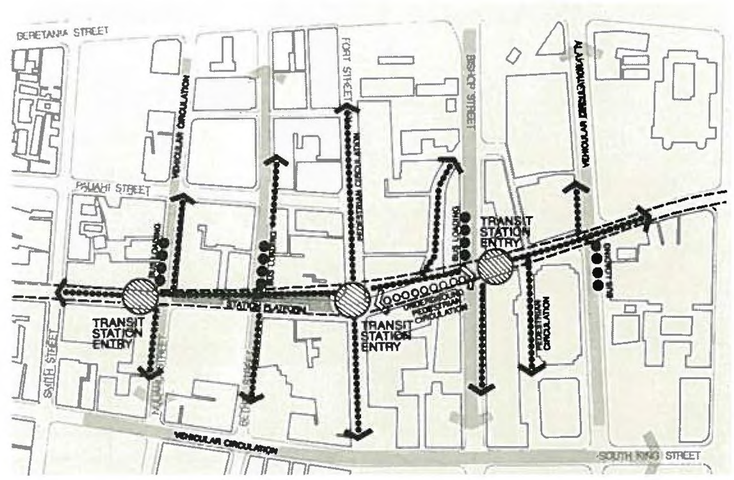


FIGURE 9-9 *Fort Street Circulation Diagram*

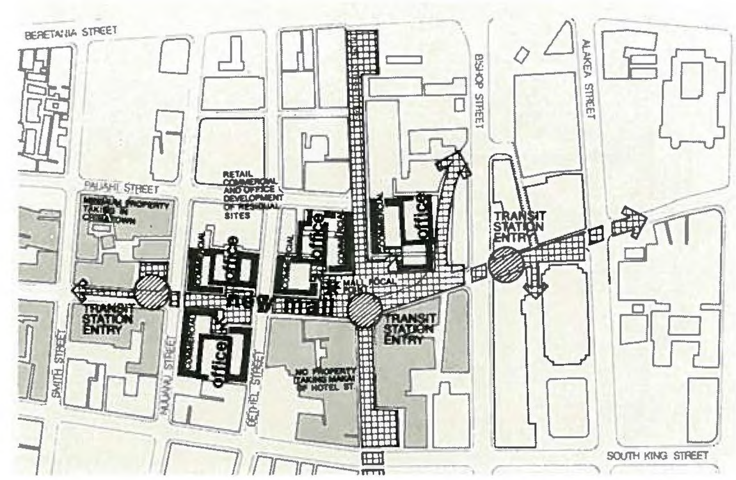


FIGURE 9-10 *Fort Street Urban Design Concept Diagram*

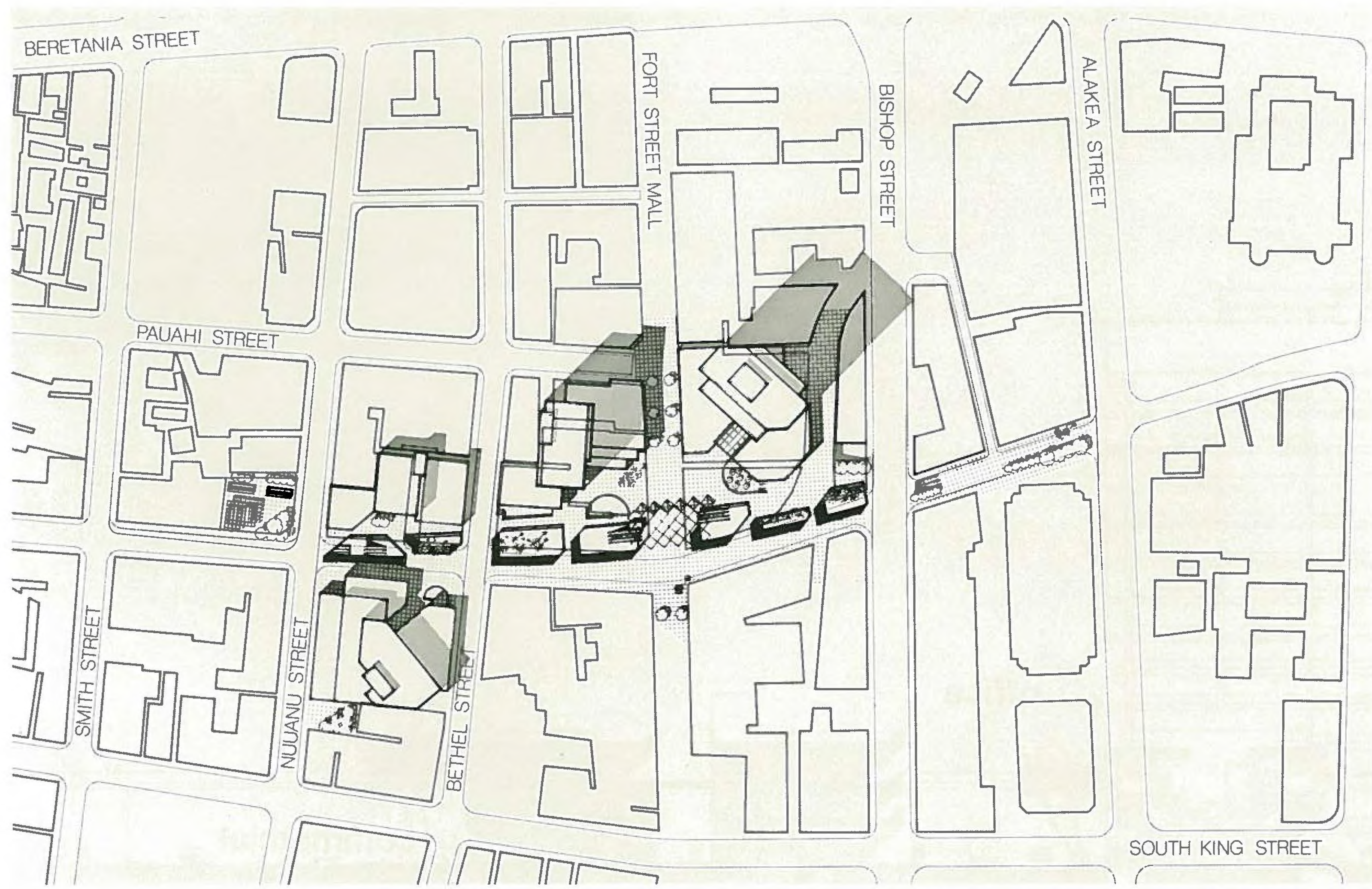


FIGURE 9-11 *Fort Street Urban Design Concept Site Plan*

fort
street
station

AR00053915

CIVIC CENTER

Virtually all governmental activities represented on the Island of Oahu are located within the Civic Center area; Federal, State and City-County. The "Oahu Civic Centers Study" in 1967 outlined a master plan for the future development of this governmental center and recommended traffic rerouting and street closings in order to create a "governmental campus" within which the expansion of facilities could take place. Although not officially adopted by the State or the City, this study has been used as a guideline in directing growth. This study further recommended that rapid transit be placed underground on Hotel Street with a station located in the vicinity of Punchbowl Street to serve the surrounding government facilities.

The proposed rapid transit station for the Civic Center has been placed in the heart of this park-like governmental campus and has been schematically designed as a sunken garden within which the rapid transit line would be accommodated. Platform levels would be open to natural light and air with gently sloping embankments to provide a landscaped transition between the park area and the underground station.

SITE DEVELOPMENT PRINCIPLES

- **TRANSIT ACCESS:** easy access to transit station from both City Hall, the State Capitol and Municipal Office Buildings, with possibility of future direct underground pedestrian connections.
- **NEW PARK:** establish a new, defined park "square" and civic open space, made possible by the planned (DLUM) Kapiolani Boulevard closing and South Street widening.
- **"STATION IN THE PARK":** integration of station into campus/park-like setting of Civic Center area, with minimal number of above surface structures.
- **VEHICULAR MOVEMENT:** clarification and simplification of auto movement, bus routes, and bus stops.
- **PRESERVATION OF TREES:** preservation of existing plant material and addition of new landscaping suitable to park-like surroundings.

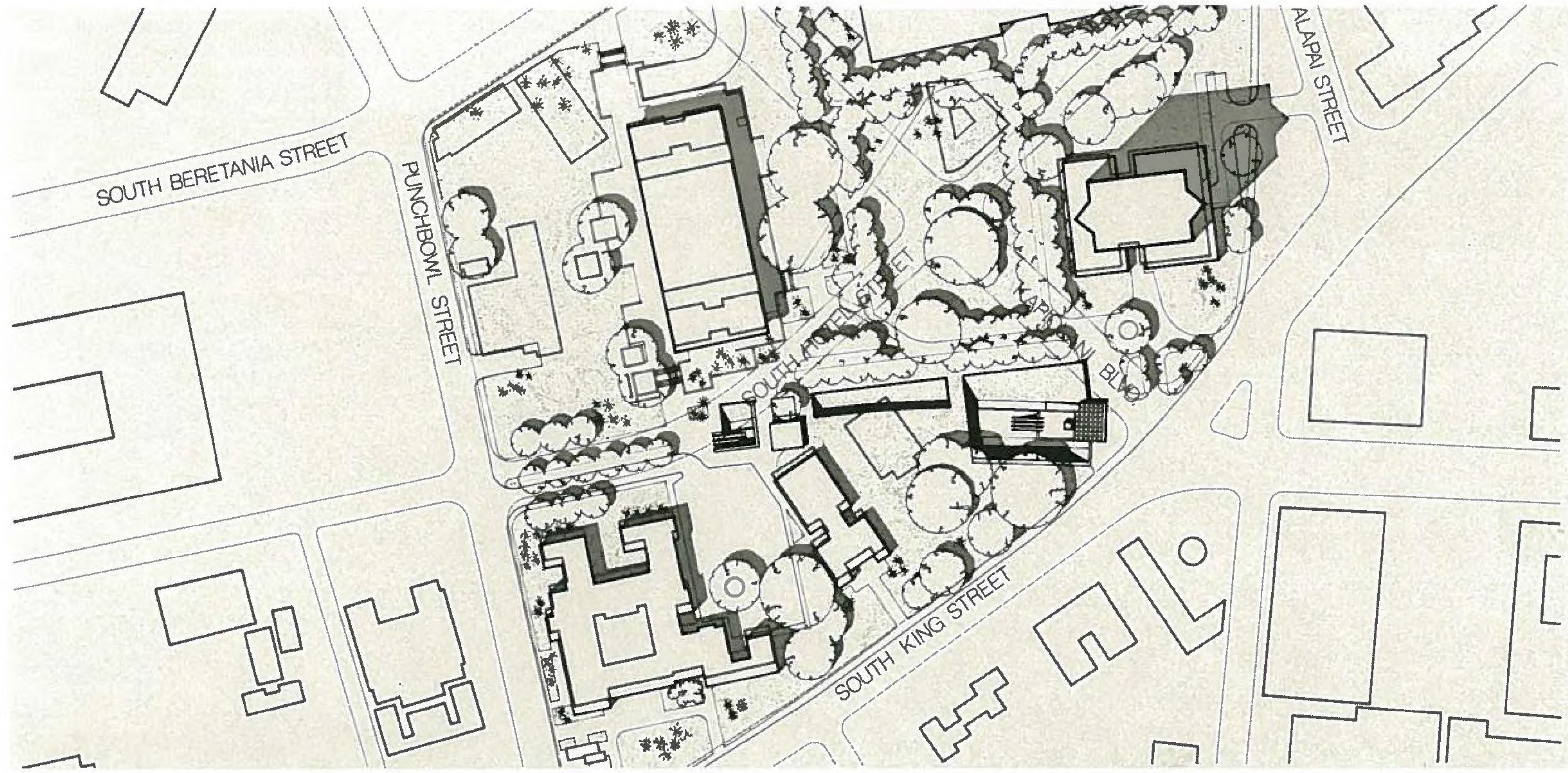


FIGURE 9-13 Civic Center Urban Design Concept Site Plan

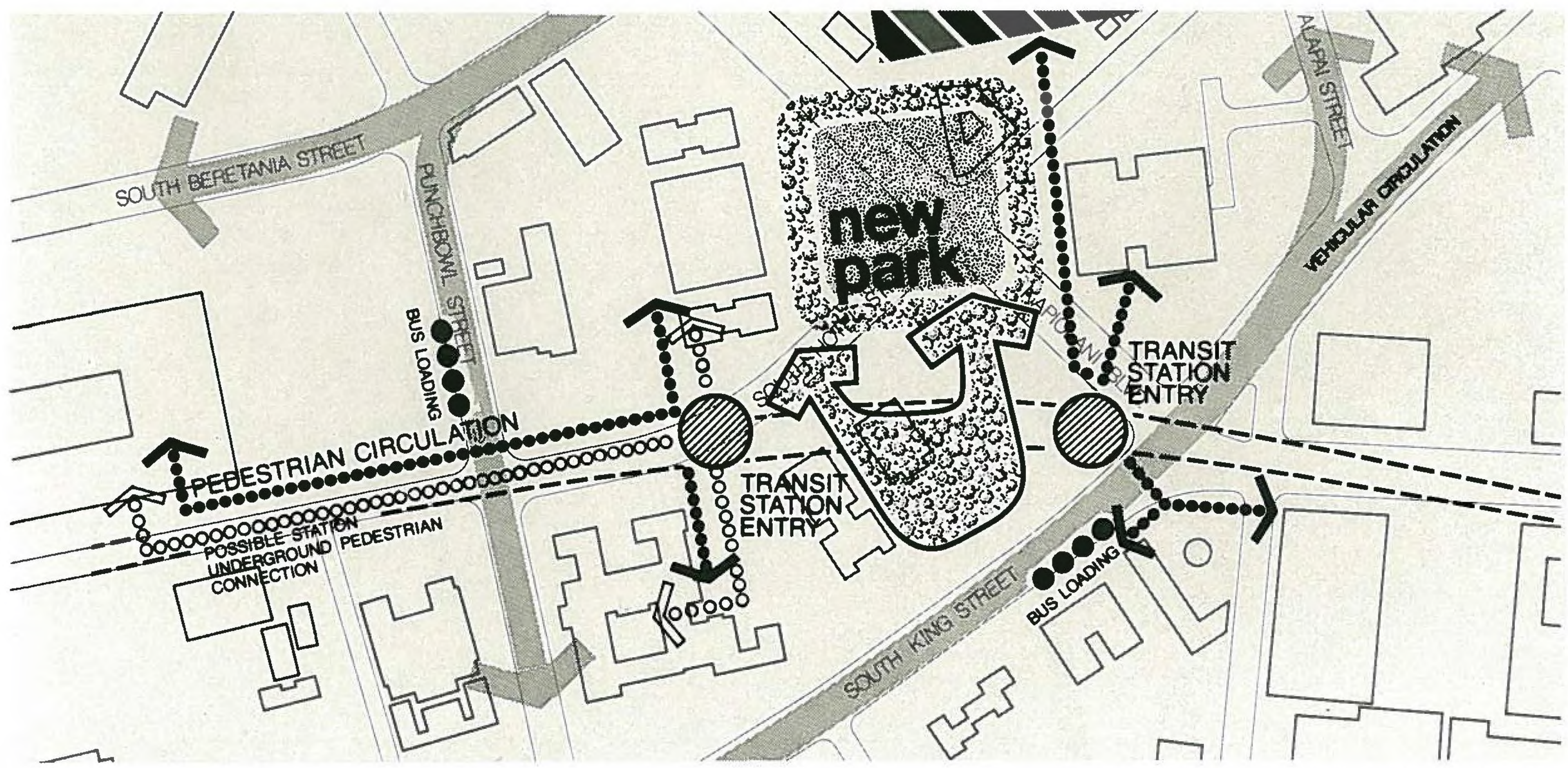


FIGURE 9-14 Civic Center Concept Diagram

civic center station

AR00053917

WAIKIKI

Waikiki, one of the most densely populated areas on the Island of Oahu, is divided from the City of Honolulu by the Ala Wai Canal and is structured in a linear fashion by three major lateral arterial streets; Ala Wai Boulevard, Kuhio Avenue, and Kalakaua Avenue.

The Waikiki Transportation Plan recently completed by Futrell Hawaii, Inc. for the Department of Traffic called for the conversion of Kalakaua Avenue to a pedestrian mall and the creation of a traffic couplet with Ala Wai Boulevard and Kuhio Avenue. Concurrent route planning for the rapid transit system resulted in the development of a fine grained subsystem utilizing both the limited mall on Kalakaua Avenue as well as the Kuhio/Ala Wai couplet to provide efficient and convenient service to a trunk-line rapid transit station at the gateway to Waikiki. This sub-system would be planned as an attractive part of Waikiki's urban-resort environment and would provide broad coverage for the varied patrons in the area: tourists, residents, employees, and shoppers.

The trunk-line station site has been developed conceptually as a "Gateway to Waikiki"[13] and would be planned to provide both residents and visitors alike with a pleasant environment transition into the Island's tourist and entertainment center.

SITE DEVELOPMENT PRINCIPLES

- **"GATEWAY TO WAIKIKI":** development of the triangular site defined by Kapiolani Boulevard, Kalakaua Avenue, and McCully Street as a unified urban design element identifying the gateway-entrance to Waikiki.
  - Utilization of views and natural beauty of site
  - Maintenance of Ala Wai "Promenade" on mauka side of Ala Wai Canal
  - Develop "Gateway Park" and Waikiki sub-system pavilion on makai side of canal
- **SUB-SYSTEM INTERFACE:** control of transit feeder and sub-system interface to clarify vehicular movement and preclude further congestion of Kalakaua/Kapiolani intersection
  - Waikiki sub-system interface on makai side of Ala Wai Canal
  - Direct pedestrian link (people-mover) to interface point from transit station
  - Waikiki sub-system pavilion designed to accommodate possible future development of automated (people-mover) system down Kuhio Avenue
  - Grade-separated pedestrian crossing of Kapiolani Boulevard to bus interface
- **DESIGN FLEXIBILITY:** provision for possible future expansion of station to include development of Airport-Waikiki express system.[14]

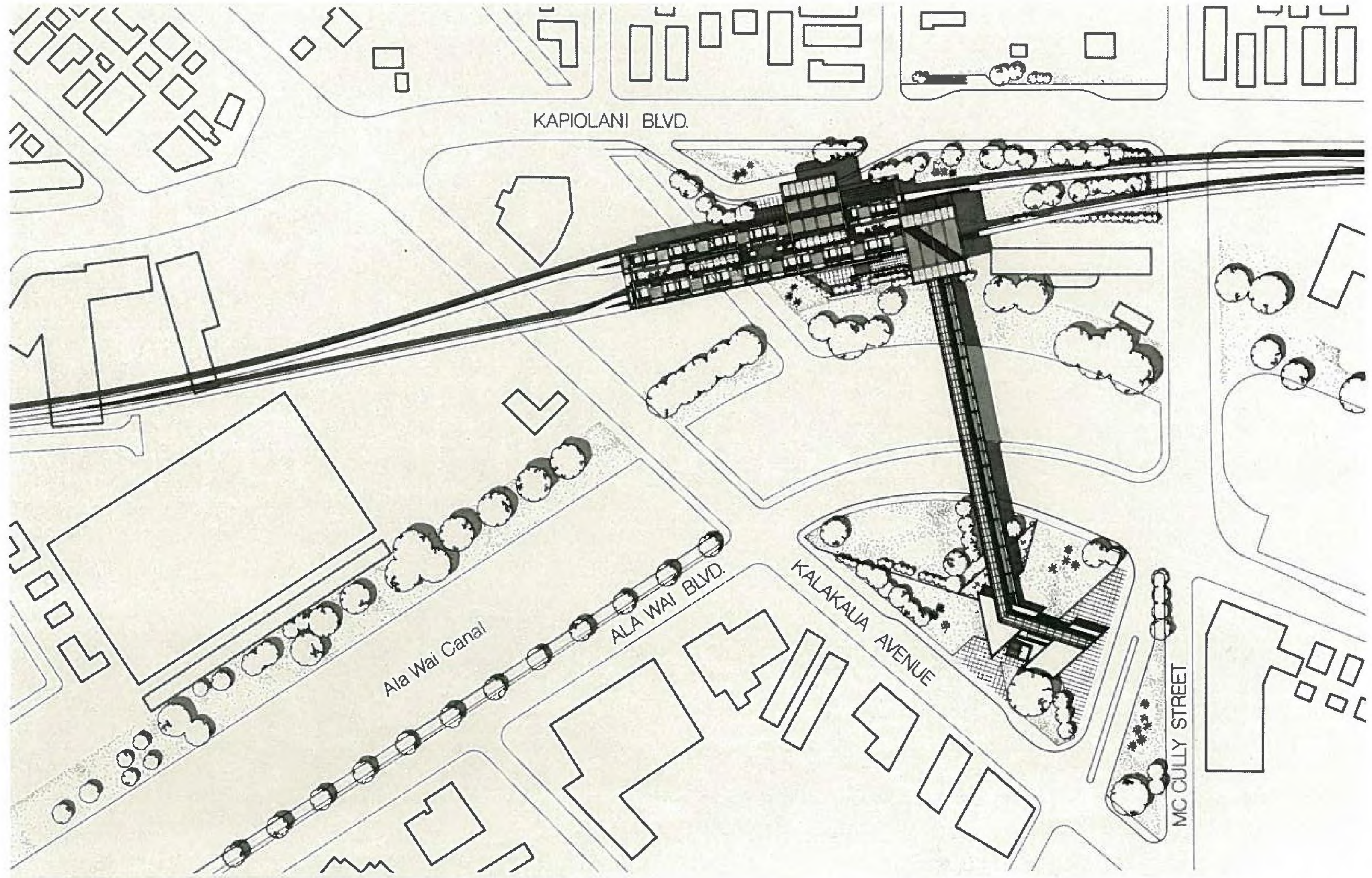


FIGURE 9-16 Waikiki Urban Design Concept Site Plan

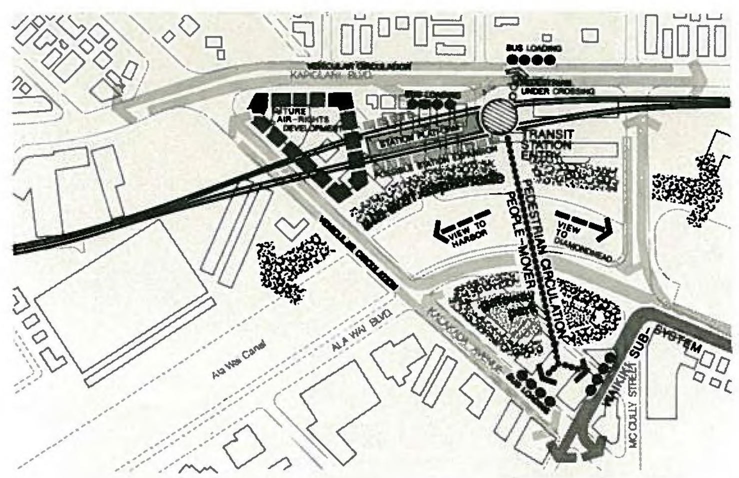


FIGURE 9-17 Waikiki Urban Design Diagram

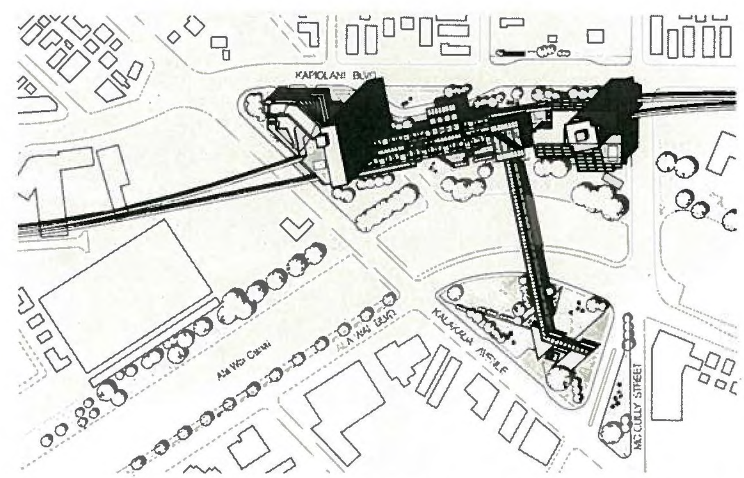


FIGURE 9-18 Waikiki Future Air Rights Development

waikiki gateway station

AIRPORT

The Honolulu International Airport handled over 7 million passengers in 1970 and projections indicate that this figure will increase dramatically by 1985. The airport facilities are currently being expanded with a major new terminal under construction and a proposed off-shore runway to accommodate the anticipated increase in air passenger volume.

The rapid transit station located within the terminal complex mauka of the existing parking structure has been positioned to take maximum advantage of the proposed expanded wiki-wiki service and the future automated people-mover. The development potential of the station will depend, for the most part, upon policies established by the planning agencies of the Honolulu International Airport, however, the station location has been coordinated with future airport planning to insure integration of both the air transportation facility and the public transit facilities.

