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COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
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Comprehensive Study of Water
and Related Land Resources

Puget Sound and Adjacent Waters

State of Washington

Appendix VIII
Navigation

Puget Sound Task Force—Pacific Northwest River Basins Commission

March 1970

PARTICIPATION

STATE OF WASHINGTON

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Department of Commerce & Economic Development
Office of Nuclear Development
Department of Fisheries
Department of Game
Department of Health
Department of Highways
Department of Natural Resources
Department of Water Resources
Canal Commission
Oceanographic Commission
Parks and Recreation Commission
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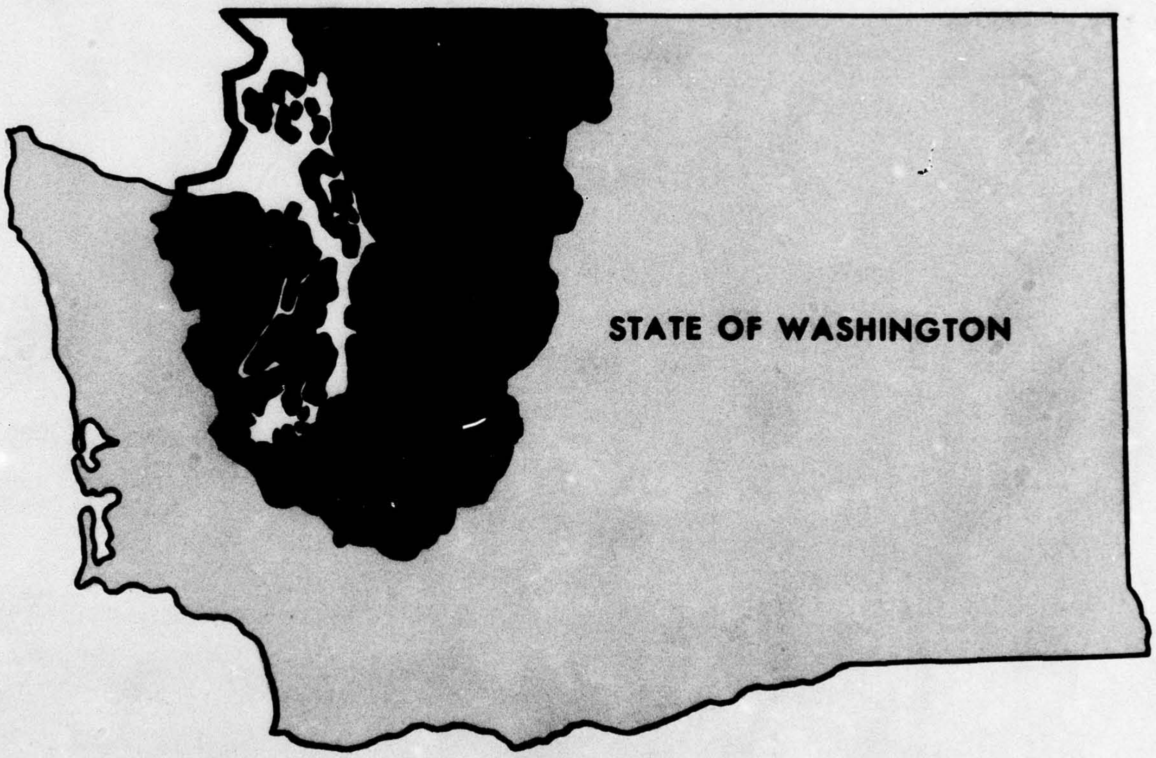

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Comprehensive Study of Water and Related Land Resources, Puget Sound and Adjacent Waters,

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APPENDIX VIII. NAVIGATION,

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Alfred T. Neale, Sydney Steinborn,
Lewis F. Kehne, Ernest E. Allen
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11 Mar 70

12 343p.

Navigation Technical Committee

ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE.

PUGET SOUND TASK FORCE of the PACIFIC NORTHWEST RIVER BASINS COMMISSION
1970

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FOREWORD

Appendix VIII, Navigation, contains a detailed report on the navigation component of the Comprehensive Water Resource Study of Puget Sound and Adjacent Waters. It is one of the technical appendices providing supporting data for the overall water resource study.

The Summary Report is supplemented by 15 appendices. Appendix I contains a Digest of Public Hearings. Appendices II through IV contain environmental studies. Appendices V through XIV each contain an inventory of present status, present and future needs, and the means to satisfy the needs, based upon a single use or control of water. Appendix XV contains the formulation of basin plans.

The purpose of this appendix is to inventory the present terminal facilities, harbors, channels, small boat harbors, and related industrial development; evaluate the future needs for new development to meet the predicted population and industrial growth; and propose a single purpose plan to meet the immediate and long term needs for waterborne transport facilities.

River-basin planning in the Pacific Northwest was started under the guidance of the Columbia Basin Inter-Agency Committee (CBIAC) and completed under the aegis of the Pacific Northwest River Basins Commission. A Task Force for Puget Sound and Adjacent Waters was established in 1964 by the CBIAC for the purpose of making a water resource study of the Puget Sound based upon guidelines set forth in Senate Document 97, 87th Congress, Second Session.

The Puget Sound Task Force consists of ten members, each representing a major State or Federal agency. All State and Federal agencies having some authority over or interest in the use of water resources are included in the organized planning effort.

The published report is contained in the following volumes.

SUMMARY REPORT

APPENDICES

I. Digest of Public Hearings
II. Political and Legislative Environment
III. Hydrology and Natural Environment
IV. Economic Environment
V. Water-Related Land Resources
V. a. Agriculture
b. Forests
c. Minerals
d. Intensive Land Use
e. Future Land Use
VI. Municipal and Industrial Water Supply
VII. Irrigation
VIII. Navigation
IX. Power
X. Recreation
XI. Fish and Wildlife
XII. Flood Control
XIII. Water Quality Control
XIV. Watershed Management
XV. Plan Formulation

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Other Port Authorities in Puget Sound
Washington Public Ports Association
Washington Department of Commerce and Economic Development
Washington Department of Highways
Washington State Canal Commission
American Association of Railroads

APPENDIX VIII
NAVIGATION

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FIGURES

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CONTENTS—Continued

INTRODUCTION

The navigation resources of the Puget Sound Area, combining deep water ports easily accessible from the Pacific Ocean with sheltered waterways and saltwater beaches is a priceless heritage for future generations. The use of this resource requires cooperative planning on a continuous basis to insure that the needs for commercial developments are met in a manner which preserves environment. Navigation use of the Puget Sound Area has been one of the several reasons for its rapid economic growth. The deep waters can serve the largest ships afloat. Pleasure boating is readily available to all residents with the Area having one of the highest per capita participation rates of any area in the Nation. The accommodation of these demands makes navigation one of the most important components of the Comprehensive Study of Puget Sound and Adjacent Waters. This appendix assess the present situation of navigation, including pleasure boating, evaluates its future demands and presents an orderly plan for accommodating these needs.

PURPOSE AND SCOPE

The objective of the navigation study was to develop plans for navigation improvements to meet foreseeable short- and long-term needs of shallow and deep draft commerce, transport oriented industry, and recreational boating. The study included an inventory of harbors, channels, small boat basins, terminal facilities and support areas, vessels, waterborne commerce, water-oriented industries, and potential sites for navigation related developments. Investigations were made of existing problems related to physical limitations of channels, harbors, terminal facilities, support areas, and water transport oriented industrial development. Future demands for terminal facilities and water transport oriented industries were projected as were waterborne commerce and moorage demand by pleasure craft. From these projections and the inventory of existing facilities, needs for future navigation-related development were determined. Plans were then formulated to meet the needs. In keeping with the methodology employed in the comprehensive study of Puget Sound and Adjacent Waters the navigation study was undertaken on a single-purpose basis with no attempt made to resolve possible conflicts with other resource uses.

DESCRIPTION OF AREA

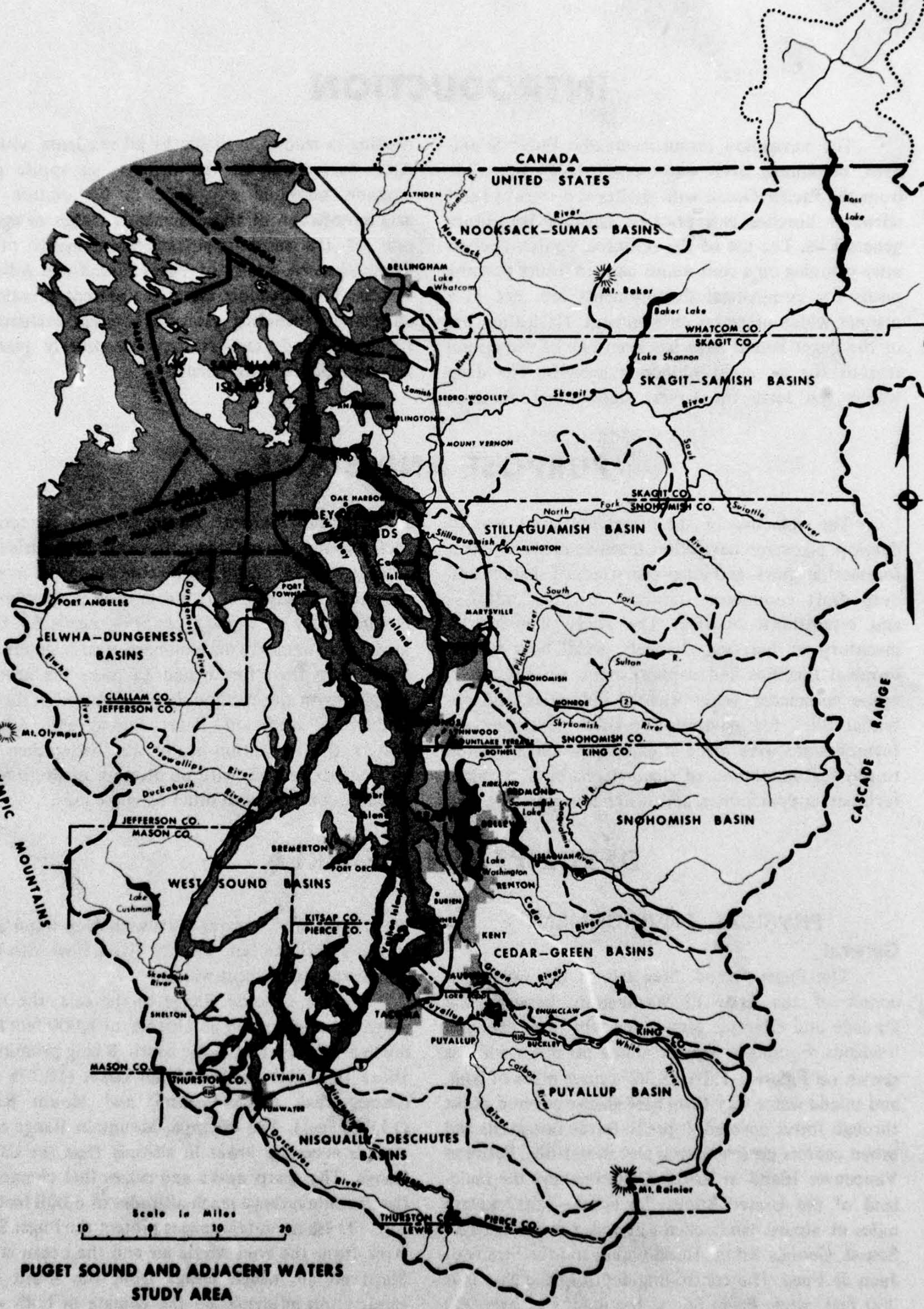
PHYSICAL ENVIRONMENT

General

The Puget Sound Area lies in the northwest corner of the State of Washington, between the Cascade and Olympic Mountains with near sea level lowlands forming a trough about 50 miles wide as shown on Figure 1-1. Its 13,367 square miles of land, and inland water vary from bare glacier covered peaks through forest covered slopes to fertile farmlands and urban centers on river deltas and shorelands. Between Vancouver Island in British Columbia and the mainland of the United States, lie nearly 2,500 square miles of almost landlocked salt water forming Puget Sound, Georgia Strait, Hood Canal, and the Straits of Juan de Fuca. The controlling depth in the Straits is 200 feet, while Puget Sound has depths of over 900 feet. There are 10 major ports with deep water access to the Pacific Ocean. Twenty rivers flow into Puget Sound and its adjacent waters.

In the Cascade Range to the east, the higher ridges generally reach an altitude of 8,000 feet in the north and 5,000 feet in the south. Rising prominently above this ridge line are Mount Baker (10,778 feet); Glacier Peak (10,541 feet); and Mount Rainier (14,410 feet). The Olympic Mountain Range to the west is generally lower in altitude than the Cascade Range. The sharp peaks and ridges that characterize this mountain range reach altitudes of 6,000 feet.

These mountain ranges protect the Puget Sound Area from the cold Arctic air and the ocean storms. Maritime air which enters from the south has a moderating influence on the climate in both winter



Basins in the Puget Sound Area

1966

FIGURE 1-1

and summer. Mean annual precipitation varies from less than 20 inches in the lowlands of the Elwha-Dungeness Basins to 120 to 180 inches along the upper reaches of the Cascade Mountains. Seventy-five percent of the precipitation occurs in the 6-month period, October through March, with winter precipitation falling as rain below 1,500 feet altitude, as snow or rain between 1,500 and 2,500 feet, and as snow at the higher altitudes. Although extremely warm temperatures as high as 95°F to 100°F, have been recorded in the lower valleys, high temperatures usually range from 85°F to 90°F to 15 days per year. Mean temperatures range from 70°F during the summer to 30°F to 40°F during the winter.

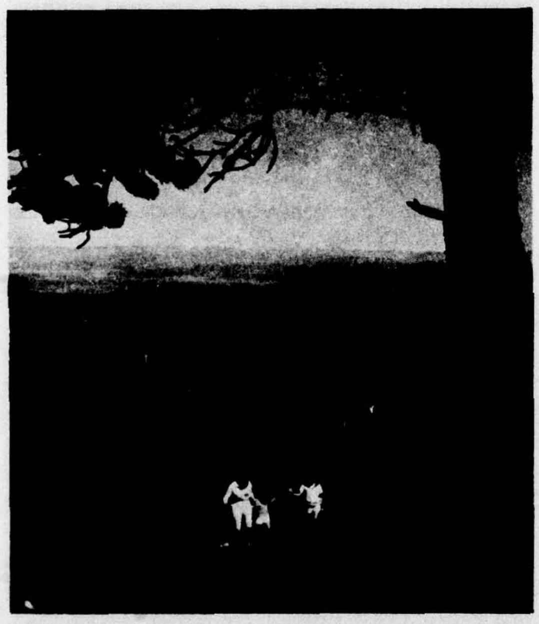


PHOTO 1-1. Marine waterways cover about 2,500 square miles, giving a maritime air to the Puget Sound Area.

The rivers of the Puget Sound Area vary from a few miles to 135 miles in length. Glaciers, located at the higher elevations are the source for many of these streams, extending stabilizing influences on summertime low flows. The upper portions of most basins are characterized by narrow mountain valleys with steep gradients which drain forested areas. In the lowlands, rivers follow meandering courses across the flood plains. The total runoff for the Puget Sound Area during the period 1931-1960 averaged about 38,865,000 acre-feet per year. Average annual runoff ranges from 15 inches in some of the northern lowlands to as much as 140 inches in a few mountain area. Additional climatic and hydrological data are given in Appendix III, Hydrology and Natural Environment.

PHOTO 1-2. Mountains and forested foothill typify upper reaches.

Tides and Currents

The mean daily (or diurnal) range of the tide in the Puget Sound Area varies from 7.20 feet at Port Angeles to 14.45 feet at Olympia. The maximum range varies from 14.5 feet at Port Angeles to 22.5 feet at Olympia. At Seattle, in Elliott Bay, the mean daily range is 11.30 feet and the difference between maximum observed high tide and minimum observed low tide is 19.3 feet.

In Admiralty Inlet and Puget Sound the tidal currents are subject to daily inequalities similar to those of the tides.

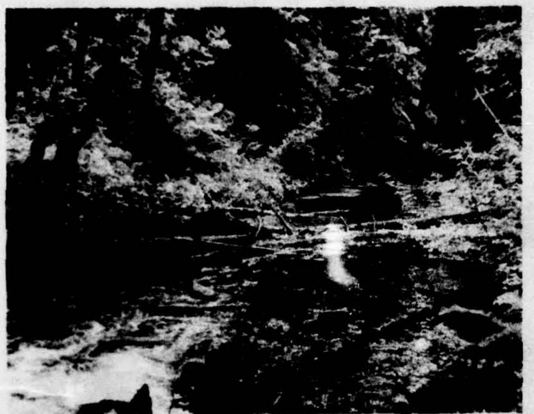


PHOTO 1-3. Picturesque streams, deep river canyons, and midland plateaus lie between the mountains and lowlands.

HISTORY

Although three centuries after the discovery of America, the Pacific Northwest was still an unknown wilderness to the people of Europe, it actually was visited many times from the sea.

The initial visit was on the first centennial of Columbus' discovery of America by a Greek pilot sailing under the Spanish flag, under the name of Juan de Fuca. He claimed that in 1592, sailing along the west coast of North America, he had entered a broad strait while searching for a Northwestern Passage. His discovery was recorded in a book titled "The Pilgrims" published in 1625, as follows:

> "I met in Venice, in 1596, an old Greek mariner called Juan de Fuca, but whose real name was Apostolos Valerianos, who stated that in 1592 he sailed in a small caravel from Mexico in the service of Spain along the coast of Mexico and California until he came to the latitude of 47 degrees, and there, finding that the land trended north and northeast, with a broad inlet of sea, between 47 degrees and 48 degrees of latitude, he entered sailing therein more than 20 days; and at the entrance of the said strait there is, on the northwest coast thereof, a great headland or island with an exceedingly high pinnacle or spired rock, like a pillar thereon."

Two centuries later, in 1792, Captain George Vancouver, commanding the ships Discovery and Chatham, passed the mouth of the Columbia River without finding any entrance. On the afternoon of 28 April 1792 his ships anchored off Destruction Island because of a sudden calm. He had sailed some 300 miles along the west coast of "North America" without seeing another human being, but in sight of a beautiful, fertile, wooded shore. The next morning, while still anchored, he caught sight of another vessel coming up over the western horizon, with the Stars and Stripes at the masthead. It was the Columbia, 19 months out of Boston, commanded by Robert Gray, who had entered Puget Sound and discovered Victoria harbor.

Captain Gray generously revealed all his discoveries to Captain Vancouver, who than sailed northward to Cape Flattery and entered the Straits of Juan de Fuca, spending the greater part of May and June exploring Hood Canal and Puget Sound. Vancouver's crew included Second Lieutenant Peter Puget, for whom Puget Sound is named. Other crew members for whom landmarks were named were Lieutenant Joseph Baker (Mt. Baker) and Master Joseph Whidbey (Whidbey Island).

In 1833, the first white settlement on Puget Sound, Fort Nisqually, was built by the Hudson's Bay Company on the delta of the Nisqually River. Two years later this outpost became the home port of the first Pacific Coast steamer, the Beaver. About 1845, the McAllister family settled at Tumwater, founding the first American settlement on Puget Sound.

When the settlers migrated westward, they did so in search of farm land; however, those who came to the shores of Puget Sound were initially drawn there because of the forests. They found that the shores of the Sound were lined with tall, virgin timber of the finest quality. The proximity of this type of timber to tidewater answered the need for piling and ship spars developing elsewhere on the west coast. As a result, logging operations were soon underway.

Puget Sound soon was attracting ships which otherwise might have entered the Columbia River for lumber cargoes. An early paper stated, "every vessel can save from five to six hundred dollars in pilotage and towing by coming to the Puget Sound after their cargoes, instead of the Columbia River." The Coast Survey of 1855 listed 16 sawmills on Puget Sound with a total output of 85,000 board feet of lumber per day.

By 1855, shipments were going to many points along the west coast and to world markets as well. By 1913, the newspaper at Port Townsend reported 5,943,826 tons of commerce cleared by Puget Sound ports, most of which was timber or timber products.

The Puget Sound Area today supports a large diversified, forest based industry. Local manufactures of lumber and other timber products provide a large share of the national demand for timber products. In 1962, the Puget Sound Area supplied approximately 8 percent of the softwood lumber, 12 percent of the softwood and 34 percent of the wood pulp consumed in the United States.

The purchase of Alaska in 1867 and the subsequent discovery of gold in 1897 caused a dramatic increase in activity on the Seattle waterfront. Shortly after the advent of dry land farming in eastern Washington, northern Idaho and Montana in about 1866, wheat and other small grains were exported overseas through Seattle. The tonnage of small grain exports from Puget Sound ports averaged 1.3 million tons annually from 1956 to 1965.

The Puget Sound Area emerged from a pioneer way of life in slightly more than a hundred years. Approximately two million persons, or about 60 percent of the population of the State of Washington now live in this Area.

Although the waterborne commerce of the area did not recover from the slump of the 1930 depression years until the 1950's, the trend has been for general increase for more than 10 years. Foreign and domestic coastwise traffic increased from about 11,000,000 tons in 1952 to over 17,000,000 tons in 1966. During this same period the annual domestic internal traffic in the area increased from about 20,000,000 tons to 24,600,000 tons. The total waterborne traffic has averaged about 45 million tons for the five years concluding in 1966. Major contributors to the increasing waterborne traffic are: forest products, fisheries, oil refineries, aluminum production, chemicals, local construction, aerospace and related industries.

Port authorities and private industries are responding to the increasing shipping demands by actively improving and expanding their terminal facilities. Adequate facilities are necessary to sustain the region's economic growth as related to water transportation.

PRESENT DEVELOPMENT

Economy

The Seattle, Tacoma, and Everett metropolitan areas contain a large and growing industrial community that is heavily oriented toward activities in aerospace, shipbuilding, maritime trade, transportation and diversified manufacturing. The Boeing Company's aerospace industry constitutes the Area's leading industrial employer. These cities also serve as the major shipping and trading centers on Puget Sound, which has many inlets, bays, and harbors, and fine deep-water facilities for ocean-going vessels.

Government activities also play a major role in the economy. The Puget Sound Naval Shipyard, second largest industrial employer in the Area, dominates the economy of Bremerton and the Kitsap peninsula. McChord Air Force Base and Fort Lewis are major sources of personal income in the Tacoma area. Activities providing government services contribute heavily to the economy of Olympia, the State capitol, and vicinity.

In the remainder of the Area, economic activities center around forest product industries, commercial fishing, farming, and miscellaneous light industries.

Accompanying the desirable effects of improved and expanded economic opportunities are changes in population distribution and further urbanization, increasing the demands on shoreland along saltwater bodies. In addition, the increase in population accompanying the economic growth produces additional requirements for recreational sites. These demands reduce the acreage available for industrial and commercial use. This accelerating need for recreational land promises to continue as the Area becomes more industrialized.

The population trend in the Puget Sound Area, in keeping with increased industrialization, displays rapid growth. Census figures show nearly a 10 percent increase between 1960 (1,768,000) and 1965, (1,942,700). Since 1940, the population has more than doubled.

PHOTO 1-4. The urban skyline—Seattle, Washington.

Census estimates for 1966 include 14 cities in the Area with populations greater than 10,000. There is an uneven distribution of population resulting from differences in topography, accessibility, and recent industrialization. Nearly 75 percent of the populace resides in or adjacent to the Everett, Seattle and Tacoma metropolitan areas. In contrast, the western and northern portions of the Puget Sound Area are sparsely populated. The rapid increase in population will likely continue and will place an added burden on the water and land resources.

PHOTO 1-5. Agriculture and forest harvesting support many small communities, which contain only a small percentage of the population.

Land Use and Transportation

Land Use and Ownership. The present pattern of land use ranges from areas with intense residential, commercial, and industrial concentrations to undeveloped cut-over lands and areas of second-growth timber. A general land use picture is shown on Figure 1-2 and in Table 1-1.

PUGET SOUND AND ADJACENT WATERS STUDY AREA 1966

Generalized Land Use

FIGURE 1-2

TABLE 1-1. Puget Sound Area, present land use and ownership (acres in thousands)

		Land Ownership					Land Use						
		Federal	State	County and City	Private	Total	Crop Land	Range Land	Forest[1]	Rural Non-Farm	Urban Build-Up	Fresh Water	Total
Nooksack-Sumas	Acres	277	87	7	437	808	137	12	610	13	21	12	804
	% Basin	3.2	1.0	0.1	5.1	9.4	1.6	0.1	7.1	0.1	0.2	0.1	9.4
Skagit-Samish	Acres	1,378	107	8	433	1,936	100	20	1,753	20	19	35	1,948
	% Basin	16.1	1.2	0.1	5.2	22.5	1.2	0.2	20.5	0.2	0.2	0.4	22.7
Stillaguamish	Acres	178	72	2	190	442	36	1	385	6	7	5	438
	% Basin	2.1	0.8	0.0	2.2	5.2	0.4	0.0	4.5	0.1	0.1	0.1	5.1
Whidbey-	Acres	8	6	1	119	134	23	2	84	12	11	1	134
Camano Is.	% Basin	0.1	0.1	0.0	1.4	1.6	0.3	0.0	1.0	0.1	0.1	0.0	1.6
Snohomish	Acres	430	142	56	588	1,216	72	2	1,065	29	36	24	1,218
	% Basin	5.0	1.7	0.7	6.9	14.2	0.8	0.0	12.3	0.3	0.4	0.3	14.2
Cedar-Green	Acres	76	24	116	520	736	63	3	477	34	166	39	743
	% Basin	0.9	0.0	1.4	6.1	8.6	0.6	0.0	5.2	0.4	1.9	0.5	8.7
Puyallup	Acres	307	19	13	439	779	37	6	593	26	97	11	770
	% Basin	3.5	0.2	0.2	5.1	9.1	0.4	0.1	6.9	0.3	1.1	0.1	9.0
Nisqually-	Acres	135	64	5	447	650	46	43	507	20	20	10	646
Deschutes	% Basin	1.6	0.7	0.1	5.2	7.6	0.5	0.5	5.9	0.2	0.2	0.1	7.5
West Sound	Acres	368	122	20	782	1,291	46	5	1,124	64	42	13	1,294
	% Basin	4.3	1.4	0.2	9.2	15.1	0.5	0.1	13.1	0.8	0.5	0.1	15.1
Elwha-	Acres	332	27	2	80	442	24	2	409	5	6	2	448
Dungeness	% Basin	3.9	0.3	0.0	0.9	5.2	0.3	0.0	4.7	0.1	0.1	0.0	5.2
San Juan Is.	Acres	1	9	1	101	113	19	9	72	9	3	1	113
	% Basin	0.0	0.1	0.0	1.2	1.3	0.2	0.1	0.8	0.1	0.0	0.0	1.3
TOTAL	Acres	3,490	679	232	4,147	8,547	592	106	7,039	239	428	152	8,557
	% Basin	40.8	8.0	2.7	48.4	100.0	6.9	1.2	82.2	2.8	5.0	1.8	100.0

[1] Including open and barren land associated with forest areas.

Source: Appendix V, Water-Related Land Resources.

Forest land predominates and accounts for 82 percent of total land use. The area contains sevcn million acres of forests, most of which are capable of producing a timber crop of commercial quality. Much of the forest land is under Federal jurisdiction (about 43 percent of the total), and the remainder is held in State and private ownership.

There are over 591,000 acres of cropland in the Puget Sound Area which is about seven percent of the total land use. Agricultural operations are confined largely to the wide, fertile lowlands which are utilized for fruit, berry, and vegetable growing and also for dairying and poultry raising. Cropland is well established in the river valleys of the Nooksack, Puyallup, Green and Sammamish, Skagit and Elwha-Dungeness basins (See Figure 1-1). Crop and pasture lands are

PHOTO 1-6. Manufacturing, shipping, trading and financial activities, with dense urban buildups, center around natural harbors.

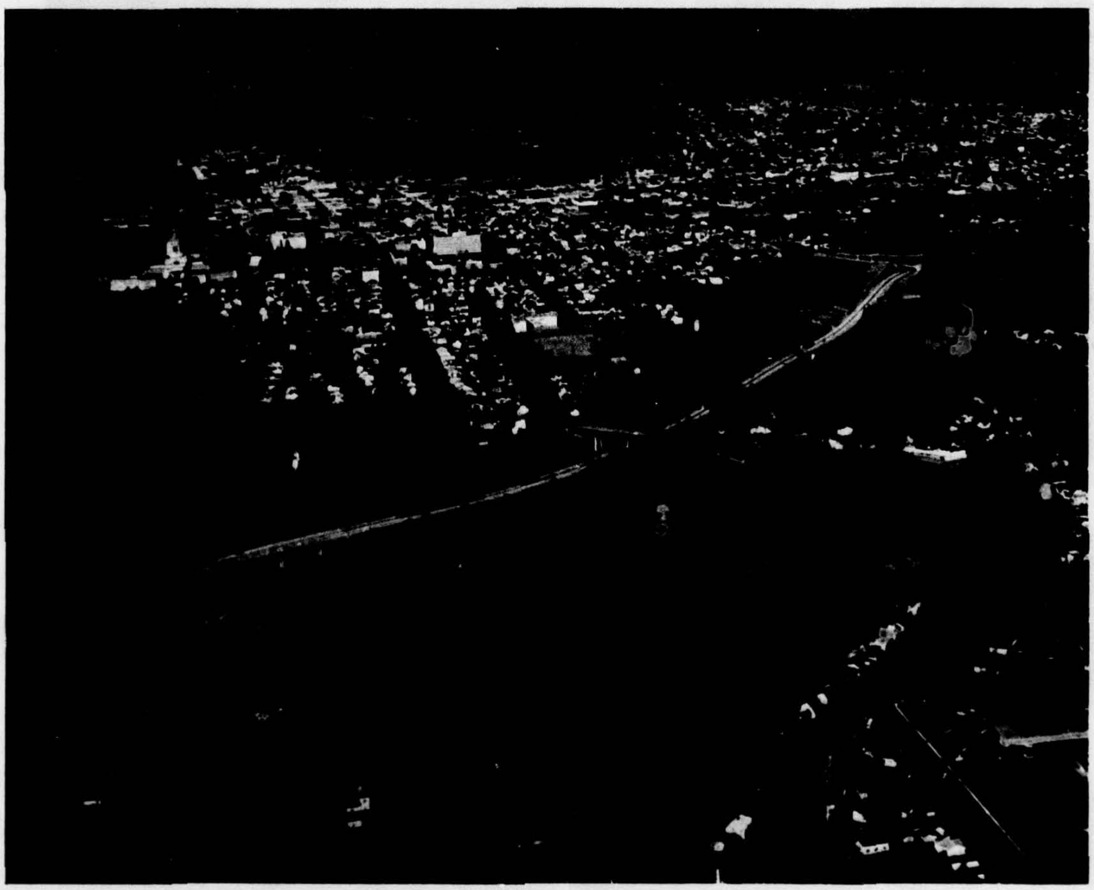


PHOTO 1-7. Commercial use of land—downtown Olympia.

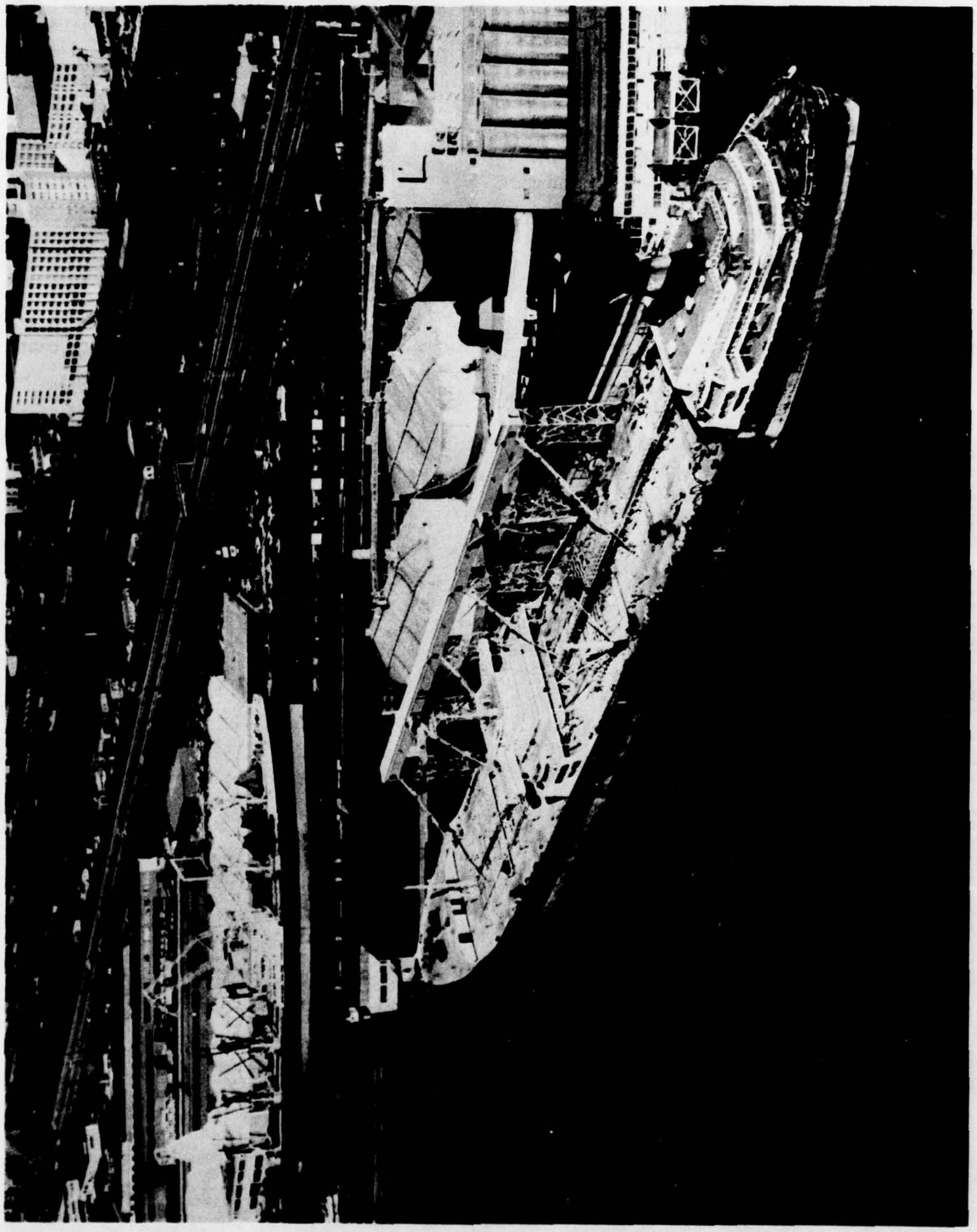


PHOTO 1-8. Manhattan.

not extensive in the Area, but the resulting production is very important to the general economy.

Urban buildup accounts for five percent of total land use of the Area. Most urban development, to date, is found adjacent to the shores of Puget Sound and in the lowlands. Heavy industry is concentrated along the shores of Commencement Bay and Elliott Bay, on the tideflats near the mouth of the Puyallup River, and in the lower Duwamish River area. Developed lands are concentrated in the Central Division where the Seattle-Tacoma-Everett metropolitan and industrial complex and numerous small cities and suburban residential areas comprise approximately two-thirds of the Area's total urban land use. Inland waters–streams and lakes–make up about two percent of the total land use. The fresh waters are utilized for outdoor recreation, salmon spawning grounds, various types of industrial operations and domestic water supply. The present pattern of land ownership in the Area is 41 percent Federal, 11 percent State and local, and 48 percent private. Most of the Federally-owned lands lie in the national forests and national parks.

The major centers of urban population are located in the lowlands along the east shore of Puget Sound–Seattle (580,000)[1], Tacoma (156,000) and Everett (52,000). Along the west shore of Puget Sound, the largest city is Bremerton (36,900). The most important urban center in the north is the city of Bellingham (36,500). The cities of Port Angeles (15,800) and Olympia (21,400) are the urban centers in the western part of the area.

At the present time, the combined population of Seattle and Tacoma represent about one-third of the total population of the Area, and when suburban areas are included their share increases significantly. As these cities and the city of Everett continue to expand, a single urban area extending from Tacoma on the south through Seattle to the city of Everett on the north will develop.

Transportation. The Puget Sound Area is served by all forms of transportation. Figure 1-3 shows the principal transportation routes.

Four major transcontinental railroads: Northern Pacific, Milwaukee Road, Great Northern and Union Pacific offer direct routings and expedited service between Seattle and Chicago, the Twin Cities, Omaha, Kansas City, St. Louis, Denver and points east of the Mississippi River. Three lines have connections with the Canadian lines to the north, and three lines have connections to the Portland-Vancouver area and thence to the south and east. Two lines have connections to the Grays Harbor area and one has a branch line to Bremerton. A line from Port Townsend to Port Angeles is served by rail-barge connection.

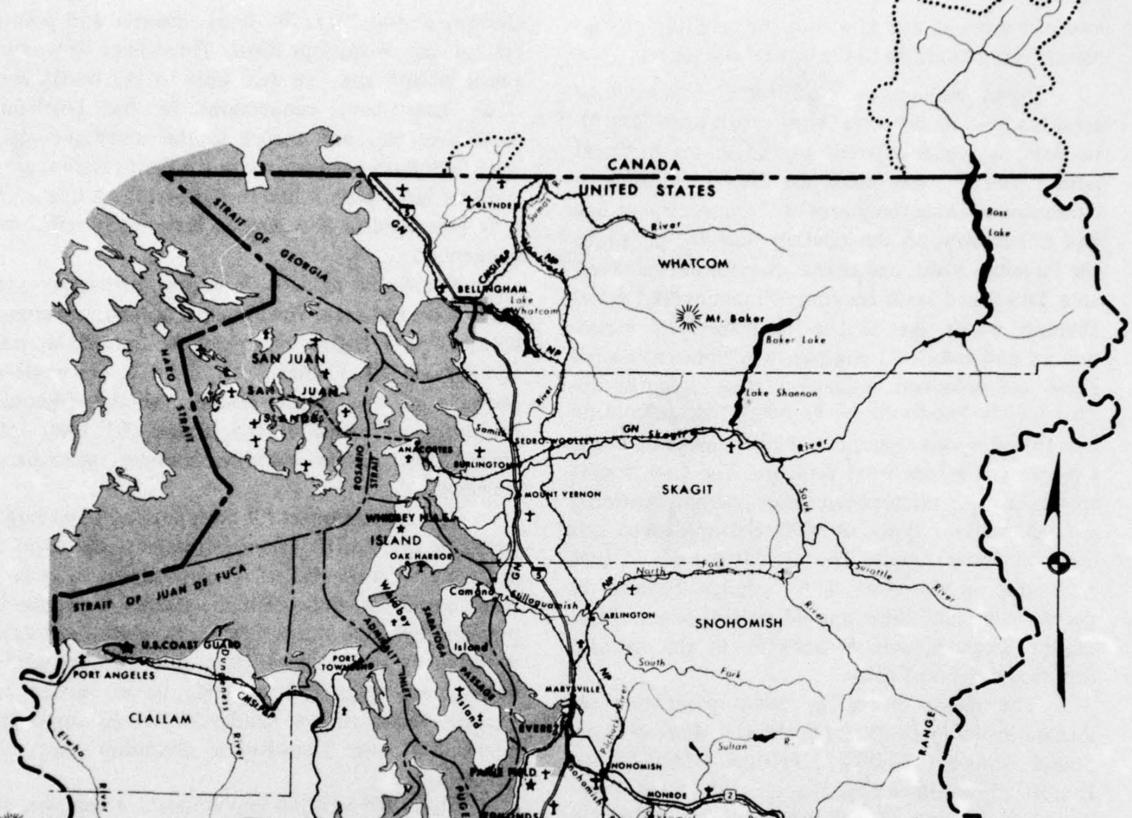
Numerous modern freeways, highways, and roads serve the Area. The principal north-south artery is Interstate 5. Highways crossing the Cascade Mountains include U.S. Routes 2, 10, and 410. The western portions of the Puget Sound, on the Olympic Peninsula, are served by U.S. Route 101. Over 150 truck lines provide common contract, specialized transport.

The largest airport for both passenger and cargo traffic is the Seattle-Tacoma International Airport, but there are a number of smaller airports in various communities of Puget Sound. Domestic service is provided by seven major airlines. Service to Alaska is provided by four airlines. There are two transpacific airlines and two lines provide direct service to Europe. Major airlines handle import air cargo (in connection with Trans-Pacific steamship lines) on Sea-Air rates.

From half a dozen lumber ports, a complex of ports now serves the region. Figure 1-4 shows the location of major ports and gives information on the controlling depth at the harbor entrance, facilities available at the ports and present valuations. The total valuation of waterfront facilities at these ports was estimated at approximately $100 million on a depreciated basis in 1967. The controlling depth at the harbor entrances at most ports is practically unlimited, while at waterways and at berths along docks, the controlling depth varies from 25 to 70 feet. These ports are among few natural harbors of the world which can handle "super bulk carriers," such as the "Manhattan" which has a draft of 51 feet fully loaded.

Ports of the Puget Sound Area have the full range of facilities required to handle both bulk and general cargo efficiently, including containerization facilities and backup areas. Many of the ports provide small boat moorage facilities for recreation boating and accommodations for commercial fishing fleets. Registered pleasure boat ownership was about 62,000 in 1966, creating large demands on small boat facilities. In 1964, 48,000 persons were employed directly, or were engaged in work dependent on

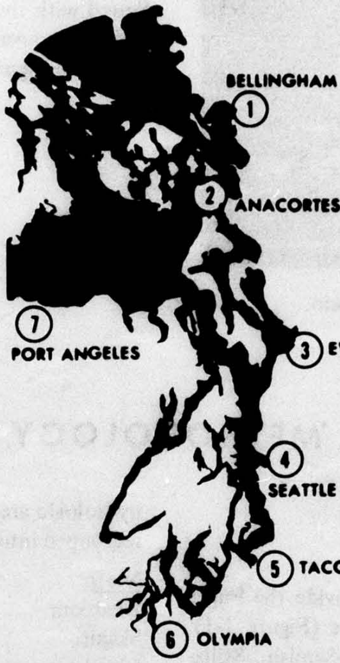
[1] 1967 estimated population. Planning and Community Affairs Agency, State of Washington.



Transportation Facilities in the Puget Sound Area

FIGURE 1-3

Major Ports of Puget Sound



No.	Major Ports of Puget Sound	Controlling Depth at Harbor Entrance (feet)	No. of Berths–1966: General Cargo	Commercial Fish	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk
1.	Bellingham	Unlimited	7	15	--	9	11	5	1
2.	Anacortes	50	4	14	--	3	11	1	--
3.	Everett	Unlimited	11	2	--	26	7	2	2
4.	Seattle	Unlimited	45	17	2	32	52	35	5
5.	Tacoma	Unlimited	15	1	2	29	11	14	2
6.	Olympia	40	5	--	--	17	5	2	--
7.	Port Angeles	Unlimited	7	4	--	4	3	4	1

FIGURE 1-4

PHOTO 1-9. Port of Edmonds, boat basin.

waterborne commerce. The total estimated direct value of goods, services, payroll and sales, related to waterborne commerce, amounted to $1.1 billion.

The ferry system operated by the State of Washington connects the eastern shore of Puget Sound with the many islands, the Olympic Peninsula and Vancouver Island, B.C. The ferry routes are shown on Figure 1-3.

METHODOLOGY

DELINEATION OF STUDY AREA

Natural topographic features divide the Puget Sound Area into 11 drainage basins (Figure 1-1). They are: Nooksack-Sumas, Skagit-Samish, Stillaguamish, Snohomish, Cedar-Green, Puyallup, Nisqually-Deschutes, West Sound, Elwha-Dungeness, San Juan, and Whidbey-Camano. Ridgelines running from the slopes of the Cascade or Olympic Mountains to Puget Sound bound each of these basins except the latter two, which are island groups. The other nine basins share similar topographic characteristics: one or more rivers, mountainous terrain in the upper reaches, deep valleys and canyons in the central portions, and plains and deltas in the lowlands.

PROCEDURE

The inventory phase of the study was based upon information available as of 1966. Reliance was placed upon published and unpublished reports, data from ongoing specific project studies and port development programs. Projections of economic growth of Puget Sound Area for the years 1980, 2000 and 2020 are given in Appendix IV and are summarized in Table 1-2. For purposes of the Economic Study the hydrologic area was expanded to whole counties and regrouped into the three divisions tabulated below:

North	Central	West
Whatcom	Snohomish	Clallam
Skagit	King	Jefferson
Island	Kitsap	Mason
San Juan	Pierce	Thurston

This expansion was necessary to conform with the availability of essential economic data. The economic activity in the additional land area is nominal due to the sparce population and large Federal land holdings, therefore, the findings are considered to be representative of the smaller area.

Waterborne commerce projections were based on historical trends for various commodity groups and kinds of traffic with consideration given to related water transport oriented industry projections. Future terminal land use needs were based on projected tonnages and the following general assumptions: (1) increased terminal cargo handling efficiency: (2) cooperative regional development. Land area forecasts were developed for water transport-oriented industries by considering historical land use trends and future economic trends projected for select industries.

The future numbers of pleasure boats in the Puget Sound Area were projected on the basis of annual growth rates which include projected population growth plus 1.0 percent, the latter attributed to increased disposable income and greater interest in boating.

The needs for land and facilities were estimated on the basis of these studies. Plans were then developed to satisfy these needs.

NAVIGATION, LEGISLATION AND AUTHORITIES

The Federal Government, the State of Washington, county, city and port authorities exercise jurisdiction over the various phases of inland navigation.

a. The Federal Government is responsible for health, quarantine, customs, ship and safety inspections. It maintains coast guard and lighthouse services, constructs and maintains river and harbor improvements, regulates the use of navigable waters and interstate carriers.

b. The State of Washington through the Utilities & Transportation Commission regulates intrastate carriers, warehousemen, and public utilities.

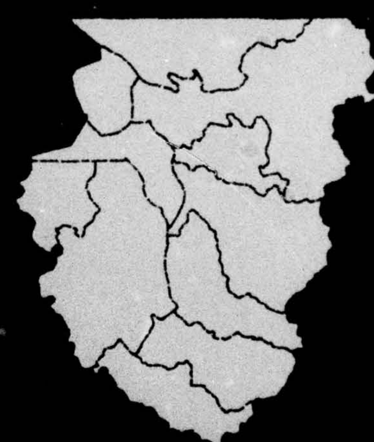
c. County government's responsibility is usually limited to county owned public landings.

d. City governments through a port warden will generally exercise control over speed of vessels, mooring, explosives handling, pier safety, and harbor pollution.

e. Port Districts are organized in the State of Washington as municipal corporations under the laws of the State with a Port Commission authorized to acquire by purchase or condemnation, land, property, leases or easements necessary for the purposes of the Port District. The Port District may construct, operate and maintain facilities, equipment or improvements necessary for the operation of the port. It is the duty of the Port Commission, before creating any improvements, to adopt a comprehensive scheme of harbor improvement in the Port District.

For more specific information concerning related laws and legislation see Appendix II–Political and Legislative Environment.

Puget Sound Area



PUGET SOUND AREA

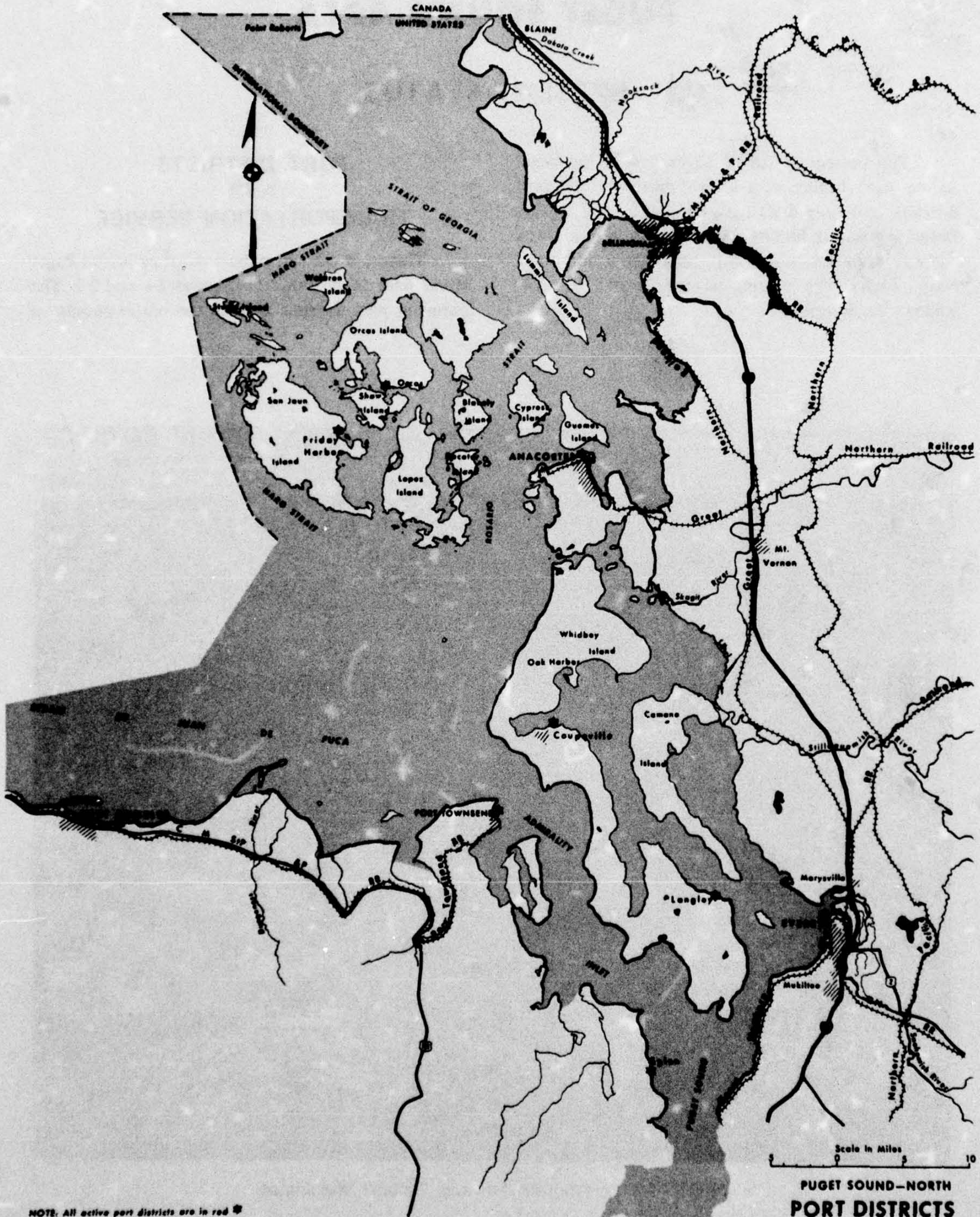
PRESENT STATUS

The present status of navigation in the Puget Sound Area begins with a description of the port districts, and deep draft navigation and ferry service. Detail is given on harbors and channels, terminal and transfer facilities, waterborne commerce and small boat harbors. The existing waterfront and industrial land is then described.

PORT DISTRICTS AND TRANSPORTATION SERVICE

There are 32 active port districts in the Puget Sound Area as indicated on Figures 2-1 and 2-2. The following port districts include the entire county in

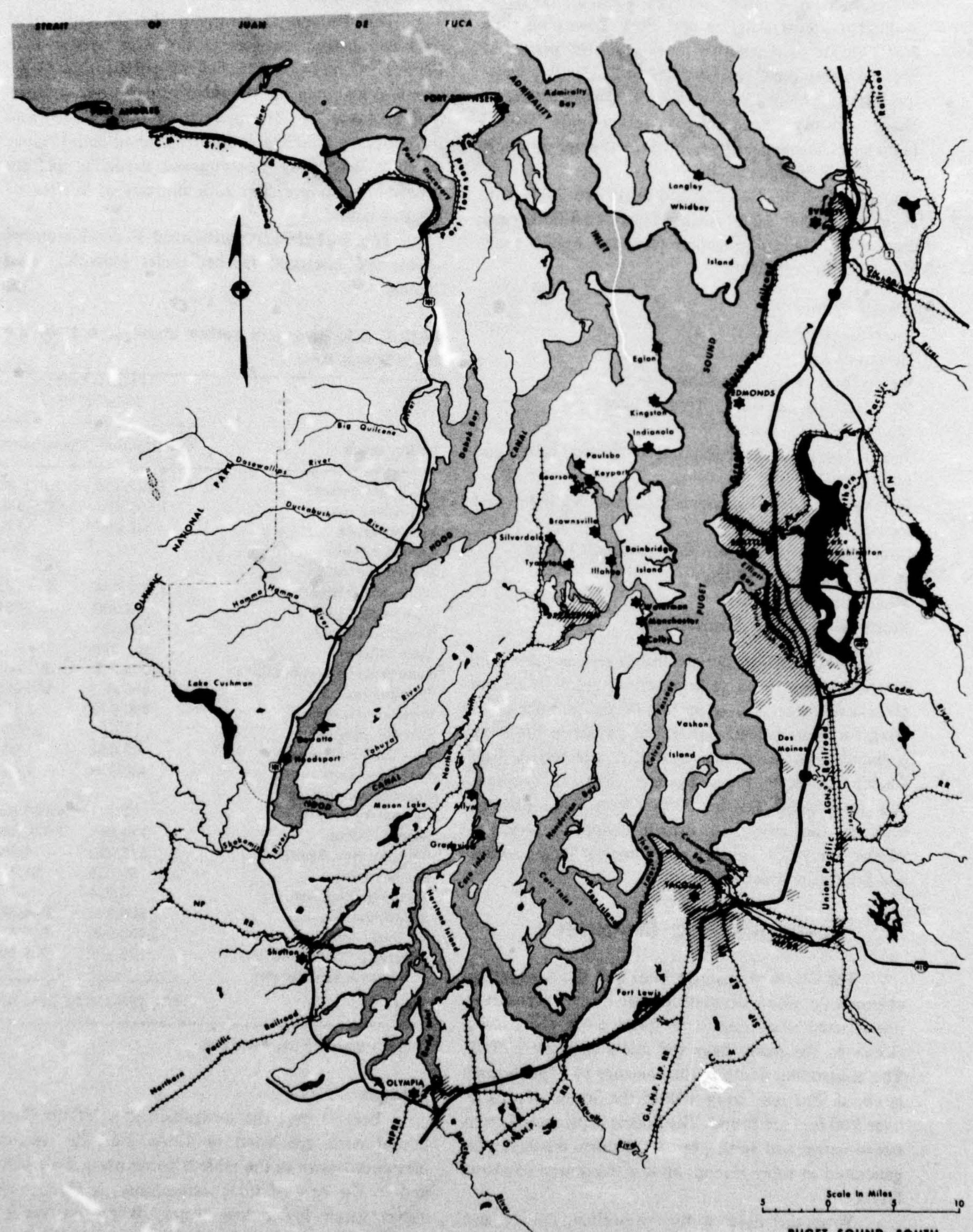
PHOTO 2-1. Port industrial district, Tacoma, Washington



PUGET SOUND—NORTH
PORT DISTRICTS

NOTE: All active port districts are in red

FIGURE 2-1



PUGET SOUND—SOUTH

PORT DISTRICTS

NOTE: All active port districts are in red

FIGURE 2-2

which each is located: Seattle, Tacoma, Olympia, Bellingham, Port Angeles and Port Townsend. The Port District of Anacortes takes in all the islands of Skagit County plus the east shore of Padilla Bay while the Port of Skagit County takes in the remainder of Skagit County. Each of the other port district boundaries are generally limited to the specific port and adjacent municipal area.

In 1967 the Puget Sound ports had 2,476 ship arrivals involving 32 steamship lines and 8 tankership companies. Steamship service from the Area is available with the following:

Alaska–5 lines
Intercoastal–3 lines
Hawaii–1 line
Mexico and Central America–5 lines
West Indies & Caribbean Area–5 lines
South America–3 lines
Japan, Hong Kong, Phillippine, Formosa, Korea and Okinawa–18 lines
Indonesia, India, Pakistan, Malaysia, Vietnam and Persian Gulf–10 lines
South Seas, Australia and New Zealand–7 lines
Northern Europe–12 lines
Mediterranean–6 lines
South, West & East Africa–1 line

In addition to the steamship service lines summarized above, 6 barge lines serve Alaska. There are 10 coastwise carriers of petroleum and lumber operating for their private use. Local freight in the Area is handled by two lines as well as the ferries. The Washington State Ferry System carries cross-sound and inter-island traffic. Three ferry lines operate between the area and British Columbia and the Alaska Ferry System operates between Puget Sound and Southeast Alaska.

HARBORS AND CHANNELS

The Strait of Juan de Fuca and the connecting channels provide natural deep water access permitting unrestricted vessel size and speed from the Pacific Ocean to the many bays and inlets of Puget Sound. The controlling depth at the entrance to Puget Sound is about 200 feet while within the Sound depths of over 900 feet are found. The Sound is protected from ocean waves and swells, but local storm waves can be generated in some reaches up to a maximum of about 8 feet.

With the deep waters prevailing, harbor and terminal facility development have been possible with a minimum of dredging.

Federal Improvements

The Federal Government has 22 authorized river and harbor projects in the Area as shown in Figures 2-3 and 2-4. The Federal costs for construction and maintenance for these projects are summarized in Table 2-1. The project for Puget Sound and its Tributary Waters provides for limited maintenance of these waters by snagging and dredging, and for removal, in cooperation with the city of Seattle, of floating debris.

The harbors and authorized Federal improvements are discussed further under individual river basins.