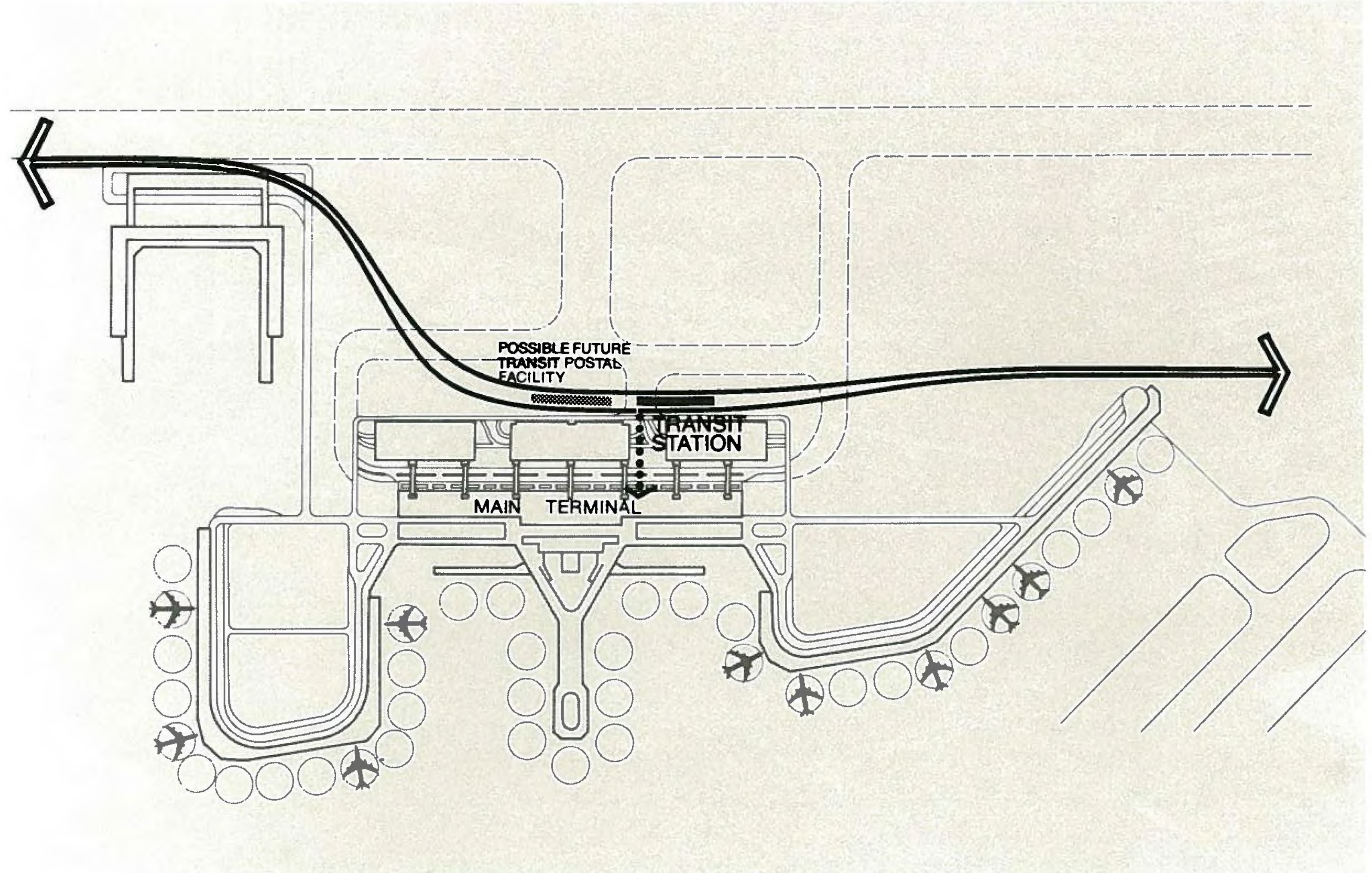


FIGURE 9-20 *Airport Station Location Diagram*

SITE DEVELOPMENT PRINCIPLES

- **PEDESTRIAN ACCESS:** provision of direct pedestrian link from station to Main Airport Terminal.
- **WIKI-WIKI/BUS ACCESS:** possibility of direct Airport Wiki-Wiki connection to Transit Station, as well as access for Intra-Airport shuttle-buses.
- **DESIGN FLEXIBILITY:** provision for possible future potential development of Honolulu International Airport—Waikiki express or dual mode systems.[14]
- **FUTURE AIR-MAIL FACILITY:** location of transit line and station design to accommodate possible future transit postal service facility.

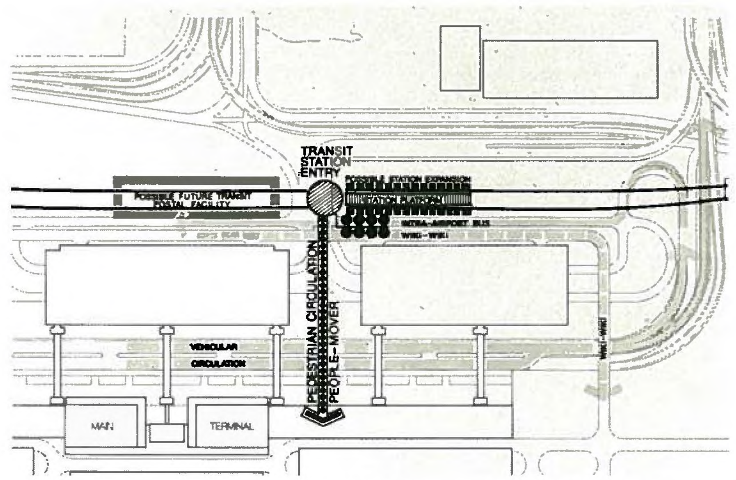


FIGURE 9-21 *Airport Circulation Diagram*

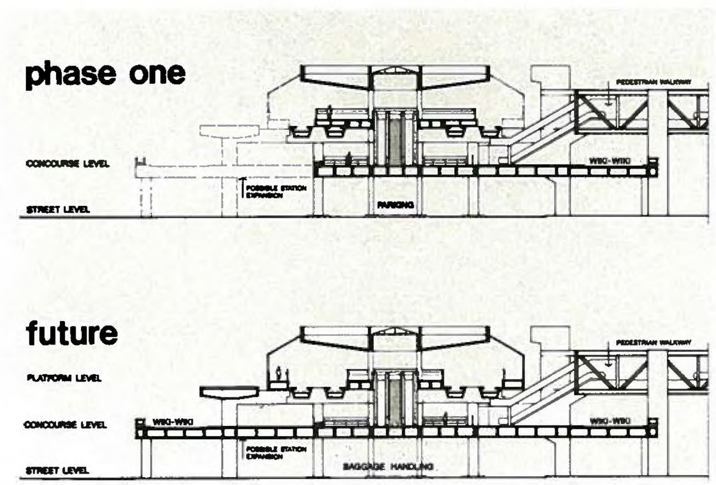


FIGURE 9-22 *Airport Future Phasing*

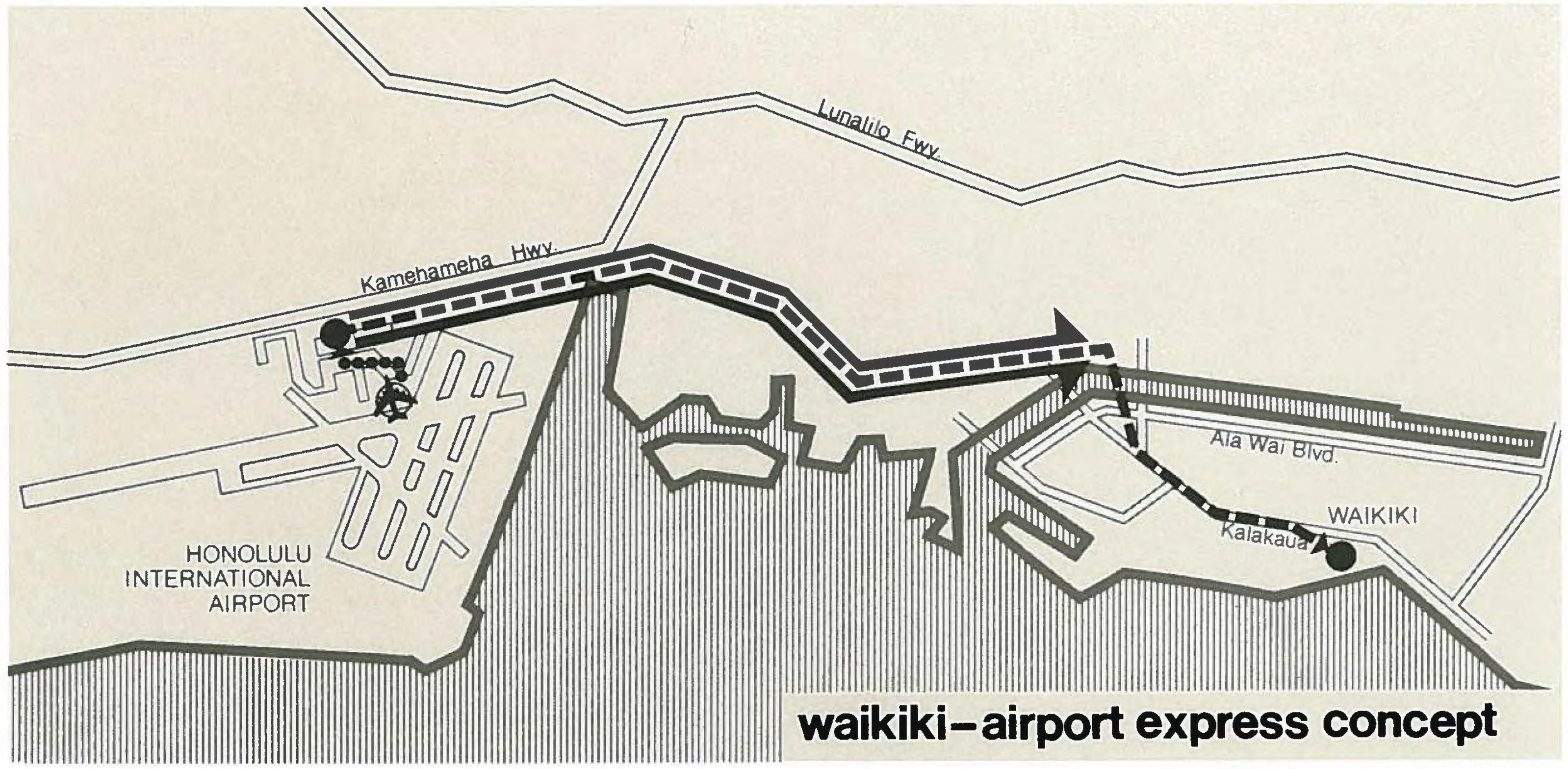


FIGURE 9-23 Airport Waikiki Diagram

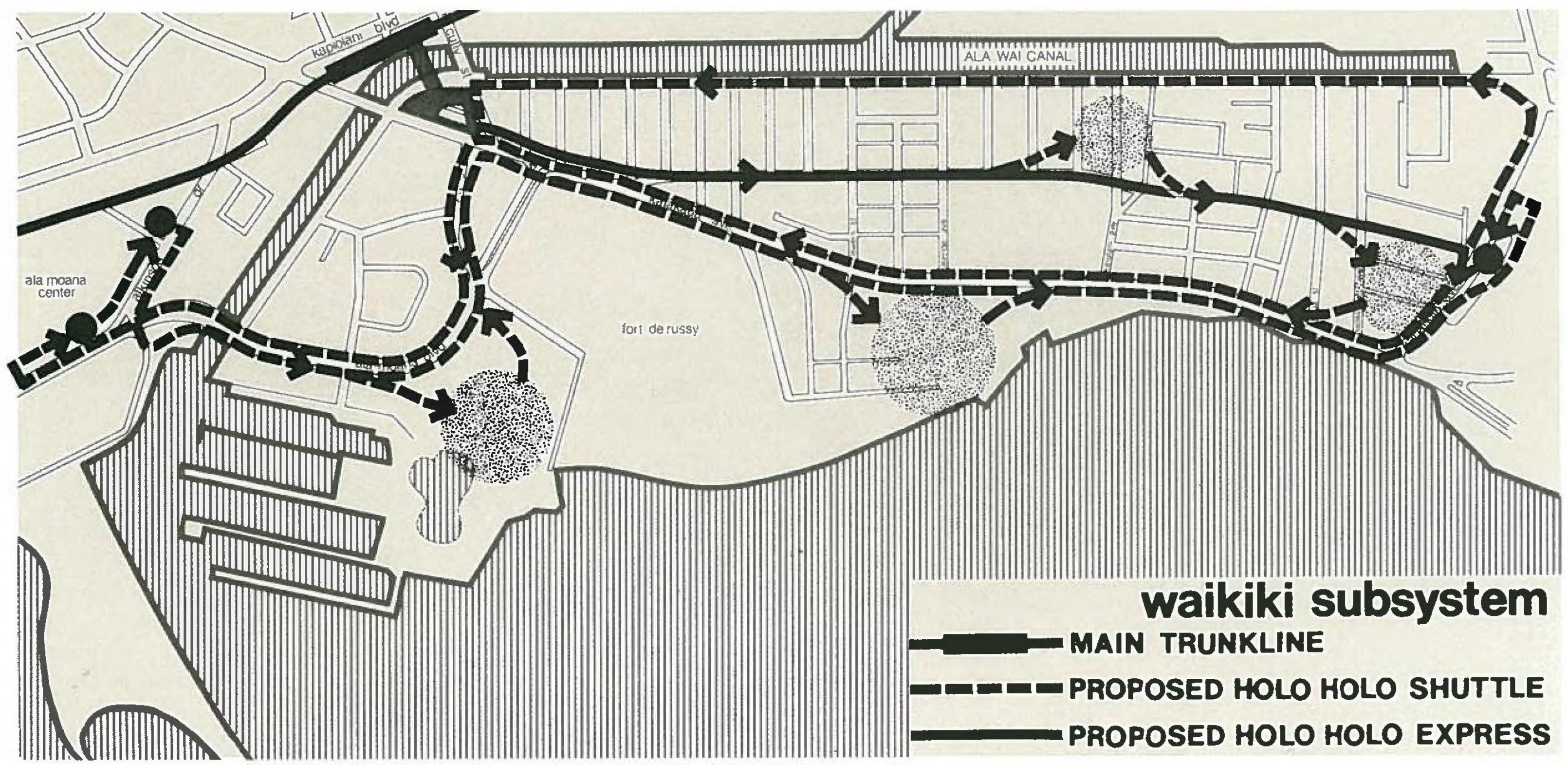


FIGURE 9-24 Waikiki Sub-System Diagram

AIRPORT—WAIKIKI

Of the total number of airport passengers, approximately 65% are tourists. Almost 80% of these visitors are destined to Waikiki, the hotel center of Oahu. This large travel movement existing between the Airport and Waikiki has been of major concern to the area and as a result, various transport modes have been suggested to supplement the existing means of travel.

The rapid transit system proposed for commuter service has been planned to serve both the Airport and the Waikiki area. Consequently, work and other trip purposes to or from these two areas would be adequately served by the rapid transit system. The handling of air passengers with baggage, however, poses special problems that can only be accommodated by providing special service.

A concept was developed for special airport express service utilizing special trains, operating non-stop, between the two points. The transit stations at Waikiki and the Airport would be expanded to provide a combination commuter and air passenger station with separate access, lobby area and platform facilities. Additional tracks would be provided at these stations to permit the commuter trains to operate in accordance with their schedule while the airport express trains are dwelling at the station.

Although local residents would be the principal users of the regional transit system, the predominant users of an Airport—Waikiki express would be tourists. The airport express service has therefore been treated separately from the basic rapid transit commuter system oriented to primarily serve the local residents.

The following parameters were established for the design of the Airport to Waikiki express facilities:

- Physically separated from commuter passenger
- Direct and convenient access to air terminal and wiki-wiki facilities
- Baggage handling at the Waikiki terminal
- Convenient interface with sub-system facilities at the Waikiki terminal to provide local collection-distribution service to major hotel complexes

KALIHI STREET

Much of the land in Kalihi-Palama is devoted to some type of residential land use, industrial areas are generally makai of Dillingham Boulevard, and commercial properties are located along the major thoroughfares intersecting the area, King Street and Dillingham Boulevard in particular.

Land use is projected to remain constant in the future, with the residential properties makai of Dillingham Boulevard being phased to industrial uses over time. The rapid transit line along the makai edge of Dillingham Boulevard would tend to reinforce this land use pattern and act as a buffer between incompatible land uses: residential, mauka of Dillingham Boulevard and industrial, makai of Dillingham.

The demographic factors prevalent in Kalihi such as low median income, high rate of unemployment and the fact that the community has suffered serious disruption in the past when public projects have been implemented, required careful and sensitive planning to minimize disruption and at the same time provide as much potential for community related benefits as possible.

Development around the station at Kalihi Street should be oriented toward community services and facilities. The station could provide a needed focal point for many community activities which will benefit from the improved mobility offered by transit. A job training and employment counseling center could provide invaluable help in securing distant jobs. A day care facility close to the station would offer working mothers and shoppers convenient child care adjacent to inexpensive transit.

SITE DEVELOPMENT PRINCIPLES

- **COMMUNITY SCALE:** maintenance of community residential scale in design of station and related structures.
- **STATION LANDSCAPING:** integration of station and way-structure into community in accordance with system-wide "linear-park" concept and thorough station landscaping.
- **COMMUNITY FACILITIES:** develop residual land from construction adjacent to station to provide needed transit-related community services in cooperation with model cities and other community groups.
- **PEDESTRIAN ACCESS AND CIRCULATION:** ease of access from station to pedestrian-related shopping facilities and possible future grade-separated pedestrian crossing of Dillingham Boulevard.
- **VEHICULAR MOVEMENT:** clarification and simplification of auto movement, bus routes, and bus stops.

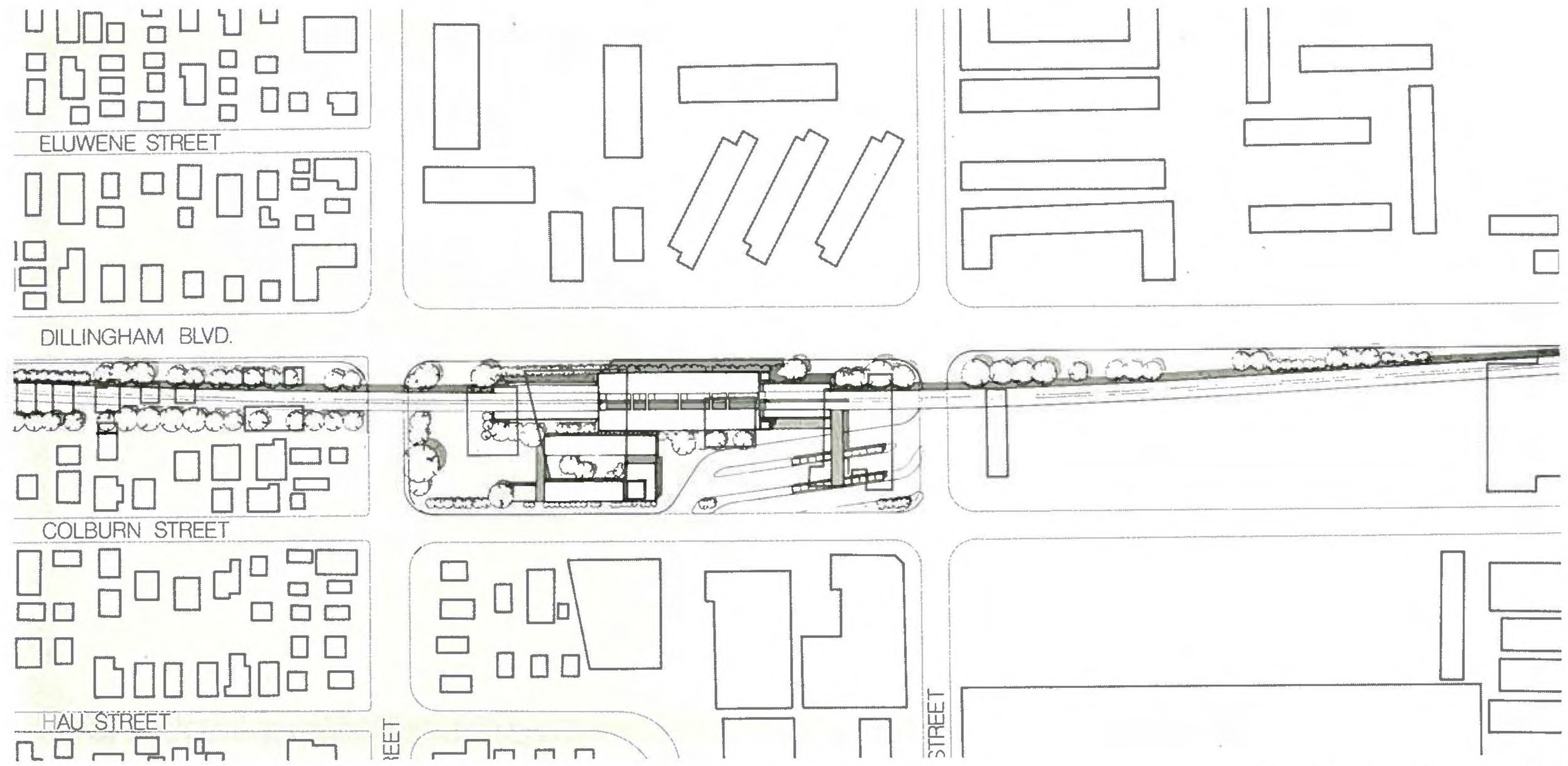


FIGURE 9-25 Kalihi Site Plan

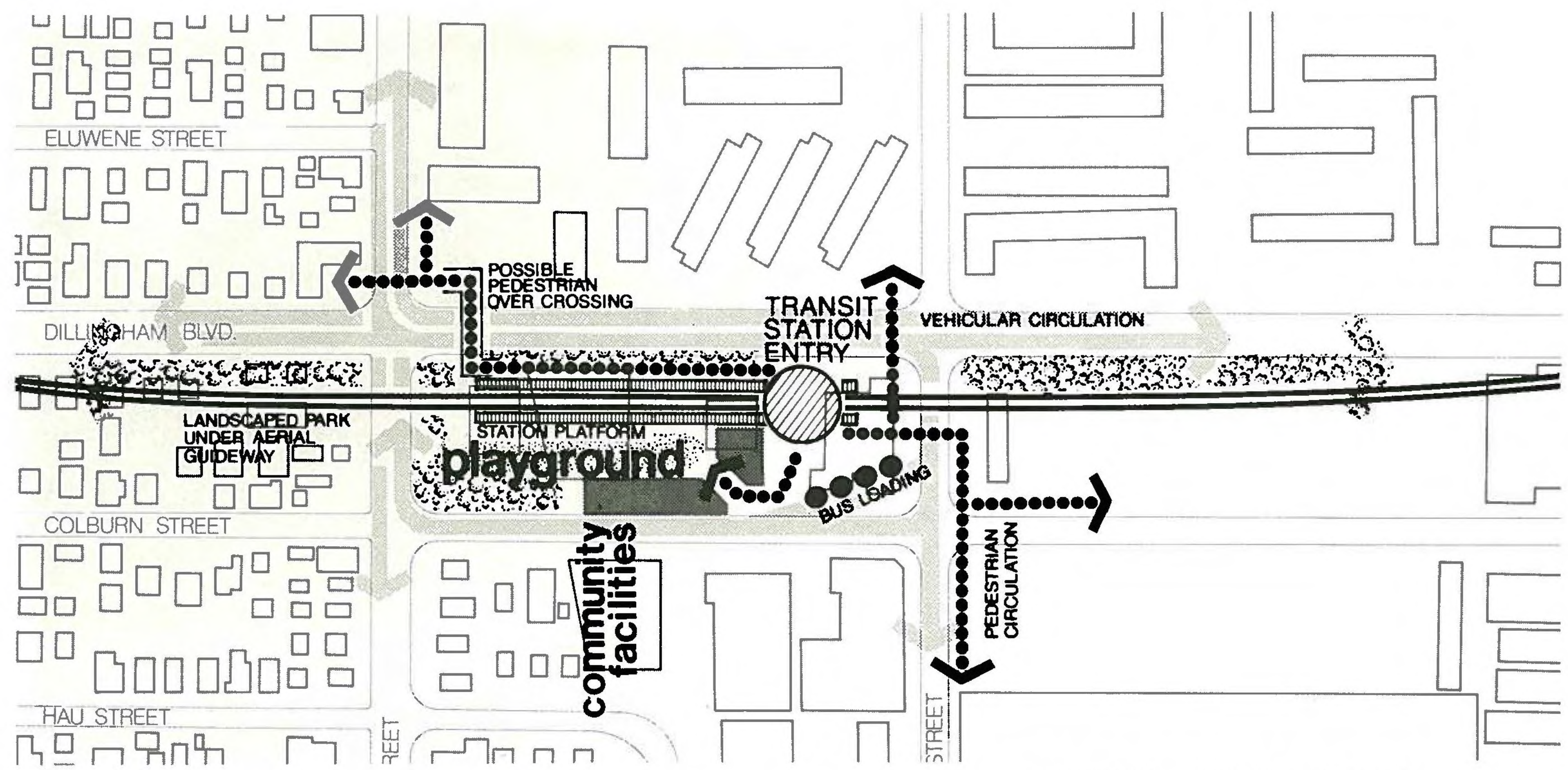


FIGURE 9-26 Kalihi Urban Design Concept Diagram

JOINT PROJECT DEVELOPMENT

The proposed Rapid Transit system for Honolulu will present numerous opportunities for joint development projects which can serve as effective means of integrating the transit facility into the surrounding environment and at the same time facilitate efficient urban development. Through careful coordination of Capital Improvement Programs, comprehensive transportation planning, private and public facility planning, community renewal programs, and land-use development planning and programming activities, joint solutions could be generated to various project needs.

A great variety of joint project opportunities exist in different land-use categories—recreational, public institutions, commercial, industrial, residential as well as other public and private developments. In conducting comprehensive planning activities related to each of these categories, planners should be made fully aware of the additional gains which might be achieved through joint development.

Joint projects associated with a rapid transit right-of-way can achieve four basic kinds of community benefits:

- the location of land-uses requiring high accessibility at transportation related sites which offer high accessibility
- environmental and aesthetic improvements achieved through coordinated design
- land conservation achieved through multiple-use rights-of way
- the maintenance of neighborhood continuity by reducing disruption and relocation problems.

Transit-related sites which offer the opportunity of meeting one or more of these objectives should be closely examined for joint development potential.

In order to take advantage of these opportunities, a procedure for joint project planning should be developed which can be incorporated within the comprehensive planning programs of specific urban areas. In general, the responsibility for independently studying joint project opportunities should lie with a comprehensive planning agency, while the transportation planning agency would invite joint project proposals. Individual agencies and developers who actually develop capital projects should also play an important role in identifying opportunities and desirable joint developments.

A major guideline for identifying joint project opportunities in both urban and suburban areas should be station impact zones. The planning of all land uses and development projects in station areas should be coordinated; joint development offers one way to ensure that the transit facility and specific adjacent land-uses are related so as to preserve the integrity and value of the transit system as well as produce highly accessible and attractive development sites.