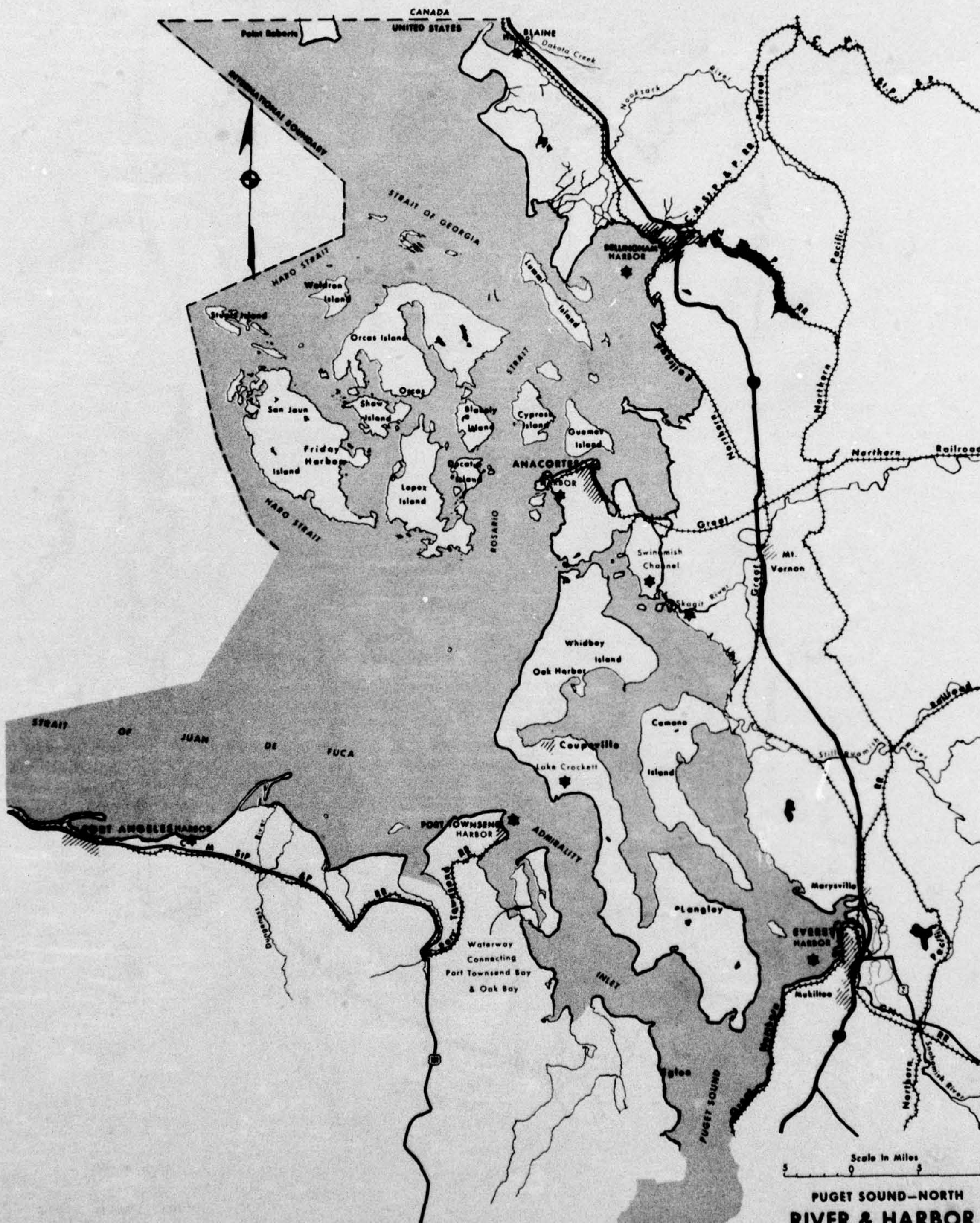
TABLE 2-1. River and harbor improvements in the Puget Sound Area.

	Federal Cost to June 30, 1967	
Improvement	Construction	Maintenance
Anacortes Harbor	$222,345	$92,528
Bellingham Harbor	1,692,473	259,588
Blaine Harbor	346,650	7,129
Edmonds Harbor	-- [1]	303
Everett Harbor & Snohomish River	1,723,744	962,172
Hammersley Inlet	9,000	14,891
Kingston Harbor	288,481	--
Lake Crockett	260,240	157,642
Lake Washington Ship Canal	4,024,297	13,381,052
Olympia Harbor	446,082	180,060
Port Angeles Harbor	470,873	2,895
Port Gamble Harbor	11,911	22,010
Port Orchard Bay	42,804	1,966
Port Townsend	480,899	1,489
Puget Sound and its Tributary Waters	43,337	4,133,162
Seattle Harbor	170,355	1,826,585
Shilshole Bay, Seattle	2,575,092	4,883
Skagit River	99,830	51,740
Stillaguamish River	4,234	--
Swinomish Channel	808,332	2,044,315
Tacoma Harbor	2,433,935	512,417
Waterway Connecting Port Townsend and Oak Bay	73,322	139,607
Total	$16,228,236	$23,796,434

[1] Constructed by local interests.

Bridges

Bridges over the navigable waters of the Puget Sound Area are listed in Table 2-2. The vertical clearance shown in the table is above mean high water and in the case of tidal waters only, is also shown above mean lower low water. When no vertical clearance is indicated, the clearance is unlimited in an open position.



PUGET SOUND—NORTH

RIVER & HARBOR PROJECTS

NOTE: Existing river and harbor projects are in red

FIGURE 2-3

PUGET SOUND– SOUTH

RIVER & HARBOR PROJECTS

NOTE: Existing river and harbor projects are in red

FIGURE 2-4

TABLE 2-2. Bridges over navigable waters of Puget Sound Area [1]

Miles Above Mouth	Location	Owner	Type [2] of Bridge	Clearance (feet) Horiz-ontal	Vertical LW	Vertical HW	Type [3] of Traffic
	NOOKSACK BASIN						
0.3	Dakota Creek, Blaine	Whatcom County	F	58		10	Hwy-FB
9.8	Dakota Creek, Blaine	G. N. Ry. Co.	F	26		19	RR
0.8	Dakota Creek, Blaine	Wash. State Hwy Dept	F	40		14	Hwy-FB
	Nooksack River						
0.2	Marietta, Wash	Whatcom County	SW	88	20	13	Hwy
3.5	S of Ferndale, Wash.	Wash. State Hwy Dept	F			4	Hwy-FB
5.8	Ferndale, Wash.	Whatcom County	F	102		8	Hwy-FB
6.0	Ferndale, Wash.	G. N. Ry. Co.	SW	102		12	RR
6.4	Ferndale, Wash.	Wash. State Hwy Dept	F	215		7	Hwy-FB
7.0	Ferndale, Wash.	Wash. State Hwy Dept	F.	215		7	Hwy-FB
15.0	1½ Mi. SW of Lynden, Wash.	Wash. State Hwy Dept	F	205		8	Hwy-FB
17.0	½ Mi. S of Lynden, Wash.		F	195		12	Hwy
19.0	Nugents Crossing 4 Mi. below Deming, Wash.	Wash. State Hwy Dept	F	174		11	Hwy
	SKAGIT BASIN						
	Skagit River						
3.1	North Fork–Rexville	Skagit County	F	120		48	Hwy-FB
5.5	South Fork–Fir	Skagit County	SW	115		10	Hwy
12.5	Mt. Vernon	Wash. State Hwy Dept	SW	105		7	Hwy-FB
16.8	1 Mi. N of Mt. Vernon	Wash. State Hwy Dept	F	110		17	Hwy-FB
17.0	1 Mi. N of Mt. Vernon	Wash. State Hwy Dept	SW	108		10	Hwy-FB
17.8	N of Mt. Vernon	G. N. Ry. Co.	SW	80		5	RR
21.8	Sedro Woolley	Wash. State Hwy Dept	F	296		14	Hwy-FB
22.0	Sedro Woolley	N. P. Ry. Co.	SW	91		10	RR
24.0	Sedro Woolley	PUD Skagit City	SUS			15	PL
25.0	Sedro Woolley	Wash. State Hwy Dept	F	296	38	19	Hwy-FB
50.0	Concrete	Skagit County	F	292		9	Hwy
80.0	Marblemount	Wash. State Hwy Dept	F	272		6	Hwy
1.5	Dry Slough–NW of Fir	Skagit County	F	31		3	Hwy
0.1	Canoe Pass–Anacortes	Wash. State Parks	F		150	100	Hwy-FB
0.5	Deception Pass–Anacortes	Wash. State Parks	F		111	104	Hwy-FB
0.2	Swinomish Slough near Anacortes	G. N. Ry. Co.	SW	100	13	5	RR
0.5	Swinomish Slough near Anacortes	Wash. State Hwy Dept	VL	100	24	16	Hwy-FB
5.4	Swinomish Slough, LaConner	Skagit County	F		53	45	Hwy-FB
0.5	Samish River–Edison	Skagit County	F	30	15	7	Hwy
0.5	Brown Slough, Conway	Skagit County	F	44		5	Hwy
3.5	Tom Moore Slough–Milltown	Skagit County	F	60		5	Hwy
	STILLAGUAMISH BASIN						
0.5	West Pass–Stanwood	Wash. State Hwy Dept	F	80	46	39	Hwy-FB
	Stillaguamish River						
4.6	Near Florence	Snohomish County	SW	86	20	14	Hwy
5.1	Stanwood	Snohomish County	F	28	14	8	Hwy-FB
0.5	Davis Slough–Stanwood	Snohomish County	F	16	12	5	Hwy-FB

TABLE 2-2. Continued

Miles Above Mouth	Location	Owner	Type of Bridge	Clearance Hori-zontal	Vertical LW	HW	Type of Traffic
	SNOHOMISH BASIN						
	Snohomish River						
3.5	Everett	G. N. Ry. Co.	SW	100	20	9	RR
3.6	Everett	Wash. State Hwy Dept	VL	105	49	38	Hwy-FB
3.6	Everett	Wash. State Hwy Dept	VL	105	49	38	Hwy-FB
6.1	Everett	Wash. State Hwy Dept	F	184	75	66	Hwy
6.7	Everett	Wash. State Hwy Dept	F	150	65	55	Hwy
6.8	Everett, Hewitt Ave	Wash. State Hwy Dept	VL	105	47	37	Hwy-FB
14.9	Snohomish	Wash. State Hwy Dept	F	296		22	Hwy-FB
15.0	Snohomish	Wash. State Hwy Dept	SW	115		10	Hwy-FB
15.3	Snohomish	N. P. Ry. Co.	SW	165		23	RR
15.5	Snohomish	G. N. Ry. Co.	SW	100		9	RR
1.4	Ebey Slough, Marysville	Wash. State Hwy Dept	F	110	52	41	Hwy-FB
1.5	Ebey Slough, Marysville	G. N. Ry. Co.	SW	108	16	5	RR
1.6	Ebey Slough, Marysville	Wash. State Hwy Dept	SW	110	21	10	Hwy-FB
7.5	Ebey Slough, Everett	Wash. State Hwy Dept	F	235	26	15	Hwy-FB
1.5	Union Slough, Marysville	Wash. State Hwy Dept	F	47	17	7	Hwy
1.6	Union Slough, Marysville	Wash. State Hwy Dept	F	47	16	6	Hwy-FB
0.7	Snoqualmie River, Monroe	Snohomish County	F	180		20	Hwy
8.5	Snoqualmie River, Duvall	King County	F	156		24	Hwy-FB
12.0	Snoqualmie River, Novelty	King County	F	232		15	Hwy
16.2	Snoqualmie River, Carnation	King County	F	189		15	Hwy
19.5	Snoqualmie River, Carnation	King County	F	176		8	Hwy-FB
3.7	Skykomish River, Monroe	Wash. State Hwy Dept	F	290		10	Hwy-FB
4.5	Skykomish River, Monroe	C. M. & St. P. Ry. Co.	F	119		3	RR
1.0	Steamboat Slough, Marysville	G. N. Ry. Co.	SW	100	19	9	RR
1.1	Steamboat Slough, Marysville	Wash. State Hwy Dept	SW	100	20	10	Hwy
1.2	Steamboat Slough, Marysville	Wash. State Hwy Dept	SW	100	20	10	Hwy-FB
2.3	Quilceda Creek, Marysville	Wash. State Hwy Dept	F	21	22	11	Hwy-FB
	CEDAR BASIN						
1.0	Shilshole Bay, Seattle	G. N. Ry. Co.	B	150	54	44	RR
	Lake Washington Ship Canal						
1.1	Seattle, 15th Ave NW	City of Seattle	B	150	30	29	Hwy-FB
1.6	Seattle, 8th Ave NW	N. P. Ry. Co.	B	150	16	15	RR
				Open	75		
2.6	Seattle, Fremont Ave	City of Seattle	B	150	32	29	Hwy-FB
2.7	Seattle, Aurora Ave	Wash. State Hwy Dept	CF	525	74	73	Hwy-FB
4.2	Seattle, Freeway Bridge	Wash. State Hwy Dept	F		129	128	Hwy
4.3	Seattle, University Bridge	City of Seattle	B	175	30	29	Hwy-FB
				Open	46		
5.2	Seattle, Montlake Bridge	City of Seattle	B	150	31	30	Hwy-FB
	Lake Washington						
	Seattle–Foster Is. Evergreen Pt.	Wash. State Toll Bridge Authority	RSP	202			Hwy
	Seattle-Foster Is. Evergreen East End	Wash. State Toll Bridge Authority	F	207	57	55	Hwy
	Seattle-Foster Is. Evergreen West End	Wash. State Toll Bridge Authority	F	206	44	42	Hwy
	Seattle-Mercer Island	Wash. State Toll Bridge Authority	P	200			Hwy-FB

TABLE 2-2. Continued

Miles Above Mouth	Location	Owner	Type of Bridge	Clearance (feet) Hori-zontal	Vertical LW	HW	Type of Traffic
	Mercer Is–East Channel Bridge	Wash. State Toll Bridge Authority	F	200	40	38	Hwy-FB
0.0	Cedar River–Renton	U.S. Air Force	RSP	80			IND
1.3	Cedar River-Renton, Logan Street	Wash. State Hwy Dept	F	110		7	Hwy-FB
	Sammamish River						
0.4	Kenmore, Wash.	King County	F	77		12	Hwy-FB
2.5	Wayne, Wash.	Wash. State Hwy Dept	F	38		12	Hwy-FB
2.8	Wayne, Wash.	N. P. Ry. Co.	F	50		14	RR
3.6	Bothell, Wash. 103rd Ave	King County	F	55		15	Hwy-FB
4.6	Bothell, Wash.	Wash. State Hwy Dept	F	32		12	Hwy
6.0	Woodinville, Wash.	N. P. Ry. Co.	F	36		13	RR
6.1	Woodinville, Wash.	King County	F	45		13	Hwy
6.1	Woodinville, Wash.	N. P. Ry. Co.	F	34		6	RR
8.1	Hollywood, Wash.	Wash. State Hwy Dept	F	30		7	Hwy-FB
10.1	York, Wash.	King County	F	52		5	Hwy-FB
12.4	Redmond, Wash.	Wash. State Hwy Dept	F	38		14	Hwy-FB
12.8	Redmond, Wash.	King County	F	53		6	Hwy-FB
	GREEN BASIN						
	Elliott Bay–Seattle						
0.3	East Waterway, W Spokane St	City of Seattle	F	14	16	6	Hwy-FB
0.4	East Waterway, Klickitat Ave	C. M. & St. P. Ry. Co.	F	14	19	8	RR
	Duwamish Waterway & River						
0.3	Seattle, W Spokane St	City of Seattle	B	150	38	27	Hwy-FB
0.3	Seattle, W Spokane St	City of Seattle	B	150	35	24	Hwy-FB
0.4	Seattle, N. P. Ry.	N. P. Ry. Co.	B	150	19	8	RR
2.5	Seattle, 1st Ave S	City of Seattle	B	150	35	24	Hwy-FB
3.8	Seattle, 14th Ave S	King County	B	125	32	21	Hwy-FB
5.3	Seattle, Boeing Plant	Boeing Airplane Co.	F	90	30	20	FB
6.4	2 Mi. S of Seattle	Wash. State Hwy Dept	F	180		5	Hwy-FB
6.8	Duwamish River Bridge	Wash. State Hwy Dept	F	202		5	Hwy-FB
7.4	Allentown	King County	SUS	150		5	FB
7.8	Riverton	King County	F	120		12	Hwy-FB
9.0	Foster	King County	F	155		7	Hwy-FB
9.8	¾ Mi. below Tuckwila	George H Eddy	SUS	248		4	FB
	PUYALLUP BASIN						
	Commencement Bay–Tacoma						
0.6	City Waterway, S 11th St	City of Tacoma	VL	200	75	64	Hwy-FB
0.8	City Waterway, 14th St	N. P. Ry. Co.	SW	100	26	15	RR
0.9	City Waterway, 15th St	U. P. Ry. Co.	SW	100	16	5	Hwy-RR
1.1	Hylebos Waterway, E 11th St	City of Tacoma	B	150	20	9	Hwy-FB
0.8	Port Industrial Waterway, E. 11th St	City of Tacoma	B	150	18	11	Hwy
	Puyallup River						
0.8	Tacoma, E 11th St	City of Tacoma	VL	150	40	29	Hwy-FB
0.9	Tacoma, E 11th St	C. M. & St. P. Ry. Co.	SW	120	23	12	RR
1.5	Tacoma, S 21st St	City of Tacoma	F	110	24	13	RR
2.0	Tacoma, Cleveland Way & E. Q	N. P. Ry. Co.	F	124	23	12	RR

TABLE 2-2. Continued

Miles Above Mouth	Location	Owner	Type of Bridge	Clearance (feet) Horizontal	Vertical LW	Vertical HW	Type of Traffic
2.1	Tacoma, Hwy 99	Wash. State Hwy Dept	F	175	46	35	Hwy-FB
2.3	Tacoma, Wash	C. M. & St. P. Ry. Co.	F	135	34	24	RR
2.5	Tacoma, Wash	U. P. Ry. Co.	F	150	24	14	RR
0.5	Days Island Waterway, Tacoma	Pierce County	F	48	34	23	Hwy-FB
3.5	The Narrows, Tacoma	Wash. State Hwy Dept	SUS	2,565	170	159	Hwy-FB
0.0	Steillacoom Cr. Waterway, Tacoma	N. P. Ry. Co.	VL	85	23	10	RR
			Open			50	
	DESCHUTES BASIN						
	Deschutes River & Waterway						
0.1	Olympia	City of Olympia	F	79	17	4	Hwy-FB
	Henderson Inlet						
0.8	Woodward Bay, Olympia	Thurston County	F	19		6	Hwy-FB
	WEST SOUND BASIN						
	Port Townsend-Oak Bay Canal						
0.2	Port Townsend	Jefferson County	F	236	65	58	Hwy-FB
	Puget Sound—Hood Canal						
5.0	Port Gamble	Wash. State Toll Bridge Authority	R-P	602			Hwy
	Port Gamble, East End	" "	F	239		55	Hwy
	Port Gamble, West End	" "	F	239		35	Hwy
	Agate Passage—Puget Sound						
1.0	Suquamish	Wash. State Hwy Dept	F	520	46	35	Hwy-FB
	Burkes Bay—Puget Sound						
0.2	Brownsville	Kitsap County	F	24		14	Hwy-FB
	Case Inlet—Puget Sound						
10.0	Detroit	Mason County	F	20		14	Hwy-FB
11.0	Grapeview	E. R. Taylor	F	21	29	16	PR
0.0	Clam Bay-Manchester	U. S. Navy	F	30	50	40	Hwy
1.5	Dogfish Bay—Keyport	Wash. State Hwy Dept	F	18		6	Hwy-FB
3.0	Hale Passage—Fox Island	Pierce County	F	105	44	31	Hwy-FB
0.1	Hamma Hamma River, Eldon	Wash. State Hwy Dept	F	120	23	13	Hwy
0.0	Henderson Bay, Purdy	Pierce County	F	184	24	12	Hwy-FB
0.4	Henderson Bay, Raft Island	Archie L. Matthew	F	21	29	17	PR
	Port Washington Narrows						
0.3	Bremerton, Wash.	Wash. State Hwy Dept	F	231	93	82	Hwy-FB
0.5	Bremerton, Wash.	City of Bremerton	F	220	91	80	Hwy-FB
0.0	Olalla Creek, Olalla	Kitsap County	F	32	20	9	Hwy

1 Reference "Bridges over the Navigable Waters of the United States Part 4, Pacific Coast", by U. S. Army, Corps of Engineers.

2 F—Fixed; SW—Swing; SUS—Suspension; VL—Vertical lift; B—Bdscule; R—Retractable; P—Pontoon; RSP—Removable Span

3 Hwy—Highway; FB—Footbridge; RR—Railroad; PL—Pileline; IND—Industrial

WATERBORNE COMMERCE

General

Commerce in the Puget Sound Area comprise freight carried by deep and shallow draft vessels and traffic moving on the ferry system. Trade is carried on with foreign nations, coastwise between regions of the country and internally within the Area. For purposes of this study traffic is classified as:

Foreign Imports and Exports. Traffic between the Puget Sound Area and foreign ports including the Canal Zone.

Domestic Coastwise Receipts and Shipments. Domestic traffic receiving a carriage outside of the Puget Sound Area.

Domestic Internal Receipts and Shipments. Domestic traffic between ports or landings wherein the entire movement takes place within Puget Sound Area.

Intraport receipts and shipments which include traffic between the arms or channels of a port, as between the inner and outer harbor of the Port of Seattle, and local traffic movement of freight and passengers within the confines of a single arm or channel of a port are excluded from the statistics and projections presented herein. This traffic has amounted to over 4,000,000 tons in recent years with about 80 percent being forest products; mostly rafted logs. Although the handling of this traffic poses local problems, it was excluded because of limited significance in long range navigation planning.

United States Army and Naval vessels, such as Army transports and Navy tankers, entering or clearing without commercial cargo and foreign military and naval craft also have been excluded from these figures. Statistics for shipping previous to 1952 are not included as they are considered to be influenced by war conditions.

Waterborne commerce in the Puget Sound Area covers a wide variety of goods which are grouped on the basis of similar handling characteristics into general cargo, bulk grain, forest products, petroleum, other dry bulk and other liquid bulk. Specific commodities falling under each of these broad groupings as shown in Table 2-3 are identified using the Standard Industrial Classification (SIC) adopted in 1965 by the Department of Commerce and by a code published in the Waterborne Commerce of United States (WBC) for 1962.

TABLE 2-3. Puget Sound Area—commodity grouping by Standard Industrial Classification (SIC) and Waterborne Commerce (WBC) Codes.

SIC	COMMODITY GROUPING	WBC	SIC	COMMODITY GROUPING	WBC
	Bulk Grain			**Bulk Petroleum**	
0103	Corn	100	2911	Gasoline	507
0105	Rice	101	2914	Gas oil & distillate fuel oil	510
0102	Barley	102	1311	Petroleum, crude	511
0107	Wheat	103	2912	Jet fuel, all types	512
0104	Oats	104	2913	Kerosene	513
2041	Wheat flour & semolina	107	2915	Residual fuel oil, including bunker oil	514
0106	Grain sorghums	108	2951	Petroleum asphalt	516
0109	Grains, nec.	108	2918	& products	
			2917	Aliphatic naptha (except motor fuel or gasoline) mineral spirits, solvents, & other finished light aliphatic products, not elsewhere classified	518
	Forest Products				518
2311	Logs	400	2916	Lubricating oils & greases	519
2412	Rafted logs	401	2991	Petroleum products, not elsewhere classified	520
0861	Post, poles	405		Natural gasoline	522
2414	& piling				
2413	Wood, unmanufactured, not elsewhere classified	408			
2421	Lumber & shingles	413			
2431	Wood containers & shooks; cooperage & cooperage stock except empty barrels; plywood & veneers	416			
	Railroad ties	417			

TABLE 2-3. Continued

SIC	COMMODITY GROUPING	WBC
	Other Dry Bulk	
2042, 0122	Animal feeds (fodders & feeds), not elsewhere classified	110
2061	Sugar	180
0111	Soybeans	231
0112	Flaxseed	232
	Copra	233
	Castor beans	234
0119	Oilseeds, not elsewhere classified, including castor beans	235
0119	Oilseeds, not elsewhere classified, except castor beans	236
	Seeds, except oilseeds	260
2415	Pulpwood	440
1111	Anthracite coal	501
1121	Bituminous coal & lignite	502
	Coal & coke briquets & related coal products	503
3241	Building cement	523
0129	Field crops, nec.	
1451	Clays & earths	540
1494	Gypsum or plaster rock, including gypsum cements	548
1492	Sulphur dry	550
1411	Limestone, crushed (not suitable for building or monumental purposes	551
1491	Salt	553
1442, 1421	Sand, gravel & crushed rock, except limestone	554
1499, 3271, 3291	Nonmetallic minerals & manufacturers not elsewhere classified	555
3312	Slag, metal refuse	556
1011	Iron ore & concentrates	600
4011	Iron & steel scrap, including tin plate scrap	602
1061	Manganese, including ferromanganese	613
1081	Chrome, including ferrochrome	614
1051	Aluminum ores, concentrates (alumina) & scrap	617
1021	Copper ore, concentrates, unrefined copper & scrap	620
	Lead ores, concentrates & scrap	640
	Nickel ore, concentrates, scrap, & semifabricated forms	652

SIC	COMMODITY GROUPING	WBC
	Other Dry Bulk	
1021	Tin ore, concentrates & scrap	660
	Tin ore, concentrates, scrap & semifabricated forms	662
	Zinc ores, concentrates & scrap	670
1091, 3321, 4012	Other nonferrous ores, concentrates, metals & scrap, except precious, in crude & semifabricated forms	682
2810	Sodium hydroxide or caustic soda	827
2891	Other industrial chemicals, except SC_i	828
2861	Industrial chemicals, not elsewhere classified	829
2875	Ammonium sulphate (fertilizer material)	849
2871	Nitrogenous fertilizers & fertilizer materials, except ammonium sulphate	851
1471	Phosphate rock	852
2873	Super phosphate	854
2872	Potash fertilizer materials	855
2879, 1479, 2874	Fertilizer & fertilizer materials, not elsewhere classified	859
2491	Wood manufacturers, nec.	
	Other Liquid Bulk	
2092	Animal oils & fats, edible	020
0161	Animal products, inedible, not elsewhere classified	095
2091	Vegetable oils & fats, edible	150
2062	Molasses, inedible	290
	Vegetable oils, fats & waxes inedible and/or crude	240
1493	Sulphur, liquid	549
2811	Crude & refined coal tar, cyclic chemical tars	801
2818	Benzol or benzene	802
	Other coal tar & cyclic chemical products	805
	Other coal tar & cyclic chemical products, except SC_i	806
2814	Sulphuric acid	825
2813	Alcohols	926

General Cargo—all items not included in one of the above categories.

Historical Trends

Foreign, domestic coastwise and domestic internal traffic for the Puget Sound Area from 1952 to 1966 is summarized in Figure 2-5. Foreign and domestic coastwise traffic are shown for the following major ports: Bellingham, Anacortes, Everett, Seattle, Tacoma, Olympia, Port Angeles, Port Townsend, Port Gamble, and Shelton. Traffic for minor ports and rivers is mostly domestic internal, and therefore, has been included in that classification. The tonnages shown for domestic internal traffic represent both the shipping and receiving ports. Local and intraport traffic, which has remained relatively constant at 4,000,000 tons per year is not shown in Figure 2-5.

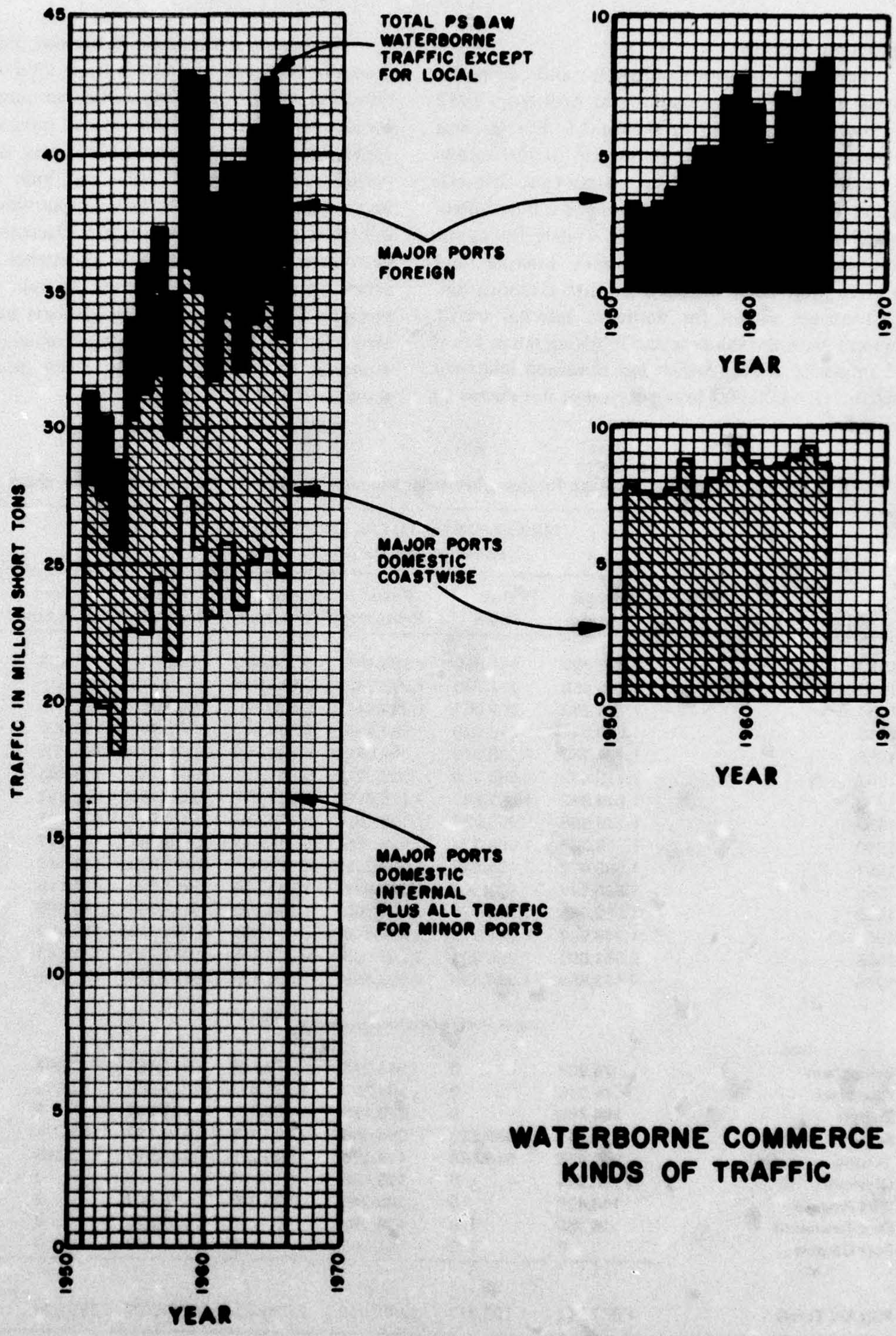
Foreign and Domestic Coastwise. Foreign and domestic coastwise commerce from 1952 to 1966 is tabulated in Table 2-4. This traffic increased about 50 percent from 1952 to 1966. Forest product exports which have increased about 20 times during this period, and other dry bulk and bulk petroleum imports have been primarily responsible for the indicated growth in total traffic. Decreases in bulk petroleum domestic coastwise shipments have been offset by a substantial increase in bulk petroleum receipts. Other commodity movements have fluctuated over this period. A disaggregation of foreign and domestic traffic for 1966 by major ports is also shown in Table 2-4.