Demonstration projects of joint development, involving air rights development, coordinated renewal programs, and cooperatively financed public/private developments should be encouraged, with the purpose of exploring the full potentials of both the joint project and the corridor concepts. New design standards and guides should be developed for coordinated planning of rapid transit and other types of public and private development, which will facilitate joint development.

The strong potential of joint projects for guiding metropolitan growth and for reserving adequate land for facilities which require high accessibility should also be examined.

Joint projects also offer an opportunity for imaginative and productive use of a wide range of federal aid programs. Many Federal agencies—HEW, HUD, Transportation, Interior, Post Office, Defense, GSA, the Corps of Engineers, and others—are engaged in supporting or conducting urban developmen-

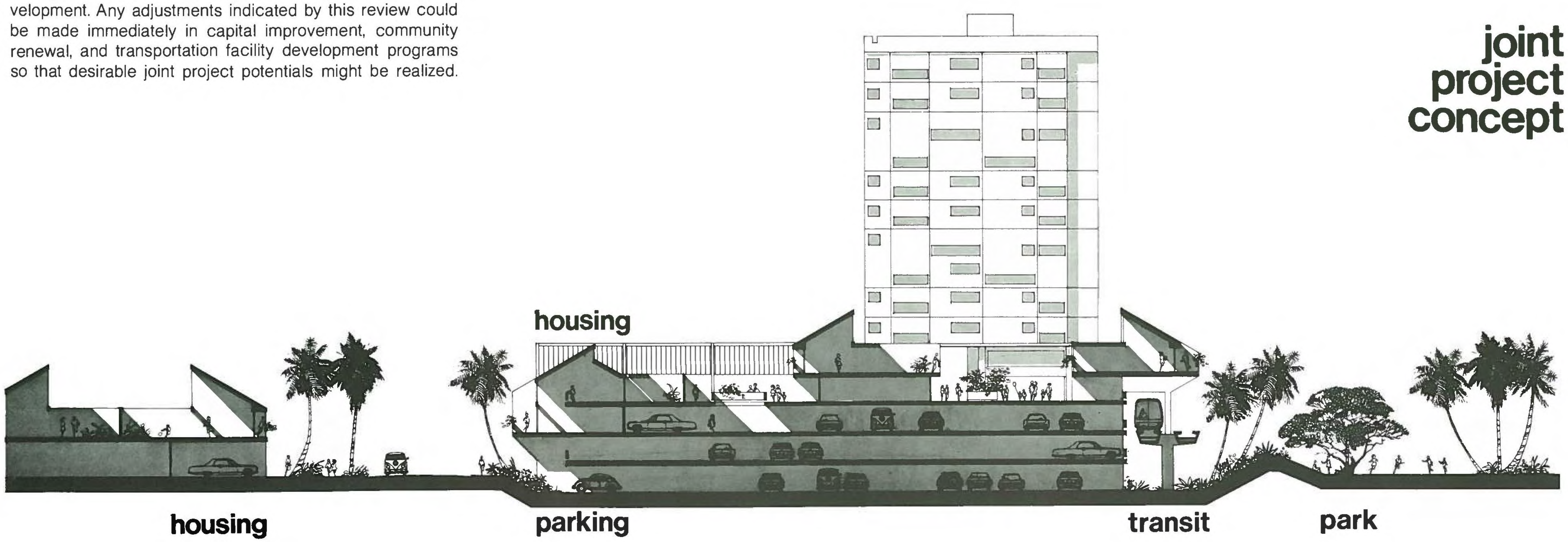
AR00053923

tal programs that could benefit from the application of the joint project concept. And many of the facilities, major office, defense, and postal installations,—need locations that are well related to a transportation system. Federal participation in financing offers a significant resource in implementing many kinds of joint project development, and both local governments and the federal governments should seek new ways for applying these aid programs. In addition, the joint project concept can offer significant economic savings to all participants by sharing such cost items as land acquisition and site development.

The joint project concept is most likely to be successfully employed where an effective procedure for joint project planning has been established which coordinates programming and project timing to insure effective joint project execution. This coordination will demand that public facility needs be anticipated and scheduled well in advance of actual construction and that capital improvement programming be sufficiently developed so that individual agency projections will lead to realistic and feasible joint project opportunities.

State and local governmental agencies should undertake immediately to review the proposed rapid transit system and related planning studies to discover existing or potential joint project potentials. This could include potentials for rezoning as well as for renewal, public facility, and private development. Any adjustments indicated by this review could be made immediately in capital improvement, community renewal, and transportation facility development programs so that desirable joint project potentials might be realized.

joint project concept



AR00053924

RELOCATION

A central premise in federally sponsored transportation project is that relocation housing must be built before construction can begin on a specific project. Given the present housing crisis in metropolitan areas and in particular the exaggerated problem on the Island of Oahu, this premise will insure housing stock replacement.

In planning the rapid transit system, every effort was made to minimize the amount of relocation which would be required and at the same time provide a fair relocation program for those who are affected.

Transit systems, like any public investment of equal magnitude, benefit large segments of the population and should not be eliminated because of conflicts they may create with certain special interest groups. However, neither should the rights of individuals or minority groups be violated because of majority convenience. Historically people and businesses dislocated by public investments such as urban expressways have not been equitably compensated for their losses. This, in part, has resulted from the legal restrictions imposed by the concept of "just compensation" to land rather than to individuals, and also from the fact that the planning process, until recently, has been unresponsive to community desires. Recent Federal regulations ("Uniform Relocation Assistance and Land Acquisition Policies Act, January, 1971") have attempted to adjust many of these inadequacies in providing compensation. The final route planning and design of the Honolulu system was determined only after receiving feedback from over 300 meetings with community and citizen groups, public agencies, businessmen's groups and local leaders. This feedback, coupled with the new Federal guidelines, resulted in a more equitable and reasonable transportation planning process which was sensitive to relocation problems.[15]

RELOCATION POLICY

Property owners and tenants affected by the Honolulu rapid transit program will receive just and adequate compensation for their property as well as relocation payments and assistance in finding adequate new housing.

In accordance with provisions of the Federal Uniform Acquisition Policies Act of 1970, policies on property acquisition and relocation are as follows:

PROPERTY ACQUISITION

- Every property owner will be paid just and adequate compensation for his property in accordance with the laws of the State of Hawaii.
- Every possible effort will be made to acquire property by negotiation; and any owner or his representative will have the opportunity to accompany the appraiser during his inspection of the property.

RELOCATION

- A relocation program will be established to assure fair and equal treatment of persons who are required to move from their homes, apartments and businesses.
- Prior to displacement, housing will be made available that is: (a) decent, safe and sanitary; (b) open to all persons regardless of race, color, religion, sex, or national origin; (c) located in an area not subject to unreasonable adverse environmental conditions and in an area not generally less desirable or less accessible with regard to public utilities and services, schools, churches, recreation, transportation, and other public and commercial facilities; (d) reasonably accessible to the displaced person's place of employment or potential employment; (e) adequate in size, facilities, and amenities to accommodate the needs of the displaced person and his family.

PAYMENTS

- Actual reasonable moving expenses will be paid.
- Homeowners, in addition to the price paid for their property, will receive replacement housing payments that will enable them to purchase an adequate and accessible replacement home.
- Tenants will receive replacement housing payments that will enable them to lease or rent an adequate, accessible dwelling; or they may receive replacement housing payments that will assist them in making a downpayment on purchase of an adequate, accessible dwelling.
- Replacement housing and relocation payments will be made under Federal and State law and will be subject to the dollar limits of such laws.

REQUIRED LAND ACQUISITION AND RELOCATION

On an island wide basis the proposed transit system will make extensive use of existing public right-of-ways (approximately 80%) and as a result will require little land acquisition. Within the urban core, however, where density and travel demands are high, placement of the grade-separated guideway structure will necessarily require more land acquisition and consequently more relocation. The route planning and selection process for the fixed guideway portion of the rapid transit system was designed to evaluate not only the functional requirements of mass transportation, but also its physical disruption to the communities through which it passed. The final route location, chosen through this process, offers the best balance between maximum service and minimum physical disruption. As the following chart indicates, a great deal of the fixed guideway system has been placed on/or adjacent to publicly owned land or rights-of-way, this has reduced significantly the amount of private property which will require condemnation.

Route Location By Land Type	Length In Miles	Percent of Total
Public R.O.W. or Publicly Owned	13.49	60%
Underground	1.60	8%
Private R.O.W.	7.24	32%
TOTAL	22.33	100%

In essence, the area from Pearl City to Middle Street and from Kahala to Hawaii Kai would have the fixed guideway facility located on public rights-of-way and as a result would necessitate very little residential or business displacement. The area from Middle Street to Kahala on the other hand, is the most dense area of Honolulu and consequently offers fewer opportunities for use of publicly owned lands. Although great care was taken to locate the fixed guideway route in these areas so as to reduce disruption, the density of the communities made some residential and business displacement necessary. However, a certain amount of this same displacement would occur in these urban areas without the introduction of a rapid transit system due to normal redevelopment trends. It is important to note that the displacement caused by this redevelopment will only provide compensation to property owners. Under normal conditions no compensation is provided in the case of renters. Federal regulations, on the other hand, require compensation to both property owners and renters in all federally sponsored projects such as the proposed Rapid Transit System for Honolulu.

Preliminary route planning and station location studies indicate that the entire fixed guideway system, from Pearl City to Hawaii Kai, will require the displacement of 884 households and 428 commercial establishments. Of the households displaced, 695 are estimated as being renter-occupied dwellings and 189 are estimated as being owner-occupied dwellings. In many instances, the dwellings and commercial establishments displaced could be re-established after completion of the transit system. Efforts will continue to be made to reduce the final number of properties taken throughout subsequent phases of planning for the rapid transit system.

environmental quality and impact 10

ENVIRONMENTAL QUALITY

The Island of Oahu is unquestionably one of the most beautiful areas in the world. Characterized by its spectacular mountains, white sand beaches, clear blue skies and surrounded by crystal waters, the Island has long been an idyllic paradise for residents and visitors alike. This beauty has, in turn, stimulated continuing growth on the Island as more and more people have come to Hawaii in order to enjoy its environment. The Island of Oahu, as a result of this and other factors, has become the most densely populated island in the State having over 80% of the State's inhabitants largely concentrated within the urban area of Honolulu from Pearl City to Hawaii Kai. For the most part, this growth has occurred in the post-war years and in particular after Hawaii became the 50th State.

Although there was a growing awareness in the post-war years of the need for government action in controlling land uses because of the very limited size of the islands, the first actual legislation was not passed until 1957 in the form of Act 234 which defined the boundaries of Forest and Water Reserve Zones. Subsequently, a State General Plan was passed in 1961 defining land uses throughout the State and in 1964 the General Plan for the City and County of Honolulu was enacted which defined land uses within the urban areas of the Island of Oahu.

During these years economic pressures continued to encourage increased development. Steady population growth, increasing land values, and land speculation all contributed to the present configuration of the City. Honolulu today is not only one of the most densely populated cities in the country, but also has one of the highest cost of living indices. In the course of this growth, considerations of environmental preservation were subjugated to considerations of economic return and providing needed housing, office space, highways and other facilities for the burgeoning population.

In recent years, citizens' groups and many government officials have become concerned that this continuing developmental process may have serious detrimental effects on the Island's most precious resource, its environment. This concern is being manifested in the form of State and local ordinances to prevent such damage and more comprehensive planning to insure the preservation of the high quality environment.

The planning of a rapid transit system for the City and County of Honolulu is a first step in these efforts to plan a more acceptable future for the region. The introduction of a rapid transit system would provide an alternate mode of transportation which would be less polluting, require less land and allow more contained or structured growth than the present system of highway construction which brings with it more pollution, large land takings, and scattered growth patterns.

The overall effect of a new rapid transit system on the region will be beneficial and will help both directly and indirectly in preserving the Island's natural beauty.

ENVIRONMENTAL IMPACT

A fundamental premise in all public investments is to insure that the benefits to be derived justify the expenditure of both public funds and resources. Although the analysis of financial costs and benefits has long been included in the decision making process for public investments, only recently have efforts been made to quantify the socio-environmental costs of these projects.

The Preliminary Engineering Evaluation Program was undertaken to develop a modern and efficient rapid transit system in sufficient detail to permit the preparation of reliable cost estimates both financially and environmentally. In order to provide the necessary documentation by which all interested parties could evaluate the socio-environmental impact of the proposed system, an extensive Environmental Impact Statement was prepared. Any project of the scope and magnitude as that of the proposed rapid transit system will certainly have some adverse impacts on the environment, however, these effects must be viewed in the context of the region's growth and future transportation demands. In order to properly evaluate the value of the proposed system, it must not only be evaluated in terms of its own advantages and disadvantages, but also compared with long-range alternative means of providing the same level of transportation mobility.

The proposed rapid transit system and three possible alternative systems were analyzed and compared in the draft Environmental Impact Statement.[1] The three alternate public transportation system concepts selected for evaluation and comparison to the basic system concept were chosen on the basis of their general feasibility and adaptability. Many types of systems such as vertical take-off aircraft, dual mode, personalized rapid transit and piggyback systems were analyzed and eliminated from comparison due to lack of technological development and/or their impracticality, given the criteria for transit system planning in Honolulu. The three alternatives compared were:

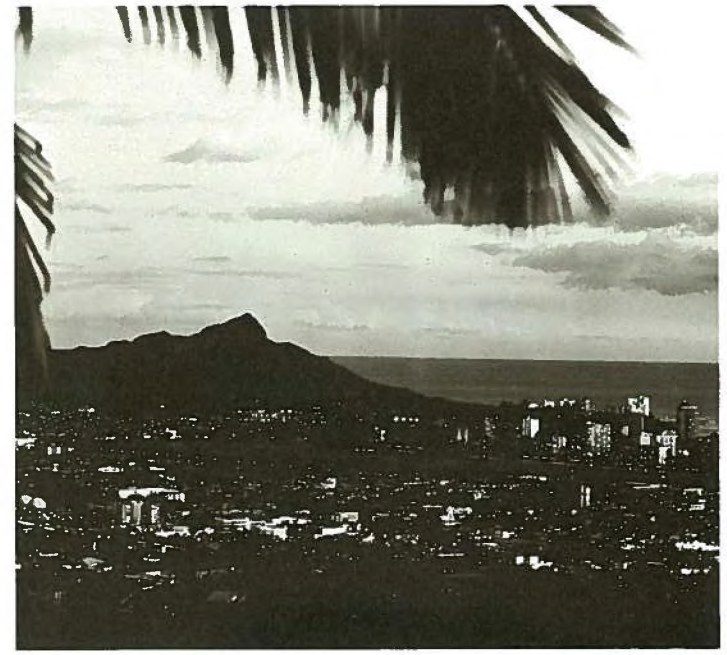
- Auto-Dominant—This system alternative utilizes surface streets and highways for an expanded bus system and continued reliance on the automobile.
- Bus on Busway—This system uses buses operating on exclusive grade-separated rights-of-way for rapid, trunk line service and an expanded surface bus operation for collection and distribution.
- Waterborne—This alternative uses high speed hydrofoils as an ocean express and smaller canal feeder boats in the waterways in and around Honolulu for collection and distribution.

Each system was evaluated on the basis of the following major elements of impact:

- Air Pollution
- Noise Pollution
- Impact to surrounding environment
- Cost
- Ability to meet long-range transportation requirements

AIR POLLUTION

The proposed rapid transit system would produce a minimal amount of air pollution, far less, in fact than any other alternative. The electrified, fixed guideway transit vehicles do not in themselves pollute and as a result there would be a reduction in all primary pollutants in the urban area. There would, however, be a slight increase in sulfur dioxide produced at power plants generating the required electricity to run the system, but this would be produced at some dis-



tance from populated areas and would be dispersed easily by the tradewinds.

The automobile, on the other hand, is the major source of pollution on the Island of Oahu; over 80% of all pollutants come from car exhausts. Even with stricter 1975 exhaust emission controls, cars will continue to generate significant amounts of air pollution, particularly since the number of registered automobiles on the island is increasing faster than the population.

With rapid transit, however, there would be a 10% daily diversion of automobile users to transit and a 20% diversion during peak hours. On extremely congested streets and freeways where cars are bumper to bumper, the pollution cannot readily disperse and results in concentration of pollutants in areas of major traffic generation. As more and more persons are diverted to rapid transit, congestion decreases, speeds on highways increase, and cars are separated by more distance, allowing pollutants to be less concentrated. In addition, as speeds increase, automobile engines operate more efficiently and pollute less.

While new buses with anti-pollution devices produce far less pollutants than the 20 to 30 cars they replace, the bus on busway system would concentrate those buses in the already congested areas of the city where pollution problems are greatest. The pollution in the downtown area would be particularly concentrated due to the fact that buses would be required to operate in tunnels in order to maintain grade separation and provide the necessary speed and capacity. On the other hand, buses used as local feeders in conjunction with rapid transit would operate in a widely distributed pattern allowing pollutants to disperse.

The waterborne system using hydrofoils would add to the Island's air pollution problem due to the large fuel consumption rates of gas turbine engines and the high number of vehicle miles required to provide the necessary levels of transit service. While much of this pollution would be carried out to sea by the tradewinds, the area around the docking facilities would be impacted more severely.

NOISE POLLUTION

The lightweight rubber-tired vehicle system recommended for Honolulu will produce less noise than any of the alternative systems compared. The noise levels would be well within the stringent Oahu Vehicular Noise Control Regulations recently adopted by the State.

The recommended system will be designed for nighttime operation at a maximum of 65 dBA through busy urban residential and commercial, and 80 dBA through industrial areas and along freeways. Sound barriers will be employed to reduce noise to levels required.

Comparison of noise levels for the transit trains with those for auto-dominant system indicates that the transit trains will produce considerably less overall noise in the community and, therefore, the impact on the community in terms of noise pollution would be considerably less. As in the case of air pollution, increased use of rapid transit would divert motorists from the City's street and highways resulting in further reductions of aural pollution.

Buses operating on a busway would help to reduce noise levels somewhat by replacing 20 to 30 cars on surface streets, however, rapid transit trains produce even less noise while carrying more passengers.

Relative to noise emission from hydrofoils, the information obtained from the manufacturer indicates that the external noise level will be less than 90 dBA at maximum power and approximately 80 dBA at normal operating speeds. These noise levels are higher than that produced by the fixed guideway system, and furthermore, significant noise reduction would have to be accomplished for the hydrofoil operation to be compatible with the Oahu Vehicular Noise Control Regulations.

IMPACT TO THE SURROUNDING ENVIRONMENT

A fixed guideway rapid transit system would require the least amount of land taking and disruption to the Island's environment. In order to achieve this minimal impact, transit cars would operate on an aerial guideway for over 90% of the system's 22 miles. This would, in turn, allow pedestrians and vehicles on the streets below to circulate freely and at the same time provide the transit patrons with a visually exciting travel environment. The aerial structure, with two 9-ft.

wide guideways, would be simple and unassuming in design and become a graceful element in the surrounding environment. The land beneath the aerial structure would be returned to the City for public use as a series of pleasantly landscaped linear parks.

The auto-dominant system would necessitate the construction of additional highways which would require more land taking in urban Honolulu. A highway with the capacity to carry the same number of patrons as the fixed guideway rapid transit system would require 10 times more land than the transit structure. While the Oahu Transportation Study showed the need for additional highways and major street improvements as well as rapid transit, the demand for expressways would be far less with rapid transit than without it.

The bus on busway system will require a structure over 10 ft. wider than that required for a fixed guideway system, and structural requirements dictate a much more massively proportioned structure. In addition, the stations required for manually operated buses on a busway are significantly larger than those needed for electrified rapid transit. The result would be substantially more land taking than that required for the fixed guideway system.

Although a waterborne system would not require a significant amount of land acquisition, it would severely disrupt another element of the Island's environment, its recreational waters. This would be particularly true in and around the City's small boat harbors. In addition, if a canal feeder system were utilized, numerous bridges would require raising and the construction of new approaches would therefore result in land taking, relocation, and damage to the visual environment.

COSTS

The Federal government can be expected to pay a substantial share of the capital or construction costs for any public transportation system selected for Honolulu, however, the local government must pay the annual operating and maintenance costs. The system chosen must therefore be as economical as possible to operate over a long period of time.

The fixed guideway rapid transit system would provide the best investment for the City and County of Honolulu and the State of Hawaii in terms of its operational economy. In a 30 year period, the present worth cost would be $1,114,000,000 more to operate an auto and bus system than that required for a fixed guideway system. A busway system would cost $165,000,000 more to operate than the recommended system and a waterborne system would cost over $1,733,000,000 more to operate than the fixed guideway rapid transit system.

ABILITY TO MEET LONG-RANGE TRANSPORTATION REQUIREMENTS

It has been established that by 1995 the Island's expanding population and employment base will require a public transit system capable of carrying some 20,000 people per hour in one direction.[6]

The recommended fixed guideway system can meet those travel demands with reliability, safety, speed and convenience. An auto-dominant system on the other hand, has practical and economic limitations in solving the rush hour traffic problem in urban areas. This has been adequately demonstrated in many mainland cities which have relatively unlimited land resources.

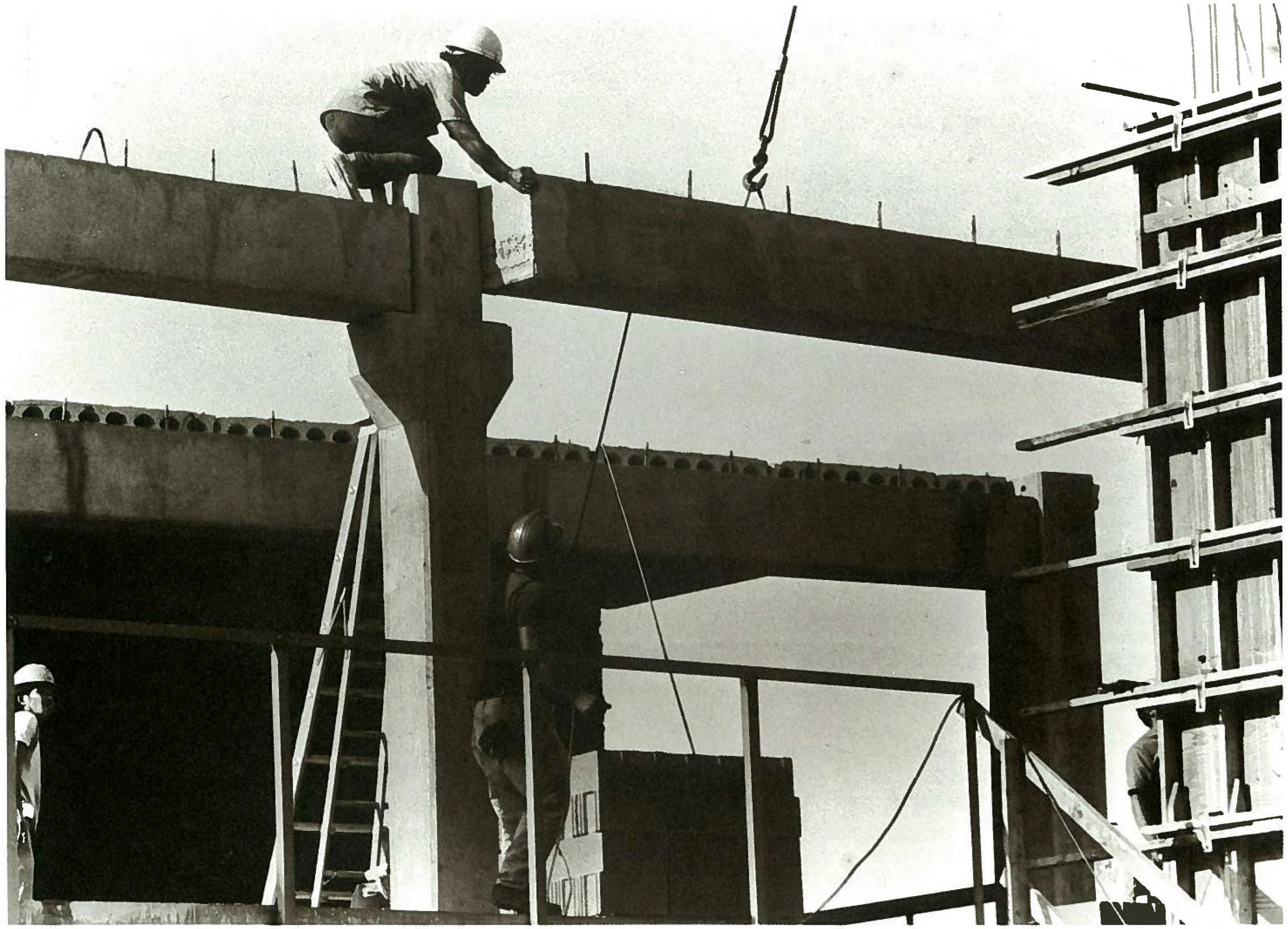
An all-bus system, utilizing busways in exclusive rights-of-way as the primary transit system for providing long-range, high level public transportation service has never been adopted by any major region. As a result there is little proven experience in busway operations and more importantly little proven experience in the actual capacities which can be safely, economically, and efficiently handled by such a system.

While hydrofoils are used throughout the world to provide inter-city (express) transportation service, nowhere have they been utilized to provide high volume rapid transit service. A waterborne system could theoretically provide the same transit service as the recommended fixed guideway system, however, the cost of providing that service would be extremely high. In addition, the travel times between point locations would, in most cases, be almost twice as long. At the same time, many routes require an extra transfer from local feeder bus to canal feeder vessel to trunk line hydrofoil. These longer travel times and extra transfers would contribute to lowering the system's convenience and efficiency to transit users and result in reduced patronage. A waterborne system has validity if used to supplement a high volume land based transit system or to provide inter-island service but cannot provide the level of service required for a high capacity public transportation system.

CONCLUSION

The electrified fixed guideway rapid transit system in the urbanized area of Honolulu, combined with a comprehensive bus system serving the entire Island, is the best long-range alternative to meet Oahu's transportation demands. This system would provide the best service with the least amount of disruption to both the environment and the community as a whole.

Finally, this type of system would provide an alternative mode of transportation which, in addition to offering expanded mobility to the traveling public, would also create a means of attaining that mobility which would be compatible with the Island way of living. Quiet, comfortable and convenient, the transit system would offer its ridership a transportation "environment" with vistas of not only the urbanized areas but also the mountains and the sea which constitute major elements in the Hawaiian environment.



construction planning and estimates 11

INTRODUCTION

Planning the construction of a project of the magnitude proposed requires careful consideration of all facets of program implementation. Construction activities must be scheduled and executed in the most expeditious manner but should take into account the impact of the program for social disruptions, on the physical environment, and on the construction industry itself. The program has been analyzed and structured to provide an orderly and logical sequence of activities to be performed within the framework of the City's transit development goals and objectives.

In addition to the City's expressed goal to implement a rapid transit system at the earliest possible date, there is an urgent need for improved public transit service and a need to construct the project in the most efficient manner possible. To this end, the basic implementation schedule has been structured on the assumption that final design would commence before the end of calendar year 1973. Allowing 1 year to prepare plans and specifications for the first contract package, construction can then commence by the end of 1974 and the first increment of the system could be ready for revenue service by late 1978.

Approximately 4 years have been provided to construct and test the initial increment of the system for revenue operation. The 4-year schedule has been analyzed relative to procurement of long-lead items, check-out of the equipment and operating systems, personnel training, and annual construction volume. Based on the Island's construction resources, it was deemed prudent to limit the maximum annual construction volume to approximately $100 million. Based on this analysis, it was determined that the first increment system of some 12 to 14 miles could be completed in 4 years. The remaining segments of the system would be staged for completion between 1 to 1½ years later with the entire 22-mile system in revenue service by early 1980. (See Figure 11-1)

An important consideration in scheduling construction is the acquisition of rights-of-way. Both the Federal and State statutes require that adequate replacement housing be available before any construction work can be initiated. Therefore, the scheduling of different segments of the system is based on delaying construction of those segments with substantial residential displacement to the latest possible dates.

In scheduling the construction program, the initial elements of work are the yards and shops, the guideway connection between the yard and the main line, and a segment of the main line to test the vehicles and operating systems. The program is scheduled for placing the vehicle procurement contract such that the prototype vehicles could be delivered by mid-1977. This is to provide sufficient time to test and debug the various vehicle components, especially the propulsion and control systems.

The first segment of the system required to be completed would then be the main line between Middle Street and the Airport. The next early segment would be the underground portion located in Hotel Street, with following segments located in the Pearl Harbor area and the Ward/Ala Moana district. All of these early segments involve very little relocation of residents. The latter segments of the initial increment would be in the Kalihi area and the segment at the Waikiki Station which begins to involve more residential relocations. The final segments would be the link to the Halawa Stadium and the segment from the Waikiki Station to the University Station. The latter segment involves a substantial amount of residential relocation.

The establishment of the first increment from Halawa Stadium to the University Station is based on opening a system that would provide service to sufficient origin areas to obtain reasonable patronage. The remainder of the system is programmed to complete the segment through the Kaimuki area to the vicinity of the Kahala Shopping Center first, then the segment to Hawaii Kai, and the last segment being from Halawa Stadium to Pearl City.

COST ESTIMATING

A transit system involves many different types of construction requiring special skills, materials, and equipment not common to the construction industry of the region. Therefore, the proposed program was carefully analyzed with respect to type and quantity of labor and material required, physical conditions of the construction areas, local construction practices, and methods and techniques of construction most adaptable to the program. Furthermore, detailed quantity take-off labor, material, and equipment was made using the preliminary design drawings and outline specifications prepared under this project. Estimates of costs were then developed based on appropriate construction prices, the program schedule, and construction conditions existing in this area.

In developing the cost estimate, careful analysis of relevant local factors was necessary due to the unique conditions of the area relative to the mainland U.S.A. An examination of general costs indicates a substantially higher relative cost existing in Honolulu. Although labor rates are somewhat lower, material and equipment prices are substantially higher than the mainland prices. Some of the local factors contributing to the higher prices are shipping cost, excise tax, higher cost of land and facilities, and limited market condition. Cost differential between Hawaii and the mainland U.S.A. has been estimated to be from 15% to as much as 25%. Research data from Construction in Hawaii published by Bank of Hawaii indicates the construction cost index for Hawaii to be 15% higher than the average U.S. index. Surveys conducted and published by the U.S. Department of the Army indicates Hawaii to have the second highest construction costs in the U.S., with Alaska being the first or the highest. This survey indicates Hawaii to be 20% higher than the base cost established for Washington, D.C.

A brief overview of construction on Oahu will show quarries producing aggregates for concrete and road construction with sand barged from the Island of Molokai, and cement being locally manufactured. Cement and aggregate are the two major construction materials locally produced but one will find that due to higher production costs, the prices are over 25% higher than those on the mainland. Most construction materials and equipment are imported and therefore would have higher prices due to shipping and attendant costs.

With cement and aggregate locally produced, reinforced concrete is the predominant structural material used for large buildings and bridges. Nearly all bridges are constructed in concrete utilizing either poured-in-place or precast methods. Therefore, the local concrete industry has the experience and capability to produce various concrete products and structures required for a rapid transit project. An additional capability existing locally is in foundation construction where both experience and equipment are abundantly available to provide pile foundations for heavy structures.

The island's construction labor force is estimated to be over 20,000 workers for all classifications. Total annual construction volume in recent years is reported to be in excess of $500 million of which over one-half is commercial, industrial and governmental construction. The proposed rapid transit program, based on the proposed construction schedule, could represent between 15% to 20% of the total annual volume.[22] Within the island's labor force, necessary skills are available for most of the trades associated with a rapid transit project. However, certain highly specialized skills may be unavailable or short in supply depending to a large extent on the state of the construction business during this program period.

The project cost estimate is shown on Table 11-1 and consists of the following.

CONSTRUCTION COST includes the following elements based on 1972 prices.

- WAY AND STATION STRUCTURES—includes cost of underground and aerial way structures, basic station structures that are integral with the way structure, special structures, earthwork, tunnel ventilation structure and equipment, utility relocation, street reconstruction, fencing, landscaping, and all related construction items.
- STATION FINISH—includes cost of facilities and equipment required to handle passengers, comprising site work, architectural and structural finishes, escalators and elevators, ticketing equipment, ventilation and air conditioning, plumbing, electrical power and lighting, landscaping, and all related construction.
- POWER AND CONTROLS—includes all facilities and equipment required for providing and distributing electrical power for vehicle propulsion and electrical and electronic facilities and equipment required to operate the entire system automatically.
- YARDS AND SHOPS—includes cost of facilities and equipment required to store, maintain, and repair the transit vehicles comprising site work, storage tracks, maintenance and repair buildings and equipment, and related costs.
- VEHICLES—includes the cost of manufacturing, delivering and servicing the required vehicles ready for revenue operations including the costs of the on-board control equipment.

PROJECT ADMINISTRATION, FINAL DESIGN, CONSTRUCTION MANAGEMENT, AND PRE-OPERATING EXPENSE—These costs cover project administration, detailed design, preparation of construction plans and specifications, control surveying, soils and materials testing, construction inspection and management, general procurement and other related professional services. Also included are all costs and expenses for testing and trial operation of the system prior to the start of actual revenue services.

Figure 11-1
FINAL ENGINEERING AND CONSTRUCTION SCHEDULE

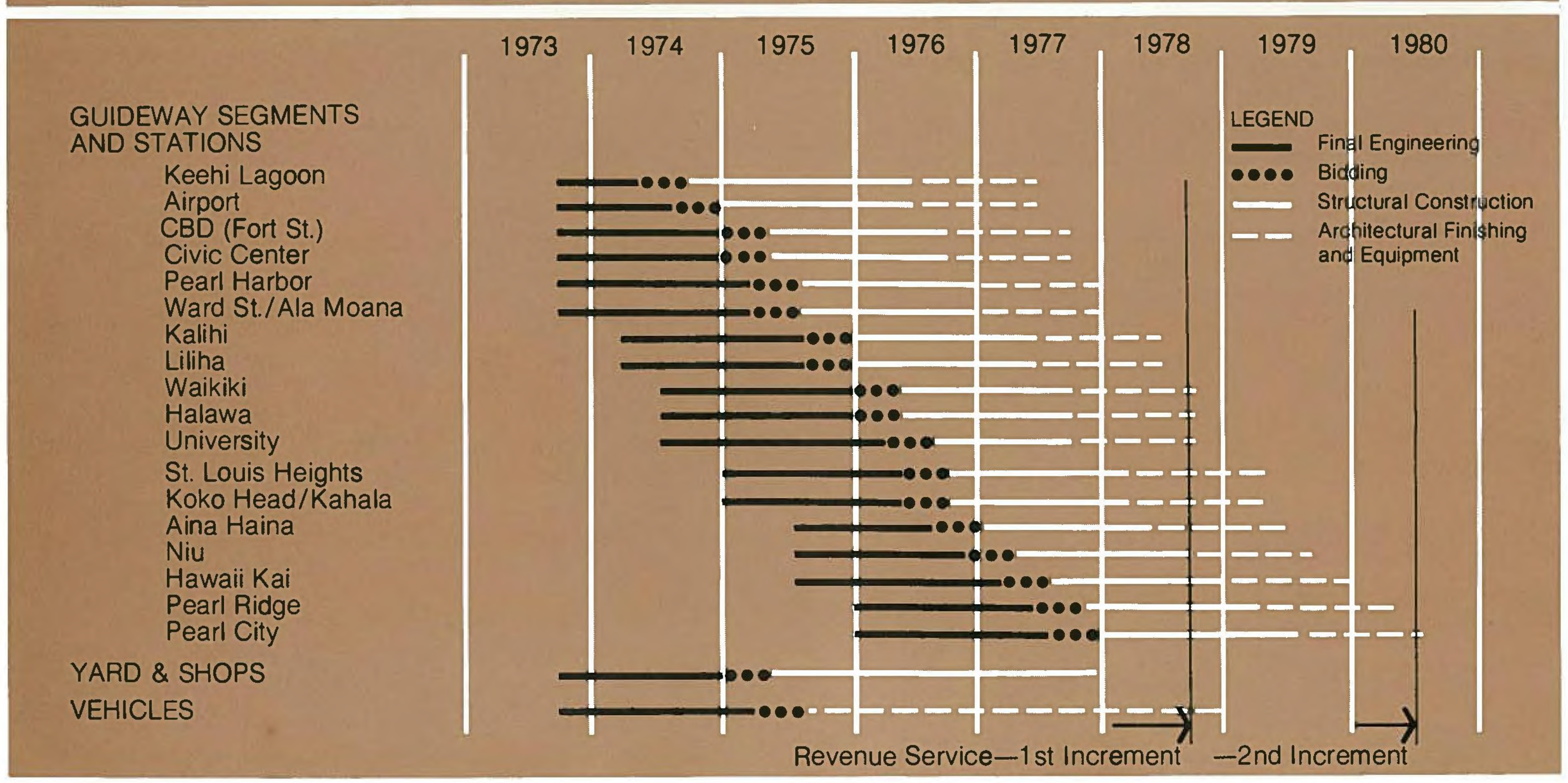


Table 11-1 **COST SUMMARY ($ THOUSANDS)**

	12-Mile Increment	14-Mile Increment	22-Mile System
Fixed Facilities & Equipment			
Way Structure & Stations	$115,090	$131,570	$188,500
Power & Control System	32,520	41,930	57,000
Yard & Shop	15,400	15,400	16,500
Vehicles	31,340	37,000	52,200
SUBTOTAL	$194,350	$225,900	$314,200
R.O.W. & Relocation	84,240	92,170	95,600
Admin., Engrg. Constr., Mgmt., & Pre-Operating Expenses	25,260	29,360	40,850
Contingency	45,570	52,120	67,590
Escalation	89,920	107,700	159,060
TOTAL	$439,340	$507,250	$677,300
4% Excise Tax	12,870	15,100	21,700
GRAND TOTAL	**$452,210**	**$522,350**	**$699,000**

RIGHT-OF-WAY ACQUISITION AND RELOCATION— These costs include acquisition of required rights-of-way to construct and operate the system including demolition and relocation expenses.

CONTINGENCY—Although the basic estimate of costs has been reliably determined, it is normal and necessary to provide for contingencies. A contingency sum equivalent to 15% of the basic estimate of cost is provided to cover the unknown and unanticipated which may develop during design and construction.

ESCALATION

All estimates of costs were developed using current 1972 prices and therefore must be adjusted to reflect future anticipated cost increases. The projection of these cost increases for a long-term construction project is a complex task and can only be based on past experience and careful consideration of future anticipated trends on costs. Since the rate of escalation has historically varied with different cost items, this analysis will treat escalation as it relates to 3 basic costs —construction work, equipment procurement, and property values.

CONSTRUCTION WORK

Most construction cost indexes measure the effects of specific wage rate and materials price trends on the basic construction costs in the U.S. However, they do not adjust for productivity, managerial efficiency, competitive conditions, automation, design changes, or other intangibles that affect the final cost to the owner or the contractor's selling price. Hence, the rate of increase measured in the indexes do not necessarily reflect actual rate of increase in the final construction cost.

In the last 3 to 4 years, the construction industry has experienced a phenomenal rise in costs. However, this fast uptrend is expected to have peaked in 1971 with the expectation that 1972 would reflect a slowdown in this trend. Two factors that are paramount in the slowdown would be the government's wage and price freeze and guidelines and the inherent slowdown in construction demand volume due to high costs.

During this highly inflationary period, it has been estimated that actual construction costs have risen an average of 6% to 8% per year. With various anti-inflationary forces now acting to slow down this trend, it is anticipated that an average increase of between 5% to 6% per year during the remainder of this decade would appear to be reasonable. Certainly greater increases could be expected for any given year and conversely, a lower annual increase could also be expected to occur during this time frame. Therefore, the allowance for escalation has been based on 5.5% per year for the program.

TRANSIT EQUIPMENT PROCUREMENT

Machinery price increases have historically been less volatile than construction price increases. It has been estimated that machinery prices have risen between 5% to 6% per year during the last several years. With the anticipation that price inflation will ease up, the allowance for escalation for transit vehicles has been based on 5% per year.

PROPERTY VALUE

Property values in Honolulu are generally much higher than other comparable size cities in the U.S. due to higher construction and land costs. Increase in property values has also been much greater than elsewhere due primarily to the scarcity of developable land on the Island.

A detailed analysis of increase in property value was made through a sampling of typical properties within the transit corridors. It was found that between 1962 and 1971, property valuation of selected parcels increased at an average rate of 7% per year. This rate of valuation increased on the land with use remaining unchanged. Changes in total valuation of all properties on Oahu was 8% per year which includes new construction and changes in land use.

Since the transit corridor traverses the older, built-up areas of Honolulu, any changes in land use would be considered to be minimal; therefore, it is projected that the increase in real property valuation during the program period would be at an average rate of 6% per year.

Table 11-2

CASH FLOW TABLE
($ THOUSANDS)

	FY 73-74	FY 74-75	FY 75-76	FY 76-77	FY 77-78	FY 78-79	FY 79-80	FY Total
12-Mile Increment								
R.O.W. & Relocation	11,500	64,400	41,590					117,490
Other Costs	6,650	25,060	75,740	107,060	84,650	35,560		334,720
TOTAL	18,150	89,460	117,330	107,060	84,650	35,560		**452,210**
14-Mile Increment								
R.O.W. & Relocation	11,500	64,400	52,600	760				129,260
Other Costs	7,000	25,200	75,900	114,300	99,690	71,000		393,090
TOTAL	18,500	89,600	128,500	115,060	99,690	71,000		**522,350**
22-Mile System								
R.O.W. & Relocation	11,500	64,400	52,600	6,110				134,610
Other Cost	8,500	29,800	80,900	124,000	129,400	106,700	85,090	564,390
TOTAL	20,000	94,200	133,500	130,110	129,400	106,700	85,090	**699,000**


TERRITORY OF HAWAII
1900
HAWAIIAN TREASURY
REPUBLIC·OF·HAWAII
MDCCCXCIV
CERTIFICATE OF DEPOSIT
SILVER CERTIFICATE OF DEPOSIT
DEPARTMENT OF FINANCE
REPUBLIC OF HAWAII
THIS CERTIFIES THAT
No 8498
THERE HAVE BEEN DEPOSITED AT THE HAWAIIAN TREASURY
FIVE DOLLARS
IN SILVER COIN
payable to the bearer on demand.
ISSUE OF 1895 - ACT No 19.
REPUBLIC·OF·HAWAII.
MDCCCXCIV
EA·O·KA·AINA·I·KA·PONO.

financing 12

INTRODUCTION

The City and County of Honolulu is empowered by Chapter 51, Hawaii Revised Statutes, to operate public transportation system on the Island of Oahu. The statute further authorizes the City and County to finance the acquisition, construction, or reconstruction of mass transit facilities through the issuance of either general obligation bonds or revenue bonds.

In December 1968, the Mass Transit Division was established under the City and County Ordinance #3315 and #3316 and which appropriated funds for mass transit purposes with the Department of Traffic budget. In 1969, the City and County initiated bus services to outlying suburban areas by contracting with private bus companies and in 1971, City-owned buses began operating in urban Honolulu.

The City and County, in 1970, passed Ordinance #3605 which authorized the purchase of the Honolulu Rapid Transit Company, the largest of several private companies operating on the Island. Immediate steps were taken to acquire the properties of the Honolulu Rapid Transit Company and as of this time, acquisition has not been consummated.

With respect to City and County finances, the functions of the government are separated into several operating funds and are accounted for under the General Fund, Highway Fund, Urban Renewal Coordination Fund, and Off-Street Parking Fund. The Highway Fund derives its revenues from the public utility franchise tax, fuel tax, motor vehicle weight tax, and other licenses and permits, intergovernmental revenue, charges for services, and miscellaneous revenue. Disbursement of these funds is limited essentially to acquisition, design, construction, improvement, repair and maintenance of public roads, and with the exception of the public utility franchise tax, for purposes and functions in connection with mass transit and now bikeways.

COSTS AND SCHEDULES OF EXPENDITURES

The proposed rapid transit system is estimated to cost $699 million for a full 22-mile system with options of building a lesser system beginning with a minimum 12-mile system estimated to cost $452 million. The cost estimates take into account specific route alignment, type of construction, and are for a completely operable system, including transit vehicles, with an appropriate allowance for incidental expenses, contingencies and price inflation.

The schedule of annual cost requirements for the project is shown in Table 12-1 which reflects the construction schedule described in Section 11 The construction program has been developed to coordinate various elements of the project in order to bring operable segments of the system into service as soon as possible.

FEDERAL AID

The major Federal program aiding mass transit projects is the Urban Mass Transportation Act of 1964, as amended, and the Urban Mass Transportation Assistance Act of 1970. Presently the Urban Mass Transportation Agency (UMTA) may assist local programs with up to two-thirds of the net project cost.

The 1970 Act stated a Federal intention to provide $10 billion for urban mass transportation over the next 12 years. The Act authorizes $3.1 billion to finance projects of UMTA beginning in Fiscal Year 1971. The Act also modified the capital assistance program to put it on a financial basis similar to the highway program. This provision allows UMTA capital assistance activities to be financed by "contract authority", whereby the Secretary of Transportation is authorized to incur obligations on behalf of the Federal government, and the full faith and credit of the Congress is pledged to appropriate the funds required to liquidate such obligations.

UMTA, in the past, has been legally constrained, through the provision in its enabling legislation, from allocating more than 12½% of its yearly appropriations to any one state. Beyond this constraint, UMTA has attempted to allocate its funds on the basis of a system of priorities which attempts to provide monies first to small metropolitan areas whose public transportation systems are failing. Historically, however, a large majority of appropriations have been allocated to major cities.

In addition to capital grants, the 1970 Act authorizes loans to local governments for acquisition of real property expected to be required for urban mass transportation purposes within 10 years. Such a loan may subsequently be retired out of capital grant loans under this program and would carry an interest rate comparable to that of currently outstanding marketable federal obligations.

LOCAL SHARE OF FINANCING

For purposes of this financial planning, it is assumed that Federal grants of two-thirds of the net project cost would be provided. It is further assumed that the UMTA loan program for advance acquisition of rights-of-way would not be considered in view of the project schedule. Accordingly, it was assumed that the local share of the net project cost would be one-third or $150 million for the minimum system or $233 million for the full 22-mile system.

The study of local financing resources determined the lack of surplus funds earmarked or available for earmarking for funding the proposed project. Further, it has been determined that operating revenues would not be available to service even a small portion of the capital debt. Therefore, no consideration was given to the issuance of transit revenue bonds to provide the one-third local share of capital costs.

As was previously stated, the City and County has the authority to finance mass transit facilities through the issuance of general obligation bonds. The payment of interest on the

Table 12-1

CASH FLOW REQUIREMENTS
(thousands)

Fiscal Year Ending June 30	12-Mile Increment Right-of-Way	12-Mile Increment Other	12-Mile Increment Total	14-Mile Increment Right-of-Way	14-Mile Increment Other	14-Mile Increment Total	22-Mile System Right-of-Way	22-Mile System Other	22-Mile System Total
1974	$ 11,500	$ 6,650	$ 18,150	$ 11,500	$ 7,000	$ 18,500	$ 11,500	$ 8,500	$ 20,000
1975	64,400	25,060	89,460	64,400	25,200	89,600	64,400	29,800	94,200
1976	41,590	75,740	117,330	52,600	75,900	128,500	52,600	80,900	133,500
1977	—	107,060	107,060	760	114,300	115,060	6,110	124,000	130,110
1978	—	84,650	84,650	—	99,690	99,690	—	129,400	129,400
1979	—	35,560	35,560	—	71,000	71,000	—	106,700	106,700
1980	—	—	—	—	—	—	—	—	85,090
TOTALS	$117,490	$334,720	$452,210	$129,260	$393,090	$522,350	$134,610	$564,390	$699,000

principal of general obligation bonds constitutes a first charge on the general fund of the City and County. The City Council has the power and is obligated to levy ad valorem taxes without limitation as to rate or amount on all real property subject to taxation in the City and County for the payment of principal and interest on general obligation bonds.

The Hawaii Constitution, Article VI, Section 3, limits the funded debt of the City and County to 15 percent of the total assessed value for tax purposes of the real property in the City and County. This limitation is applied against debt outstanding. Recognizing that the legal debt service is unduly liberal, the City and County follows a police limiting debt service to 15 percent of general fund revenues. This is a more meaningful yardstick of a community's debt burden which municipal credit analysts consider as the key indicator for bond rating.

The statutes governing the issuance of general obligation bonds by counties in the State of Hawaii provide that in determining the total funded debt of the county there shall be excluded general obligation bonds issued for a public undertaking, improvement or system from which revenues, user taxes, or a combination of both may be derived for the payment of all or part of the principal and interest as reimbursement to the general fund.

BOND FINANCING ANALYSIS

All transit bonding discussed herein refers to general obligation bonds of the City and County of Honolulu and certain basic assumptions were made with respect to all such bonds. In order to determine the magnitude of debt financing which would be required for each of the three systems, three

Although a mass transit system would qualify as a public undertaking, the revenues derived from its operation would not be sufficient to reimburse the general fund for general obligation transit bond debt service. Thus, it will be necessary to select a "user" tax which, besides being sufficient for such purpose, will be related in a legal sense to the undertaking being financed, namely a mass transit system.

In the opinion of Bond Counsel the determination of whether an auto use tax or a gas tax qualifies as a "user" tax when used to finance transit facilities is one which will have to be made by the Courts in a test suit. It is understood that the procedure for such test suits in Hawaii is relatively simple and could be concluded in about six months.

borrowing programs were developed assuming, as previously indicated, an average annual interest cost of 5½%, 25-year maturities, and level annual debt service amortization based on twenty-five equal annual installments covering both principal and interest.

Table 12-2 shows the schedule of borrowing required to meet the capital funding requirements, while Table 12-3 translates the borrowing into annual debt service requirements.

DEBT CAPACITY

The net funded debt of the City and County of Honolulu aggregated approximately $167.3 million as of June 30, 1972 after deductions for cash reserves and exclusions for self-supporting debt. The City's current Capital Improvement Program anticipates expenditures of approximately $270 million over the next five years. However, in the past expenditures actually approved have been far less than reflected in the Capital Improvement Program. The practice of the City to pay substantial portions of the cost of such improvements directly rather than by funding, further lessens borrowing requirements. Discussions with the City's financial authorities indicate that future borrowing will be on the order of magnitude of approximately $20,000,000 annually.

Taking into account authorized but unissued debt ($36.8 million), additional public improvement bonding of $100 million over the next five years and approximately $65 million of redemptions over the same period, net funded debt of the City is projected to be $239 million at June 30, 1977. This projection for mid-1977 is still well within the 1972 legal debt set by the Constitution at 15% of assessed value. Net assessed valuation of real property as of July 1, 1971 was $4.2 billion which would legally permit funded debt to be as much as $627 million.

A far more meaningful yardstick of a community's debt burden is the ratio of debt service charges to general fund revenues. Budgeted non-reimbursable debt service charges payable from the City's general fund for the fiscal year ended June 30, 1972 were $16,171,616 while general fund revenues were budgeted at $116,386,141. Thus debt service represented 13.9% of revenues. Recognizing that the legal debt limit is unduly liberal, City policy limits debt service charges to 15% of general fund operating revenues, a ratio which municipal credit analysts consider as average for this key indicator.

Assuming an annual growth of 8% in general fund revenues, the issuance of $100 million of new long term bonds over the next five years, and a 20 year maturity schedule with level principal repayments, annual debt service would be $27.0 million and general fund revenues would aggregate $171.3 million so that the debt service/revenues ratio would be approximately 15.8% at mid-1977. Depending on which of the three proposed systems the City selects, maximum annual debt service charges would add from $10.9 million to $16.8 million annually to debt service charges. It is obvious therefore, that the incurring of additional debt of the magnitude required to finance the transit project would impair the general credit of the City.

SOURCES FOR BOND SERVICE

As part of the financial planning study, a thorough examination of all possible tax sources for assisting in funding capital costs for the proposed system was made.[30] Approximately 25 different tax levies were identified and analyzed for adequacy, equity, efficiency, and feasibility of implementation. As a result of this analysis, eight priority tax sources, available to State and City and County government, were found to appear reasonable for consideration for funding capital costs of the proposed transit system. Three of these tax sources are of extreme importance to the City and County since they can be enacted by the City Council and the Mayor without State legislative authority. These tax sources which can be immediately put into effect on Oahu include:

- increasing the passenger vehicle weight tax on autos;
- increasing the fuel tax; and
- increasing the property tax.