TABLE 2-4. Puget Sound Area foreign plus domestic coastwise water borne commerce—short tons

MAJOR PORTS—TOTAL COMMERCE (Inbound plus Outbound)

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	1,578,302	961,890	903,461	5,963,662	1,687,216	73,124	11,167,655
1953	1,646,865	711,089	1,072,749	5,614,860	1,483,788	100,689	10,630,040
1954	1,798,232	562,084	1,038,914	5,546,178	1,599,813	108,840	10,654,061
1955	1,610,642	876,239	880,404	5,929,032	1,973,423	115,920	11,385,660
1956	1,824,730	1,538,379	759,672	6,899,262	2,270,870	105,235	13,398,148
1957	1,715,473	1,898,289	922,321	5,641,121	2,402,945	118,836	12,698,985
1958	1,675,942	1,092,867	1,126,659	7,227,017	2,092,709	102,882	13,318,076
1959	1,788,756	995,036	1,196,765	9,211,647	2,227,277	124,131	15,543,612
1960	1,805,338	1,694,324	1,159,155	10,114,641	2,426,681	89,158	17,289,297
1961	1,682,022	1,474,922	1,289,218	8,474,480	2,427,073	125,163	15,472,878
1962	1,608,577	971,963	1,213,854	7,511,765	2,414,623	137,110	13,857,892
1963	1,852,765	1,205,977	1,902,562	7,944,703	2,831,702	155,625	15,893,334
1964	1,918,662	1,011,578	2,930,419	8,050,933	2,884,344	119,492	16,915,428
1965	2,081,687	1,296,205	2,205,993	8,774,446	2,707,276	132,583	17,198,190
1966	2,473,884	1,394,620	2,693,355	7,565,122	2,853,171	153,069	17,133,221
			Major Ports—Disaggregation for 1963				
Area							
Bellingham	78,037	0	246,771	9,639	651,592	3,297	989,336
Anacortes	16,216	0	97,593	4,291,421	3,342	2,660	4,411,232
Everett	164,169	0	329,180	24,329	191,092	0	708,770
Seattle	1,119,141	689,529	364,450	2,897,105	614,712	140,321	5,825,258
Tacoma	289,458	516,448	414,225	599,265	1,232,542	9,348	3,061,286
Olympia	30,931	0	126,583	0	0	0	157,514
Port Angeles	140,425	0	246,249	113,698	29,907	0	530,279
Port Townsend	14,380	0	26,099	0	108,515	0	148,994
Port Gamble	8	0	51,392	0	0	0	51,400
PS&AW Totals	1,852,765	1,205,977	1,902,542	7,935,437	2,831,702	155,626	15,884,069

Source: Water-borne commerce data derived from annual reports published by the Department of the Army, Corps of Engineers and from "Shipping Statistics Handbook" compiled by the Port of Seattle.



WATERBORNE COMMERCE KINDS OF TRAFFIC

FIGURE 2-5

Domestic Internal Traffic. Table 2-5 tabulates domestic internal waterborne commerce for all Puget Sound Area ports for the period 1952-1966 and a distribution of commerce between ports for 1963. Tonnage has remained relatively stable since 1952. However, commodities comprising this traffic have shown a degree of fluctuation but are balanced out in the aggregate.

TABLE 2-5. Puget Sound Area domestic internal water-borne commerce—short tons

ALL PORTS—TOTAL COMMERCE

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	741,350	370	12,456,166	2,317,927	4,499,107	11,888	20,026,808
1953	750,536	370	12,168,990	2,315,564	4,529,166	737	19,765,363
1954	889,591	195	9,936,410	2,638,282	4,596,440	678	18,061,596
1955	981,778	313,187	11,950,457	4,277,222	5,045,101	2,873	22,570,618
1956	1,317,847	112,162	11,690,906	4,658,061	4,636,696	44,481	22,460,153
1957	1,240,775	681,852	9,803,444	5,795,540	6,892,598	75,355	24,489,564
1958	746,653	27,970	8,329,079	6,761,054	5,575,541	54,663	21,494,960
1959	864,136	98,452	10,338,425	6,432,017	9,636,374	52,829	27,422,233
1960	807,669	0	9,234,505	6,967,768	8,464,719	68,258	25,542,919
1961	829,853	0	7,430,556	7,738,869	6,965,202	72,688	23,037,168
1962	928,192	0	8,042,253	8,380,959	8,339,167	33,291	25,723,862
1963	1,161,169	0	5,928,082	8,107,281	8,169,962	22,202	23,388,696
1964	1,145,352	7	6,917,947	9,807,107	7,100,451	31,947	25,002,811
1965	813,722	0	6,387,129	8,779,087	9,429,666	47,556	25,457,160
1966	1,010,482	0	7,407,257	6,319,683	9,816,498	27,809	24,581,729

ALL PORTS—DISAGGREGATION FOR 1963

Area	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
Bellingham	67,876	0	159,293	61,641	154,086	0	442,896
Anacortes	9,595	0	196,022	1,887,633	8,863	0	2,102,113
Everett	8,794	0	696,417	19,749	133,902	0	858,862
Seattle	360,490	0	656,981	2,793,995	3,201,520	8,663	7,021,649
Tacoma	110,133	0	576,780	808,335	422,242	9,574	1,927,064
Olympia	12,043	0	346,963	127,379	105,096	2,207	593,688
Port Angeles	245,943	0	260,900	85,832	57,872	0	650,547
Port Townsend	67,029	0	197,951	20,674	307,825	0	593,479
Port Gamble	43,832	0	124,426	0	0	0	168,258
Shelton	210	0	146,889	13,779	78,308	0	239,186
Major Ports—Totals	925,945	0	3,362,622	5,819,017	4,469,714	20,444	14,597,742
Blaine	20,519	0	0	244	0	0	20,763
Skagit River	0	0	7,279	0	679	0	7,958
Stillaguamish River	0	0	25,384	0	0	0	25,384
Snohomish River	220	0	1,031,266	4,827	51,772	0	1,088,085
Other minor ports	214,485	0	1,501,531	2,283,193	3,647,797	1,758	7,648,764
Total minor ports	235,224	0	2,565,460	2,288,264	3,700,248	1,758	8,790,954
Grand Totals	1,161,169	0	5,928,082	8,107,281	8,169,962	22,202	23,388,696

Source: Water-borne commerce data derived from annual reports published by the Department of the Army, Corps of Engineers and from "Shipping Statistics Handbook" compiled by the Port of Seattle.

Ferry Traffic. Vehicle and passenger traffic transported by Washington State ferries is summarized in Table 2-6 for the years 1952 through 1966. During this period, the movement of vehicles increased by 47 percent while passenger traffic exclusive of drivers, only increased about 10 percent.

TERMINAL AND TRANSFER FACILITIES

Berthing space for the major ports is shown in Table 2-7. Berthing space increased about 11 percent between 1952 and 1963. For the most part this increase was confined to bulk handling facilities other than grain. The major gains were in the Bellingham and Anacortes areas where nearly 6,000 feet of berthing space was added for the new petroleum industries and about 1,500 feet of berthing space added for handling dry bulk for the new aluminum plant and other industry.

In the Puget Sound Area, during 1963, over 10 miles of berthing space was used for handling "General Cargo" or nearly 40 percent of the total for all cargo. Noncargo handling use for mooring of miscellaneous vessels also used over 10 miles of berthing space while "Construction and Repair" used nearly as much.

Better estimates can be made of potential cargo handling capacities by using water frontage and waterfront acreage for terminal facilities than lineal feet of berthing space. Water frontage and waterfront areas used for Puget Sound Area terminal facilities in 1963 are summarized in Tables 2-8 and 2-9, respectively.

PHOTO 2-2. Port of Anacortes

TABLE 2-6. Puget Sound Area, Washington State ferry traffic, vehicles and passengers (1000's)

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Vehicles	2136	2305	2356	2456	2569	2585	2681	2696	2612	2559	2616	2569	2707	2843	3149
Passengers	4937	5065	4994	5172	5262	5328	5443	5365	5197	5354	6737	5699	5790	5952	6297

Source—Economic Evaluation Kitsap Peninsual, Bainbridge Island connector bridge routes, January 1969, Washington State Department of Highways.

* Exclusive of driver

TABLE 2-7. Puget Sound Area terminal facilities 1963—berthing space in feet

Port Area	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Total for Cargo	Ferry & Passenger Terminals	Construction & Repair	Mooring
Bellingham	5,000	0	2,175	2,449	2,286	150	12,060	0	1,990	11,426
Anacortes	2,870	0	985	4,265	20	0	8,140	Slips	772	6,448
Everett	4,195	0	13,135	1,151	505	160	19,146	0	812	6,582
Seattle	28,672	2,113	5,375	11,690	7,940	1,807	57,597	1,545	38,822	17,966
Tacoma	9,118	1,090	12,594	2,771	4,959	168	30,700	Slips	3,324	9,126
Olympia	2,300	0	2,255	425	450	0	5,430	0	290	0
Port Angeles	3,083	0	1,090	1,340	515	830	6,858	Slips	5,222	1,717
TOTALS	55,238	3,203	37,609	24,091	16,675	3,115	139,931	1,545	51,232	53,265

Source: U.S. Army Corps of Engineers, Port Series.

TABLE 2-8. Puget Sound Area terminal facilities 1963—water frontage in feet

Port Area	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Total for Cargo	Ferry & Passenger Terminals	Construction and Repair	Mooring
Bellingham	3,200	0	2,600	1,900	1,200	0	8,900	0	1,400	2,850
Anacortes	3,000	0	3,050	2,900	0	0	8,950	900	500	1,650
Everett	1,050	0	12,430	1,600	600	200	15,880	0	1,050	2,300
Seattle	16,300	1,500	6,400	8,400	6,750	1,800	41,150	1,600	15,250	8,250
Tacoma	10,200	1,500	16,200	4,450	5,210	300	37,860	300	4,000	8,760
Olympia	2,200	0	2,600	800	600	0	6,200	0	550	0
Port Angeles	1,750	0	2,800	1,100	280	0	5,930	200	1,300	2,000
TOTALS	37,700	3,000	46,080	21,150	14,640	2,300	124,870	3,000	24,050	25,810

TABLE 2-9. Waterfront terminal lands in 1963 in acres

Basins	General Cargo	Bulk Grain	Forest Products	Bulk Petro-leum	Other Dry Bulk	Other Liquid Bulk	Cargo Totals	Passenger & Ferry Terminals	Moorings	Total
Nooksack-Sumas	36	0	29	45	33	0	143	3	33	179
Skagit-Samish	48	0	38	270	2	0	358	14	38	410
Snohomish	17	0	100	10	7	2	136	4	40	180
Cedar-Green	260	24	85	158	93	28	648	50	108	806
Puyallup	49	6	111	56	80	6	308	8	77	393
Nisqually-Deschutes	12	0	28	6	5	0	51	0	0	51
Elwha-Dungeness	20	0	27	20	1	0	68	3	16	87
Subtotals	442	30	418	565	221	36	1,712	82	312	2,106
Other Basins	54	0	36	73	11	4	178	2	33	213
TOTALS	496	30	454	638	232	40	1,890	84	345	2,319

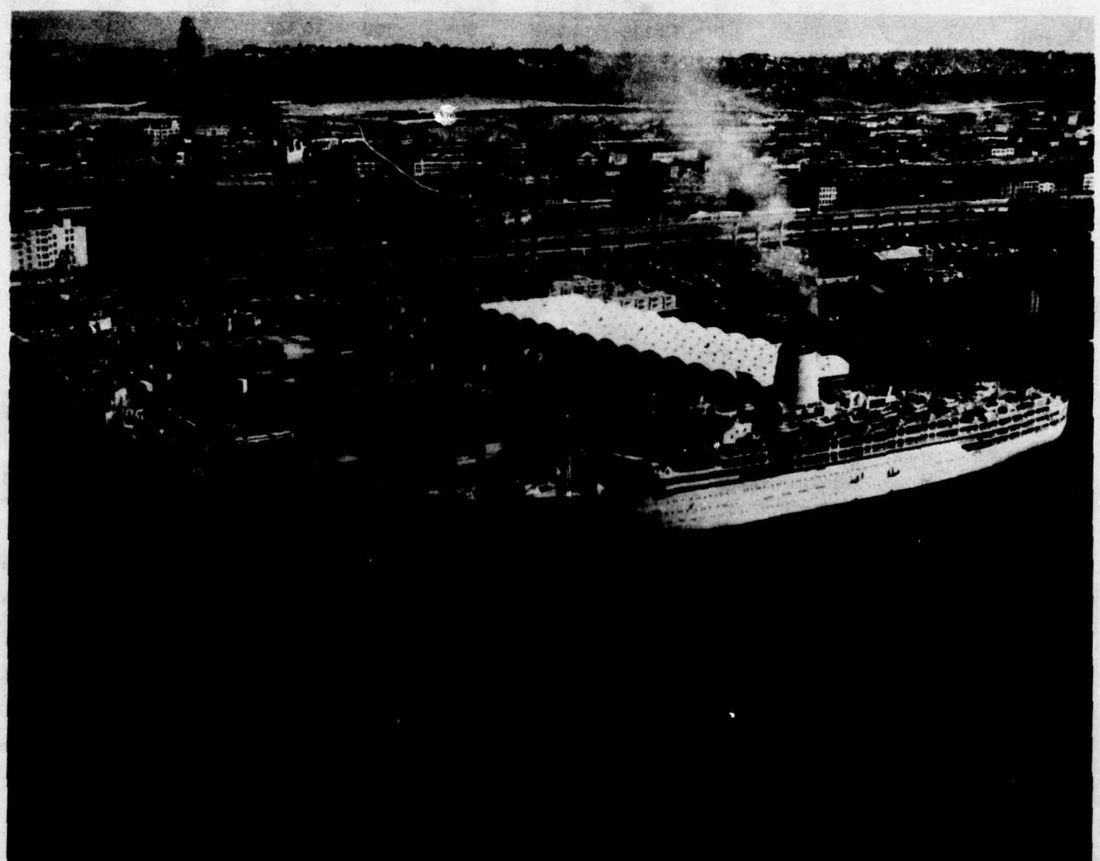


PHOTO 2-3. Terminal 46, Port of Seattle

WATERFRONT AND RELATED INDUSTRIAL LAND INVENTORY

The waterfront along Puget Sound and Adjacent waters and the related industrial land was inventoried and land use for these purposes was established for the base year of 1963. Land use information was obtained from the existing port authorities, studies made by county planning organizations and the following reports.

Source Material For Industrial Land Use

1. **Pacific Northwest Major Industrial Plant Sites**—U.S. Department of the Interior, Bonneville Power Administration.

2. **Economic Growth of the Puget Sound Region**—(San Francisco: Arthur D. Little, Inc. 1964).

3. **Waterside Site Plant Location and Expansions**—1966, The American Waterways Operators Inc.

4. **Future Economic Development of the Port Region and Guidelines for Port Activity to Port of Olympia**—March 31, 1965, Battelle Memorial Institute.

The inventory covered the land being used for terminals and water transport-oriented industries and land having potential for development for these purposes. The categories adapted for the inventory were:

a. Existing Terminal Facilities—The area of piers, wharves, open and covered storage areas used for waterborne commercial cargo and passenger service together with mooring areas for such vessels.

b. Existing Water Transport-Oriented Industries—Waterfront and other lands being used by industries that require or gain a significant advantage by nearness to water transport facilities. Industries of this type were:

Transportation Equipment Manufacture
Primary Metal Manufacture
Chemicals and Allied Products Manufacture
Petroleum Refining and Related Industries
Paper and Allied Products Manufacture
Wholesalers with Stocks, Distributors
Lumber and Wood Products Manufacture
Stone, Clay and Glass Products Manufacture
Warehousing and Storage

c. Existing Vessel Repair and Construction—These facilities which are part of the water-oriented industries have been tabulated separately because of their special requirement of being on the waterfront.

d. Potential Terminal Facilities—Waterfront open space that is suitable for waterborne commerce terminals and generally includes water area out to the pierhead line or about 40 feet depth below MLLW.

e. Potential Water Transport-Oriented Industries—Open space areas suitable for water transport-oriented industry including waterfront land not required for terminal facilities and inland to a maximum of about five miles from possible deep water transport terminal.

The acres of potential sites were divided into favorable and less favorable sites. The less favorable sites were sites that would be very difficult and expensive to develop.

To obtain the net land areas available for industrial and terminal use, the gross site areas were reduced by 25 percent to allow for the land requirements for streets, highway and railroad rights-of-way.

f. Existing and Potential Pleasure Boat Mooring Areas—Areas under this category were sites now developed for pleasure boat moorages or having physical characteristics suitable for this use.

The inventory of terminal lands and water transport-oriented industry is complete for the major port areas of the Puget Sound Area. However, every small pier or other installation involved in local and internal shipping activity has not been included. The areas of potential terminal or industrial sites are limited to areas known to have been considered suitable for such use by industry or public agencies.

Land Use And Potential In 1963

Land areas in actual use in 1963 for terminal facilities, vessel repair and construction and for water transport-oriented industries are summarized in Table 2-10. Also, this Table provides an estimate of potential areas suitable for development for terminals and related industries. A more detailed breakdown of existing water transport-oriented lands by commodity groups is given in Table 2-11.

In 1963 about 34,000 (net) acres of land in the Puget Sound Area appeared to have a favorable potential for waterfront terminals or water transport-oriented industrial site development. Some 2,550 (net) acres of land have a less favorable potential for development. Other potential sites could no doubt be found in the West Sound Basins, but most water transport-oriented development in these Basins is restricted due to a lack of highway and railroad connections, their isolated location, or lack of favorable waterfront. Potential sites on Indian reservations

TABLE 2-10. Waterfront and industrial land summary for 1963

	Acres in Use (Net)				Acres Potential			
					Favorable		Less Favorable	
Basins	Terminal Facilities	Vessel Repair & Construction	Other Water Transport Oriented Industry	Totals	Gross	Net	Gross	Net
Nooksack-Sumas	179	12	690	881	6,620	4,985	3,400	2,550
Skagit-Samish	410	9	845	1,264	6,200	4,650	0	0
Snohomish	180	8	510	698	15,504	11,628	0	0
Cedar-Green	806	284	1,718	2,808	5,992	4,494	0	0
Puyallup	389	34	881[2]	1,304[2]	4,860	3,645	0	0
Nisqually-Deschutes	51	7	76	134	4,840	3,630	0	0
Elwha-Dungeness	87	15	105	207	1,280	960	0	0
Other Basins[1]	213	--	--	213	--	--	--	--
Totals	2,315	369	4,825	7,509	45,296	33,992	3,400	2,550

1 Acreage of the types inventoried are estimated for terminal lands. Industrial lands not given.

2 Excludes 2,440 acres used by DuPont Chemical Plant for manufacture and storage of explosives.

TABLE 2-11. Water Transport-Oriented industrial lands in 1963 in acres

Basins	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Ship Construction & Repair	Totals
Nooksack-Sumas	132	--	70	200	288	--	12	702
Skagit-Samish	20	--	21	800	4	--	9	854
Snohomish	101	--	391	2	16	--	8	518
Cedar-Green	1,018	--	140	201	307	52	284	2,002
Puyallup	406	--	295	37	62	81	34	915
Nisqually-Deschutes	20	--	43	5	8	--	7	83
Elwha-Dungeness	15	--	77	5	8	--	15	120
Totals	1,712	--	1,037	1,250	693	133	369	5,194

and military reservations were not considered available because their future use could not be forecast. Residential development is occurring on some Indian lands while tribal approval often is difficult to obtain for projects or land use. Industrial sites adjacent to air fields were omitted as these lands would be required to satisfy the demands of air transport-oriented industries.

SMALL BOAT HARBORS

Puget Sound with its 2,500 square miles of nearly landlocked salt water, its scenic environment and sport fisheries provides an ideal setting for recreational boating. An estimated 34 percent of the Area's population engage in some form of recreational boating. Area residents participate more intensely in this form of recreation than the national population with 8.3 activity days per person expanded annually, as compared to a national average of 2.6. A marine temperature climate enables at least one-third of the boat owners having craft of more than ten horsepower to use their craft all year around.

This section provides an estimate of registered and documented craft owned by residents of the Puget Sound Area, reports on boating facilities and discusses sites having the potential for development of small boat harbors. Information for this study was derived from a questionnaire survey of boat owners having their craft registered with the U.S. Coast Guard and from an inventory conducted by automobile, boat and airplane in addition to office studies. The survey finding is reported on in detail in the "Pleasure Boating Study, Puget Sound and Adjacent Waters, Washington."[1] From field interviews and other studies, about 95 percent of the demand for Puget Sound Area pleasure boating facilities on marine waters is estimated to be from owners of registered craft. Therefore, the Coast Guard register was considered an appropriate base from which to measure marine boating facility demand through a statistical sampling survey.

[1] Pleasure Boating Study, Puget Sound and Adjacent Waters, Washington, prepared by Seattle District, Corps of Engineers and the Pacific Northwest Region, Bureau of Outdoor Recreation in cooperation with Washington State Department of Commerce and Economic Development and the Parks and Recreation Commission.

Pleasure Boats

The Coast Guard is required by the Federal Boating Act of 1958 to register undocumented boats propelled by motors of more than ten horsepower that are used on navigable waters of the United States. Pleasure vessels over five tons net, are documented by the Coast Guard at the owners option. The estimated registered or documented privately-owned pleasure boats in the Puget Sound Area in 1966 are tabulated below by type of craft.

Inboard	15,500
Outboard	45,000
Auxiliary Sailboat	1,200
Total	61,700

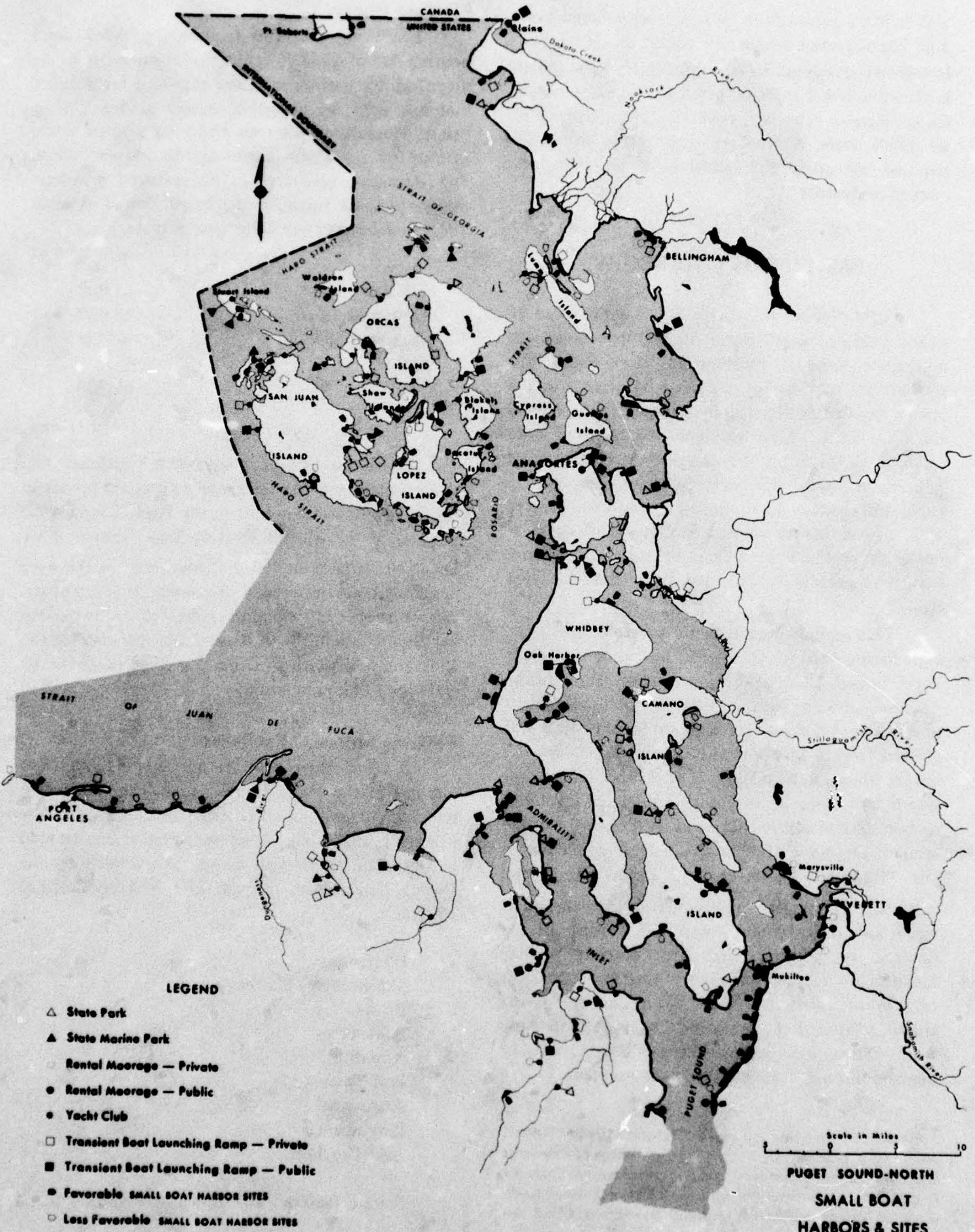
Based on other surveys the registered and documented craft are estimated to account for about one-third of the total craft in the Puget Sound Area. Expanding the 61,700 pleasure boats shown above yields an estimate of 181,000 total craft in the Area including non-registered craft consisting of rowboats, canoes, rubber rafts, prams, skiffs, etc. An ownership in 1966 of about 90 craft per 1,000 persons for the Area compares with a national average of about 40 craft per 1,000 population.

Existing Moorage Facilities

In 1966 there were 21 public and 119 private marinas in the Puget Sound Area. The number of rental moorages are summarized in Table 2-12. The following small boat harbors were either constructed and/or maintained with assistance provided by the Federal Government through the U.S. Army Corps of Engineers:

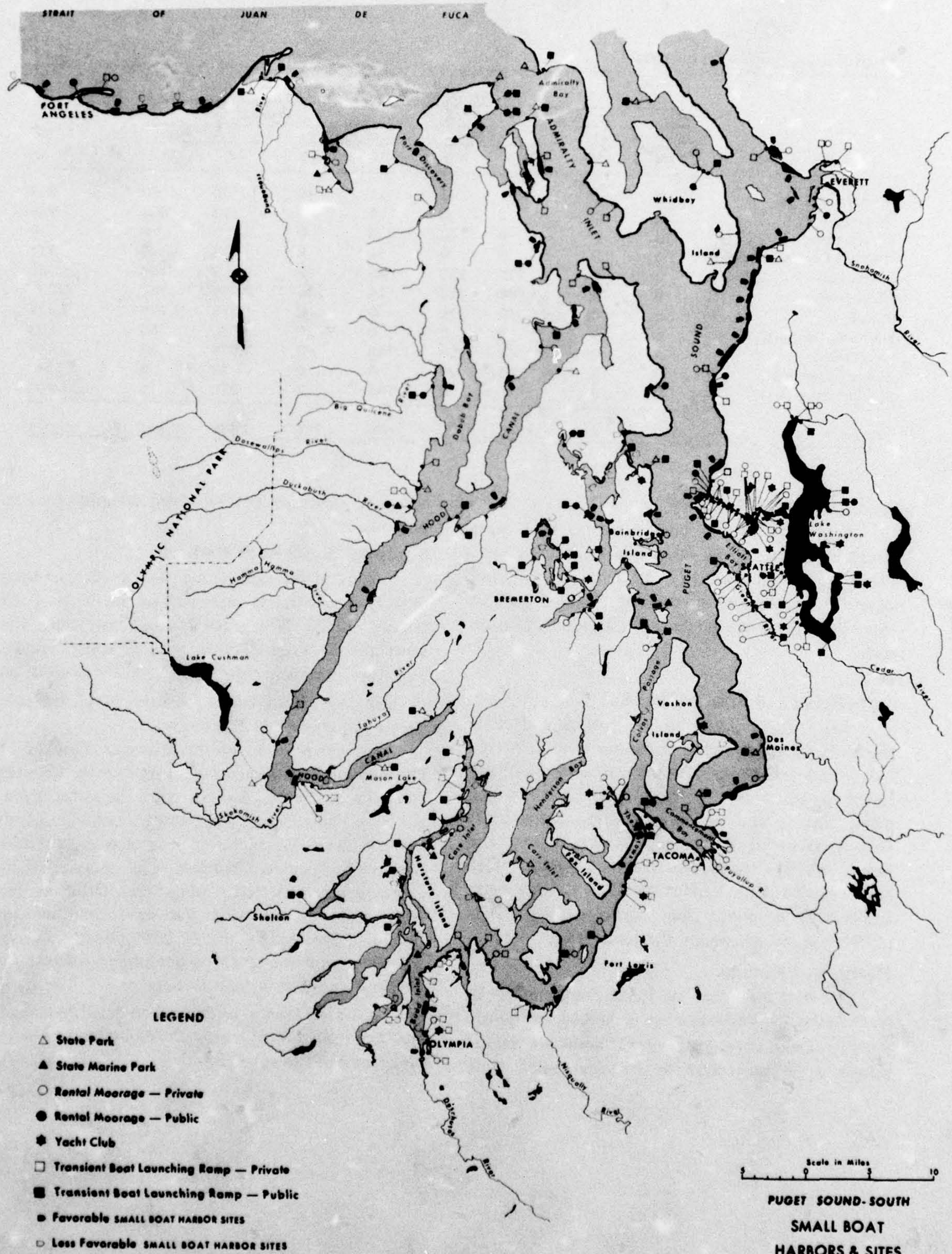
Edmonds
Shilshole Bay Marina
Blaine
Bellingham
Kingston
Port Townsend
Anacortes
Port Angeles
Lake Crockett

Marine facilities are shown in Figures 2-6 and 2-7.