The remaining five priority sources requires State legislative action for creation of a new tax, either at the State or City and County level, or for an increase in the levy at either level of government. These tax sources include:

- special one-time tax on autos, new and used, entering Oahu;
- hotel room tax;
- City and County sales tax or increase in general excise tax;
- increase in the State income tax such as a surcharge for transit; and
- abolish real property tax homeowners exemptions.

Another possible tax source that has been widely discussed in Hawaii as well as throughout the country is the taxing of gains in increase in property values adjacent to transit stations. The questions of who are the special transit beneficiaries and how much of the property value increase is related directly to transit rather than to normal market forces and scarcity are quite complex and difficult to assess. The basic concept of taxing the direct beneficiaries of a public works program is well accepted, but the difficulties of accomplishing them for a transit system are obvious by the fact that no such system of taxation exists for any transit system in the nation. Due to the complexity of implementing this concept combined with the limited dollar amounts involved, especially in the early year, indicated that this source should not be considered for financing the initial stage of the transit system.

FUNDING AND BOND SERVICE

It has been shown that if the City were to assume the entire one-third local share of the capital cost, its debt burden would be excessive and would impair the general credit of the City.[7] Accordingly, in order to bring the debt service charges down to more reasonable levels, several assumptions were made. First, it was assumed that the State would participate in the amount equal to 50 per cent of the local one-third share of the net project cost. Under this assumption, the City's borrowing requirements would be exactly half of the amounts shown in Table 12-2 and half of the annual debt service shown in Table 12-3.

It was also assumed that the City would enact a new tax or increase an existing one relating to transportation and thereby permit direct payment of a portion of the costs to reduce bonding requirements. Based on the assumptions that the State and the City would share equally the one-third local funding requirements and that the City would enact a tax revenue source yielding $8.4 million annually, beginning in 1974, the debt service requirements would be significantly reduced to $2.2 million, $3.2 million, and $5.6 million for the 12-mile, 14-mile, and 22-mile systems, respectively.

In summary, it is concluded that the bond requirements could be reduced to a manageable level by direct payment of a portion of the capital costs. Therefore, it is recommended that a transit tax levy be enacted at an early date whereby funds can be accumulated to make such direct payments. The final selection and enactment of the funding source is currently under study by local governments and should, of course, be determined locally in the context of other needs of the area.

Table 12-2

GENERAL OBLIGATION BONDING PROGRAMS

(thousands)

Date of Issue	12-Mile Increments	14-Mile Increments	22-Mile System
July 1, 1973	$ 20,000	$ 20,000	$ 20,000
July 1, 1974	—	—	20,000
January 1, 1975	20,000	20,000	—
July 1, 1975	20,000	20,000	20,000
January 1, 1976	20,000	20,000	25,000
July 1, 1976	20,000	20,000	20,000
January 1, 1977	25,000	20,000	20,000
July 1, 1977	—	20,000	20,000
January 1, 1978	21,000	15,000	20,000
July 1, 1978	—	14,000	20,000
January 1, 1979	—	—	20,000
July 1, 1979	—	—	21,000
TOTALS	$146,000	$169,000	$226,000

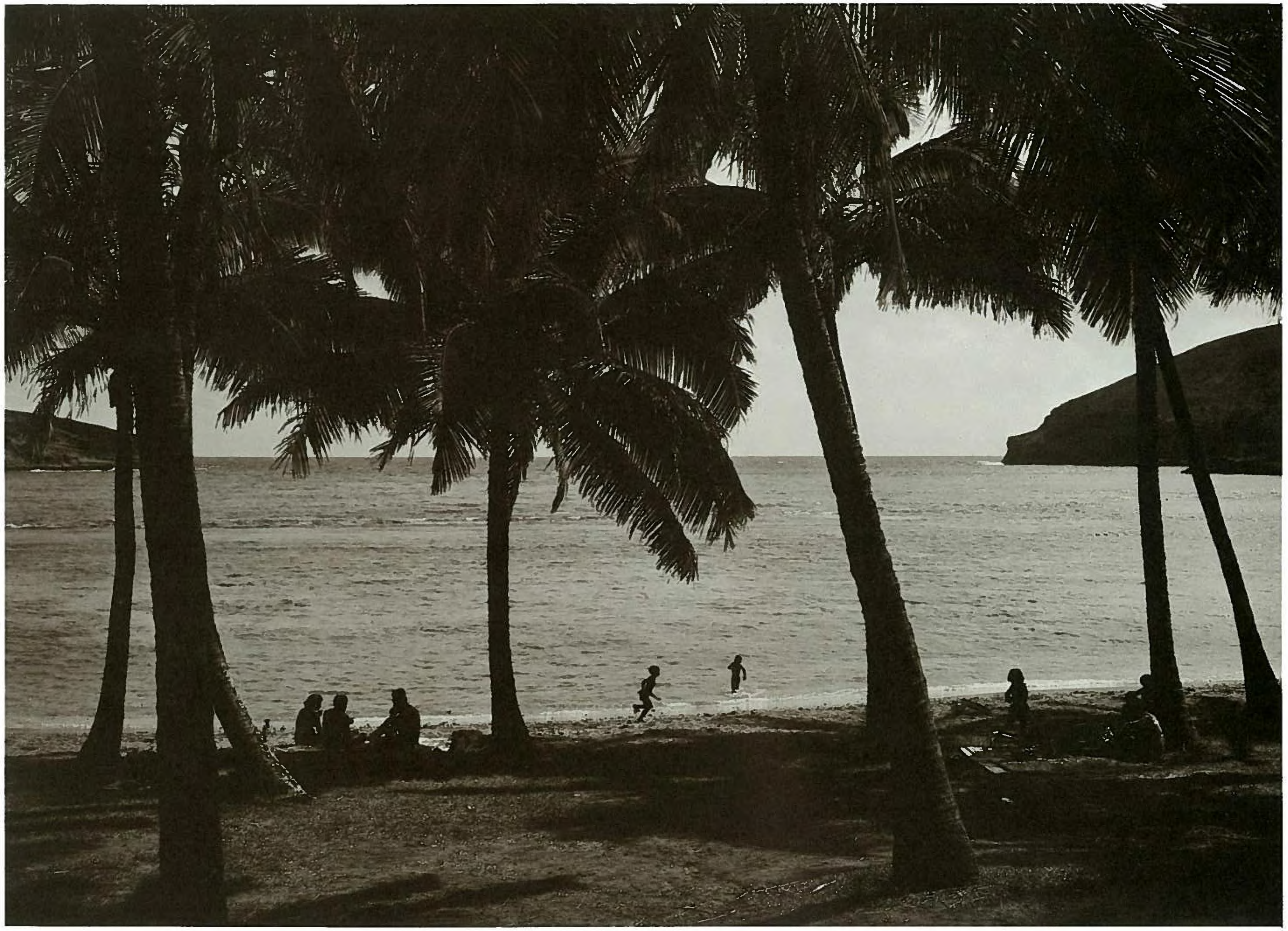
Table 12-3

ANNUAL DEBT SERVICE REQUIREMENTS*

(thousands)

Fiscal Year Ending June 30	12-Mile Increments	14-Mile Increments	22-Mile System
1974	$ 1,491	$ 1,491	$ 1,491
1975	2,432	2,432	2,982
1976	5,414	5,414	5,414
1977	8,631	8,396	8,769
1978	10,307	11,142	11,751
1979	10,885	12,599	14,733
1980	10,885	12,599	16,849
1981	10,885	12,599	16,849
1982	10,885	12,599	16,849
1983	10,885	12,599	16,849
1984	10,885	12,599	16,849
1985	10,885	12,599	16,849
1986	10,885	12,599	16,849
1987	10,885	12,599	16,849
1988	10,885	12,599	16,849
1989	10,885	12,599	16,849
1990	10,885	12,599	16,849
1991	10,885	12,599	16,849
1992	10,885	12,599	16,849
1993	10,885	12,599	16,849
1994	10,885	12,599	16,849
1995	10,885	12,599	16,849
1996	10,885	12,599	16,849
1997	10,885	12,599	16,849
1998	10,885	12,599	16,849
1999	9,394	11,108	15,358
2000	7,903	9,617	13,867
2001	4,921	6,635	10,885
2002	1,566	3,653	7,530
2003	—	1,044	4,548
2004	—	—	1,566

*Full one-third local share



benefits to the island 13

INTRODUCTION

The proposed rapid transit system for Honolulu will require major investments by the people of Hawaii and particularly by residents of the City and County of Honolulu.

In order to determine the value of this project to the community, a comprehensive comparison of the quantifiable benefits and the estimated costs was carried out.[8] This evaluation will permit decisions to be based on careful analysis of the expected return on the investment of public monies. A Benefit-Cost Analysis is the expression of benefits and costs of the project in explicit monetary terms for comparative purposes. It identifies and values the gains and losses to affected groups and the community at large of a particular course of action. The Benefit-Cost Analysis is distinct from the financial plan which addresses itself to an accounting of the flow of income and expenses to determine the most effective method of financing the project. Many of the benefits considered in a benefit-cost analysis, however, cannot be stated in precise monetary terms within the present state of the art. These benefits have been discussed in terms of their magnitude, in order to provide a greater perspective to the framework of explicit values set forth.

Although the use of a Cost-Benefit Analysis can be a useful decision making tool, the subjective nature of many benefits which may accrue to individuals or the region as a whole makes it difficult to determine the advisability of a project on a completely objective base. Nevertheless, experience provided by other public investments has indicated that measurable or tangible benefits should exceed the estimated costs by 10 to 20% without regard to a subjective analysis of those benefits which are not susceptible to economic measurement.

The benefits and costs of the proposed rapid transit system for Honolulu have been divided into two categories: tangible and intangible. Only those benefits measured in quantifiable terms have been used in the explicit benefit-cost comparison. These benefits have been established through other transit benefit-cost analyses as measurable, desirable effects resulting from a rapid transit system and have gained acceptance by reviewing agencies for their objectivity.

Only the quantifiable benefits are used in the comparison to cost, however, this does not lessen the importance of the non-quantifiable or intangible benefits. On the Island of Oahu where the environment is of prime concern, the non-quantifiable benefits may, in fact, outweigh the quantifiable benefits in evaluating the long term effects of the system. Impingements on the environment are difficult to measure as is the assignment of a monetary value to the relief from detrimental effects provided by rapid transit. These benefits are nevertheless, significant and have been discussed in some detail in Section 10, "Environmental Quality and Impact" as well as in later portions of this section.

The quantifiable benefits are those net economic increases resulting from the Honolulu Rapid Transit System which can be assigned a dollar magnitude. For the most part, these quantifiable benefits accrue to specific groups which are identified in the summary of findings.

A rapid transit system is made up of numerous major components with varying lengths of serviceability. The lands in the corridor have a perpetual life; the way structure and stations, an indefinite life; and the vehicles and electronic components, a potential life of twenty-five years or more.

To account for the long life of many of the components and be comparable to the analysis of other public investments, benefits and costs were evaluated over a 50 year period. The year 1995 was selected as the "study year" and benefits and costs were scaled forward or backward in time from this base point.

The initial cost or capital costs of the system occur during construction. These costs cover the components of the fixed guideway system including way structures and stations, electrical control and communication systems, support facilities, and transit vehicles. The system also includes costs of the feeder and express bus system. In addition to the modal cost, capital cost covers administration and engineering, pre-opening, contingency, and right-of-way and relocation.

The cost estimates were based on 1972 dollars. In order to arrive at total project costs, it was necessary to project or escalate the estimate to the actual year in which they would be expended.

There are, of course, costs that will occur after the system is complete and operational. These are actual operations and maintenance cost and replacement cost. The cost of operations and maintenance is assumed to be covered by fare box revenues and therefore represents no net increase in actual expenditures on the system. While the net cost of operations and maintenance are reduced to zero, it is immediately recognized that these out-of-pocket expenses must be met by those individuals paying the fare box revenues; accordingly, they are treated as a reduction in benefits to the transit user.

The replacement cost on the other hand, must be borne by the general public in a like manner to the capital cost. These costs are therefore shown on the cost side of the benefit-cost ratio.

The costs of the system occur at differing times, and therefore, are projected to the year of occurrence to arrive at a realistic estimate. The capital cost was increased at rates of 5, 5½, and 6% per annum depending on the items to the year of occurrence. As with capital costs, this cost of operation and maintenance, as well as replacement cost, was increased at an average 5% per annum to the year of opening. The operations and maintenance cost will occur annually thereafter and the replacement cost will occur at one point in time approximately twenty-five years from the opening date; therefore, both must be projected to these distant points in the future. Over this period, 2% per annum was used which reflects the average cost increase displayed in the Honolulu price index for the period 1940 thru 1970. This same rate of increase was used in the measurement of benefits to obtain conservative values for this analysis.

The proper comparison of benefits to cost necessitates that both be stated at a comparable point in time. In order to adjust the flow of cost and benefits over widely ranging years, both factors were discounted to their present value. This technique is perhaps best illustrated through an example. If $0.78 were invested today at a return of 5% compounded annually, it would be worth $1.00 in five years. This procedure, of course, reflects the rate of return on capital during a specific period of time. Conversely, it is also true that, at a 5% rate of return, the $1.00 received 5 years from today is worth only $0.78 currently. The estimated costs and benefits occurring over the entire life of the project were discounted to their present value in 1979 dollars for comparison. A discount rate of 5% was used to reflect the cost of capital to the public. Other transit studies have used similar discount rates ranging from 4 to 6%. Five per cent is slightly higher than the 4.78% recently suggested by the Department of Commerce.

The measurement of benefits is somewhat more complicated than that of cost. A rapid transit system will draw substantial patronage from the beginning; however, we would not expect capacity patronage until some time in the future. As previously indicated, the base year 1995 was selected as the study year. Patronage estimated for this year provided the point of reference from which benefits would be measured.

Using 1995 as a reference point, it was estimated that initial patronage would be in excess of 55% for both peak hour and total patronage. It was further assumed that patronage would grow arithmetically from 1980 to 1995 and the midpoint would represent an average for the first 15 years. Further it was estimated that peak hour patronage would increase by one third by 2010 while total patronage would increase by 20%. Again assuming an arithmetic growth the midpoint of these trends represent an average for the next 15 years. The system would be near capacity at this time, therefore, patronage for purposes of the benefit-cost comparison was held constant for the next 20 years.

SUMMARY OF FINDINGS

The proposed rapid transit project is estimated to be a sound public investment. (See Table 13-1)

- The project is expected to generate total benefits of $3.2 billion, which exceeds the anticipated cost by 279%.
- The Benefit Cost ratio is 3.79 to 1. This means that for every dollar invested in the Honolulu Rapid Transit system, more than $3.79 will be returned in quantifiable benefits.
- Each dollar invested by the citizens of Honolulu (1/3 of total costs) will return more than $11.41 in quantifiable benefits.

TRANSIT USER BENEFITS:

- Time savings (Diverted motorists and former bus users): $498 million
- Vehicle operating savings: $658 million
- Insurance savings: $27 million
- Vehicle parking savings: $298 million
- Vehicle ownership savings: $546 million
- Gain in personal income by reduction in fatalities: $56 million
- Less increase of fares over present for rapid transit and buses: $699 million

NON-TRANSIT USER BENEFITS:

- Time savings to motorist: (private and commercial) $1,534 million

REGIONAL BENEFITS:

- Increased personal income in construction related employment: $256 million
- Value of project: $20.3 million

CONCLUSION

An investment program of such magnitude and importance should be approached with prudence. Consequently, a very conservative approach has been taken in estimating the benefits of rapid transit to the Island of Oahu. Based on these conservative assumptions, a public investment program which returns $3.79 for every $1.00 invested is considered above the normal expectation. In point of fact, if benefits were only 1/3 of what they actually are, the rapid transit system could still be considered a sound investment for the citizens of Honolulu.

Table 13-1

TANGIBLE BENEFITS AND COSTS

Benefits	Present Value [1979] (million of $)	Total
Travelers		
transit users*	1384	
non-transit users	1534	
regional	277	
TOTAL BENEFITS**	3195	**3195**
Costs		
Initial System Cost (Rounded)	700	
Cost of additional equipment and replacement	141	
TOTAL COST	841	**841**
Benefit Cost Ratio 3.79 to 1		
*Net of Fares		
**Net Present Value of Benefits	2354	

ANALYSIS OF BENEFITS

The total benefits of the Honolulu Rapid Transit System can be categorized into three distinct areas: transportation benefits, regional benefits and service area benefits. The following discussion will cover the analysis of both tangible and intangible benefits in each of these categories:

TRANSPORTATION BENEFITS

The introduction of a rapid transit system to the urban areas of Honolulu will reduce the overall cost of traveling both for rapid transit patrons who will be diverted to the integrated transit system from their automobiles and for those who will still use the highway and surface transportation system.

TRANSIT USER BENEFITS

Persons who utilize the transit system will benefit from:

- Time savings
- Vehicle operating savings
- Vehicle insurance savings
- Gain in personal income by reduction in fatalities
- Increase mobility to those who find private transportation is not available

TIME SAVINGS

The individual diverted from the automobile to an efficient and dependable rapid transit system will realize a time saving in work commute trip by avoiding the congestion associated with peak hour commuting on the highway system. The total time saved by the diverted motorist is estimated at 5,080 hours per day for the study year 1995.

Those individuals traveling to work by present public mass transportation face many of the same problems that face the automobile commuters in that buses must travel on surface streets and are therefore subject to the same traffic delays. The rapid transit system will be separated from normal traffic flow providing increased headways and shorter wait time, therefore allowing an estimated time saving of 10,292 hours per day for work commute trips.

The time saving accruing to the transit user was valued on the basis of a 1969 study presented to the 49th Highway Research Board Conference in 1970. This study concluded the value of time connected with work trips to be $3.00 per person per hour, in 1969 prices. All other factors being equal, individuals will allocate their time between different activities in such a way that the marginal value of time will be exactly the same in each activity. In other words, an individual will allocate so much time to work, leisure and rest. For work he is willing to "sell" so many hours for a given price; at equilibrium the last hour worked was paid at the rate necessary to induce the individual to give up other activities. Therefore, any reduction in time, whether achieved by some time-saving device in the home or by a faster mode of transport, should be valued at the money wage rate, regardless of whether the time savings were achieved during work hours or not.

The value of commercial vehicles time was valued at $5.75 per hour based on a 1967 study by Texas Transportation Institute, using a conservative estimate of one person per vehicle.

OPERATING SAVINGS

The diverted auto user will also save the operating cost of his vehicle for that mileage provided by rapid transit. Private vehicle operating costs not incurred by the transit user included gas, oil, maintenance and tires. A 1968 report by the U.S. Department of Transportation, Federal Highway Administration, determined the per mile cost of gas and oil at 2.9 cents and maintenance, accessories, parts and tires at 2.1 cents per mile, all in 1967 prices.

transportation benefits

FIGURE 13-1

INSURANCE SAVINGS
In addition to the actual cost of operating the vehicle, the commuters who forego the use of their automobile for work trips will save on their automobile insurance premiums and parking cost. Current practice in the automobile insurance industry calls for a minimum surcharge of 15% if the automobile is used for work commute trips. In 1971 this represented a $26.70 mark up on a basic insurance policy.

PARKING SAVINGS
The commuter driving his automobile to work must, in most cases, pay for parking. Therefore, diverted motorists will avoid this out-of-pocket expense. The average parking cost for all day parking in 1971 was 60.2 cents per day. This average is low because there are still a few areas in Honolulu where all day parking is free.

OWNERSHIP SAVINGS
As a result of the speed and convenience of rapid transit, many households will find they can eliminate ownership of a second or third car, and in some cases the first car. Those individuals who no longer need an automobile can therefore eliminate insurance premiums and depreciation from their annual expenditures. The average annual cost of basic insurance coverage of a new automobile in 1971 was $204.70. The average price of a new automobile purchased in 1971 was $3,510.00. Depreciated over 10 years on the straight line method provides a cost of $351.00 per annum.

REDUCTION IN FATALITIES
The fatality rate on transit is much lower than that of automobiles and will result in a saving of lives. The value of a human life cannot be objectively measured; however, we can measure the lost income attributable to a fatality. The reduction in fatalities represents a savings of this lost income. On this basis, the lost income adjusted for the unemployment portion of non-work trips contributes a saving of $2.2 million annually to the transportation benefits.

RAPID TRANSIT FARES
The fares for the rapid transit system will be structured so as to cover operation and maintenance of the full system, both the fixed guideway, and feeder and express buses. These costs will be borne by all transit users and therefore are treated as a deduction from benefits so as to identify net saving to the transit user.

ADVANTAGES TO THOSE WHO DEPEND ON PUBLIC TRANSPORTATION
Many of our citizens are dependent upon public transportation facilities by choice or circumstance. Our school children depend on public transportation for school and other social activities when transportation is not provided by the parents. The safety and convenience of rapid transit will no doubt induce many parents now dropping off their children at school to utilize this as a means of mobility for their children. This may also permit many children to participate in school activities that might not have been otherwise possible due to lack of transportation facilities.

Furthermore, many of our senior citizens and the handicapped depend upon public transportation for mobility. Again, the safety and convenience provided by the rapid transit system will make the necessary trips more comfortable and permit greater enjoyment of cultural and social benefits. In effect, any group that may find private transportation a problem will gain greater satisfaction from the additional mobility provided by rapid transit.

NON-TRANSIT USER BENEFITS

Rapid transit will also generate major benefits to those who do not use the system.

Table 13-2

POTENTIAL ANNUAL SAVINGS OF A TYPICAL COMMUTER (1972 DOLLARS)

	Diverted Motorist Using Rapid Transit	Non-Rapid Transit User
Vehicle Operating Savings	$ 223	$ 45
Automobile Insurance Savings	28	—
Downtown Parking Savings	300	—
Time Savings	130	116
Subtotal	$ 681	$161
Vehicle Ownership Savings	$ 914	$ —
Potential Savings	$1,595	$161
Less: Fares Paid	$ 198	$ —
Total Potential Savings	$1,397	$161
Rapid Transit System Capital Cost	$ 20	$ 20
Net Potential Savings (Annual)	**$1,377**	**$141**

TIME SAVINGS
The diversion of automobile commuters to rapid transit will produce an increase in average speed for those still using the highway system during peak hours regardless of remaining traffic volumes. This will further result in time savings and a decrease in non-user car-operating expenses. The remaining motorist will therefore realize decreased travel time for work commute trips estimated to total 39,800 hours per day in the study year 1995. The commercial vehicles on the highway system will likewise gain from the same factors providing gain to the continued motorist. It is estimated this gain will be 3,700 hours daily.

OPERATING SAVINGS
The fact that reduced congestion will allow motorists still using the highways to move at increased speeds will result in savings in vehicle operating expenses. In addition, those individuals who still utilize the private automobile for transportation will find some satisfaction in knowing there is a back-up system. The automobile, while generally a very reliable machine, will at times fail to perform. If this should occur at the dawning of a trip or if the car is simply incapacitated a short time for routine maintenance, the transit system will provide stand-by transportation.

REGIONAL BENEFITS

Benefits which accrue to the region as a whole originate from rapid transit as the least costly means of providing equivalent transportation and from increased productivity generated by rapid transit. The former group of benefits results from expenditures not made for other transportation modes and the operation, maintenance and repair of those facilities. The latter group of benefits accrue to the region as a by-product of the rapid transit system. Those benefits which will therefore accrue to the region as a whole are:

- Postponement of freeway construction cost
- Postponement of parking structure cost
- Operating, maintenance and repair expense for freeways and surface streets
- A reduction in air and noise pollution

SAVINGS FROM EXPENDITURES NOT INCURRED

While the Oahu Transportation Study showed the need for additional highways and major street improvements as well as rapid transit, the demand for expressways would be far less with rapid transit than without it. The diversion of motorists to rapid transit will therefore result in less required investment for additional freeway construction.

It was estimated for a portion of H-1 Freeway under study, that cost of one mile of highway with one lane in each direction would vary from approximately $500,000 per mile at grade to over $2.5 million per mile with an aerial structure. Obviously the need for additional highways and streets would represent a substantial cost were transit not to be built.

In addition to the required highways and streets, it is estimated that parking structures cost from $250 per uncovered stall to $4,000 per covered stall. The scarcity of land in the Central Business District would suggest parking in this area would be multi-level at $4,000 per stall. On the basis of 46,000 automobiles in the year 1995 requiring all day parking, this would represent cost avoided or postponed in excess of $18 million.

Another very important factor in considering automobiles is the land take requirement. There have been many economic studies associated with the economic gain and losses around freeways, highways, streets, and transit facilities. Theoretically one may conclude that with sufficient demand, increases in property values around improved transportation facilities will more than offset tax loss incurred by property take. However, the law of diminishing returns would be applicable to this phenomenon. Certainly at some point of increasing highway space, the surrounding lands no longer increase in value and may in fact, decrease. Should this occur there would be a tax loss on the lands taken for highway space and a loss on the surrounding lands because of the detrimental effects of the highway.

As opposed to highways, transit has the capability of carrying large numbers of people with a comparatively small land take. It is also anticipated that the increased efficiency attributed by transit will increase the value of the lands surrounding transit sufficiently to offset any tax loss to the region.

Savings from costs avoided or postponed are not counted as quantifiable benefits in this Benefit-Cost Analysis. However, it is important to note that without rapid transit there would necessarily be heavier reliance on the automobile which would involve many additional costs arising from increased congestion, air pollution, land acquisition, and the like.

regional benefits

FIGURE 13-2

PERSONAL INCOME

The increased construction activity generated by the Rapid Transit System will create increased personal income in construction related employment. It will also help to reduce unemployment and/or draw some migrant workers to the area from other regions for the duration of the project. This gain will accrue not only to those directly related to the construction field, but to those in all sectors. The increased income should result in increased consumption in other areas of the private sector which in turn results in greater tax collection by the public sector.

SALVAGE VALUE

Another quantifiable gain is the salvage value of the project. This has been based solely on the value of the lands in the corridor which will represent a valuable asset to the people of Honolulu.

AIR POLLUTION

The Rapid Transit System proposed for Honolulu offers the potential for significant improvement in the environment and quality of life on the Island of Oahu, particularly in terms of air pollution.

Electric-powered rapid transit cars do not pollute and new surface buses with anti-pollution devices produce far less pollutants than the 20 to 30 cars each bus replaces. There would be a slight increase in the amount of sulfur dioxide produced by the power plants generating the electricity required to operate the system, however, they are located away from the City and under the normal tradewind conditions, these pollutants would be taken out to sea.

In addition, as more and more persons are diverted to rapid transit during rush hour, there would be fewer cars using the streets and highways and as a result, less pollution. Air pollution affects our environment in many ways. It may lead to injury of plant and animal life and deterioration of trees and forest. It leads to increased cleaning cost for personal clothing and other possessions. It increases maintenance costs for public and private industry. It would be extremely difficult to measure the relief provided by rapid transit on these individual effects in Honolulu, however, we may consider as a proxy, the estimates of $150 to $300 per automobile to meet the 1975 air pollution standards.

NOISE POLLUTION

Noise levels in American cities have been increasing at approximately one decibel per year. In Honolulu, concern for this problem has been manifested in the Oahu Vehicular Noise Control Regulations recently adopted by the State. New buses and rapid transit vehicles can be designed to produce a minimum amount of noise and will materially improve the amount of noise pollution in the city. In addition, increased use of public transportation can reduce the number of automobiles on the streets and highways and therefore aid significantly in reducing aural pollution.

SERVICE-AREA BENEFITS

Service-area benefits are those generated in the immediate area of impact around rapid transit stations. By increasing property values and accelerating property development, rapid transit stations can generate a higher real estate tax base for the taxing jurisdiction. They also stimulate higher residential densities which result in higher retail sales, increased employment in these areas, and lower infrastructure costs. The physical design and separation of the rapid transit system will also minimize conflict with pedestrians. Social and cultural facilities will become more accessible to more people, including the underprivileged, handicapped, youthful and senior citizens.

Furthermore, the transit system will provide a tremendous planning tool by which urban designers and planners can structure potential developments throughout the city.

It is generally held that the economic value of real estate is created by two fundamental things: people and accessibility. The station area impact study in conjunction with the Preliminary Market Study revealed that rapid transit will have little effect on total demand but will cause some spatial shifting of this demand due to greater accessibility. The economic significance of this shift is believed to be of nominal value in terms of benefit to the region.

INTANGIBLE BENEFITS

The rapid transit system will offer improved accessibility to the entire region and as a result bring the expanding suburbs closer to the urban core. In conjunction with good planning, this should increase the potential for orderly economic expansion.

City dwellers, including many of the poor, the handicapped, and the aged of the Island, will enjoy inexpensive public transportation to points that might otherwise be inaccessible except by private car. The entire population will have improved access to public services, shopping, jobs, cultural and recreational facilities, and other City attractions. Employment opportunities will greatly improve and the island-wide business base will experience a subsequent rise in productivity.

Rapid transit can do much more than simply move people from place to place. It can be the means by which older areas can be revitalized and newer areas can be planned and built with greater efficiency. Each of the 20 rapid transit stations has been planned to provide the best possible potential for development to its immediate neighborhood and the city as a whole. Urban renewal projects, new housing, both private and public, as well as schools, commercial and recreational projects can be planned to take advantage of the opportunities offered by rapid transit. It will provide opportunities for guiding orderly development and redevelopment beyond the year 2000 which can help to consolidate and reduce governmental services and thus hold down property taxes.

Finally, the street and freeway congestion, already a source of expense and annoyance to commuters, will be reduced as thousands of persons are diverted to rapid transit. This diversion of commuters to rapid transit will not only help to reduce highway congestion but will also reduce the amount of air pollution to the region. Air pollution generated by the fixed guideway system is considerably less than that produced by an equivalent automobile oriented transportation system. Furthermore, the overall environmental impact of the rapid transit system would also be minimal when compared to that of an equivalent highway transportation mode in terms of required land taking and disruption, as well as noise and air pollution.

In short, what is rapidly becoming a sprawling metropolis, can be bound together and both its urban and suburban communities greatly strengthened by an integrated transportation network which includes rapid transit as an essential element.

service area benefits

FIGURE 13-3


KAMEHAMEHA I

implementation 14

INTRODUCTION

The Preliminary Engineering Evaluation Program constituted the first step of the long-range transit development program for the Island of Oahu. It provides the City with information and data on transportation needs of the Island and how these needs can best be satisfied by evaluating various alternative transportation systems. It also measures, qualitatively and quantitatively, the social, economic, and environmental impacts of alternative systems on the community. It then recommends the best transit system concept to serve the Island and defines the concept plan.

Based on the information developed, the City Administration has adopted the policy to take necessary and immediate actions leading towards implementation of the program at the earliest possible date. By expeditiously advancing the program, it has been determined that the earliest possible date to place the first increment of the rapid transit system in operation would be late 1978. With this as a goal, an implementation schedule with major activities and milestones to be met has been identified. (Figure 14-1)

The basic schedule establishes the calendar year of 1973 to take necessary steps and actions for providing funds to implement the program. In calendar year 1974, final engineering would commence including the preparation of the construction plans and specifications for the first contract package. Beginning in 1975, nearly 4 years would be provided to construct the initial increment of the system, approximately 14 miles, such that it can be ready for revenue service at the end of 1978. An additional 1 to 1½ year would be allowed to complete the remainder of the system.

To meet this opening date of late 1978, the key period would be 1973 wherein most of the critical policy decisions must be made. Concurrent activities leading to the obtaining of capital funding from various levels of government must be initiated at an early date. There are also important statutory requirements to be met before any funds can be expended which are critical in meeting the schedule. Additional technical activities to be performed as an extension of this program phase have been identified as well as the organizational form and structure of the transit entity most suitable to operate the system. The following paragraphs describe the major and critical activities to be performed in order to advance the transit program on an expeditious basis.

ENVIRONMENTAL IMPACT STATEMENT

The protection of environment has in recent years become one of the most important concerns of both the public and the government. A comprehensive assessment of impact on the environment is necessary and required by both State and Federal statutes before any funds are expended for capital improvements.

The statutes further require reviews of the impact assessment by cognizant public agencies and interested private individuals and organizations. Based on these reviews and comments received at public hearings, the environmental protection agencies of both State and Federal governments are required to act on the approval or disapproval of the impact statement.

The draft Environmental Impact Statement was prepared as part of this program phase. It was filed with the State Clearinghouse (Office of Environmental Quality Control) for dissemination to various public agencies and private organizations for their review. The report will also be referred to the State's Environmental Council for review and also for this body to determine if a public hearing is to be held. At the end of this process, the State Clearinghouse will assemble and review the comments and recommend additions or modifications to the draft statement.

Based on the above review process, the City, as the sponsoring agency, is obligated to finalize the impact statement with or without further studies or investigation. The final Environmental Impact Statement is then required to be filed with the State Clearinghouse, the National Environmental Protection Agency and the Department of Transportation.

GENERAL PLAN AMENDMENT

One of the statutory requirements of the City and County of Honolulu is to reflect all new public facilities on its General Plan through the amendment process. This process involves the preparation of a special report to be submitted to the Planning Department for review and processing through the Planning Commission for formal action by the City Council and the Mayor.

The development policy of the City and County of Honolulu is currently set forth in the City's General Plan. Since transportation systems play a significant role in the actual implementation of the General Plan, the interaction between land use policies and the rapid transit system must be analyzed in final detail.

The General Plan Amendment Process will entail the following:

- A review of the detailed requirements necessary to formally modify the policy of the City and County in order to incorporate the transit route into the General Plan.
- Supplementing the rapid transit impact analysis with additional information as necessary to permit evaluation of the transit system's impact on land use and public facilities in the context of policy decisions to be made.

RELOCATION ASSISTANCE PROGRAM

The Federal Uniform Relocation Act requires the City, as the sponsoring agency, to provide adequate replacement housing and ensure that it has been made available to re-

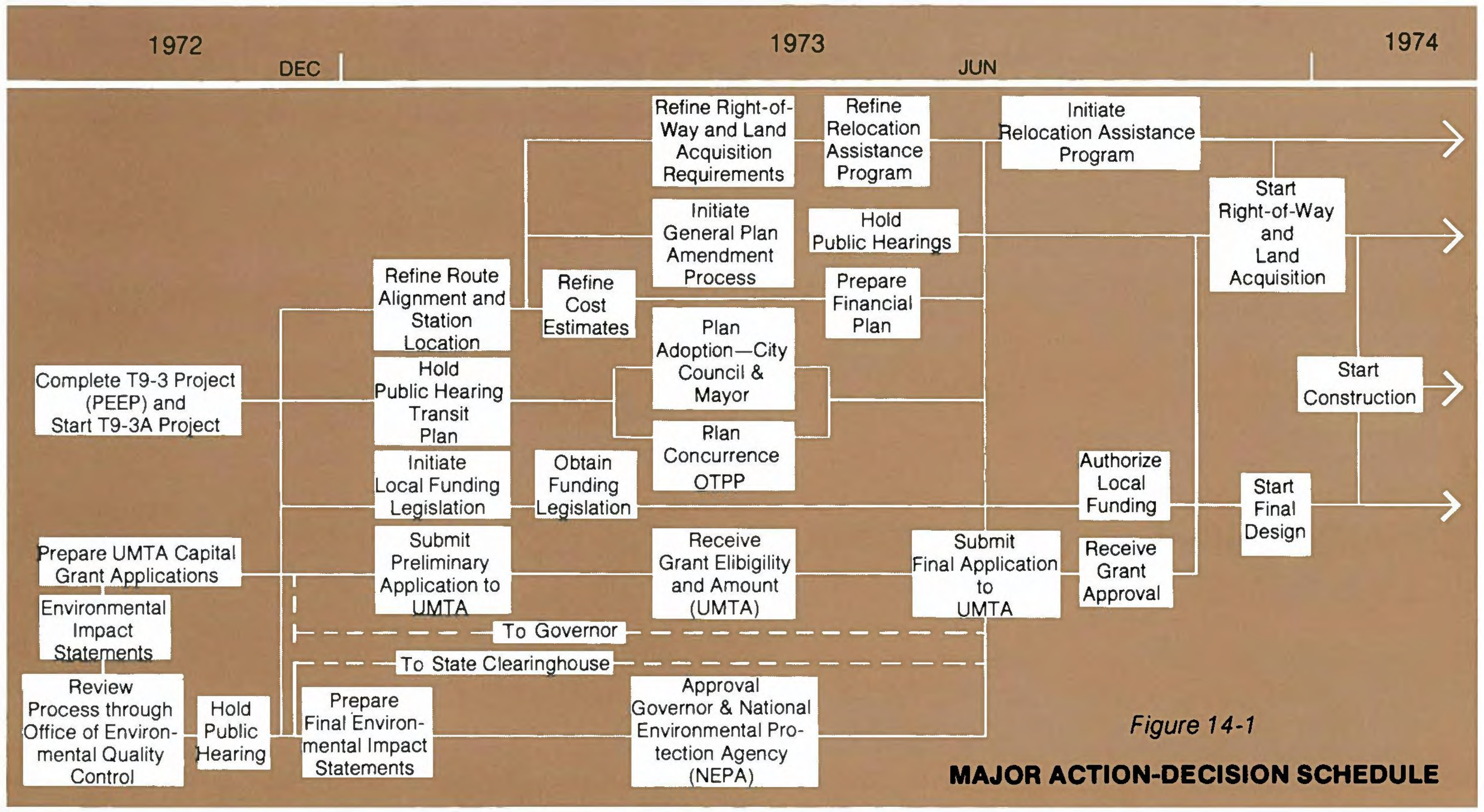


Figure 14-1

MAJOR ACTION-DECISION SCHEDULE

locatees prior to commencing with any physical construction work. Based on relocation studies conducted under this phase of the program, it was found that Honolulu is experiencing a critical housing shortage and that finding suitable replacement housing for the potential relocatees would be very difficult if not impossible. It is estimated that the overall vacancy rates have been less than 2% with the rate for low-income units to be somewhat less.

Over 800 dwelling units or households are estimated to be affected by the project of which some 100 units are considered to be single occupants or bachelor quarters. Some 250 households affected would fall into the critical, low-income category. Based on the magnitude of relocation, it is contemplated that a special relocation housing program is required to be initiated by the City. It is estimated that the City's current redevelopment projects would be able to accommodate only a small fraction of the potential transit project relocatees.

In view of the foregoing relocation outlook, it is necessary for the City to institute an early-action housing program which would provide new housing units in the general area of the transit facilities. With the contemplated time schedule for the project, the providing of suitable replacement housing would be very critical. Unless immediate steps are taken to define and initial supplemental housing program, it would be difficult to meet the project schedule.

TECHNICAL ACTIVITIES

The implementation schedule allows approximately 1 year to prepare final plans and specifications for the first contract package to be awarded for construction. One year is a relatively short period and in order to meet this schedule, advance work should be done in as many areas as possible. For example, reliable topographic survey data is required in the design of nearly all facilities. Surveying activities can be initiated in advance of final engineering as long as the route and station locations are known. Other technical activities that are either necessary by virtue of the final engineering schedule or related to meeting certain statutory requirements have been identified and are described herein.

There is a need for further refinement of the route alignment and station location due to deficiencies in reliable and current data on the physical conditions of the transit corridor. Reliable physical data is essential due to the high intensity of development existing in the areas traversed by the transit. The effects of the transit facilities on certain lands and structures can only be established by further refinements of alignment based on detailed and reliable data.

Another major problem identified is the need for close coordination between the transit facilities and other major public improvement projects. Various projects currently under planning or final design may require certain modifications to permit economical construction of the transit facilities. If they are not coordinated, costly modifications would be required or degradation of the transit system design could result.

Although transit systems have been built and operated for a long time in the United States, there are many legal, safety, operating, and other institutional considerations that have not been uniformly adopted and applied by cognizant agencies. Therefore the development of basic policies and criteria prior to final engineering will aid immeasurably in expediting the implementation of the project.

As was indicated previously under statutory requirements, one of the requirements is the City and County of Honolulu statute regarding the General Plan. Where changes in land use is contemplated, including public facilities, it is required to amend the affected portion of the General Plan. This process requires a comprehensive review of the impact of the proposed facility on the area. The study of the impact will require technical input including precise location of the facilities and the consequent effects on all public facilities and services.

ORGANIZATIONAL FORM AND STRUCTURE

The implementation of a wholly new rapid transit system for a region requires an appropriate organization to effectively manage the program and to operate the system.[16] Currently, the City and County of Honolulu has the responsibility for operating the public transit system comprising some 140 buses. This responsibility is assigned to the Department of Transportation Services. Under the current City organization, the Director of Transportation Services reports to the Managing Director who in turn is responsible to the Mayor.

Various forms of transit organization to own and operate the system are available based on the needs, history, and government structure of the area served. If any one pattern can be discerned among other transit organizations, it is a trend toward public, regional agencies that encompass broader geographic area than the central cities. These regional agencies have been established in recognition of the fact that transit matters are an area-wide, not local, concern.

Metropolitan areas on the mainland encompass many municipalities, often more than one county and, in several instances, more than one state; thus the form of transit organizations necessarily reflects multiple government requirements. Since the City and County of Honolulu encompasses the entire Island of Oahu, the City is in effect a regional or metropolitan form of government. Therefore, this unique local government structure precludes the need for modeling the form of the transit organization after those on the mainland.

Alternative forms of organization most suitable to meet local needs and harmonize with the existing government pattern for the control and operation of the proposed transit system are:

- Department of the City—control and policy-making authority would be exercised by the Mayor and/or City Council in a manner similar to other City departments.
- Board of Transportation—a semi-autonomous agency of the City responsible for operation and maintenance of the transit system with certain powers delegated to the Board.
- Transit Authority—an autonomous entity chartered to operate and/or own the transit system with policy-making powers and overall control exercised by the Authority except the Authority would have no taxing power.
- Transit District—an autonomous entity similar to the Transit Authority but with taxing power.

In evaluating the above alternative organizations, the Transit District was found to be unsuitable in view of the taxing powers now available to the City for transit purposes. The establishment of a District would create an additional taxing agency which would not be consistent with the present local government pattern and would set a precedent without demonstrated need.

Based on the evaluation of the 3 remaining alternatives, it was found that no clear cut superiority of one form over the others exists. It was concluded that the selection of the most suitable organization is appropriately that of the City's elected officials at the time the decision is made to implement the transit plan, giving consideration to the City's overall organization goals. If the most important consideration is control by elected officials, then a City Department for control should be utilized. On the other hand, if the goal is an independent transit operation, establishment of a Board or Authority would be most appropriate.

MANAGEMENT ORGANIZATIONAL STRUCTURE

The size of the proposed bus and rapid transit system, in terms of number of employees and dollars of revenue generated, will be of such magnitude that an experienced and knowledgeable group of top management personnel will be required for its operation. A well-designed organization structure will facilitate efficient operation and the providing of high-quality service to transit patrons.

The functions that will have to be performed in the operation of the proposed transit system have been identified as the first step in structuring the organization. Several of these functions are being performed by existing City departments in support of other City activities and could appropriately be expanded to support the transit system. Other functions are uniquely related to the transit operation and should be provided by the selected transit organization.

The organization structure selected for the management of the proposed bus and rapid transit system should be one that will help to achieve the following goals:

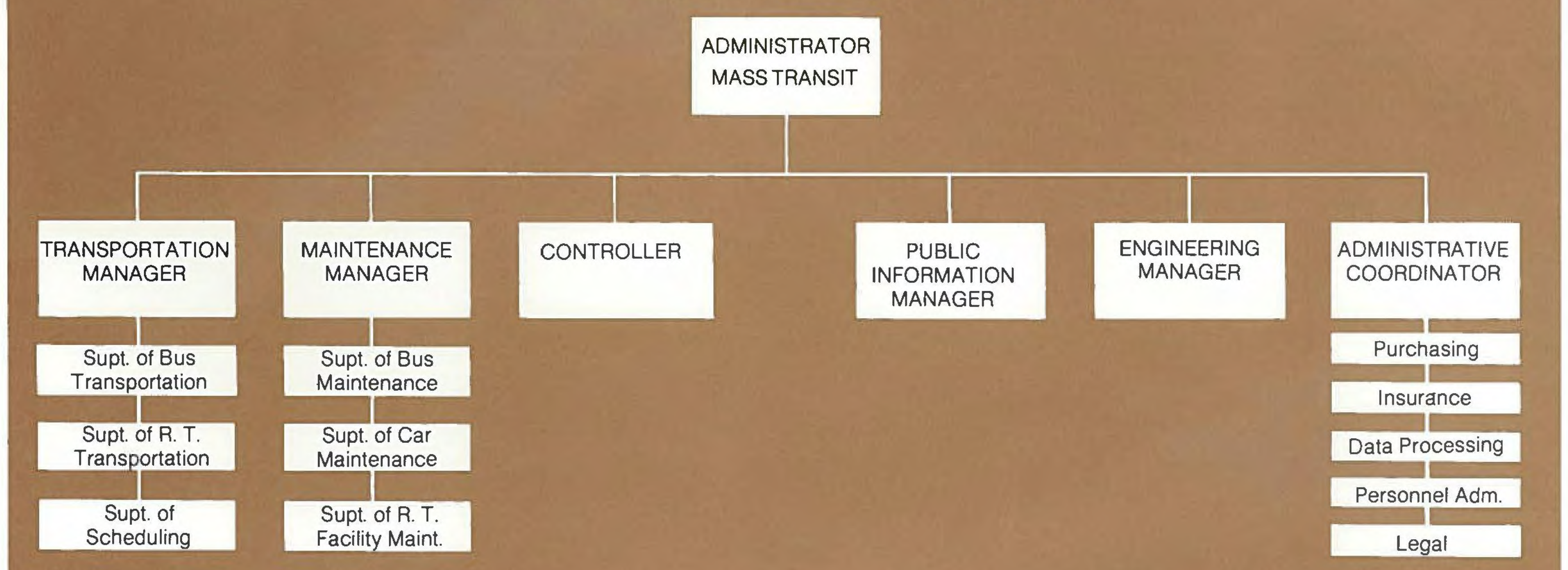
- Coordinated bus and rapid transit operations,
- Reliable, frequent and safe service,
- Economy and efficiency of operation,
- Clear lines of authority and assignment of responsibility.

It is recommended that the management organization be developed in accordance with the plan shown in Figure 14-2. In this structure, a Transportation Manager will be responsible for both bus and rapid transit operations and a Maintenance Manager will be responsible for maintenance of rolling stock and fixed facilities of both modes. The transit agency will have its own Controller, Public Information Manager and Engineering Manager. An Administrative Coordinator will be responsible for coordinating City support services in the areas of purchasing, insurance, data processing, personnel administration and legal.

Another approach that should be considered prior to the transit agency employing its own management personnel is the retaining of outside professional management by means of a management contract. The contract could be with firms specializing in transit management or with well-qualified individuals. This would be one method of overcoming the salary limitations of existing City salary schedules, and it would also be a means of assuring continuity of management.

Figure 14-2

PROPOSED MANAGEMENT ORGANIZATION CHART



AR00053949

appendicies

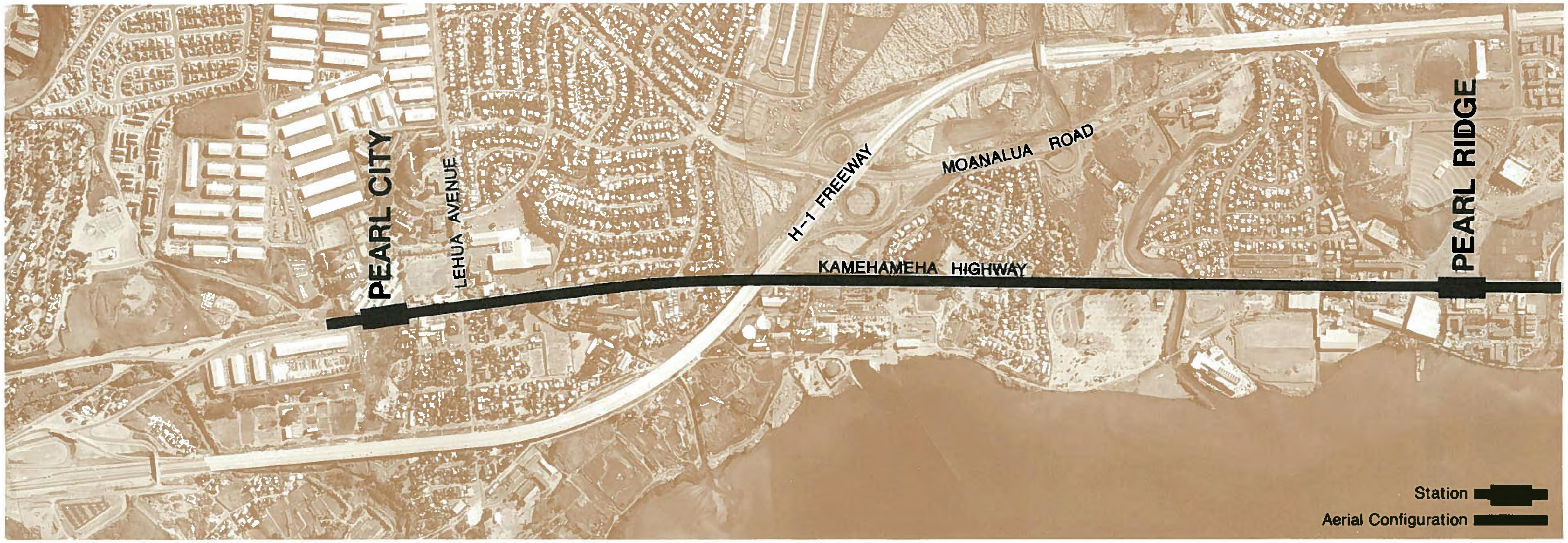
a Phase 1 Plans and Profiles

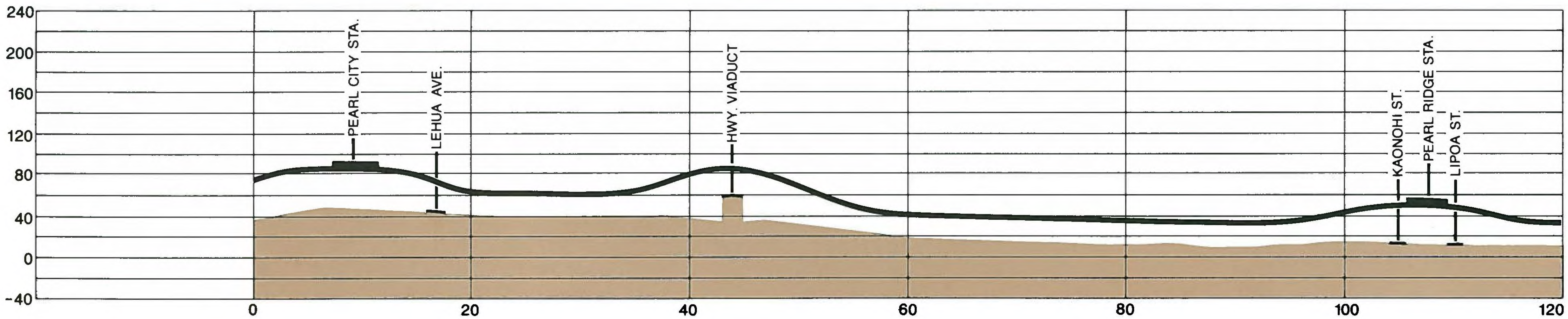
b Glossary of Terms

c Reference Documents

d Public Information Program

appendix a





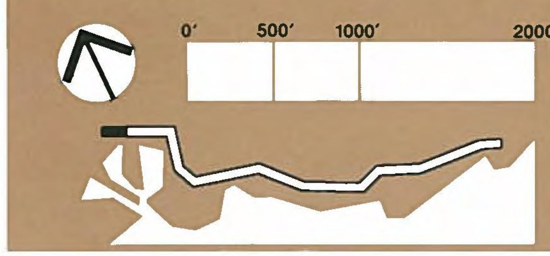
Preliminary Engineering Evaluation Program