PUGET SOUND-NORTH
SMALL BOAT
HARBORS & SITES

FIGURE 2-6



PUGET SOUND- SOUTH
SMALL BOAT
HARBORS & SITES

FIGURE 2-7

TABLE 2-12. Small boat harbors

Basins	Rental Moorages—1966 Public Summer Only Wet	Public Summer Only Dry	Public All Year Wet	Public All Year Dry	Private Summer Only Wet	Private Summer Only Dry	Private All Year Wet	Private All Year Dry	Total Moorages
Nooksack-Sumas	0	0	102	0	22	10	90	60	284
Skagit-Samish	0	0	375	0	0	0	180	400	955
Stillaguamish	0	0	0	0	0	0	0	0	0
Whidbey-Camano Islands	0	0	8	0	16	9	78	6	117
Snohomish	0	0	772	150	90	0	2	154	1,168
Cedar-Green	0	0	1,688	118	14	204	3,999	783	6,806
Puyallup	0	0	73	475	0	0	1,275	1,104	2,927
Nisqually-Deschutes	0	0	0	0	0	0	519	54	573
West Sound	117	0	482	22	149	60	1,576	40	2,446
Elwha-Dungeness	0	0	265	21	0	0	10	0	296
San Juan Islands	0	0	0	0	185	2	210	6	403
Totals	117	0	3,765	786	476	285	7,939	2,607	15,975

Boat Launching Facilities

Transient pleasure boat needs in 1966 were served by 79 public and 80 private launching ramps. These ramps had a total of 208 lanes. In addition, about 31 installations in the Puget Sound Area in 1966 provided hoist facilities for handling pleasure craft.

State Parks and Public Beaches

State Parks accessible to boaters and State Marine Parks are normally located in areas protected from wind and waves. These areas are particularly suited for all forms of water activities including skin diving, fishing and swimming. State Marine Parks provide sheltered anchorage, moorage buoys, and floats. In 1966 there were 25 State Parks and 15 State Marine Parks and over 200 beaches were available to the public along the saltwater shoreline of Puget Sound and adjacent waters.

Harbors of Refuge

No harbor located on Puget Sound and adjacent waters is designated as a harbor of refuge. Several of the larger public boat basins are able to afford some protection to transient small craft; however, moorages have not been set aside for this purpose.

Potential Small Boat Harbors

Many of the existing marinas can increase their moorage capacities to meet part of the needs of the boating public. New small boat harbors along the shoreline of Puget Sound will generally require expensive breakwater protection and the acquisition of high value waterfront property to provide the necessary parking and backup areas.

An examination of the saltwater shoreline of Puget Sound and adjacent waters revealed sites where new marine facilities could be constructed. Saltwater shoreline areas appearing feasible for development were noted after considering approach depths, dredging requirements, land access, parking area and beach material composition. Office studies were made of the wind and wave conditions at potential sites. Approximately 200 miles of saltwater shoreline were found to be potentially suitable for development of small boat harbors.

More detailed information on small boat harbors and related facilities is included in the river basin discussions of this appendix.

FUTURE NEEDS

GENERAL

The needs of navigation in the Puget Sound Area were estimated for the years 1980, 2000 and 2020. Projections of commerce, pleasure boating, harbors, channels, and land requirements were made using available data and techniques to provide the best forecasts possible within the time and fund limitations of this study. Further in-depth investigations are needed to refine these estimates and keep them current to reflect changing conditions.

This chapter first examines the economic environment and trends of the Puget Sound Area as presented in detail in Appendix IV. Waterborne commerce was projected considering historical trends. Current pleasure boat moorage needs were examined and relationships to population growth and projected per capita income increases were established. Industries requiring water transport were selected and their growth prospects identified. As requirements for terminal and transfer facilities depend both on industrial requirements and on commerce, the initial steps were analyses of waterborne commerce prospects, trends of vessel size and draft and handling of cargo. The findings were used to arrive at an estimate of navigation needs of the Puget Sound Area. These needs are disaggregated into basin needs in subsequent chapters. The methods of projection are detailed under each subject as the procedure differs in each case.

ECONOMIC ENVIRONMENT AND TRENDS

The Puget Sound Area is undergoing rapid economic growth. In 1967 and 1968, indicators of economic activity soared above national averages. Employment growth in the Seattle-Tacoma-Everett metropolitan area was double that of other large West Coast urban centers and the nation as a whole. Personal income and population rose substantially.

Appendix IV gives details on the economic environment and projects its future growth patterns. The main findings are given briefly herein to establish a base for evaluation and projection of navigation needs. The methodology used to develop trends and projections for Appendix IV were:

a. The major natural resource oriented industries of the area, i.e., agriculture, forests and minerals were accorded detailed studies.

b. Consulting Services Corporation of Seattle was employed to make the projections utilizing the inputs from the resource studies, the data available from the Washington State Input-Output Analysis and from supplementary studies. The Consultant adapted the model from the State of Washington as of 1963 to the Puget Sound Economic Area and used this model as a base for projecting a similar model for the year 1980.

Projections were then made for the years 2000 and 2020. For some industries, particularly those in agriculture and forest products, independent projections were made. For other industries the 17 year trend rates from 1963-1980 were extended to 2000 and 2020. Allowances were made for technological changes and productivity increases. Projections developed the future industrial output which in turn determined employment opportunities from which population estimates were derived.

Assumptions regarding the probable direction and level of national economic growth were adopted. These assumed trends and conditions which may not be fully realized, specifically identify the constraints under which the projections are made. National assumptions for this study were those adopted by the Bonneville Power Administration and their economic study of the Pacific Northwest. All Government agencies and private consultants and universities which contributed to that study used these assumptions. These explicit assumptions are:

a. Sufficient quantities of water of acceptable quality will be available through timely development to avoid being a constraint to economic growth.

b. The Federal Government, as a matter of national policy, will actively support programs designed to stimulate economic growth.

c. There will be no general war nor any appreciable cessation of the cold war throughout the period to 1980. Expenditures on national security will continue to account for approximately 10 percent of the gross national product. After 1980, gradual disarmament will decrease the relative cost of military expenditures.

d. There will be a continued relaxation of trade tariffs and quotas and an accompanying expansion in international commerce.

TABLE 2-13. Puget Sound Area—present and projected output, value added, employment by industry and population

Industry	1963 Output[1]	1963 Value Added[2]	1963 Employment	1980 Output[1]	1980 Value Added[2]	1980 Employment	2000 Output[1]	2000 Value Added[2]	2000 Employment	2020 Output[1]	2020 Value Added[2]	2020 Employment
	Millions of 1963 $			Millions of 1963 $			Millions of 1963 $			Millions of 1963 $		
Agri., Fish., For., Mining	$ 196.7	$ 99.5	23,700	$ 261.1	$ 139.0	18,200	$ 360.0	$ 190.0	13,500	$ 516.0	$ 268.0	11,000
Food & Kindred Prods.	698.5	223.3	15,900	1,240.9	405.3	19,500	2,333.4	900.2	22,900	4,088.7	1,906.6	25,600
Lumber & Wood Prods.	413.7	174.6	19,700	371.3	154.6	8,300	305.5	146.0	2,800	234.2	136.0	900
			(21,500)			(17,000)			(14,700)			(12,600)
Paper & Allied Prods.	349.2	168.1	9,400	683.1	334.9	14,700	1,009.4	561.0	15,900	1,101.5	705.1	12,400
			(9,800)			(10,300)			(10,900)			(9,300)
Chemicals	70.4	33.9	2,300	138.6	68.4	1,900	287.0	170.4	1,400	553.7	420.2	1,000
Petroleum Refining	255.9	61.5	1,200	511.8	123.0	1,300	1,080.2	301.4	1,400	2,124.7	729.1	1,300
Stone, Clay, Glass	92.4	37.9	3,800	172.5	71.1	5,000	337.1	161.2	6,500	614.0	361.1	8,000
Primary Metals	118.8	53.6	4,100	518.6	216.7	7,300	885.3	392.1	8,700	1,408.5	699.8	9,900
Other Non-Durable Mfgrs.	168.7	92.0	15,100	344.3	187.6	19,700	740.8	468.6	25,200	1,485.6	1,555.8	30,900
Other Durable Mfgrs.	1,815.9	959.6	86,200	5,460.7	2,408.6	175,700	18,707.1	7,707.4	380,700	58,086.5	24,349.1	787,400
Transportation	615.6	461.1	40,200	1,192.8	894.6	36,200	2,422.7	1,990.8	29,700	4,585.6	4,373.5	23,300
Wholesale & Retail Trade	1,250.3	1,011.3	140,000	2,269.4	1,835.4	202,600	4,267.4	4,006.3	292,300	7,477.7	8,634.1	402,400
Services	1,149.5	842.2	144,000	2,185.9	1,604.5	230,100	4,356.0	3,711.8	388,800	8,088.8	8,477.0	627,300
Construction	673.8	277.0	41,200	1,359.7	558.8	54,500	2,869.9	1,395.9	70,500	5,644.7	3,442.6	87,200
Government	--	734.0	115,800	--	1,565.1	178,100	--	4,140.9	275,100	--	10,816.5	405,800
Consumption	--	600.8	--	--	790.8	--	--	1,191.6	--	--	1,773.0	--
Total	$7,869.4	$5,830.4	662,600	$16,710.7	$11,358.4	973,100	$39,961.8	$27,435.6	1,535,400	$96,010.2	$68,247.5	2,434,500
Population			1,830,000			2,726,900			4,300,500			6,809,400

1 Output is equivalent to sales, except for those industries where "margin" entries are used. "Margin" represents "mark-up" costs as in case wholesale retail trade.

2 Value Added: A firm's sales less the purchase of goods and services from other firms. It is equivalent to the firm's contributions to gross regional product.

3 Data in parentheses is new data made available after the input-output study was completed.

Note: Figures may not add to totals due to rounding.

Source: Appendix IV, Economic Environment.

e. United States population will expand to:

1980	259,584,000
2000	338,219,000
2020	469,126,000

f. The Federal Government will use its resources energetically to promote maximum employment, production and purchasing power. Accordingly, employment will prevail at approximately 96 percent of total civilian labor force throughout the forecast period.

g. United States Gross National Product will increase in billions of 1960 dollars to:

1980	$1,130
2000	$2,472
2020	$5,402

h. Development of technological process, together with expansion of workers' skills and capital formation, will increase productivity per manhour approximately 2.9 percent per year.

The findings of this study for the Puget Sound Area are briefly summarized in Table 2-13. By 1980, population is projected to expand over the 1963 figure by about 1 million to 2.7 million. Value added is expected to almost double to $11.4 billion in 1963 dollars. Employment is forecasted to rise approximately 1 million people. By-passing the year 2000 and observing the year 2020, the population is estimated to be 6.8 million with area employment projected at 2.4 million and value added of $68 billion.

WATERBORNE COMMERCE

General

Planning for navigation depends on forecasts of waterborne commerce. Although these projections are crucial guides to development and investment, little progress has been made in the Nation and the region toward gathering the facts needed as a base for a rational approach toward developing reasonable estimates. Cargo transported by water through ports stems from a wide range of regions and is destined for many places both far and near. The activities of individual ports are related to each other and the economy of international, national and local markets. Technological changes both in shoreside handling and in water transport have important roles in the volume and character of waterborne commerce.

Projections of waterborne commerce deserve an exhaustive study based on facts developed by detailed examination of traffic origins and destinations and the evaluation of the economic forces governing the flow of this traffic. Such a study, although needed, would require an investigation covering an area extending over at least the western United States and its trading area. Both time and available funds precluded a study of this scope. Accordingly, the tools at hand were used to project future commerce recognizing their limits and the fact that the approximations arrived at would of necessity require refinement by later investigations.

In preceding chapters, the historical record of waterborne commerce has been compiled from 1952 to 1966. Even though the period of record is short, it is representative reflecting more stable conditions without the major distortions from wars and recovery during the previous decade. An examination was made of the future based on extension of trends over the past years for total commerce and for the broad commodity groups of general cargo, bulk grain, forest products, bulk petroleum, other dry bulk and other liquid bulk. The resulting projections were extensions of the past without recognition of the growth forces reasonably expected to govern the flow of commodities through the Puget Sound ports. The relationship of waterborne commerce with both national and local economic parameters were examined and projections were made where the characteristics of commodity flow could be correlated with the economy. Where correlation could not be established on this basis, the future growth trends were based on past performance.

Both linear and compound growth trends were fitted to time series data for the period 1952 to 1966. The equation form selected for each commodity grouping was based upon judgment and the degree of correlation. An electronic computer was employed to develop the time trends using a linear regression program. The linear equations were developed directly by the computer while a logrithmic transformation of the time series data was necessary to obtain compound growth trends.

The forecast for separate commodity groups were then aggregated and compared to the projections of total commerce previously developed. The difference was taken as unidentifiable commerce resulting from changes in technology, changes in consumer tastes, or from other reasons. The difference was then prorated on a selective basis to the individual commodity forecasts.

Forecasts of ferry traffic were not made in this study, but recent projections for 1975 and 1990 performed for the Washington State Highway Commission and Washington Toll Bridge Authority by the Washington State Department of Highways, with the assistance of the Puget Sound Governmental Conference[1], are available by ferry run. Ferry traffic is estimated at approximately 5,800,000 vehicles for 1975 and over 10,000,000 vehicles for 1990.

Total Commerce

For purposes of forecasting waterborne commerce, commodity movements previously defined by general groupings are presented by "Foreign and Domestic Coastwise," "Domestic Internal" and "Total" tonnages. The future tonnage of each general group was forecast on the basis of past trends and where applicable, on the basis of correlations with economic parameters contained in Appendix IV and summarized in Table 2-13.

Total waterborne commerce in the Puget Sound Area is generally related to the economic activity in the Area. Therefore, one apparent means of forecasting future commerce would be from a statistically derived correlation with historical Gross Regional Product and projections of Gross Regional Product contained in Appendix IV. However, the lack of GRP values prior to 1963 prevented employment of this approach. Consequently, linear regressions of Area waterborne commerce by each tonnage grouping with Gross National Product were made and found to have good correlation. Accordingly, projections of future commerce for 1980, 2000 and 2020 were made using GNP values employed in the Economic Base Study and correlations established by the regression models. As the Puget Sound Area economic growth is expected to exceed national economic growth, use of GNP for projecting area waterborne commerce is recognized as being conservative.

Foreign and Domestic Coastwise. This commerce is with foreign nations and parts of United States outside the Puget Sound Area. The historical record of this tonnage shows a progressive increase from about 11,000,000 tons in the early 1950's to over 17,000,000 tons in 1966. This historical record indicates a growth at an average annual compound rate of 3.6 percent. Assuming that this growth rate would continue, waterborne commerce would reach 29,000,000 tons in 1980, 60,000,000 tons in 2000 and 123,000,000 tons in 2020. This trend is shown graphically on Figure 2-8.

[1] Economic evaluation Kitsap Peninsula, Bainbridge Island connector bridge routes, January 1969, Washington State Department of Highways.

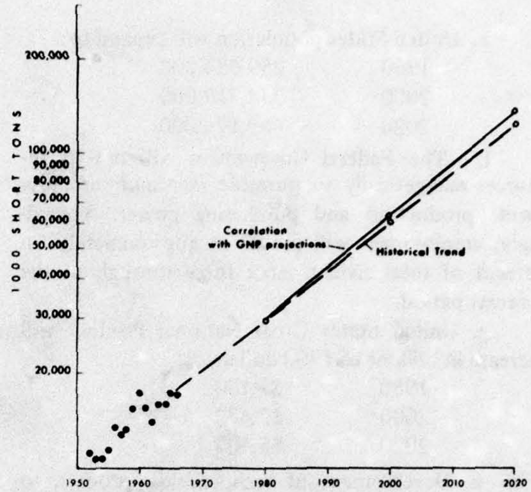


FIGURE 2-8. Puget Sound—Projected Total Foreign and Domestic Coastwise Waterborne Commerce.

This estimate can be considered illustrative only because no recognition is given to economic forces changing the future. To reflect these effects, the historical behavior of this commerce was compared to the Gross National Product and a good correlation was found between these variables. Projections are shown graphically on Figure 2-8.

Domestic Internal. Traffic between ports or landings entirely within Puget Sound is covered by this category. In the past this tonnage has followed an erratic pattern rising from 20 million tons in 1952 to a peak of 27 million tons in 1959 and stabilizing near 25 million tons through 1966. The average annual growth over this period has been 1.9%. Assuming this growth would hold for the future, tonnages would be 34,000,000 in 1980; 49,000,000 in 2000 and 71,000,000 in 2020 as illustrated in Figure 2-9.

As in the case of foreign and domestic coastwise commerce, the growth trends were correlated with the GNP. Projections were developed in the same manner and are given on Figure 2-9.

Projections of Total Commerce. Total commerce of the Puget Sound Area over the period of 1952 through 1966 has increased from 31,000,000 to almost 42,000,000 tons. Rapid growth occurred in the early half of this period reaching a plateau from 1960 to 1966. The historical record demonstrates an annual compound rate of growth of 2.5%. Both historical and future commerce are shown graphically on Figure 2-10 and indicate that by extending the past trend waterborne commerce could reach 62,600,000 tons in 1980; 103,300,000 tons in 2000 and 170,200,000 tons in 2020.

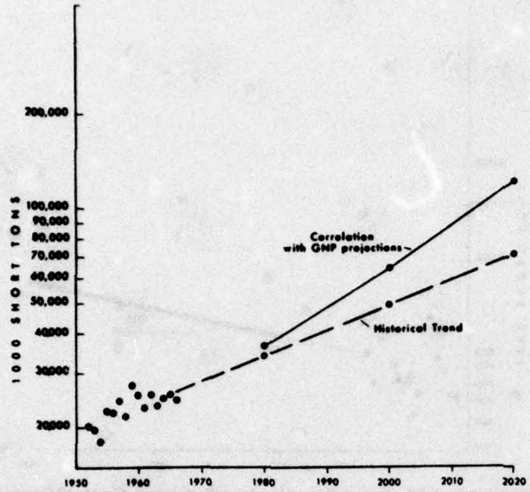


FIGURE 2-9. Puget Sound Area—Projected Total Domestic Internal Waterborne Commerce.

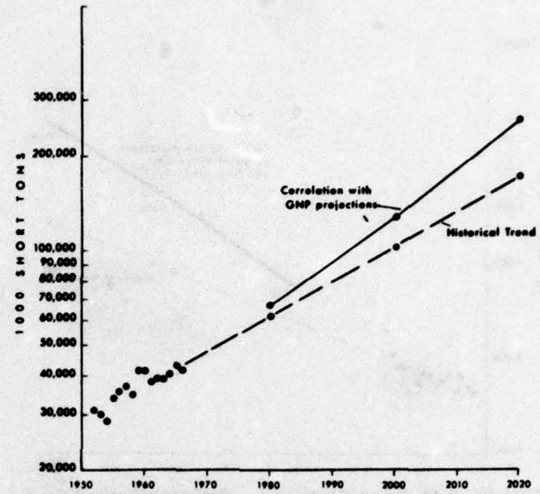


FIGURE 2-10. Puget Sound Area—Projected Total Waterborne Commerce.

Forecast based on the past can only be considered as a rough approximation having limited use for planning. To recognize economic forces, historical commerce trends were compared to GNP and found to have reasonable correlation. Projections were then based on the relationship with this national index. The results are given on Figure 2-10 and are tabulated below:

Total Waterborne Commerce
(in 1,000 tons)

	1980	2000	2020
Total	65,500	126,300	259,100

General Cargo

General cargo consists of the output and requirements of the manufacturer and the consumer. Commodities range from fabricated metals and machinery to fish products and a wide range of products handled in wholesale and retail trade. The growth pattern of this commerce relates directly to business activities in the wholesale and retail trades.

Foreign and Domestic Coastwise Commerce—Although fluctuating in yearly volume, general cargo in foreign and domestic coastwise trade in the Puget Sound Area has increased from 1,600,000 tons in 1952 to 2,500,000 tons in 1966. The trend for this period was an average compound rate of growth of about 1.8 percent annually as illustrated on Figure 2-10. An extension of this trend would indicate the tonnage could be 2,600,000 tons in 1980, 3,800,000 tons by 2000 and 5,400,000 tons by 2020. However, projecting the future based on the past does reflect the recent increase in volume due to containerization, high economic growth of the area and increasing trade with other nations, particularly the orient.

As most of general cargo comprises goods in the wholesale and retail trades, a correlation of these variables would be expected. The historical relationship of national wholesale and retail trade product with general cargo tonnages were examined and found to have a high correlation. Accordingly, general cargo for the Puget Sound Area was projected using output forecast for wholesale and retail trades given in Table 2-13. The resulting projections are shown on Figure 2-11.

Domestic Internal Commerce—Domestic internal traffic, although small in tonnage when compared to foreign and domestic coastwise trade, has grown from 741,000 tons in 1952 to 1,010,000 tons in 1966. The average annual compound rate of growth for this period, as indicated by the trend was about 1 percent. Figure 2-12 gives an extension of this trend. Based on past performance, this tonnage could be expected to reach 1,150,000 tons in 1980, 1,400,000 tons in 2000 and 1,700,000 tons in 2020. The flow of this traffic between ports of the Puget Sound Area is governed by internal marketing conditions and transportation rate structures. Accordingly, a correlation with economic trends such as wholesale and retail trade would not be possible. For planning purposes in this study, a projection based on historical trends was deemed to be appropriate.

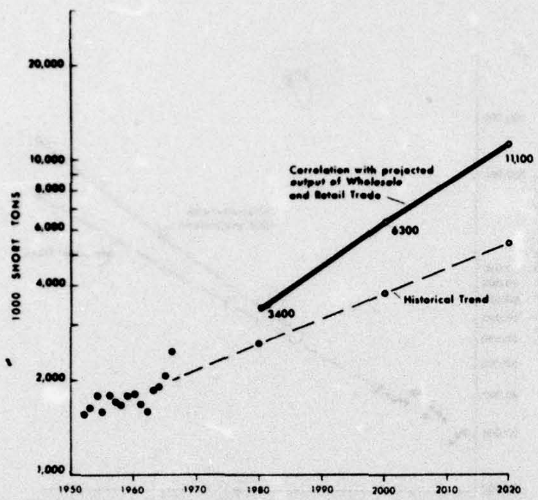


FIGURE 2-11. Puget Sound Area—Projected General Cargo Foreign and Domestic Coastwise Commerce.

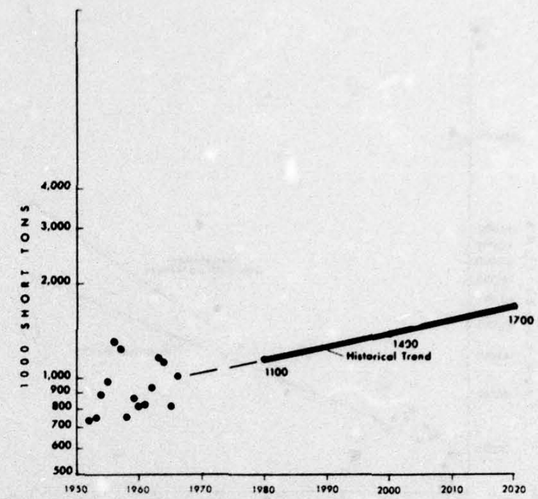


FIGURE 2-12. Puget Sound Area—Projected General Cargo Domestic Internal Waterborne Commerce.

Total General Cargo—*The projections of foreign* and domestic coastwise and domestic internal commerce in the category of general cargo have been consolidated into total commerce. Figure 2-13 gives the total general cargo projected for the Puget Sound Area in years 1980, 2000 and 2020. *These projec*tions are summarized below:

General Cargo (In 1,000 Tons)

	1980	2000	2020
Foreign & Domestic Coastwise	3,400	6,300	11,100
Domestic Internal	1,100	1,400	1,200
Total	4,500	7,700	12,300

Bulk Grain

Bulk grain is confined to foreign exports and is largely dependent on world needs and overall wheat production and consumption in foreign countries. A projection of historical trends in foreign grain exports indicates an average annual increase of about 3.4%. This would place the 1980 tonnage at 2,203,000 tons; 4,184,000 tons in 2000, and increasing to 7,947,000 tons in 2020. The trend line is shown in Figure 2-14 and is not necessarily a valid forecast because no consideration is given to future grain production levels. Likewise, a forecast based on total production of wheat in those areas most likely to ship through Puget Sound ports does not give satisfactory results as, during years of world-wide high yield, exports are down and grain is stored. Also, the origin of some bulk grains exported through Puget Sound is not always from the wheat producing areas of the *three* Western states and Western Montana. For instance, if India is the buyer, the Midwestern wheat is preferred to that produced in the Northwest. On the other hand, the Japanese buyers prefer the Western wheat. Reliable sources have indicated that

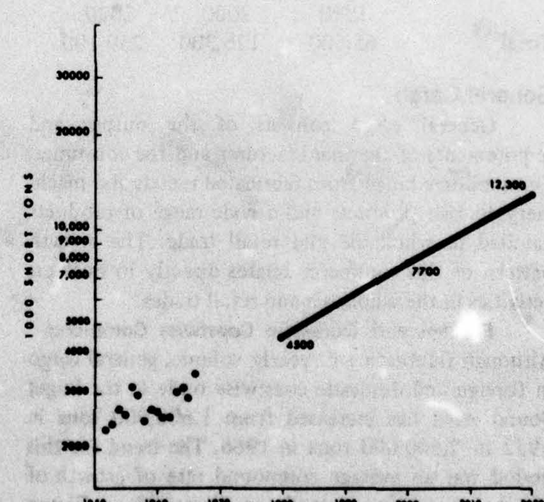


FIGURE 2-13. Puget Sound Area—Projected General Cargo Total Waterborne Commerce.

export of midwest grain could increase substantially if satisfactory unit train rail rates can be negotiated. This coupled with the highly automated grain terminal being constructed by the Port of Seattle, could increase the export grain forecast.

For the purposes of this report, the forecast for future tonnages assumes that all export will be from the Western wheat producing areas previously mentioned. The projections assume that 90% of all wheat produced in this Area will be exported and that Puget Sound ports will continue to maintain a share of the total export market which is based on their average share over the past 15 years. Based on the foregoing, and grain production forecasts from the Columbia-North Pacific Regional Study,[1] tonnages would be 2,100,000 tons in 1980; 2,300,000 tons in 2000 and 2,700,000 tons by the year 2020. This forecast is shown in Figure 2-14 and summarized below:

Bulk Grain (In 1,000 Tons)

	1980	2000	2020
Foreign & Domestic Coastwise	2,100	2,300	2,700
Domestic Internal	--	--	--
Total	2,100	2,300	2,700

Forest Products

Lumber, wood products, pulp, paper and associated commodities form the commerce under the broad classification of forest products. The volume of this commerce depends on foreign and domestic markets outside the Puget Sound Area for exports and on the capability of outside sources such as Canada and the Phillipines to provide imports to meet demands. The output of the forest area tributary to the Puget Sound Area is a constraint on the level of this commerce.

Foreign and Domestic Coastwise Commerce—The volume of this commerce has decreased from about 1,000,000 tons in 1952 and 1954 to 760,000 tons in 1957 and then increased to approximately 2,700,000 tons in 1966 primarily as a result of the growing market for logs and chips in the Far Eastern

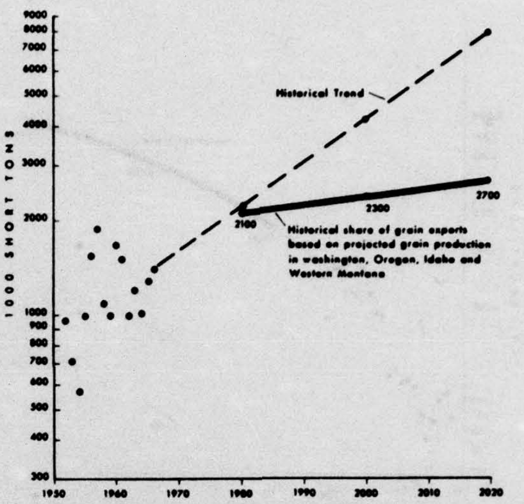


FIGURE 2-14. Puget Sound Area—Projected Bulk Grain Foreign and Domestic Coastwise Waterborne Commerce.

countries. The trend in this period had an average rate of growth of 106,800 tons annually. Figure 2-15 shows an extension of this trend. On this basis tonnages would be 3,600,000 tons in 1980; 5,700,000 tons in 2000 and 7,900,000 tons in 2020. Although the economic forecasts of output of forest and wood products in Table 2-13 indicate a major decrease by 2020, this downward trend is compensated by increases in output of paper and allied products. Therefore, tonnages would be available for further growth of waterborne commerce. The volume of this commerce depends upon demands for these commodities in foreign countries and on the capabilities of countries having timber resources to meet this demand as well as the legal restrictions imposed on exports and imports. An examination of the maze of changing conditions impacting the volume of future commerce results in the conclusion that the past performance of this commerce would be the best indicator of the future.

Domestic Internal Commerce—As shown on Figure 2-16, domestic internal commerce has declined from about 12,000,000 tons in the early 1950's to 10,000,000 tons in 1957 and thence to about 7,500,000 tons in 1966. This commerce is interchange of forest products between producing centers and the distribution of these products to internal markets. The decline in tonnage of this type is due to the impact of export markets on supply and the use of land storage and transport. The trend line based on past performance, shown in Figure 2-16, is not

[1] Small grain projections, Columbia-North Pacific Regional Study.

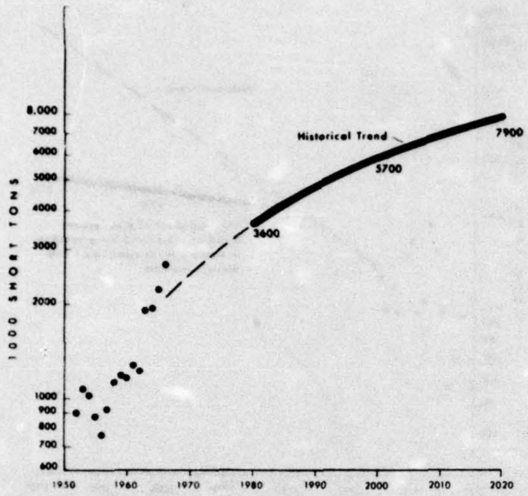


FIGURE 2-15. Puget Sound Area—Projected Forest Products Foreign and Domestic Coastwise Commerce.

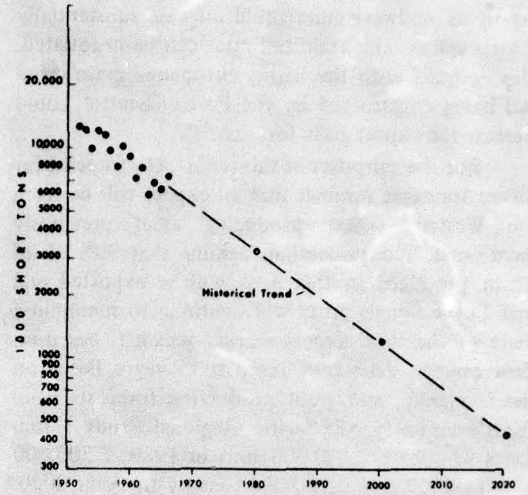


FIGURE 2-16. Puget Sound Area—Projected Forest Products Foreign and Domestic Coastwise Commerce.

expected to be followed, but instead, a leveling out near 6,000,000 tons is forecast. This is consistent with recent past performance which has ranged between 6 and 7 million tons from 1961 through 1966.

Total Forest Products—During the period of 1952 through 1966, the total commerce in forest products has ranged from 8,000,000 to 13,000,000 tons. The total of projections for forest products is given in Figure 2-17. Projected are 9,600,000 tons for 1980, 11,700,000 tons in 2000 and 13,900,000 tons in 2020. These estimates are within the volumes of past shipments and are considered acceptable for planning purposes. A breakdown of this commerce follows:

Forest Products (In 1,000 Tons)

	1980	2000	2020
Foreign & Domestic Coastwise	3,600	5,700	7,900
Domestic Internal	6,000	6,000	6,000
Total	9,600	11,700	13,900

Bulk Petroleum

In 1963 the petroleum refinery capacity of the Pacific Northwest satisfied about 46% of the consumption of petroleum products in the region with

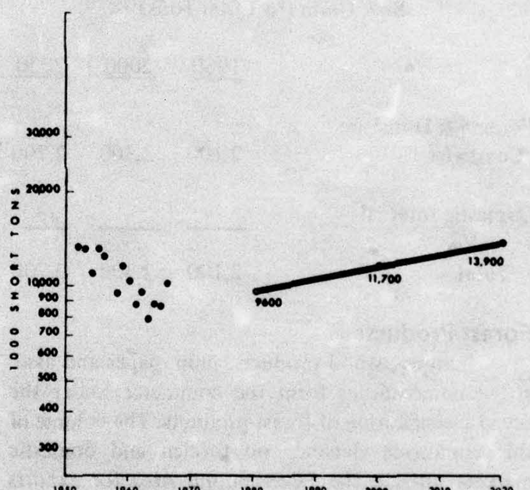


FIGURE 2-17. Puget Sound Area—Projected Forest Products Total Waterborne Commerce.

the refinery capacity of the region being 165,100 barrels per calendar day (b/cd), of which 157,700 barrels per calendar day were produced by refineries in the Puget Sound Area[1]. The refinery complex in the Puget Sound Area has expanded from two small refineries in 1954 with an output of 9,500 b/cd in 1964. The location of these refinery sites was

[1] Source: Pacific Northwest Economic Base Study for Power Markets, U.S. Department of Interior, Volume II, Part 11c, Petroleum, 1966.

influenced by the available deep water which permits loading and unloading large tankers. Further, the geographical location provides flexibility for receiving foreign and Alaskan imports of crude oil as well as for dispatching finished products to major Northwest market areas. Finally, there is a dependable power supply. Electric energy requirements for refining are approximated at 3-kilowatt-hours per barrel of crude oil input with a high load factor.

The future growth of refining in the Pacific Northwest will depend in part on the current search for reserves in the coastal waters of Oregon and Washington and the method employed in marketing the vast new oil fields on the north slope of the Arctic Ocean in Alaska with resources[1] estimated from 20 to 50 billion barrels or double the present United States oil reserves. Present planning for marketing include a large pipeline to Valdez and thence to Puget Sound tanker or to the midwest by pipeline across Canada. A pipeline from Seattle to Chicago also has been mentioned. An indication of the present views of the industry is the recent announcement by Atlantic Richfield of their plans for construction of a refinery at Bellingham, Washington to process 100,000 b/cd of Alaskan crude, thus bringing the total refinery capacity of the Puget Sound Area to about 272,000 b/cd by 1980.

The implementation of these potentials could mean that the Puget Sound Area would experience a large growth in refineries, the Pacific Northwest region would undergo a transition from a net importer to a net exporter of refined petroleum products and that the market area of the Puget Sound Area petroleum output could encompass the entire region and parts of northern California. The changing situation with respect to this industry and the many variables dependent on decisions by the industry, preclude the development of projections except on an approximate basis recognizing the probability of large future changes.

Foreign and Domestic Coastwise Commerce—This commerce has grown in volume from about 6,000,000 tons in 1952 to a high of 10,000,000 tons in 1960. Assuming that historical trends continue, an average compound annual rate of 3.2% future commerce would be 13,900,000 tons in 1980; 26,200,000 in 2000 and 49,000,000 tons in 2020 This trend is shown graphically on Figure 2-18.

The volume of future commerce depends on a wide range of variables as discussed in the opening

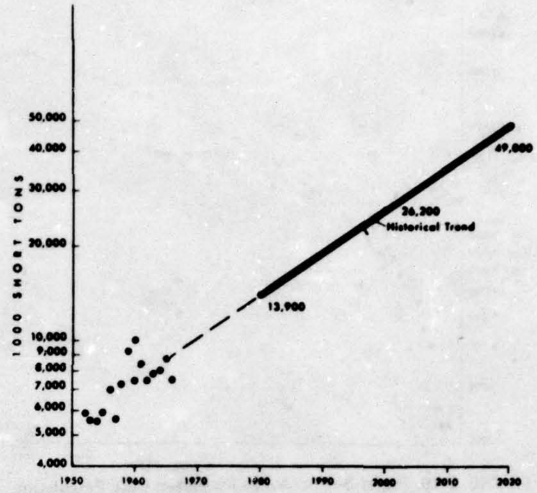


FIGURE 2-18. Puget Sound Area—Projected Bulk Petroleum Foreign and Domestic Waterborne Commerce.

paragraph of this section. The foregoing projections, based on past performance, are considered to be acceptable for planning purposes subject to revision as facts become available. The average compound rate growth trend of 3.2% annually is consistent with Bonneville Power Administration's forecasts of gasoline consumption which are expected to average about 3.1% in the period of 1960 to 1985.[2] The 1980 projection of 13,900,000 tons appears consistent with the area refining capacity in tons when Atlantic Richfield's refinery is added to existing plants. Also, the growing market demand of the region assures consumption. The projections for 2000 and 2020 are reasonable when compared to the market.

Domestic Internal—Refined petroleum moves into the markets of Puget Sound by tanker, barge, pipelines, tank cars and tank trucks. The internal waterborne movements of this commodity increased from about 2,300,000 tons in 1952 to 9,800,000 tons in 1963 and then decreased to 6,300,000 tons in 1966. The trend prior to 1963 would indicate an average annual rate of growth of 475,800 tons yielding 16,000,000 tons in 1980; 25,600,000 tons in 2000 and 35,100,000 tons in 2020, as illustrated on Figure 2-19. However, the construction of pipelines

[1] Business Week, February 1, 1969.

[2] Pacific Northwest Economic Base Study for Power Markets, BPA, Volume II, Part 11c, Petroleum, 1966.

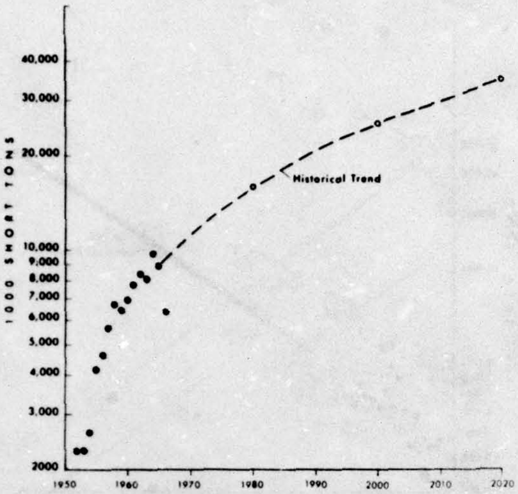


FIGURE 2-19. Puget Sound Area—Projected Bulk Petroleum Domestic Internal Waterborne Commerce.

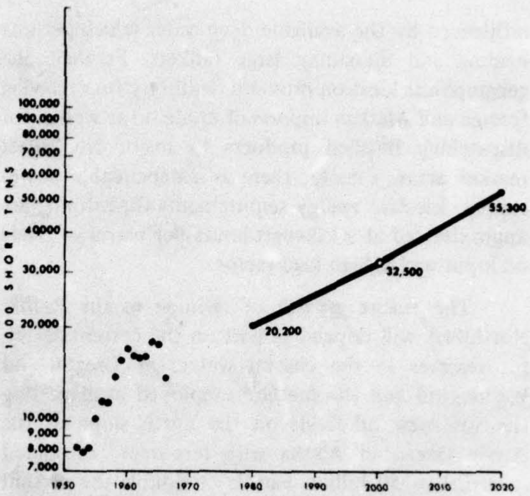


FIGURE 2-20. Puget Sound Area—Projected Bulk Petroleum Total Waterborne Commerce

connecting major centers of distribution has altered this trend as revealed by the decreasing tonnages from 1965 through 1966. Future tonnages of waterborne commerce will vary from year to year depending on pipeline capacities, location of consumers and the transportation cost structure. An evaluation of past trends indicates that 6,300,000 tons of traffic by water in 1963 represents an average of future volume of this waterborne commerce.

Total Bulk Petroleum Commerce—Available evidence supports continual growth of the petroleum industry of Puget Sound Area to fill the growing demands of Pacific Northwest. The development of the large Alaska oil fields are expected to play an increasing role in the source of crude oil in future years. Although there are many variables influencing the location of refineries and the flow of traffic, the forecast derived herein is considered reasonable on the basis of available information and suitable for planning purposes. Figure 2-20 shows the forecast trend of bulk petroleum commerce for years 1980, 2000 and 2020. A summary of this commerce is:

Bulk Petroleum
(In Millions of Tons)

	1980	2000	2020
Foreign & Domestic	13,900	26,200	49,000
Domestic Internal	6,300	6,300	6,300
Total	20,200	32,500	55,300

Other Dry Bulk

Commodities associated with this classification of traffic are ores, stone, clay, glass, sand, gravel, rock, cement, bulk dry chemicals, fertilizers and agricultural products other than grain. The bulk volume of this commerce is a function of activity in the primary metals industry and depends on the demands for construction to meet the requirements of the expanding population in the Puget Sound Area.

Foreign and Domestic Coastwise Commerce—Except for a short period of decline in the early 1950's, this commerce composed of alumina imports and of bulk other than sand, gravel and rock has steadily increased from 1,687,000 tons in 1952 to 2,853,000 tons in 1966. The trend in the period of 1952 to 1963 had an average compound rate of growth of 4-3/8% annually. As shown on Figure 2-21, an extension of this trend would indicate tonnages of 5,523,000 in 1980; 13,043,000 in 2000; and 30,795,000 tons in 2020. To obtain projections more accurately representing the economic conditions governing the flow of commerce, forecasts were based on an analysis of the aluminum and other primary metals industries.

Alumina—The requirements of aluminum refineries are the main source of commerce under this category. In the Puget Sound Area, the first aluminum smelter was constructed at Tacoma in 1944 and a second plant was constructed at Ferndale in 1966, providing a total capacity of 269,000 tons of aluminum ingots annually. The volume of alumina received

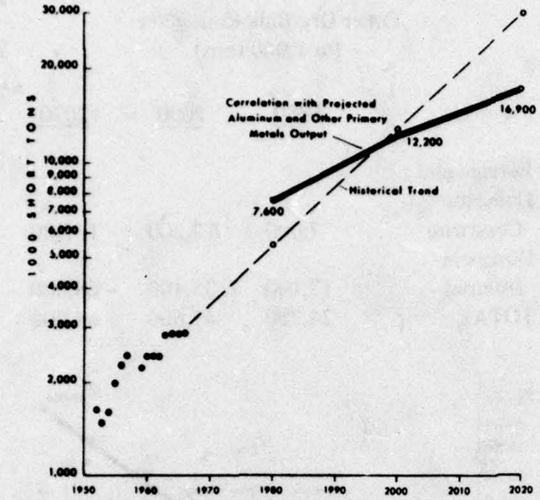


FIGURE 2-21. Puget Sound Area—Projected Other Dry Bulk Foreign and Domestic Coastwise Waterborne Commerce

in the Puget Sound Area has increased from 5,000 tons in 1963 to 392,000 tons in 1967. The gradual shift to deep draft movement of alumina coupled with the development and processing of bauxite deposits in Australia has caused the rapid growth of this commerce in recent years, a situation expected to continue in the future.

Alumina received in the Puget Sound Area is destined both for the existing smelters and for transhipment to reduction plants in Western Montana and Eastern Washington. The Port of Tacoma has constructed handling facilities with a storage capacity of 50,000 tons, and is in the process of adding another 100,000 tons of storage. This facility is supplying imported alumina to Kaiser Aluminum and Chemical Company Corporation plants at Tacoma and Mead, Washington. The Port of Everett is completing construction of a similar installation for transhipping alumina to the Anaconda Aluminum Company smelter at Columbia Falls, Montana. The storage facility will have a capacity of 50,000 tons per year.

The annual compound rate of increase in aluminum consumption in the United States was estimated by the U.S. Department of Commerce as 9.4% from 1960 to 1980 and 5.1% from 1980 to 2000.[1] Studies by the Bonneville Power Administration forecast national consumption at 7.4% from 1965 to 1975 and 5.0% from 1975 to 1985.[2] The Consulting Services Corporation in their forecast of aluminum output of Puget Sound aluminum smelters given in Appendix IV estimated the compound annual growth rate from 1980 to 2020 as 3%. This rate appears reasonable as the long range outlook from reliable sources indicate that as high as half of future reduction plants may be built at or near the source of bauxite as a requirement by the foreign country for exploitation of the resource.

The aluminum reduction plants in the Puget Sound Area are expected to reach a capacity of 620,000 tons in 1980[3] and then grow at an annual compound rate of 3% reaching capacities of 1,130,000 in 2000 and 2,060,000 in 2020. The smelters at Mead, Washington, and Columbia Falls, Montana, would expand from a total capacity of 328,000 tons in 1970 to 440,000 tons in 1980 at an annual compound rate of 3%, and to 790,000 tons in 2000 and 1,420,000 tons in 2020. On this basis, the forecast of alumina shipments in foreign and domestic coastwise commerce to and through the Puget Sound Area, based on two tons of alumina to produce one ton of aluminum, are:

Quantity (In 1,000 Tons)

	1980	2000	2020
For Puget Sound Plants	1,200	2,300	4,100
Transhipment to Inland Plants	900	1,600	2,800
Total	2,100	3,900	6,900

Dry Bulk Other Than Alumina—Dry bulk other than alumina amounted to 2,82[illegible]0 tons in 1963. These commodities, for the most part, are composed of ores, coal, and dry chemicals with their future demand related directly to the industrial structure of the Area. This commerce was projected on the output growth trend of the primary metals industry, other than aluminum, and is estimated to be 5,400,000 tons in 1980; 8,300,000 tons in 2000 and 9,900,000 tons in 2020. The primary metals industry is expected to account for most of the tonnages shipped to the Area and therefore was taken as an indicator of future growth.

[1] Bonneville Power Administration Report.

[2] Ibid.

[3] Ibid.

Summary—Projections of other dry bulk in foreign and domestic coastwise commerce are given graphically on Figure 2-21 and tabulated below:

Other Dry Bulk in Foreign and Domestic Coastwise Commerce (in 1,000 tons)

	1980	2000	2020
Alumina	2,100	3,900	6,900
Other	5,400	8,300	9,900
TOTAL	7,500	12,200	16,800

Domestic Internal. These commodities include sand, gravel, and rock moving from quarries and borrow areas to meet construction needs of the area. Cement and other dry bulk materials are also covered under this category. The movement of these items vary from year to year depending on construction activities, but have doubled in volume in 15 years increasing from about 4,500,000 tons in 1956 to 9,800,000 tons in 1966. This traffic has an average annual growth of 380,000 tons as illustrated on Figure 2-22. Continuation of this trend would result in tonnages of 14,800,000 in 1980; 22,400,000 in 2000, and 29,900,000 tons in the year 2020. As the recent expansion trends of the economy of the Puget Sound Area are expected to continue, a projection based on construction and industrial activity would indicate the probable tonnage of this commerce. Using the trend of output for the construction activities given in Table 2-13, projections were developed for sand, gravel, rock and cement. Other domestic internal dry bulk was projected using the output trends for primary metal industry exclusive of aluminum. These forecasts are shown on Figure 2-22 and are summarized as follows:

Other Dry Bulk in Domestic Internal Commerce (in 1,000 tons)

	1980	2000	2020
Sand, gravel, rock, cement	15,800	33,300	65,500
Other	1,400	2,100	2,500
TOTAL	17,200	35,400	68,000

Total Other Dry Bulk Commerce. The projections of other dry bulk commerce for the Puget Sound Area have been totaled and plotted graphically on Figure 2-23. A summary of this commerce is:

Other Dry Bulk Commerce (in 1,000 tons)

	1980	2000	2020
Foreign and Domestic Coastwise	7,600	12,200	16,900
Domestic Internal	17,100	35,400	68,000
TOTAL	24,700	47,600	84,900

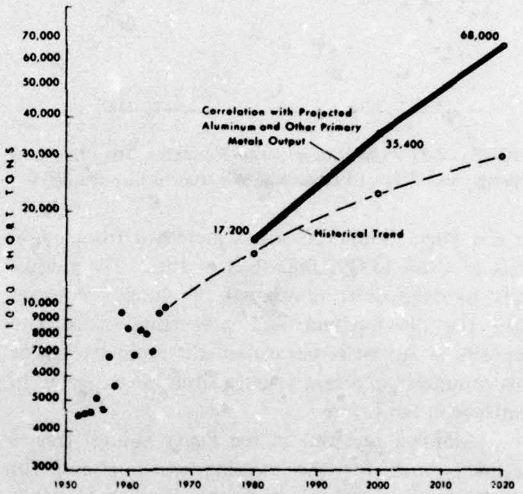


FIGURE 2-22. Puget Sound Area—Projected Other Dry Bulk Domestic Internal Coastwise Waterborne Commerce.

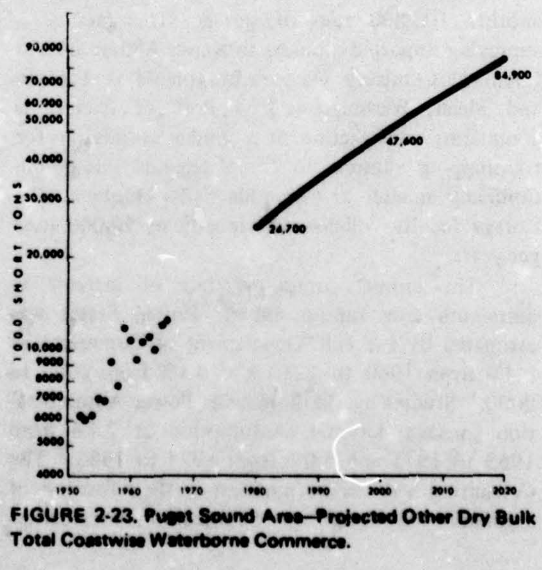


FIGURE 2-23. Puget Sound Area—Projected Other Dry Bulk Total Coastwise Waterborne Commerce.

Other Liquid Bulk Commerce

All commodities handled in bulk liquid form other than petroleum fall in this category of commerce. Some of these liquids are alcohol, liquid sulphur and sulphuric acid, coal tar and related chemicals, and vegetable and animal oils and fats. The demand for a large portion of this commerce is related to the chemical industries associated with petroleum refining and forecasts are subject to many of the potentials and changing conditions previously discussed under bulk petroleum.

Foreign and Domestic Coastwise Commerce. From about 100,000 tons in the early 1950's, this commerce increased to about 150,000 tons in 1966. Historical trends show an average compound rate of growth of 3.3 percent annually which is extended on Figure 2-24. The resulting tonnage would be 227,000 tons in 1980; 446,000 tons in 2000, and 852,000 tons in 2020. As the growth pattern of this commerce is associated with the chemical industry, a projection was based on the trends of output for the chemical industry estimated in Table 2-13. The resulting forecasts are 280,000 tons in 1980; 570,000 tons in 2000, and 1,120,000 tons in 2020.

Domestic Internal Commerce. This traffic between ports of the Puget Sound Area increased from 1,000 tons or less in 1953 and 1954 to an average of about 50,000 tons in subsequent years. This historical trend has been an average annual growth of 2,100 tons. If extended as illustrated graphically on Figure 2-25, the tonnage would be 82,000 in 1980; 125,000 in 2000, and 167,000 in 2020. Projecting this commerce on the basis of the output forecast in Table 2-13 for the chemical industry gives 70,000 tons in 1980; 160,000 tons in 2000, and 280,000 tons in 2020.

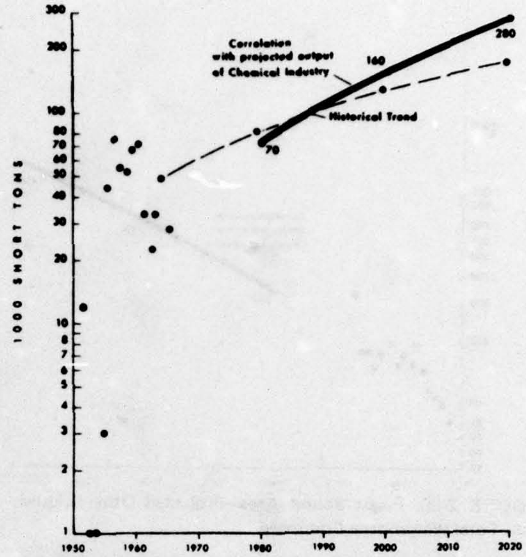


FIGURE 2-25. Puget Sound Area—Projected Other Liquid Bulk Domestic Internal Waterborne Commerce.

Total Other Liquid Bulk Commerce. Figure 2-26 shows historical total commerce in this classification and the total forecasts developed by the preceding evaluations. These projections are summarized in the following tabulation.

Other Liquid Bulk Commerce
(in 1,000 tons)

	1980	2000	2020
Foreign & Domestic Commerce	280	570	1,120
Domestic Internal Commerce	70	160	280
TOTAL	350	730	1,400

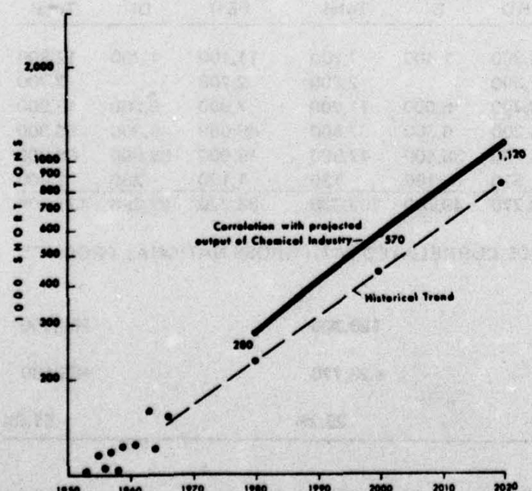


FIGURE 2-24. Puget Sound Area—Projected Other Liquid Bulk Foreign and Domestic Waterborne Commerce.

Projections of Waterborne Commerce

The historical commerce of the Puget Sound Area for the period 1952 through 1966 was examined to provide a basis for projecting future tonnage to the years 1980, 2000 and 2020. Initially, an overview of total traffic was obtained by extending trends developed from correlations with Gross National Product. These projections provided an umbrella of gross

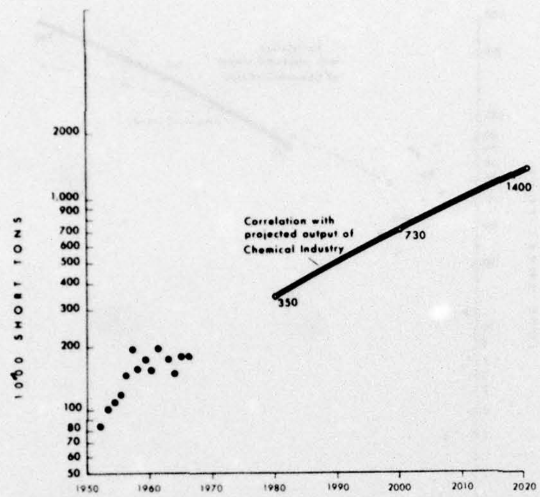


FIGURE 2-26. Puget Sound Area–Projected Other Liquid Bulk Total Waterborne Commece.

tonnage forecasts against which an aggregation of individual commodity forecasts could be compared. Projections were made by segregating broad commodity groupings into foreign and domestic coastwise commerce and into domestic internal commerce. Table 2-14 *individual commodity* group forecasts and compares the totals for each of the target years with estimates derived by projecting total commerce. The aggregation of individual projections for 1980 was less than 7 percent of the value derived from the projection of total commerce. The variation for 2000 increased to 23.2 percent and reached 51.6 percent by 2020.

The difference between the tonnage estimated by commodity groups and the total tonnage forecasts by correlation with the Gross National Product was considered to be unidentified products resulting from a wide range of factors and conditions, most of which cannot be documented with knowledge or facts available at this time. Some of these factors could be changes in technology, changes in consumer taste, new products, new demands for old products, or shifts in sources, marketing and transportation patterns. Table 2-15 lists projections of waterborne commerce adjusted to more nearly conform with the forecasts of total commerce. The tonnages of general cargo, bulk grain, bulk petroleum, other dry bulk and other liquid bulk shown in Table 2-14 were increased by 6.6 percent, 23.2 percent, and 51.6 percent for 1980, 2000 and 2020 respectively. Forest products were not adjusted as the resource is considered to be limited. The adjustments were supported on the basis of the following evaluations:

General Cargo. With the advantage of greater natural water depths and a shorter distance from the Northern Orient than any other continental United States port, the Puget Sound Area has the long range prospects for greatly increased general cargo tonnages. Containerization is expected to increase the

Table 2-14. Puget Sound Area, projected waterborne commerce (in 1,000 tons)

Cargo	1980 F&D[1]	1980 DI[1]	1980 Total	2000 F&D	2000 DI	2000 Total	2020 F&D	2020 DI	2020 Total
General Cargo	3,400	1,100	4,500	6,300	1,400	7,700	11,100	1,700	12,800
Bulk Grain	2,100	--	2,100	2,300	--	2,300	2,700	--	2,700
Forest Products	3,600	6,000	9,600	5,700	6,000	11,700	7,900	6,000	13,900
Petroleum	13,900	6,300	20,200	26,200	6,300	32,500	49,000	6,300	55,300
Other Dry Bulk	7,600	17,100	24,700	12,200	35,400	47,600	16,900	68,000	84,900
Other Liquid Bulk	280	70	350	570	160	730	1,120	280	1,400
TOTAL	30,880	30,570	61,450	53,270	49,260	102,530	88,720	82,280	171,000

COMPARISONS WITH PROJECTIONS OF TOTAL COMMERCE CORRELATED WITH GROSS NATIONAL PRODUCT

	1980	2000	2020
Total	65,500	126,300	259,100
Difference[2]	+4,050	+ 23,770	+88,100
Variation	6.6%	23.2%	51.6%

1 F&D—Foreign and Domestic; DI—Domestic Internal.

2 Unidentified tonnage resulting from unforseen and unpredictable changes in technology, shifts in consumer demand, new products and new demands for old products.

TABLE 2-15. Puget Sound Area, projected commerce (adjusted to fit projections of total commerce[1]) (1000 tons)

Cargo	1980	2000	2020
General Cargo	6,800[2]	9,500	19,400
Bulk Grain	2,200	2,800	4,100
Forest Products	9,600	11,700	13,900
Petroleum	21,500	40,000	83,800
Other Dry Bulk	26,300	58,600	128,600
Other Liquid Bulk	370	890	2,100
TOTAL	66,770	123,490	251,900

1 Projections in Table 2-14 were increased 6.6 percent for 1980, 23.2 percent for 2000 and 51.6 percent for 2020, except for forest products which were accepted without change.