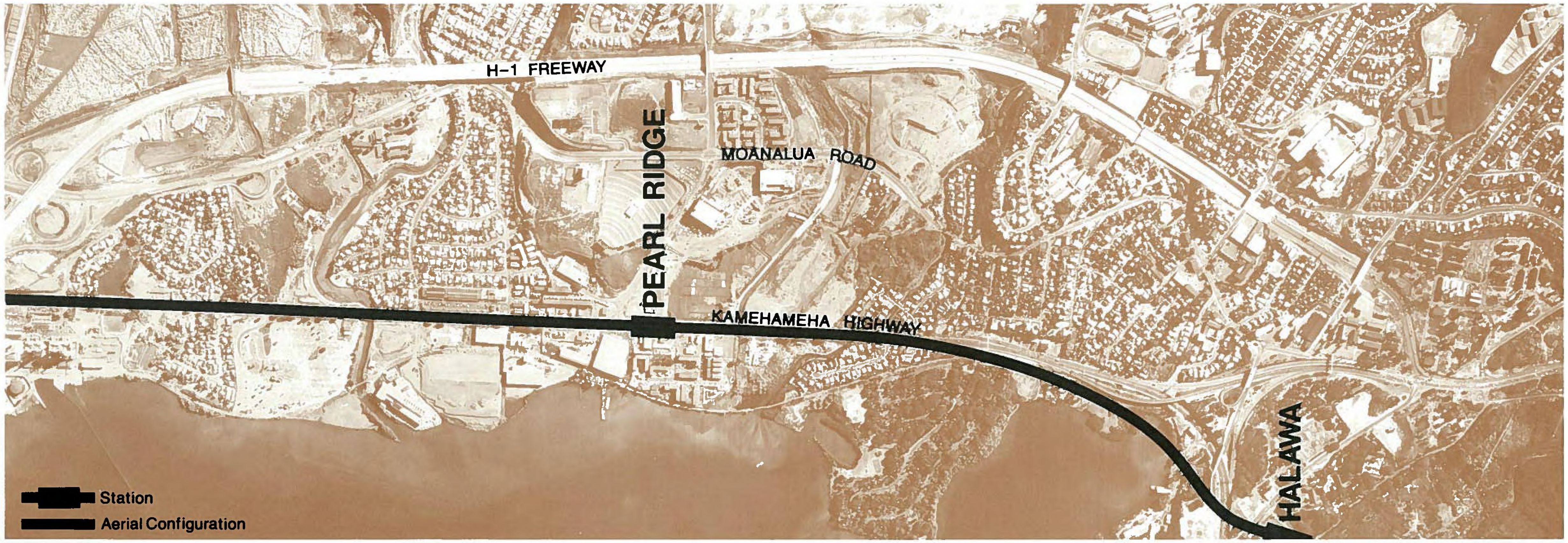
CITY AND COUNTY OF HONOLULU

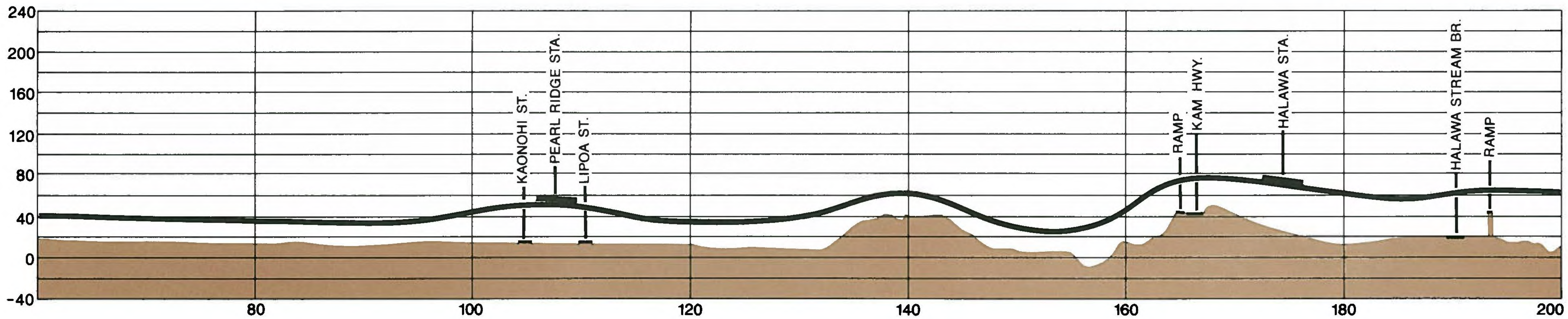
DANIEL, MANN, JOHNSON, & MENDENHALL

PLAN AND PROFILE

Pearl City







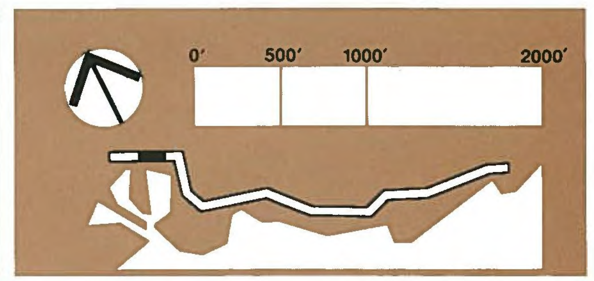
Preliminary Engineering Evaluation Program

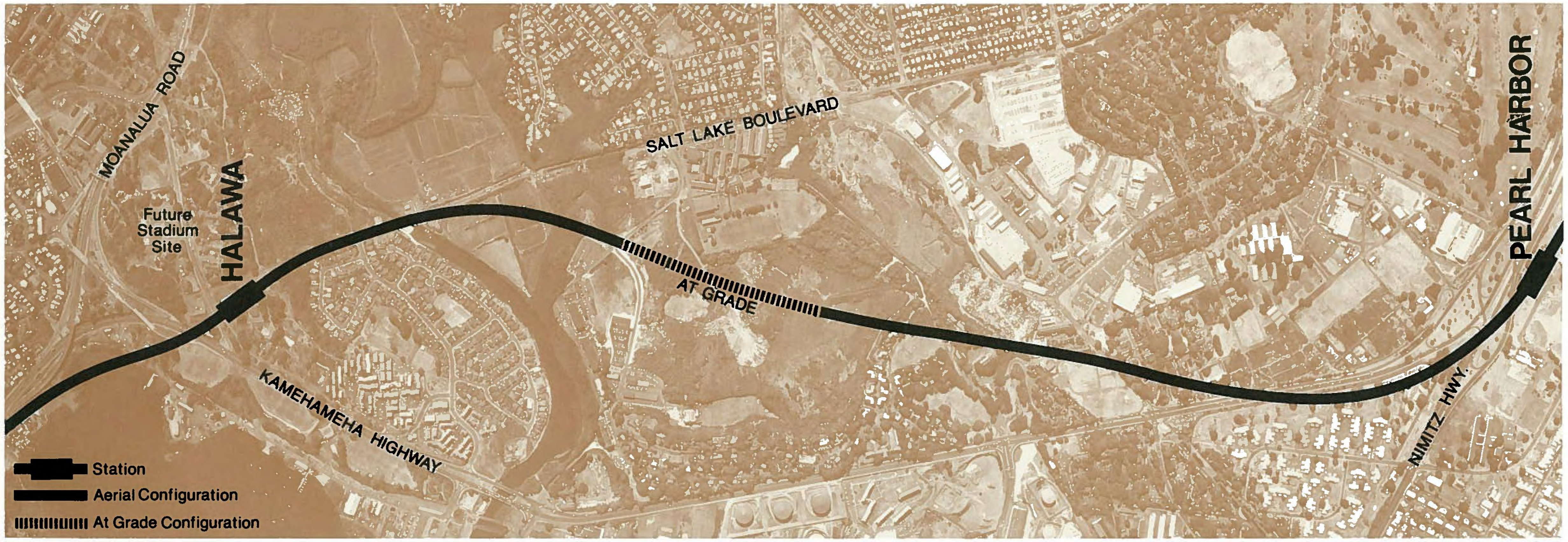
CITY AND COUNTY OF HONOLULU

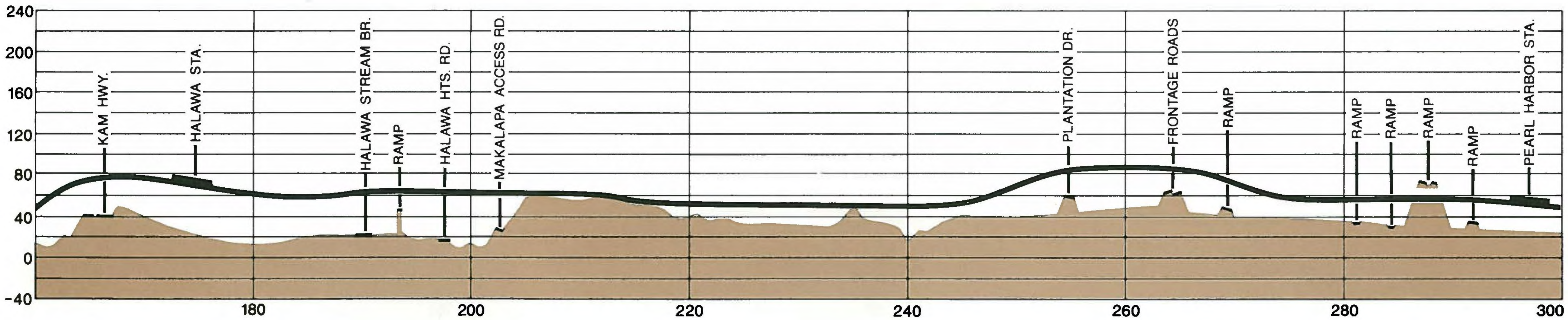
DANIEL, MANN, JOHNSON, & MENDENHALL

PLAN AND PROFILE

Pearl Ridge







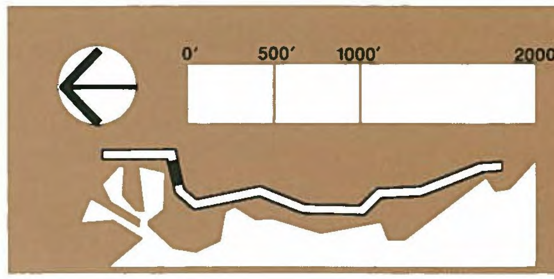
Preliminary Engineering Evaluation Program

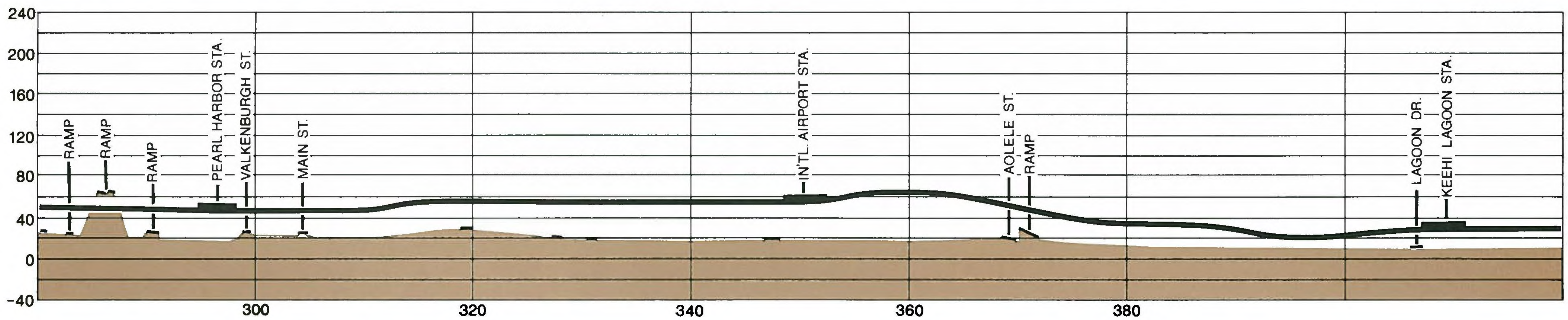
CITY AND COUNTY OF HONOLULU

DANIEL, MANN, JOHNSON, & MENDENHALL

PLAN AND PROFILE

Halawa





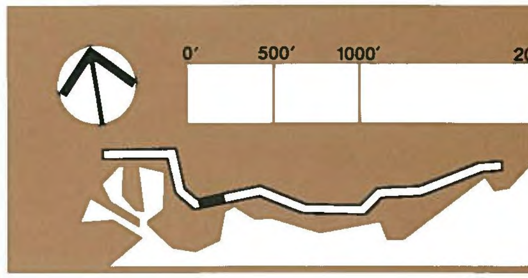
Preliminary Engineering Evaluation Program

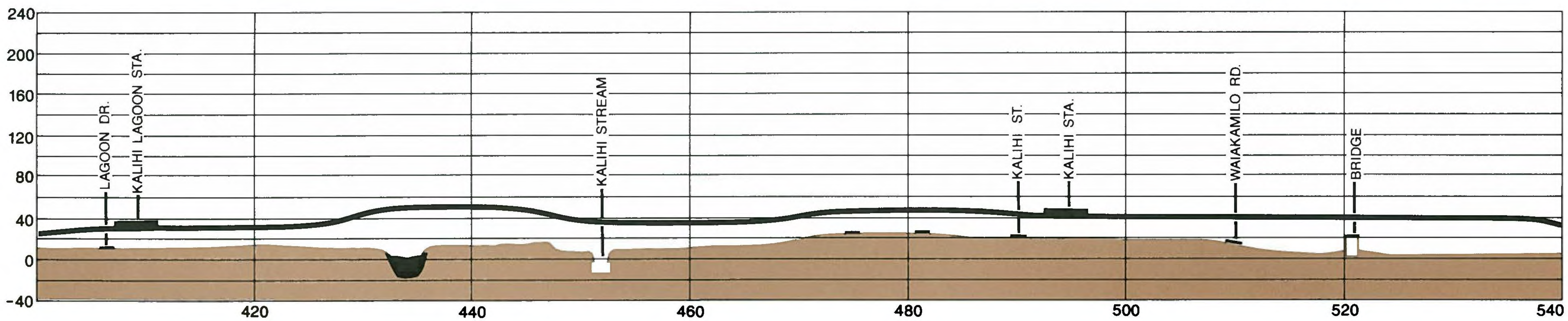
CITY AND COUNTY OF HONOLULU

DANIEL, MANN, JOHNSON, & MENDENHALL

PLAN AND PROFILE

Pearl Harbor-Airport





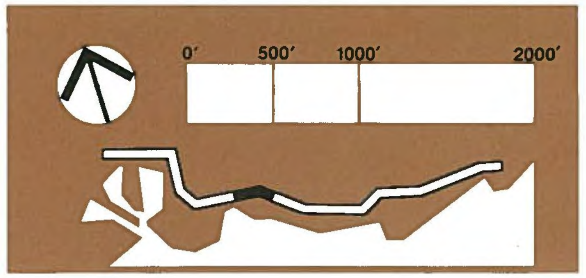
Preliminary Engineering Evaluation Program

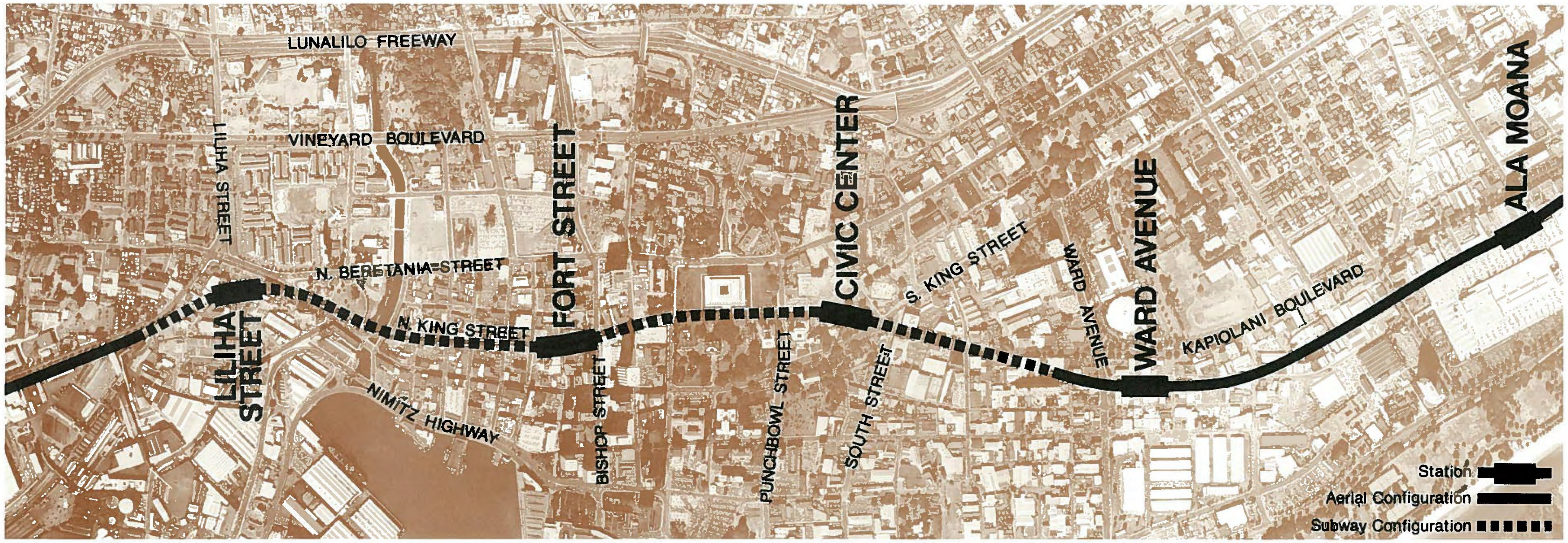
CITY AND COUNTY OF HONOLULU

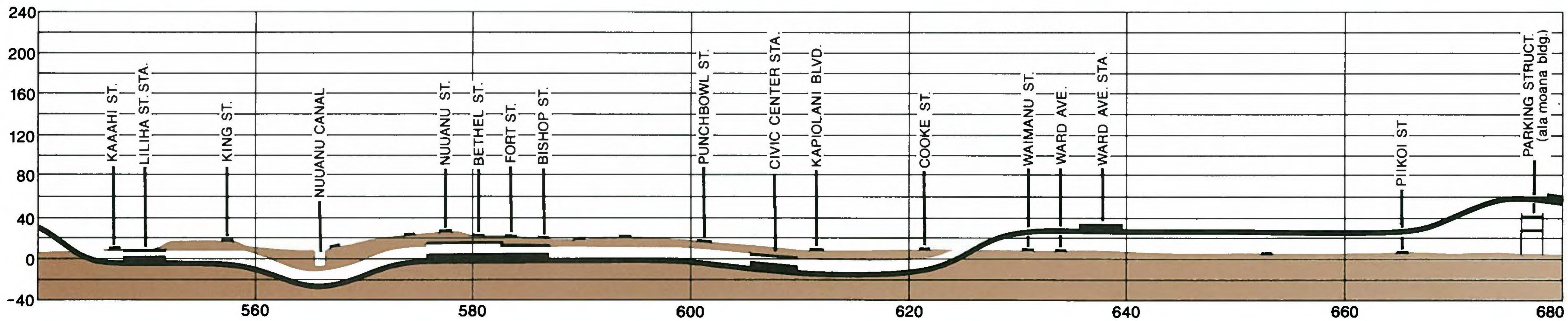
DANIEL, MANN, JOHNSON, & MENDENHALL

PLAN AND PROFILE

Keehi Lagoon-Kalihi







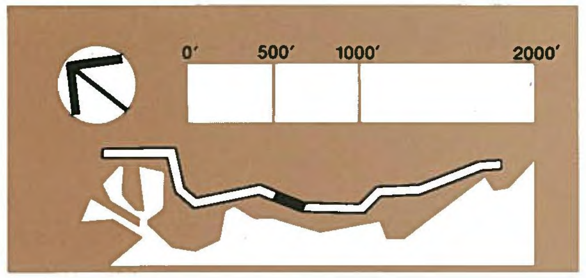
Preliminary Engineering Evaluation Program

CITY AND COUNTY OF HONOLULU

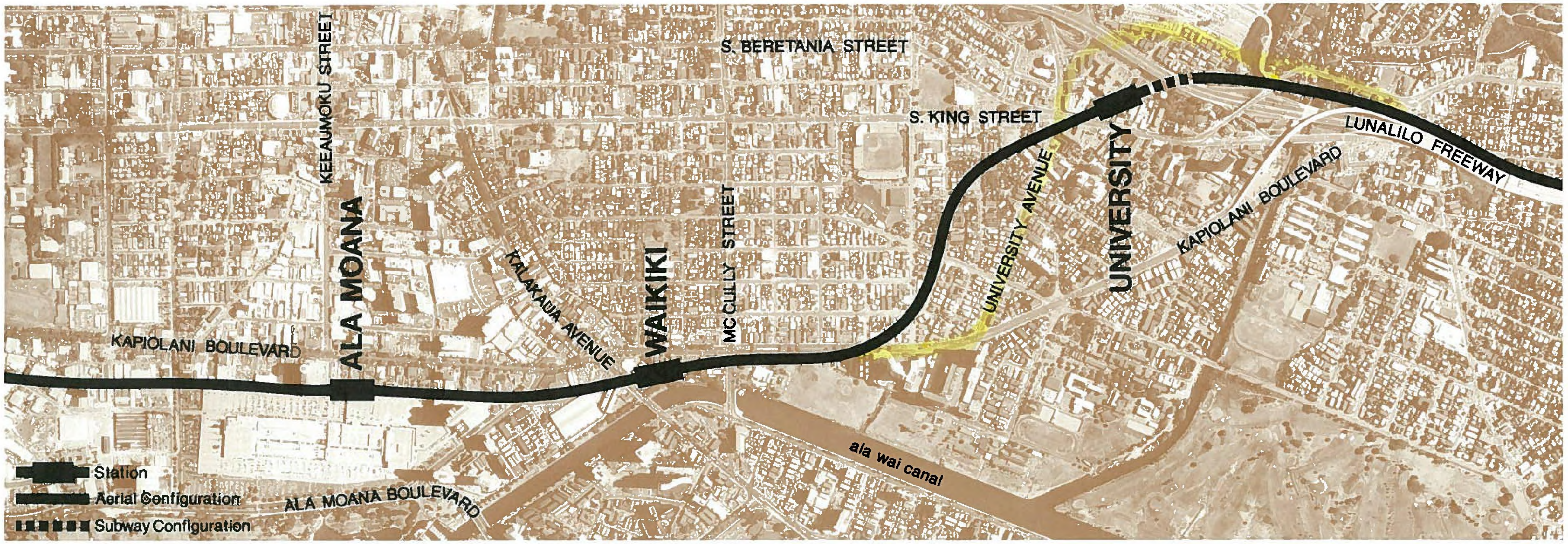
DANIEL, MANN, JOHNSON, & MENDENHALL

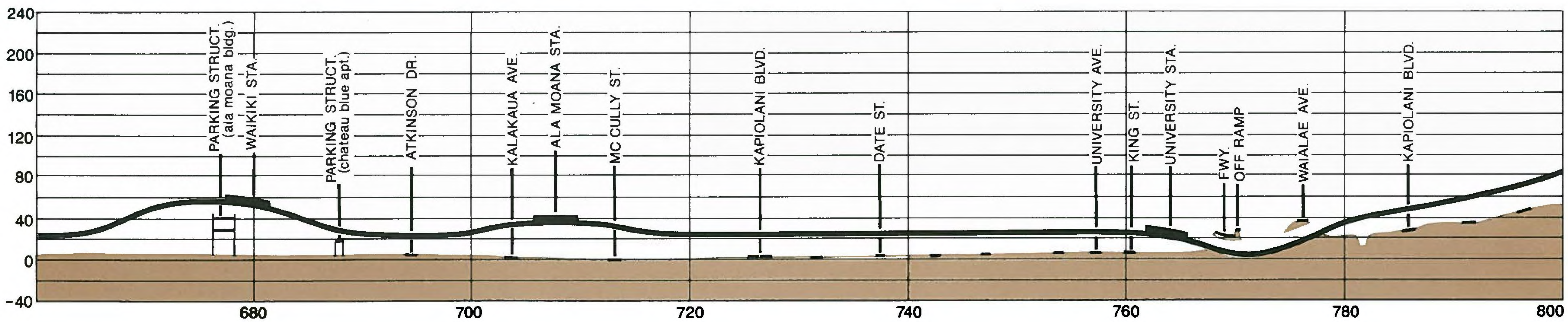
PLAN AND PROFILE

Downtown-Civic Center



AR00053956





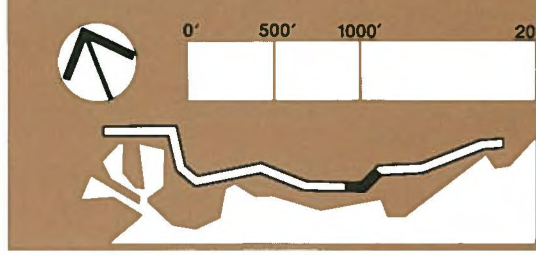
Preliminary Engineering Evaluation Program