2 Increased by 2,000,000 tons to reflect accelerated growth of containerized freight.

tributary area served by Puget Sound ports. A study in-depth by the Port of Seattle in 1964[1] analyzed cargo suitable for containerization from the Far East in 1966 and estimated for the period 1967 to 1975 that containerized import cargo will grow at a rate of 15 percent annually and exports at 10 percent annually. With rapid industrialization of Japan and possible opening of other Pacific Rim markets there is a potential for an even greater increase in containerized general cargo in 1980 to 2020 because of savings in cost and time of handling.

The "land bridge" concept which uses the United States railroads to form a direct transportation route linking waterborne commerce of the Atlantic and Pacific to serve the Far East and Europe, could result in savings of up to two weeks time and overall costs. The implementation of such a plan is another long range potential for general cargo in the Puget Sound Area.

Bulk Grain. The export of midwest grain to the growing markets of the Far Eastern countries has a potential for substantial increases when satisfactory unit train rates are established. This possibility together with the highly automated grain terminal being constructed by the Port of Seattle could result in large future grain exports through the Puget Sound Area.

Forest Products. The constraints imposed on this commerce by level of output from the resource, legal and political considerations, and future United States market demands, limit the level of this commerce. There is no apparent basis for increasing these forecasts.

Bulk Petroleum and Other Liquid Bulk. As previously discussed, the Puget Sound Area could undergo a large growth in refineries and assoicated waterborne commerce as a result of major oil developments in Alaska. The transportation pattern would be altered so that the Area would become a net exporter of petroleum products. The expansion of refineries would also result in growth of the chemical industries. All of these factors indicate major upward trends in both bulk petroleum and other liquid bulk commerce.

Other Dry Bulk. Alumina, a principal component of this commerce, was forecast at a 3 percent annual rate of growth as compared to reliable forecast of 5 percent for the nation. The advantages of large electric power blocks which can be produced by thermal plants at low composite rates when combined with existing low cost hydroelectric, gives the Pacific Northwest a long-term advantage for attracting future aluminum plants. The Puget Sound waterborne commerce would in turn share this growth because of its attractive tidewater plant sites and as its location as a transhipment point to inland plants.

HARBOR AND CHANNEL REQUIREMENTS

Vessel Trends

General–The characteristics of the deep draft vessels of the world are undergoing rapid changes to meet the demands of efficiency and competition. Ships of tremendous size, particularly bulk carrier and tanker types are now being built in sizes which were unforseen a few years ago. Containerized cargo has only recently come to the forefront and is now one of the greatest challenges facing the maritime industry. As harbors and channels of Puget Sound, as well as terminal facilities on the shore must accommodate the pattern of future ships, an estimate of future vessel trends based on present knowledge is an essential element in the study.

The examination of vessel trends began with an inventory in drafts of self-propelled vessels entering or leaving the Puget Sound in the year 1963. Each of the vessel types were then investigated with a view toward isolating those factors basic to a forecast of the trends of future ships. The age of the merchant

1 "Containerization of Waterborne Commerce: Its Nature, Prospects, Implications and Directions for the Port of Seattle." Port of Seattle.

fleet and the trends in vessel speeds were examined to ascertain future ship construction possibilities. The findings were then summarized and estimates made of future vessel trends for the Puget Sound Area. The publication of the U.S. Maritime Commission entitled, "A Statistical View of the World's Merchant Fleets," for the years 1956, 1958, 1960, 1962, 1964 and 1966 provided much of the data used for the study. Unpublished information from the files of government agencies also was used as a base for estimating future vessel trends. The study depended on material available from other studies and developed only limited original data.

Drafts of Vessels in 1955 and 1963–The numbers of self-propelled vessels inbound with drafts of 18 feet and less, and over 18 feet have been summarized for the years 1955 and 1963 in Tables 2-16 and 2-17 respectively. These statistics show the trend to deeper draft vessels. For the passenger and dry cargo vessels in Puget Sound the total number of vessel movements decreased in the period but the percentage with over 18 feet draft increased from 2.5 percent to 4.1 percent. For the tankers there was also a reduction in total number but the percentage with over 18 feet draft increased from 42.4 percent to 61.5 percent.

Freighters–Freighters are defined as ocean going ships, including container ships, of 1,000 gross tons and over that carry general cargo. From 1956 to 1966 the number of freighters in the world merchant fleet increased from 10,782 to 11,611. Referring to Figure 2-27, the number of freighters in the 10,000 to 10,000 deadweight ton (DWT) class decreased by 1,090 vessels. This change was more than offset by the increase in the numbers of larger ships. There was also an increase of 452 ships in the 4,000 to 6,999 DWT class.

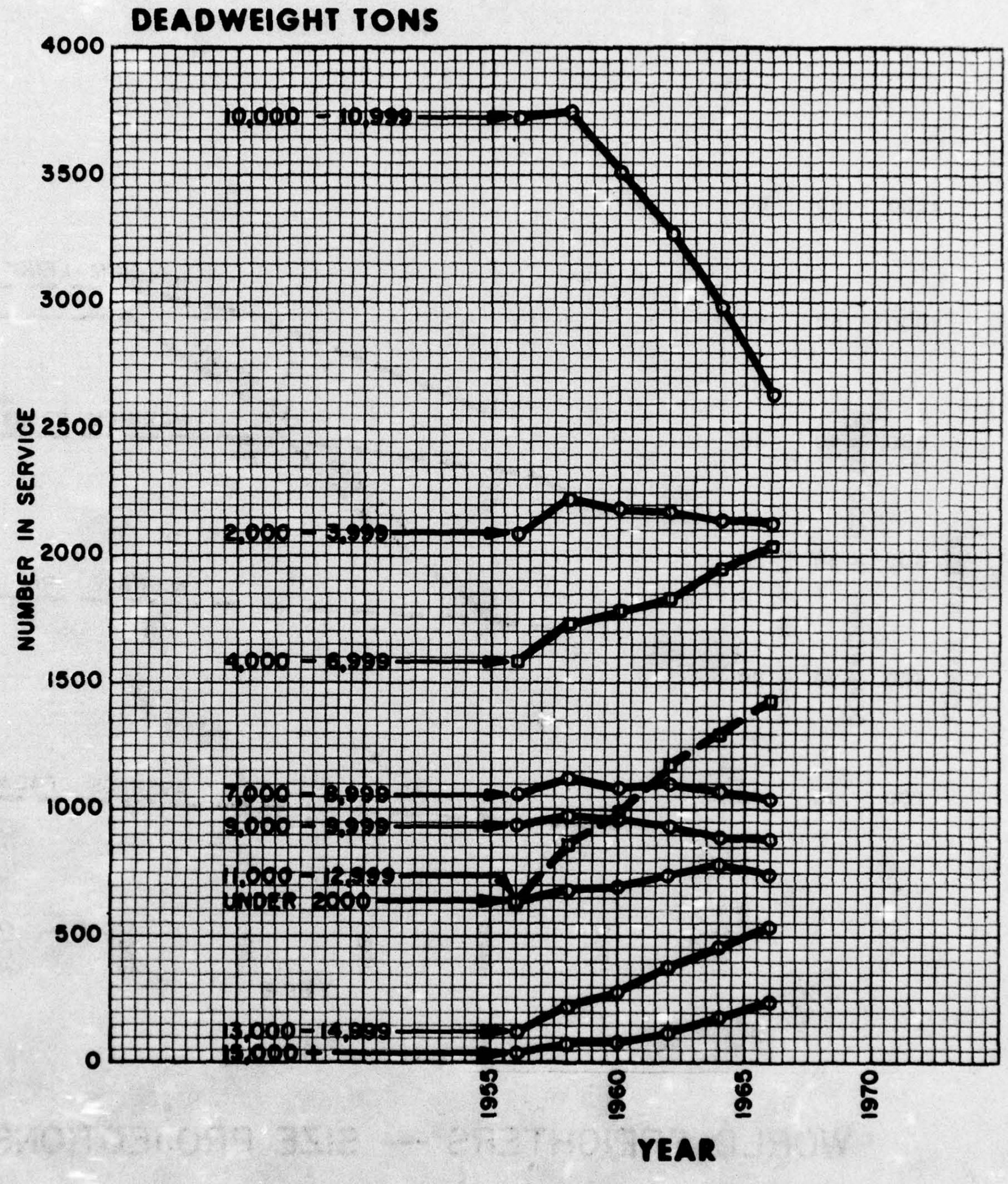
Except for one freighter that had a draft of 43 feet and is now out of service, all freighters have had less than 40 feet draft. As freighters must serve a variety of ports, most of which are limited to less than 40 feet draft, the assumption that future freighters would be limited to 40 feet draft as indicated on Figure 2-28 appears valid. The draft of

TABLE 2-16. Draft of vessels (self propelled) 1955

	Passenger and Dry Cargo				Tankers			
Area	Draft 18 ft. & Less	Draft 18'-40'	Total	% with Draft 18'-40'	Draft 18 ft. & Less	Draft 18'-40'	Total	% with Draft 18'-40'
Bellingham	5,583	133	5,716	2.3	114	6	120	5.0
Anacortes	18,003	53	18,056	0.3	55	17	72	23.6
Everett	10,172	98	10,270	1.0	39	25	64	39.1
Seattle	70,514	1,777	72,291	2.5	890	776	1,666	46.6
Tacoma	13,941	716	14,657	4.9	183	185	368	50.3
Olympia	657	124	781	15.9	87	13	100	13.0
Port Angeles	2,207	203	2,410	8.4	83	43	126	34.1
Port Gamble	40	73	113	64.6	0	0	0	0
TOTAL	121,117	3,177	124,294	2.5	1,451	1,065	2,516	42.4

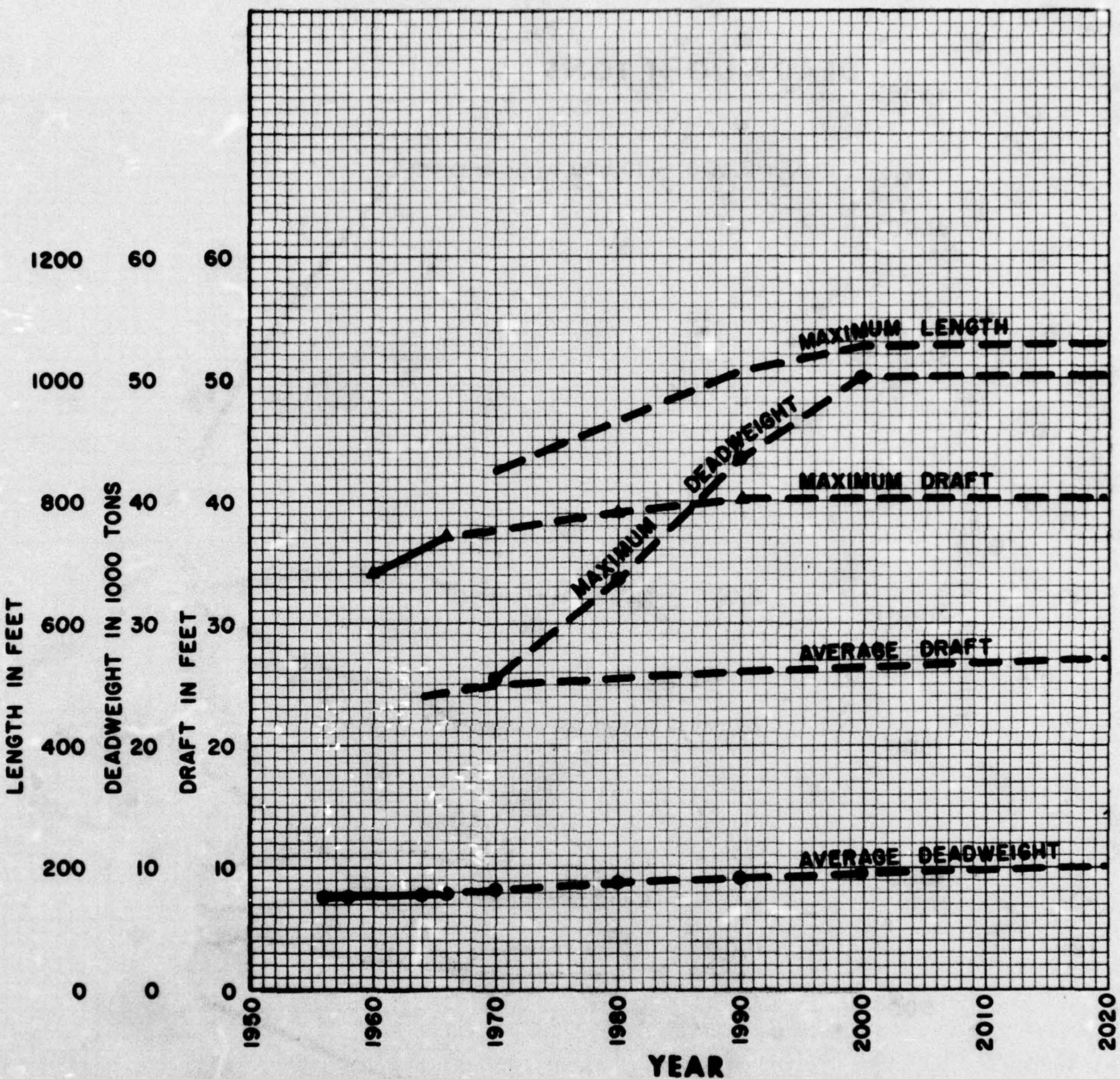
TABLE 2-17. Draft of vessels (self-propelled) 1963

	Passenger and Dry Cargo				Tankers			
Area	Draft 18 ft. & Less	Draft 18'-40'	Total	% with Draft 18'-40'	Draft 18 ft. & Less	Draft 18'-40'	Total	% with Draft 18'-40'
Bellingham	3,776	216	3,992	5.4	79	4	83	4.8
Anacortes	9,267	33	9,300	0.4	190	507	697	72.8
Everett	4,010	304	4,314	7.0	0	2	2	100.0
Seattle	50,410	1,809	52,219	3.5	356	646	1,002	64.5
Tacoma	13,068	891	13,959	6.4	148	178	326	54.6
Olympia	103	81	184	44.0	32	13	45	28.9
Port Angeles	2,656	204	2,860	7.1	62	36	98	36.7
Port Gamble	14	50	64	78.1	0	0	0	0
TOTAL	83,304	3,588	86,892	4.1	867	1,386	2,253	61.5



WORLD MERCHANT FLEET FREIGHTERS

FIGURE 2-27



WORLD FREIGHTERS — SIZE PROJECTIONS

FIGURE 2-28

world freighters has averaged about 24 feet[1] in recent years but can be expected to average 27 feet[2] or more by the year 2020.

To accommodate containerization of general cargo which tends toward increased bulk as well as efficiency realized with larger ships, new freighters are expected to increase volume by adding beam and length. Projections shown on Figure 2-28 forecast that the maximum deadweight of freighters will be about 50,000 DWT in the year 2000 or more than double the present maximum. The maximum length of freighters in the year 2000 will probably reach a limit of about 1,050 feet. As indicated on Figure 2-28, the average size of world freighters has only increased from 7,600 DWT in 1956 to 7,800 DWT in 1966 but is projected to average about 10,000 DWT by the year 2020.[2]

Most of the foreign trade from Puget Sound ports can be expected to be with Pacific Rim nations. Many of these nations are newly developing and have the advantage of planning their harbor facilities for the most modern cargo vessels. Therefore, freighters for the Pacific trade can be expected to run to larger tonnage and greater draft than the average for the European trade.

For domestic coastwise freight movement, increasing use of barge towing is expected to continue.

Combination Passenger and Cargo Ships–World vessels of this classification, including ships with a capacity of 13 or more passengers, have decreased from 1,295 in 1956 to 1,054 in 1966. The decrease is due to increased competition from air transportation. As combination passenger and cargo ships must use the same ports that are served by freighters, their size will be governed by the same restrictions. Except for local ferry service and inside passage runs to Canada and Alaska, there has been very limited passenger service in Puget Sound in recent years. Development of significant ocean-going passenger service with Puget Sound ports does not appear probable in the near future.

Tankers–In addition to tankers for bulk petroleum products this category includes tankers for chemicals, natural gas and whaling tankers. From 1956 to 1966 the number of tankers in the world merchant fleet increased from 2,834 to 3,654. During this same period the number of tankers under 17,000 DWT decreased and tankers greater than 17,000 DWT increased as shown on Figure 2-29.

Figure 2-30 shows that the maximum size tanker increased from 35,500 DWT in 1954 to 205,000 DWT in 1966. Indicative of this trend is a 312,000 DWT tanker completed in 1968. Designs have been made for a tanker of 500,000 DWT and 87 feet draft which could be in service before 1975. Studies have been made for a tanker of 1,000,000 DWT and 104 feet draft. This is believed to be about the maximum practical size under present technology. If the present trend continues, this 1,000,000 ton tanker may be in service by 1990.

The average size of tanker has increased from 15,100 tons in 1956 to 26,900 tons in 1966 (Figure 2-30). Projecting this trend, the average tanker may be 100,000 tons by the year 2020 and have an average draft of about 48 feet.[3]

Bulk Carriers–Bulk carriers include ore carriers, ore/oil carriers and coal carriers. From 1956 to 1966 the number of bulk carriers in the world merchant fleet increased from 704 to 2,104. Figure 2-31 shows that all sizes of bulk carrier vessels have increased in number during this period except for vessels under 10,000 DWT which show a slight decline after 1964.

Figure 2-32 shows that the maximum draft of bulk carriers has increased from 41 feet in 1956 to 54 feet in 1966. Bulk carriers could be built just as large as tankers. However, because of the type of service these vessels provide, and the physical limitation of the majority of world ports, a maximum practical limit would be about 400,000[4] tons. The corresponding maximum draft will probably be about 71 feet. As with tankers, the practical limit in draft for general service bulk carriers will be about 60 feet. Average deadweight in the year 2020 will probably be about 30,000 tons. Vessels with greater drafts will be restricted to special services where terminals with greater depth of water are feasible.

1 "A Statistical Analysis of the World's Merchant Fleets," U.S. Maritime Commission for years 1956, 1958, 1960, 1962, 1964 and 1966.

2 Projections based on digest of latest trend in ship construction, current reviews of various authorities and consideration of apparent practical limits in size of vessels, channel depths and terminal facilities.

3 Projections based on digest of latest trend in ship construction, current reviews of various authorities and consideration of apparent practical limits in size of vessels, channel depths and terminal facilities.

4 Projections based on digest of latest trend in ship construction, current reviews of various authorities and consideration of apparent practical limits in size of vessels, channel depths and terminal facilities.

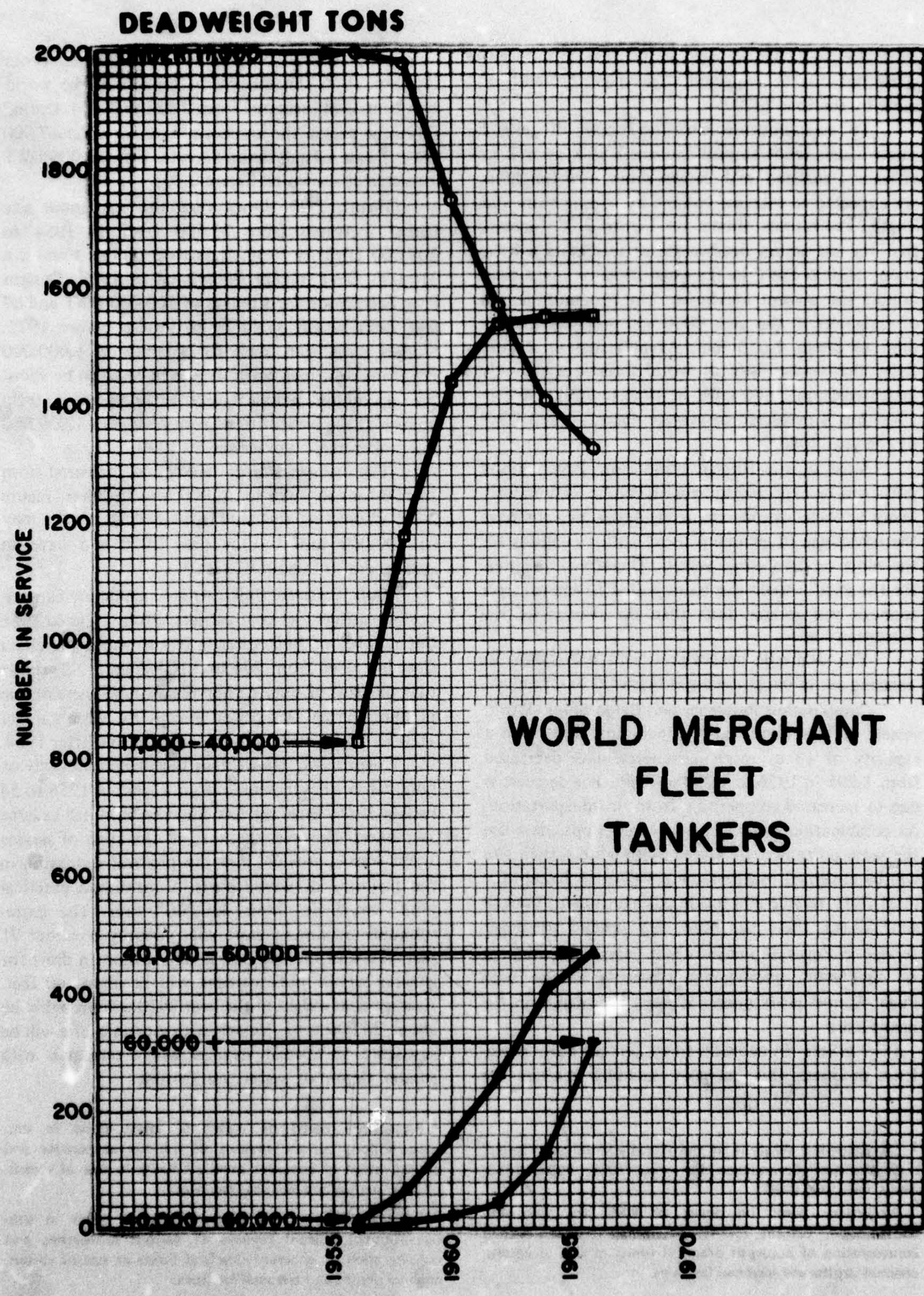
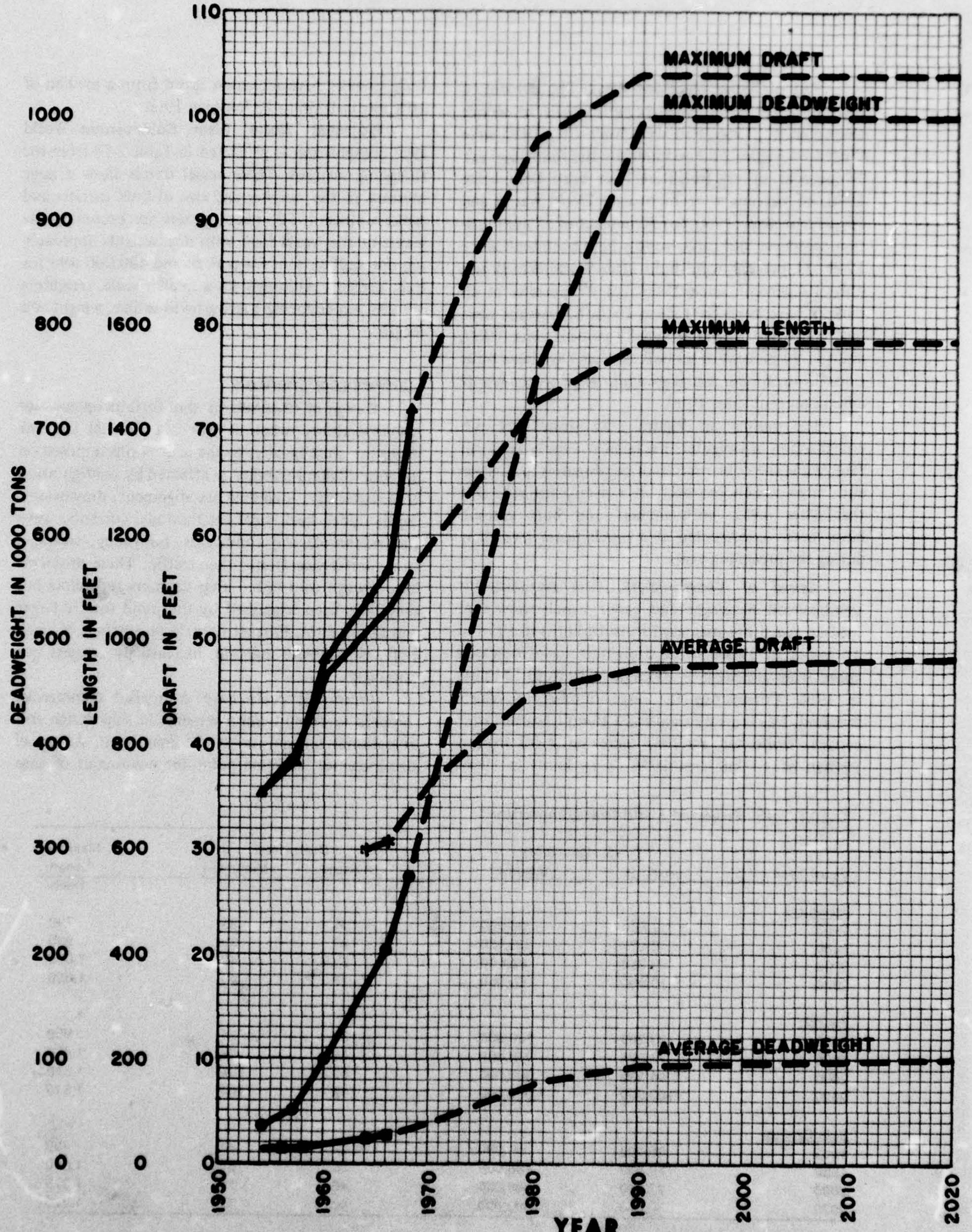

DEADWEIGHT TONS
NUMBER IN SERVICE
2000
1800
1600
1400
1200
1000
800
600
400
200
0
17,000 - 40,000
40,000 - 60,000
60,000 +
1955
1960
1965
1970
WORLD MERCHANT
FLEET
TANKERS

FIGURE 2-29



WORLD TANKERS — SIZE PROJECTIONS

FIGURE 2-30

Age of World Merchant Fleet–The percent of each of four types of merchant vessels in service December 31, 1966, that were built after 1940 were plotted on Figure 2-33 and indicate the following: (a) 91 percent of all freighters have been built since 1940, 65 percent were built after World War II and 19 percent since 1960; (b) 76 percent of all combination passenger and cargo vessels have been built since 1940, 54 percent were built after World War II and only 10 percent since 1960; (c) 97 percent of all tankers have been built since 1940, 87 percent were built since World War II and 29 percent since 1960, and (d) 94 percent of all bulk carriers have been built since 1940, 85 percent were built since World War II and 42 percent since 1960.

The graphs on Figure 2-33 show that the construction of freighters has been at a fairly uniform rate, while the construction of combination passenger and cargo vessels has been at a decreasing rate and that after 1952 both tankers and bulk carriers have been constructed at a much faster rate than during the preceding years.

Speed of Vessels–World fleet statistics for combination passenger and cargo vessels show that median speed has increased from 14 knots in 1956 to 16 knots in 1966. World freighters have increased speed from a median of 10 knots in 1956 to 13 knots in 1966. Considering the large number of vessels involved, this is a very significant trend towards faster service. World tankers have increased speed from a median of 13 knots in 1956 to 14 knots in 1966. Bulk carriers have increased speed from a median of 10 knots in 1956 to 13 knots in 1966.

Projected World Fleet Composition–World fleet composition is projected in Table 2-18 from the foregoing analysis. These vessel trends show a large increase in the number and size of bulk carriers and tankers since 1952. These vessels are becoming the giants of the world fleet with deadweights approaching one million tons for tankers and 400,000 tons for bulk carriers. Although on a smaller scale, freighters are also experiencing [illegible]e growth in size, weight and length.