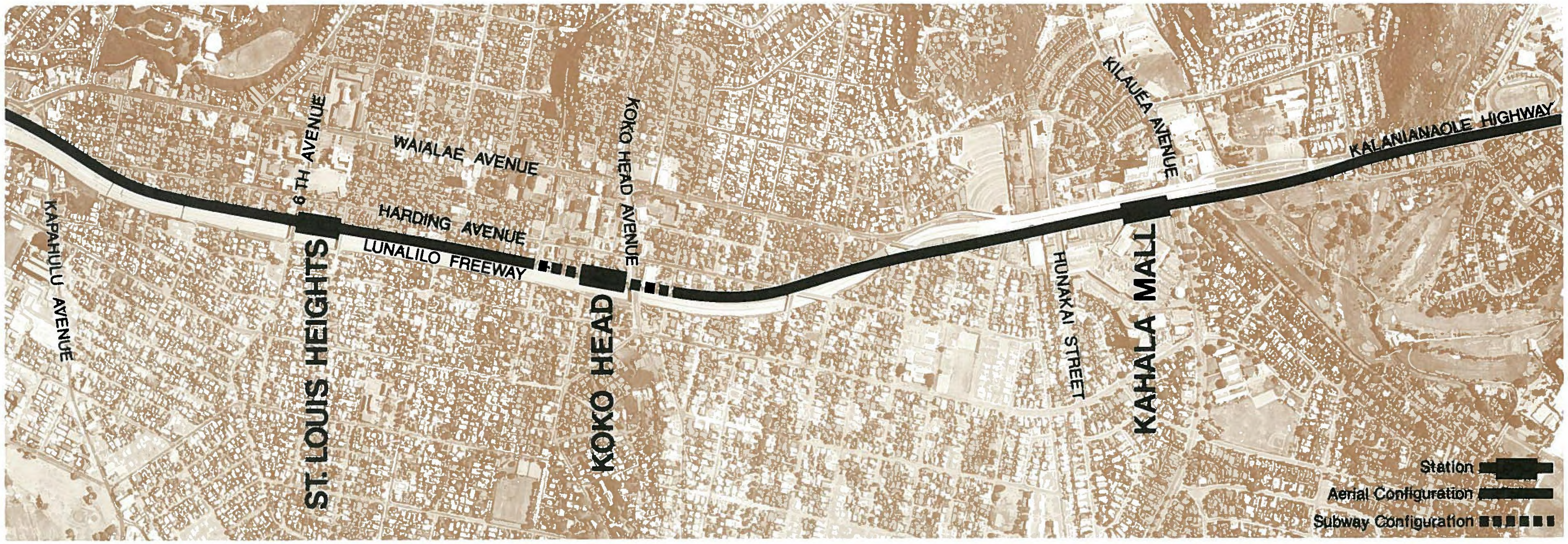
CITY AND COUNTY OF HONOLULU

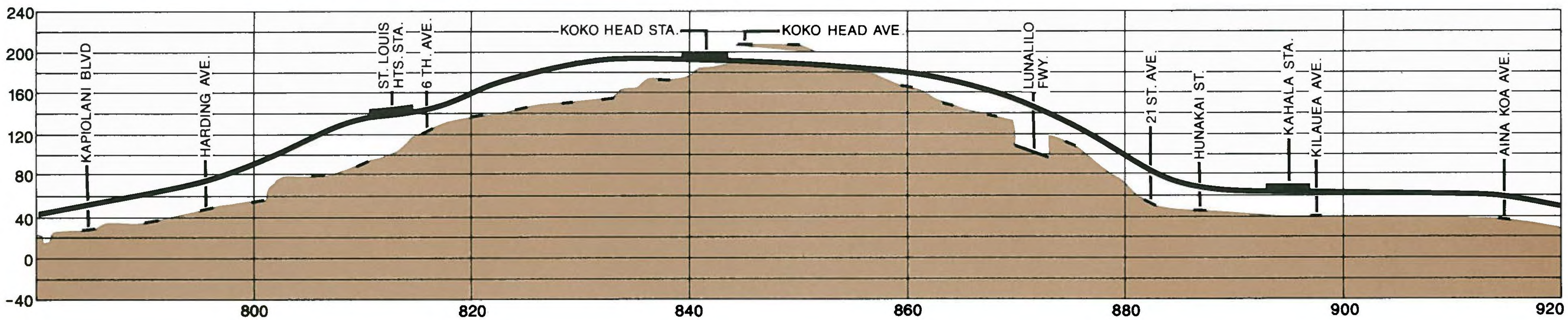
DANIEL, MANN, JOHNSON, & MENDENHALL

PLAN AND PROFILE

Ala Moana-Waikiki-University







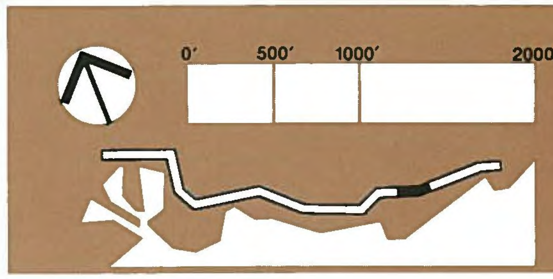
Preliminary Engineering Evaluation Program

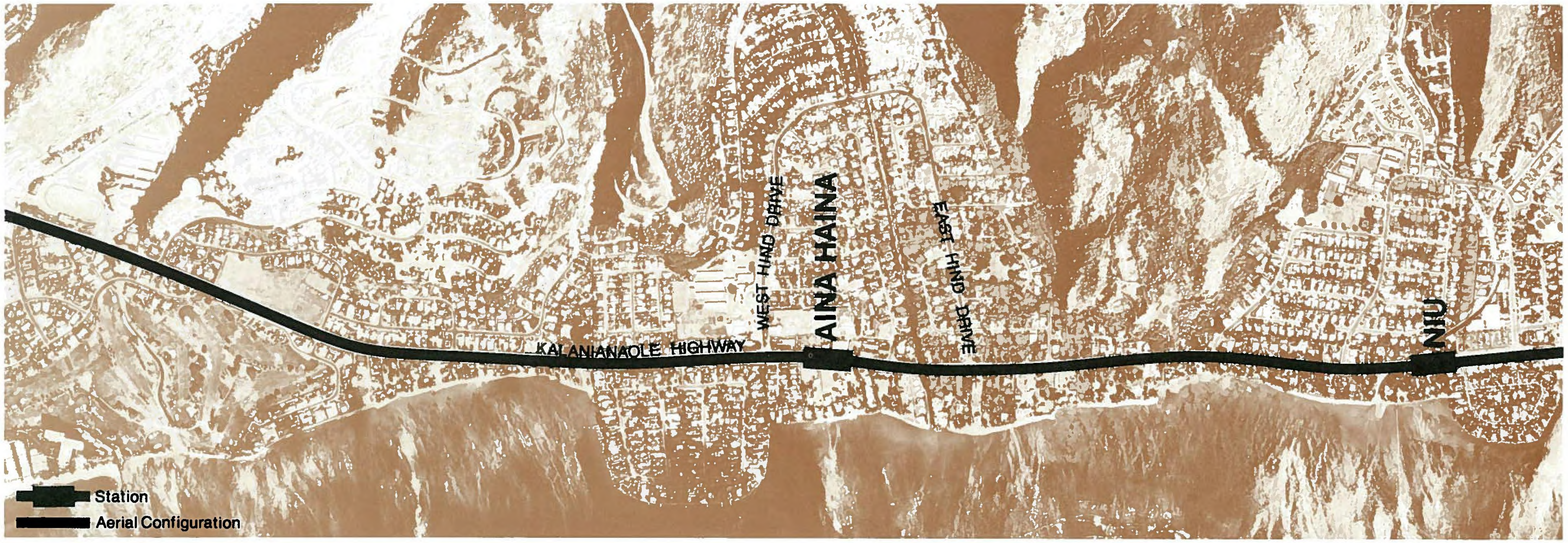
CITY AND COUNTY OF HONOLULU

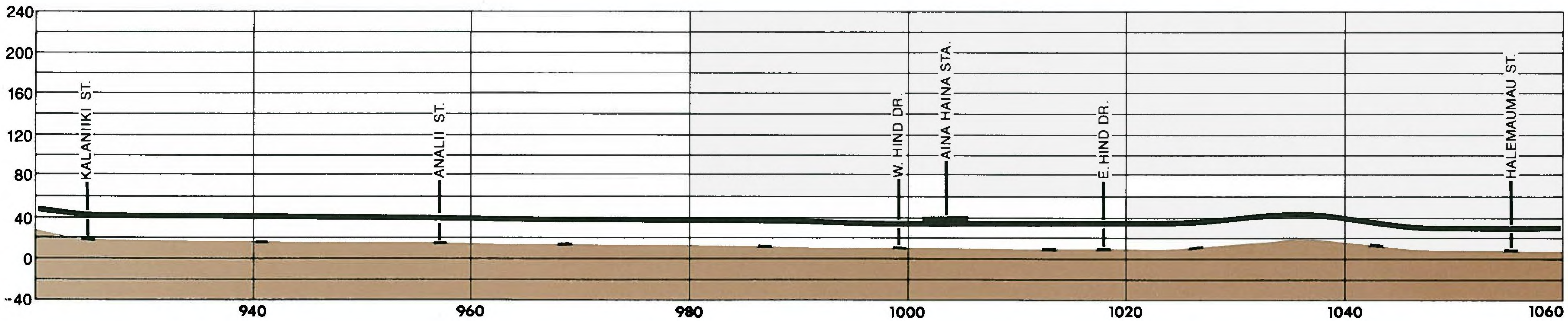
DANIEL, MANN, JOHNSON, & MENDENHALL

PLAN AND PROFILE

Kaimuki-Kahala







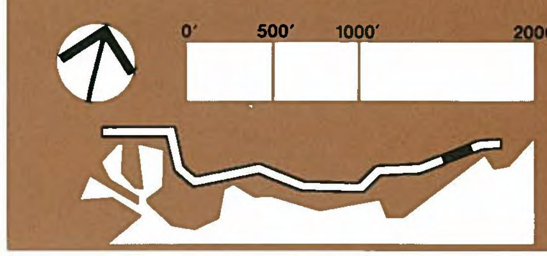
Preliminary Engineering Evaluation Program

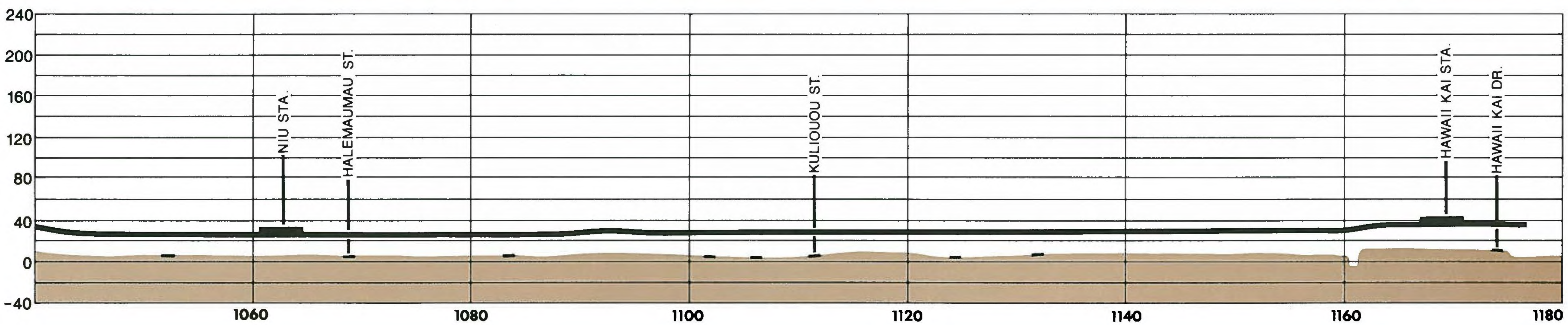
CITY AND COUNTY OF HONOLULU

DANIEL, MANN, JOHNSON, & MENDENHALL

PLAN AND PROFILE

Aina Haina-Niu





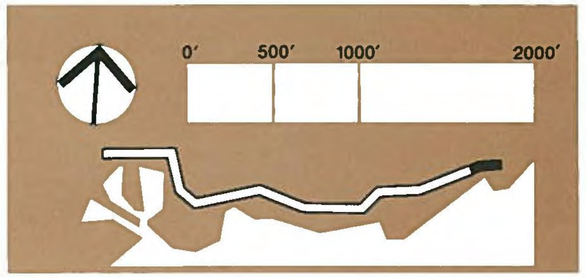
Preliminary Engineering Evaluation Program

CITY AND COUNTY OF HONOLULU

DANIEL, MANN, JOHNSON, & MENDENHALL

PLAN AND PROFILE

Hawaii Kai



appendix b

GLOSSARY OF TERMS

AIR CUSHION VEHICLE—A vehicle supported and moving on a thin film of air rather than on wheels.

AUTOMATIC TRAIN CONTROL (A.T.C.)—Automatic control system for transit operation. Electronic computers are used to regulate train speeds and provide stopping and starting of cars and opening and closing of car doors to insure safe, high-speed operation at minimum headways.

CAPITAL COST—The capital cost of the system is the cost of the construction of the complete system, right-of-way, engineering and architectural services, administration and legal services, pre-operating program, and contingencies. Also included are the costs of rolling stock.

CENTRAL BUSINESS DISTRICT, CBD, Downtown—The major business district of the city. In Honolulu, the area generally bounded on the mauka (north) side by Vineyard Boulevard, diamondhead (east) side by Richards Street, makai (south) side by Nimitz Highway, and Ewa (west) side by the Nuuanu Stream.

CONFIGURATION—The vertical placement of a transit line with respect to the ground (the three basic types are: aerial, on-grade, and subway, each with certain significant variations).

CONSIST—Number of car units in a train.

DEBT SERVICE (AMORTIZATION)—The annual payment of principal and interest to repay borrowed capital.

DYNAMIC BRAKING—Braking accomplished by using the traction motors operating as generators.

DWELL TIME—Time allotted for loading and unloading of passengers in a station.

FEEDER BUS SYSTEM—A bus route coordinated to bring transit riders from dispersed origins to a main trunk line station.

FIXED GUIDEWAY—The structure, guide track, and electrification system upon which a fixed or captive transit vehicle moves.

GRADE SEPARATION—The separation of intersecting streams of vehicular or pedestrian traffic by means of crossing structures or underpasses.

GRAVITY MODEL—A specific type of travel distribution model.

HEADWAY—The time interval between passages of consecutive vehicles or trains moving past a given point in the same direction.

INTERFACE—The transfer activity and facilities required for transfers between transportation modes, i.e., bus to train, etc.

"KISS AND RIDE"—Referring to a transit user being driven to and dropped off at a transit station by another member of his family.

MAIN TRUNK LINE—The fixed guideway, high volume portion of the rapid transit system.

MASS TRANSIT—Public transportation system operating on established schedules along designated routes with specific stops.

MAXIMUM LOAD POINT—The point on a route where the total number of passengers carried is a maximum. Generally, the total is for a 24-hour period in both directions. The maximum load point can also refer to peak-hour and/or a one-direction flow.

MODAL SPLIT—The breakdown of total travel according to the actual modes used—usually transit and automobile.

MODE OF TRAVEL—The means by which a trip is made. Generally these categories are: auto driver, auto passenger, transit passenger, and other modes.

MODEL—A mathematical expression of the relationship between various quantifiable conditions and characteristics.

OPERATING COSTS—All annual costs, including salaries, maintenance of equipment, supplies, and administrative expenses.

OPERATING REVENUE—The gross income from operation of the transit system, including basic and special fares, and income from charters, concessions, advertising, etc. It does not include interest from securities, non-recurring income from sales of capital assets, etc.

ON-LINE STATION—Transit station located along the main trunk line with access to vehicles moving in both directions of the line with no by-pass provision.

PARK AND RIDE—Referring to a situation of a transit user driving to a main trunk line station and leaving his automobile at a rapid transit station parking facility.

PEAK HOUR, A.M. PEAK, P.M. PEAK—The Peak Hour is the 60-minute period during an average weekday when the greatest number of people travel past a specific point on a specific route. The a.m. and p.m. peaks are the 1½ to 2 hours in the morning and afternoon when demand for transportation service is heaviest.

RAPID TRANSIT—Mass transportation distinguished from other transit by its operation at high average speeds over exclusive, grade-separated right-of-way.

ROUTE—A strip within a designated corridor (1-2 blocks wide), which denotes the general direction followed by a transit track.

SUBWAY—That portion of a transit line which is constructed beneath the ground surface, regardless of method of construction.

TERMINUS STATION—Transit station located at the terminus points of the main trunk line (with service provided in one direction only) requiring a section of guideway to allow vehicles to turn around or reverse direction.

TRAVEL ASSIGNMENT—The procedure of determining the exact path a person would follow in making a point-to-point trip through a network of specified routes.

TRIP—The one-way movement of one person between point of origin and point of destination: includes walking to and from the means of transportation.

TRIP GENERATION—The procedure of estimating the amount of travel demand for various purposes from a specific analysis area.

TRIP DISTRIBUTION—The procedure of estimating the geographic orientation in distance and direction of the travel demand from a specific analysis area.

HAWAIIAN DIRECTIONAL TERMS

DIAMONDHEAD—Toward Diamond Head Crater, generally in the easterly direction.

EWA—Towards the Oahu community of Ewa, generally in the westerly direction.

KOKOHEAD—Toward Koko Head Crater (generally referred to only east of Diamond Head Crater), generally in the easterly direction.

LEEWARD—Referring to the side of the Island of Oahu protected from the prevailing winds—generally the south-southwestern side of the Island.

MAKAI—Towards the sea, generally in the southerly direction.

MAUKA—Towards the mountains, generally in the northerly direction.

WINDWARD—Referring to the side of the Island of Oahu from which the prevailing winds blow—generally the north-northeastern side of the Island.

appendix C

REFERENCE AND OTHER SUPPORTING TECHNICAL DOCUMENTS

1. Draft Environmental Impact Statement
   - Volume 1—Project Description and Analysis for Regional and Local Impact
   - Volume 2—Air and Noise Pollution, Alternative Systems Evaluation, and Cost/Benefit Analysis
   - Volume 3—Appendices: Land Use Impact, Relocation Study, Air Pollution Study, Kalanianaole Highway Route Planning Addendum, Landscape Design Study, Waterborne System Study and Bus on Busway System Study
2. Long-Range Regional Transit Plan—Interim Report
3. Route Planning Studies
   - Volume 1—Introduction, Conclusions, Criteria and Evaluation Methodology
   - Volume 2—Alternative Route Evaluations
   - Volume 3—Computer Sensitivity Analysis
4. Preliminary Report on Fares and Fare Collection Systems (AMVA)
5. Evaluation of Transit Concepts and Vehicles—Interim Report
6. Patronage, Operations and Revenue (AMVA) Final Report
7. A Financial Plan for a Honolulu Rapid Transit System (Smith, Barney & Co., Inc.)
8. Preliminary Engineering Evaluation Program Costs and Benefits—Interim Report
9. Public Information Program Preliminary Engineering Evaluation—Honolulu Rapid Transit
10. Land Use Impact Study—Interim Report (DWA)
11. Preliminary Market Study (Environmental Capital Managers, Inc.)
12. Report on Alternative Route Potentials Through Chinatown, Downtown and the Civic Center
13. Waikiki Route Location and Sub-System Study Maps
14. Airport—Waikiki Express Study
15. Relocation Study (DWA)
16. Report on Organization Alternatives (Gottfried Consultants, Inc.)
17. Economic Impact Study—Transit Station Areas (Environment Capital Managers, Inc.)
18. Rapid Transit System and Goals and Objectives (Interim Report)
19. Patronage Study—Interim Report (AMVA)
20. Preliminary Investigation of Subway Construction (John Witte)
21. Progress Report on Geologic and Soils Engineering Services (Dames & Moore)
22. Survey of Construction Conditions on Oahu
23. Preliminary Report on Potential Use of Transit for Air Cargo and Air Mail Hauling (AMVA)
24. Preliminary Report on Air Passenger Patronage for Alternative Transit Systems (AMVA)
25. PEEP Public Information Program Planning Work Element 9 Prospectus and Task Approach
26. Preliminary Report on the Comparison of Pollution Emissions by Mode of Travel
27. Monorail Systems Analysis—A Supplement to the Interim Report on Evaluation of Transit Concepts and Vehicles
28. Report on Social Impact Investigations Child Care, Elderly, Handicapped (DWA)
29. Preliminary Implementation Schedule
30. Financial Resources Study Interim Report
31. Central Honolulu Urban Characteristics Maps and Overlays
32. Island-Wide Alternative Growth Pattern Maps
33. Kalihi-Palama Route Alternative Study Maps
34. Kalanianaole Highway Corridor Route Location and Configuration Studies

DRAWING LIST

ARCHITECTURAL

A-1	Pearl Ridge Station—Plans & Sections
A-2	Halawa Station—Plans & Sections
A-3	Airport Station—Plans & Sections
A-4	Airport Station—Plans & Sections
A-5	Airport Station—Plans & Elevations
A-6	Civic Center Station—Plans & Sections
A-7	Fort St. Station—Plans & Sections
A-8	Fort St. Station—Plans & Sections
A-9	Typical Air Station—Side Platform Plans & Sections
A-10	Ala Moana Station—Plans & Sections
A-11	Ala Moana Station—Plans & Sections
A-12	Waikiki Station—Plans & Sections
A-13	Waikiki Station—Plans & Sections
A-14	Waikiki Station—Plans & Elevations
A-15	Waikiki Station—Elevations & Plans
A-16	Koko Head Station—Plans & Elevations
A-17	Kahala Station—Plans & Sections
A-18	Aina Haina Station—Plans & Sections
AS-1	Pearl City Station—Site Plan
AS-2	Pearl Ridge Station—Site Plan
AS-3	Halawa Station—Site Plan
AS-4	Pearl Harbor Station—Site Plan
AS-5	Airport Station—Site Plan
AS-6	Keehi Lagoon Station—Site Plan
AS-7	Kalihi Street Station—Site Plan
AS-8	Liliha Street Station—Site Plan
AS-9	Fort Street Station—Site Plan
AS-10	Civic Center Station—Site Plan
AS-11	Ward Avenue Station—Site Plan
AS-12	Ala Moana Station—Site Plan
AS-13	Waikiki Station—Site Plan
AS-14	University Avenue Station—Site Plan
AS-15	St. Louis Heights Station—Site Plan
AS-16	Koko Head Avenue Station—Site Plan
AS-17	Kahala Station—Site Plan
AS-18	Aina Haina Station—Site Plan
AS-19	Niu Station—Site Plan
AS-20	Hawaii Kai Station—Site Plan

CIVIL

C-1 Drawing Index
C-2 Plan & Profile Station 0+100 to 62+00
C-3 Plan & Profile Station 62+00 to 130+00
C-4 Plan & Profile Station 130+00 to 186+00
C-5 Plan & Profile Station 186+00 to 260+00
C-6 Plan & Profile Station 260+00 to 314+00
C-7 Plan & Profile Station 314+00 to 380+00
C-8 Plan & Profile Station 380+00 to 450+00
C-9 Plan & Profile Station 450+00 to 504+00
C-10 Plan & Profile Station 504+00 to 570+00
C-11 Plan & Profile Station 570+00 to 630+00
C-12 Plan & Profile Station 630+00 to 693+00
C-13 Plan & Profile Station 693+00 to 764+00
C-14 Plan & Profile Station 764+00 to 832+00
C-15 Plan & Profile Station 832+00 to 905+00
C-16 Plan & Profile Station 905+00 to 971+00
C-17 Plan & Profile Station 971+00 to 1040+00
C-18 Plan & Profile Station 1040+00 to 1105+00
C-19 Plan & Profile Station 1105+00 to 1178+00
C-20 Car Storage & Maintenance Yard—Site Plan
C-21 Car Storage & Maintenance Yard—Layout Plan
C-22 Heavy Repair Shop, Inspection & Service Shop, and Washing Facilities—Plan & Section

STRUCTURAL

S-1 Drawing Index, Design Criteria & General Note
S-2 Typical At-Grade Way Structure
S-3 Typical Underground Way Structure & Cross Section at Civic Center Station
S-4 Typical Way Structure—Foundations
S-5 Typical Way Structure—Pier Cap and Column
S-6 Typical Aerial Girder—Details and End Connections
S-7 Typical Aerial Girder—Prestressing and schedule
S-8 Special Span Way Structure
S-9 Allowable Column Offsets and Retaining Wall Schedule
S-10 Typical Side Platform Aerial Station—Foundation & Concourse Plans
S-11 Typical Side Platform Aerial Station—Platform Plan
S-12 Typical Side Platform Aerial Station—Roof Plan
S-13 Typical Side Platform Aerial Station—Cross Section
S-14 Scheme 1 Center Platform Aerial Station—Plan & Section
S-15 Scheme 1 Center Platform Aerial Station—Cross Section
S-16 Scheme 2 Center Platform Aerial Station—Plan & Section
S-17 Scheme 2 Center Platform Aerial Station—Cross Section

ELECTRICAL

E-1 Utility Power & Propulsion Stations
E-2 Propulsion Stations & Sources of Power
E-3 Propulsion Stations & Sources of Power
E-4 Typical Feeder & Booster Cable Connections
E-5 Connections to Power Rails
E-6 Typical Light & Power Substations
E-7 Electrical Distribution in Yard
E-8 Central Control Electrical Display Board
E-9 Central Control Electrical Display Board
E-10 Central Control Electrical Display Board
E-11 Central Control Electrical Display Board
E-12 Central Control Panel
E-13 Central Control Panel

appendix d

PUBLIC INFORMATION PROGRAM

The goal of the public information program formulated for the Honolulu Rapid Transit Project was to prepare and disseminate information concerning the project as it was developed. This would provide the basis for government and citizen participation in the planning process. Through an extensive program of informational meetings, workshops, and seminars, a continuing dialogue was established and resulted in the development of a public transportation system which will respond to the goals and objectives of the community. To that end, the following civic and community organizations were partners in the rapid transit planning process:

CIVIC ORGANIZATIONS

- Life of the Land
- Citizens for Hawaii
- Downtown Improvement Association
- Waikiki Improvement Association
- Oahu Development Conference
- Outdoor Circle
- Ala Moana Improvement Association

COMMUNITY ORGANIZATIONS

- Windward Citizens Planning Conference
- Chinatown Association
- Aiea District Council
- St. Louis Heights Community Association
- Kaneohe Community Council
- Kailua Community Association
- Waimanalo Community Association
- Moiliili, McCully and Manoa Community Council
- Hawaii Kai Community Council
- Kahaluu Community Association
- Kapahulu Community Association
- Kaimuki Business and Professional Association
- Sunset Beach Community Association
- Kahuku Community Association
- Ewa Beach Community Association
- Waialae-Iki Ridge Community Association
- Waipahu Community Association
- Central Honolulu Association
- Mililani Town Community Association
- Kalihi Valley Community Association
- Pearl City Community Association
- Moanalua-Lakeside Community Association
- East Foster Village & Foster Village Community Association
- Aliamanu Community Association
- Palolo Community Association
- Wahiawa Community Association
- Waialua Community Association