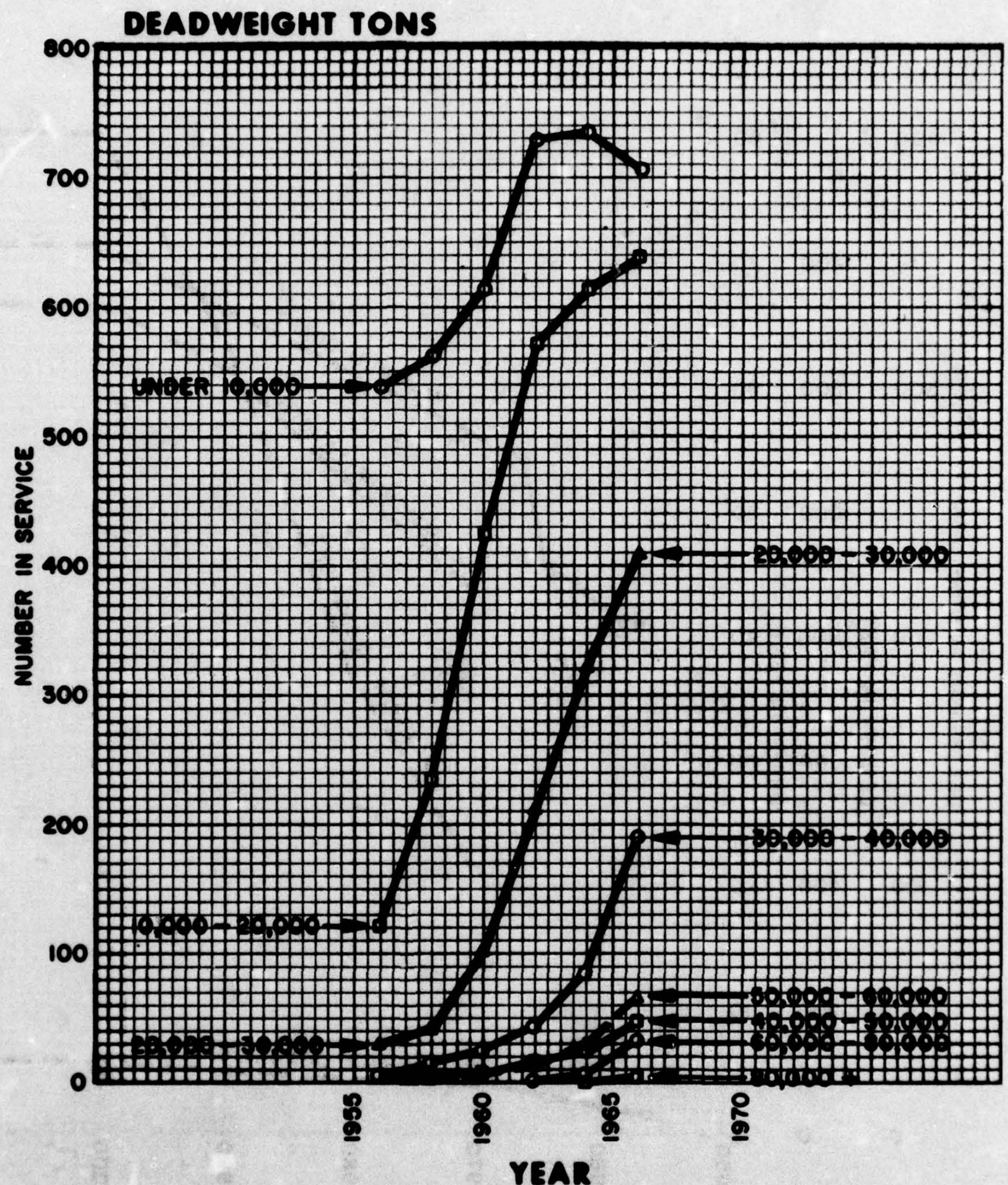
Harbors and Channels

Design of Channels–A ship forfeits open-water maneuverability when it enters a channel and the navigator must be alert to the restrictions imposed on his ship. Maneuverability is affected by configuration of a waterway, including its alignment, dimensions, depth under keel, tidal fluctuations, currents, wave and meteorological conditions, buoyancy, steerage, and interference from other traffic. These problems have always confronted ship captains and pilots but they have been magnified by the trend toward larger and faster ships. Furthermore, large numbers of small craft, both power and sail, increasingly congest our waterways.

Increasing costs have compelled commercial shippers to exploit improvements in ship design and operational techniques to the maximum. As vessel size increases, at some point the economics of ship

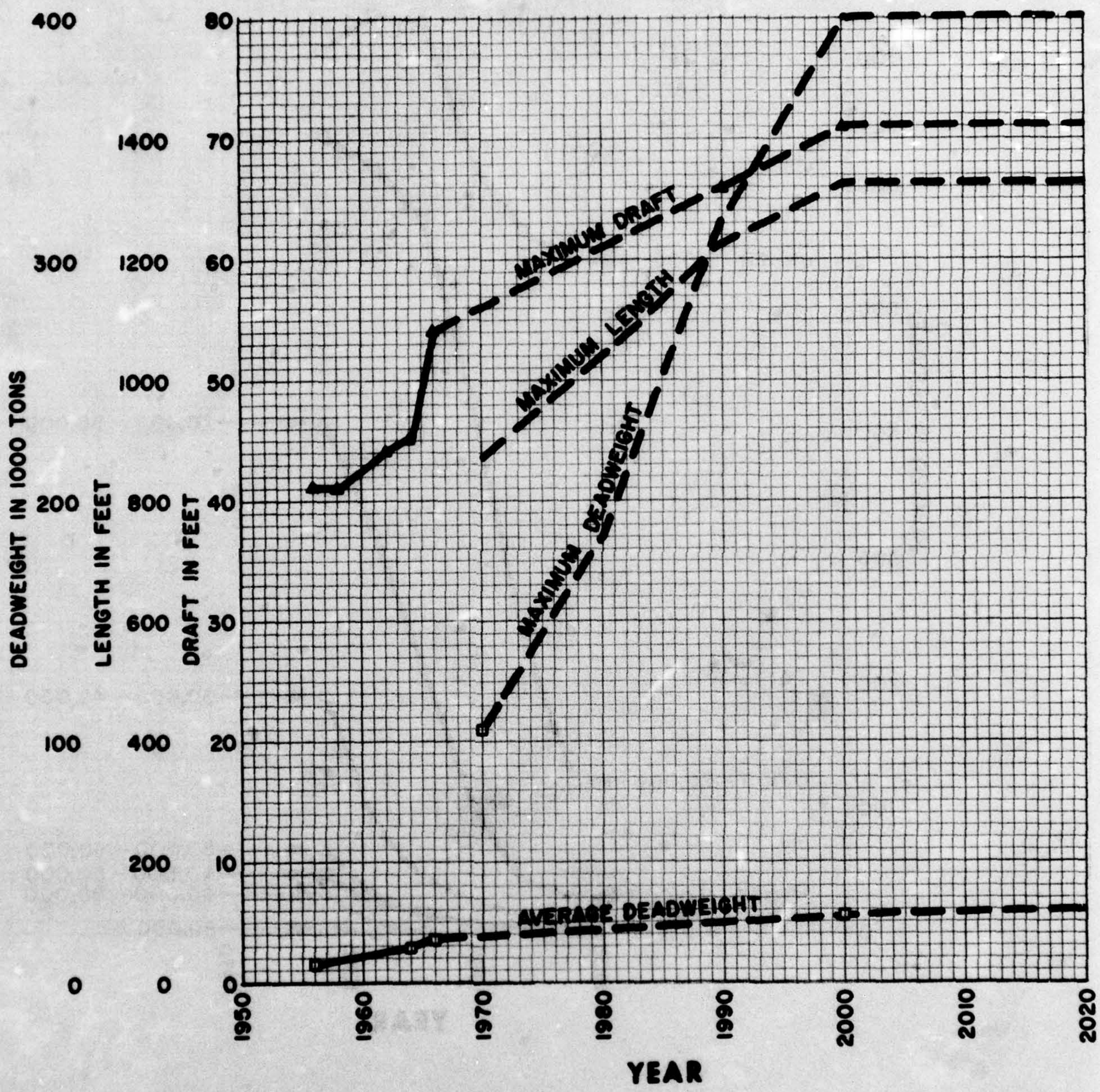
TABLE 2-18. Projected world fleet composition

Vessel Type	Deadweight (tons) Average	Deadweight (tons) Maximum	Draft (feet) Average	Draft (feet) Maximum	Maximum Length (feet)
Freighters					
1963	7,800	20,000	24	35	790
1980	8,583	33,500	26	39	930
2000	9,350	50,000	26.5	40	1,050
2020	10,000	50,000	27	40	1,050
Tankers					
1963	23,200	130,000	30	54	950
1980	76,225	760,000	45	98	1,460
2000	94,325	1,000,000	47	104	1,570
2020	100,000	1,000,000	48	104	1,570
Bulk Carriers					
1963	15,000	50,000	27	44	750
1980	18,750	185,000	35	57	1,040
2000	27,350	400,000	40	71	1,325
2020	30,000	400,000	40	71	1,325



WORLD MERCHANT FLEET
BULK CARRIERS

FIGURE 2-31



WORLD BULK CARRIERS SIZE PROJECTIONS

FIGURE 2-32

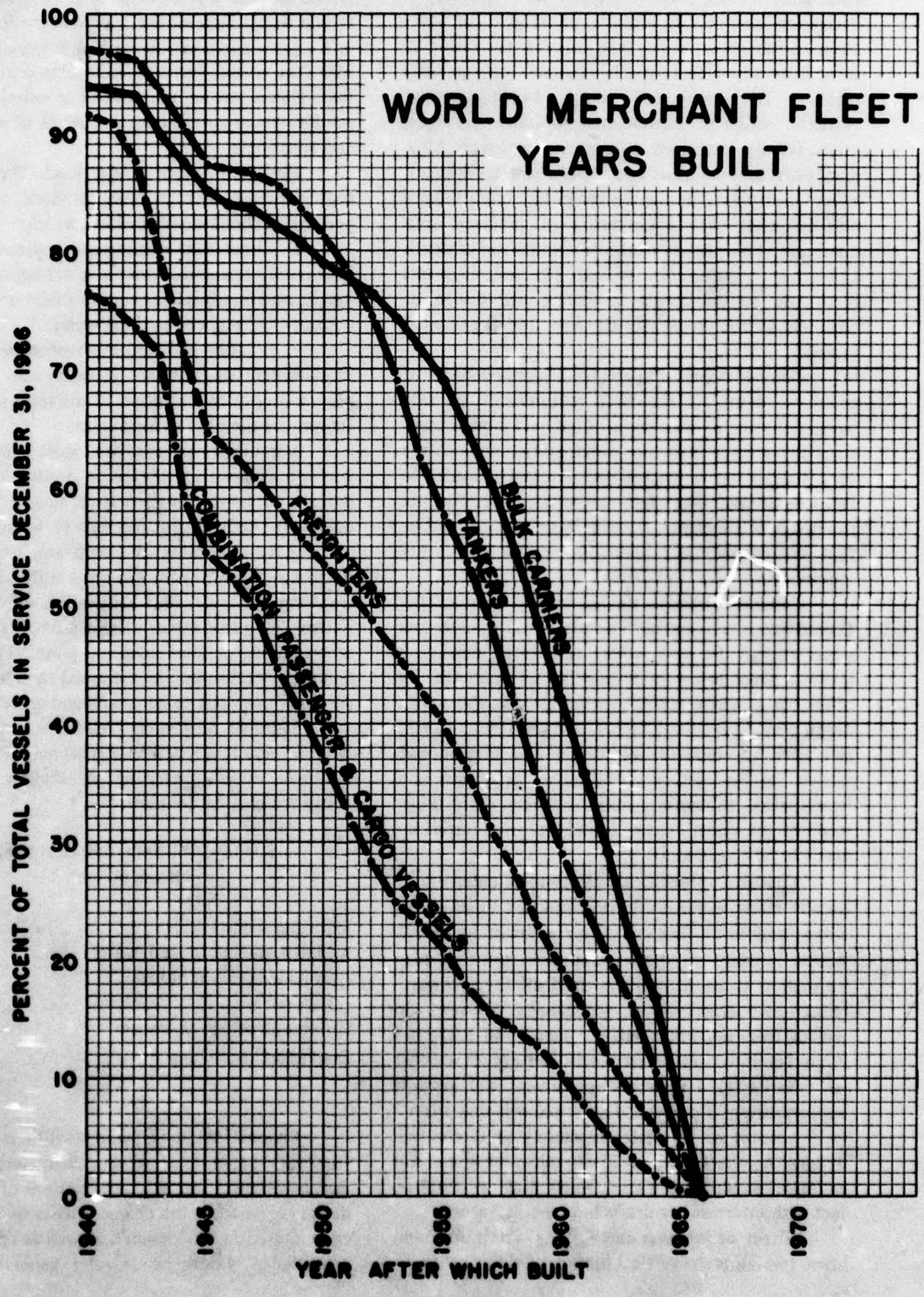

WORLD MERCHANT FLEET
YEARS BUILT
PERCENT OF TOTAL VESSELS IN SERVICE DECEMBER 31, 1966
YEAR AFTER WHICH BUILT
BULK CARRIERS
TANKERS
FREIGHTERS
COMBINATION PASSENGER & CARGO VESSELS
100
90
80
70
60
50
40
30
20
10
0
1940
1945
1950
1955
1960
1965
1970

FIGURE 2-33

operation and of channel construction and maintenance must conflict. The design of new or enlarged navigation channels in estuaries must give consideration to the effect of the tidal forces in the channels as well as any effect of the channels on the tidal regimen. They may cause major changes in tidal currents, sediment movements, shoreline configuration, salinity intrusions, and mixing processes. Also, local operating practices and vessel characteristics are essential elements in the design of economical channels to meet the requirements of practical ship operation. This applies to the determination of depth and other characteristics as well. The following sets forth the considerations governing the design of channels in the Puget Sound Area for tug-assisted vessels.

Channel Depth—Experience has established that adequate depth is the first requirement of safe navigation in a waterway. Channel depths substantially greater than the loaded static drafts of the vessels using the waterway are required in order to ensure safe and economic navigation. Therefore, in the design of a channel, the minimum depth would be first considered, and then the width and other requirements.

Common practice on the Pacific coast of the United States is to establish depths at mean lower low water (mllw). In cases where the traffic density is great, a plane below mllw may be selected. On the other hand, where traffic density is low, the design depth may be set for a higher tide level, such as half tide level. The basis for selection will be an economic analysis of the cost of vessel delays, operation, and light-loading balanced against dredging costs. Each reach of the vessel's entire round trip on a waterway needs to be considered.

Loaded Draft of Design Vessel—"Loaded draft" usually refers to the draft amidships of a vessel at rest when loaded to the salt water summer load line. Actual loadings may be less than this, and they may be such as to cause a greater draft aft than forward (trim down at stern), or occasionally vice-versa. In passing from sea water having a density of 1.026 (64 lb/cu ft) into fresh water with density of 0.9991 (62.4 lb/cu ft), a vessel's displacement will increase approximately 3 percent. The vessel will sink from 2 to 3 percent of its draft, depending upon the hull design. A vessel with a 35-ft. saltwater draft, for example, would have a fresh water draft of about 36 feet with intermediate drafts in brackish waters.

Effect of Pitching and Rolling—Pitch, roll, and heave (which is the vertical motion of ship's center of gravity) occur under the influence of waves. In open sea conditions, a pitch angle of 2.5 degrees in a 1,000 ft ship would increase draft forward by about 22 feet. A 5 degree angle of roll for a ship having a beam of 100 feet would increase amidships draft about 4.4 feet. This is not an unusual roll at entrances, even in semiprotected conditions, as a result of waves, wind, and turn angle.

Minimum Depth Under Keel—The conditions that produce sinkage also produce violent flow patterns in shoal water or canals which:

a. Affect ship steering and maneuverability. It is generally recognized that a vessel becomes hard to handle and requires large rudder angles unless speed is considerably reduced in shoal water.

b. Produce bed-load movements with resulting displacement of material. A vessel may readily displace a foot or two of material and leave it piled up in the way of the next passing vessel.

A minimal clearance of at least 2 feet under the keel of a vessel in motion is needed to (a) avoid damage to ships propellers from sunken timbers and debris, (b) reduce displacement of bottom material, and (c) avoid fouling of pump and condensers by bottom material. There is a great difference between touching the soft fluff which lies on the channel bottom of many estuaries and striking rock bottom or grounding on hard sand and gravel. The clearance under the keel should be increased to at least 3 feet if the bottom is rock or hard sand and gravel.

Estimate of Design Depth—A typical calculation of minimum depth of channel for a large tug-assisted vessel traversing a shallow freshwater restricted channel follows:

30,000-DWT Ship, 650 ft in Length
Beam 86 feet

Saltwater loaded draft	35.0 ft
Added draft due to fresh water	1.0 ft
Trim down at stern or bow	1.6 ft
Sub Total	37.6 ft
Minimum bottom clearance	2.0 ft
Required channel depth	39.6 ft

Channel Width—Channel width is determined from the beam and steering characteristics of the design vessel, from a consideration of the traffic density, and from the characteristics of other vessels encountered in the channel, as well as currents, wave conditions, winds, bends, and general alignment.

General practice is for the width of the channel to be measured at the design depth, or bottom of the side slopes. The design width should be sufficient to insure adequate control of the ships that must use the waterway under expected conditions of ship speed, currents, and traffic.

Vessel Operation–Among the factors to be considered in selection of the channel width for safe navigation are: one-way traffic or two-way traffic, overtaking and passing of large vessels or spacing between transiting ships, use of pilots' and other operating rules. Maximum vessel speed through the water is an important economic and safety consideration, along with necessary reduction in speed when passing another vessel and operating with limited visibility in fog or rain.

The handling characteristics of the using vessels is another factor to be considered. Twin-screw, single-rudder types, typical of many tankers and bulk carriers, are likely to have poor handling qualities as compared with the excellent handling qualities of most Naval vessels which have two rudders of large area located directly in the slip stream of the propellers. Width requirements may be increased by other conditions:

a. Crosscurrents are critical for extremely large vessels.

b. Strong winds on the beam or quarter are an important factor on partly loaded ships, or very large vessels. Winds having velocities of 50 to 80 mph may cause a vessel to side slip 10 to 15 degrees from course (yaw, or crabbing, angle).

c. Waves have to be very great for inland waters to affect the control of large ships. However, rough water and tide rips are important considerations for the smaller vessels and recreational boats, because control may be difficult and uncertain.

Estimate of Required Channel Width–The width of the channel is measured at the bottom of the slope, i.e., at the design depth, which is either the required depth for safe navigation of the design vessel or the economic depth. Some of the factors that must be given consideration in determining the proper width of the channel are: whether the design vessel must pass a similar vessel, or a smaller vessel or vessels; the controllability of the vessel; current velocities and directions; wave action or wind that will cause the vessel to yaw; whether the channel occupies the entire waterway, as in a canal, or is located in a wide waterway many times the width of the channel; and the characteristics of the banks of the channel, i.e., whether they are rocky or composed of soft sediments.

The width of the maneuvering lane may be as little as 160 percent of the beam of the design vessel where it is known that the design vessel has very good controllability. This value appears to be applicable for channels in wide waterways as well as restricted channels where there are no currents at an angle to the channel, or winds or waves that will cause vessel yaw. In places where these yawing forces exist, the width of the maneuvering lane should be that required to accommodate the oscillations of the vessel as it yaws back and forth, which is determined by the length of the vessel and the angle of yaw that may be expected or 160 percent of the beam figure, whichever is the greater. It is considered that these widths are minimal. When consideration is given to the disaster and economic loss that occur when great ships collide, or the damages suffered when they go aground, it is likely that the more conservative lane width of 180 percent of the beam of the vessel will be employed for reaches where there are no yawing forces, or perhaps even 200 percent of the beam of the design vessel in cases where that vessel is known to have poor controllability. For reaches where aground, it is likely that the more conservative lane width premised on a percentage of the vessel beam might be increased for the yaw as a result of this kind of judgment.

Harbor and Channel Requirements of Puget Sound Area–The vessels projected for the fleets of the world are potential users of the Puget Sound Area. The application of the criteria set forth in the preceding paragraphs provide the basis for the estimate of depth and width for future harbors and channels as shown on Table 2-19.

TERMINAL LAND AREA

General

Terminal areas include piers, wharfs, and open and covered storage space necessary to handle water-borne commercial cargo and passenger service. In order to ensure that growth of waterborne commerce, an important segment of the economy in the Puget Sound Area, is not constrained, provision must be made for the present and future land requirements of terminal facilities. Existing lands used for these purposes amounted to approximately 2,300 acres in

1963. Future land needs are dependent upon the type and amount of tonnage forecast for each of the generalized cargo groupings. Changes in technology with more efficient cargo handling equipment, both on shore and on vessels, will enable greater utilization of existing facilities as well as provide higher unit handling capabilities than have been experienced in the past. Land transportation links of rail and highways are also very important factors influencing the amount of cargo that can be processed by a port. However, with adequate systems planning, land transportation should not serve as the limiting factor in cargo handling capabilities.

A report prepared by the Maritime Administration in 1966 for the Sub-Committee on Economic Progress of the Joint Congressional Economic Committee stated: "Port facilities in the United States, in general, are more than adequate on a quantitive basis to serve the maritime industry in times of peace and during war or crisis." The report goes on to observe that many port facilities are not adequate on a qualitative basis and that capital requirements for port terminal facilities during the decade 1966-1975 are estimated to be $1,281.5 million.

For highest financial return on investment in port facilities, there should only be sufficient berths to provide for 100 percent occupancy. In such a port, ships would often be waiting for a berth which at cost of ship time from $100 to over $300 per hour would be a serious loss to shipping lines. If delays continue to occur in berthing at any port, a surcharge will generally be levied on cargoes for that port which can then result in loss of trade. At the other extreme, it would be ideal for shipping to have sufficient berths in a port so that berthing would always be possible immediately upon arrival. Obviously for overall maximum economy the number of berths will be less than the maximum number of ships that may be in port at one time. Maximum economy would be obtained when the annual cost of vacant berths plus the annual cost of waiting ships is a minimum. The point at which such maximum economy will be obtained will not only depend upon the relative cost of ship time as against vacant berth cost, but also upon the number of berths in the port. While optimum berth utilization may be over 70 percent for larger ports with 10 or more berths, utilizations of only 20 percent may be all that can be realized for the smaller ports, especially during the development stage.

The first step in providing adequate terminal facilities to handle a projected increase in shipping is to modernize the existing facilities. Not only must terminals be improved to serve the larger merchant vessels being constructed, but more efficient methods and equipment for cargohandling must be provided to reduce the time required for loading and unloading. Ideal development of each port must also balance the cost of additional berths against the cost of ship delays in determining the optimum number of berths to be provided. These and other factors are considered in the following discussion of future terminal facilities and needs for each generalized cargo grouping.

General Cargo

An estimated 75,000 tons of general cargo per berth was handled by ports in all three U.S. Coastal regions in 1960. The Maritime Administration[1] fore-

[1] A report prepared by Maritime Administration in 1966 for subcommittee on Economic Progress of Joint Congressional Economic Committee.

TABLE 2-19. Puget Sound Area—harbor and channel requirements

			Single Lane Channels[1] Depth and Width in Feet		
Vessel Type	**Cargo**		**1980**	**2000**	**2020**
Freighters	General cargo	(Max.)	44 x 200	46 x 220	46 x 220
	Forest Products	(Ave.)	32 x 120	32 x 120	32 x 120
Bulk Carriers	Grain, other	(Max.)	64 x 250	78 x 320	78 x 320
	Dry Bulk	(Ave.)	40 x 180	46 x 200	46 x 200
Tankers	Petroleum, other	(Max.)	106 x 420	112 x 450	112 x 450
	Liquid Bulk	(Ave.)	52 x 230	54 x 240	54 x 240

[1] Tug assisted vessels.

casted handling rates would increase by 5,000 tons per berth for each five-year period to as high as 100,000 tons per berth by 1985. For the 25-year forecast period this represents an average annual growth rate in berth utilization of about 1.2 percent. A handling rate of 100,000 tons per berth per year has been attained by the Port of Seattle with some of the port's berths transferring containerized cargo reaching volumes of 300,000 tons per year.

On a conventional break-bulk general cargo ship the rate of loading or unloading has been 15 long tons or about 17 short tons per hour using a 25-man crew. Pallet handling can increase this rate to as high as 210 short tons per hour with a smaller gang. The Sea-Land terminal operations in the port of New York have reflected a containerized general cargo rate of 280 tons per gang-hour. The Matson Navigation Company loads and unloads containers, each 8 feet by 8 feet by 24 feet (20 tons capacity) at a rate of one per minute and has unloaded as much as 1,456 tons per hour. Ships equipped with three or four gantry cranes can load or unload containerized cargo at rates from 800 to 1,300 tons per hour. A comparable or greater rate can be obtained with two container cranes. Previously over a week, working 24 hours a day was necessary to load a 10,000-ton vessel. With modern facilities this can now be accomplished in less than eight hours.

Since 50 to 75 percent of the cost of moving cargo from one point to another is associated with port time and the loading and unloading of the cargo, continued effort can reasonably be expected to make these operations more efficient. Rapid growth in use of containers is occurring with more ports providing proper facilities to take advantage of the efficiencies made possible by this form of cargohandling. The Port of Seattle has nearly completed Terminal 18, which provides over 50 acres of storage and handling space with two large bridge cranes to accommodate containerized cargo. The Port has pioneered in containerization and regular container service between Puget Sound and Alaska was initiated as early as 1959, but only recently has containerization experienced accelerated growth. This growth has been encouraged by standardization of containers, improvements in handling equipment, new vessels built specifically for these modules and recognition by shippers of potential cost savings.

In 1963 the ports of Seattle, Tacoma and Everett accounted for 2,053,000 of the 2,675,000 tons of general cargo handled by Puget Sound Area ports, or over 75 percent of the total general cargo commerce. This percentage is expected to increase in the future consistent with the programs of development and improvement planned by these major ports. Approximately 325 acres of terminal lands were used for general cargo handling by these three ports in 1963, resulting in an average of 6,300 tons per acre. However, adjusting for about 80 acres of terminal lands used solely for fish products[1] an average of over 8,300 tons per acre is indicated for the general cargo facilities of these ports. This compares with a rate of about 12,000 tons per acre per year experienced in 1967 at a new terminal in the Area where both break-bulk and containers are handled.

For purpose of this study a ratio of 12,000 tons/acre/year is employed to estimate the 1980 terminal land area requirements. Land-commerce ratios for 2000 and 2020 are estimated by extending the 1980 rate at an annual growth of 1.2%, equivalent to the increased utilization trend projected by the Maritime Administration. The terminal land area-tonnage ratios derived from the above are translated into future land area requirements for general cargo and shown below for each time period with corresponding projected tonnages.

General Cargo
Terminal Land Area Requirements

Year	Tons/Acre	Tonnage (1,000 Short Tons)	Terminal Area (Acres)
1980	12,000	6,800	565
2000	15,300	9,500	625
2020	19,400	19,400	1,000

Bulk Grain

The total Puget Sound Area grain elevator storage capacity in 1963 amounted to approximately 13,400,000 bushels. Studies by the Maritime Administration have indicated that for a profitable level of operation average turnover of grain through a port elevator is about 5.7 times per year. On this basis the annual shipping for the Puget Sound Area should be at least 76,000,000 bushels or about 2,300,000 short tons. In 1963 the total shipment for Puget Sound ports was 1,205,977 tons, or about 40,000,000 bushels. The combined loading rate for all grain elevator facilities in Puget Sound ports is about

[1] Fish products accounted for only 5 percent of the 1963 general cargo tonnage with this percentage continuing to decline due to a nearly limited fishery resource.

100,000 bushels per hour representing a berth space utilization of about 400 hours per year. This amounts to less than 5 percent utilization based on 365 full 24-hour working days. From the foregoing, existing facilities appear to be adequate to meet projected needs to the year 1980. However, a 10,000,000 bushel capacity grain terminal is under construction by the Port of Seattle. Possible redirection of mid-west grain shipments through the Puget Sound Area ports is seen as justification for this facility. Completion of the new grain terminal may also result in a transfer of grain handling from an existing facility within the Seattle Harbor which handled about 1,000,000 tons of grain in 1967. The new terminal will be a great deal more efficient than the existing facility.

Future land area requirements for grain terminals have been derived based on the 10,000,000 bushel capacity of the new grain terminal facility and a turnover rate of 5.7 times per year. The new facility will occupy about 25 acres of land with 8 acres being developed for green belts, parkway and access. The remaining 17 acres are considered as being used for grain handling.This provides an annual grain handling rate of 100,000 tons per acre per year. In 1963 bulk grain facilities occupied 30 acres of land. Future terminal land area requirements are tabulated below:

Bulk Grain
Terminal Land Area Requirements

Year	Tons/Acre	Tonnage (1,000 Short Tons)	Terminal Area (Acres)
1980	100,000	2,200	22
2000	100,000	2,800	28
2020	100,000	4,100	41

Forest Products

An average of 17,200 tons of forest products/acre were handled on the 454 acres of terminal lands used for this cargo in 1963. As the maximum projected tonnage for forest products is only slightly higher than tonnages handled in the past, the existing terminal areas are considered more than adequate to meet future needs. Projected forest product tonnages and the tons per acre associated with the terminal lands are tabulated in the following:

Forest Products
Terminal Land Area Requirements

Year	Tons/Acre	Tonnage (1,000 Short Tons)	Terminal Area (Acres)
1980	21,200	9,600	454
2000	25,900	11,700	454
2020	30,600	13,900	454

Bulk Petroleum

In 1963 terminal areas servicing the 16,000,000 tons of bulk petroleum for that year amounted to 638 acres, providing a utilization rate of 25,000 tons/acre annually. Although substantial increases in bulk petroleum traffic are projected, terminal facilities for this commodity can usually be expanded on existing land areas. Only additional pumping equipment, pipelines, and possibly pier extension are necessary to provide greater tonnage handling capacities. Accordingly, no increase in terminal land area for bulk petroleum is forecast.

Discovery and development of the North Slope oil fields in Alaska may result in the acquisition of additional terminal lands, integral with lands acquired for refineries on the shores of Puget Sound. Any new terminal lands developed due to the Alaskan oil find are viewed as part of the water transport-oriented industrial lands and included within those projected acreages.

The projected tonnages and terminal land utilization ratios derived from the 638 acres of land in use in 1963 are tabulated below:

Bulk Petroleum
Terminal Land Area Requirements

Year	Tons/Acre	Tonnage (1,000 Short Tons)	Terminal Area (Acres)
1980	33,800	21,500	638
2000	62,700	40,000	638
2020	134,500	83,800	638

Other Dry Bulk

Total other dry bulk terminal areas amounted to 228 acres in 1963. For purposes of estimating terminal area requirements this generalized commodity grouping is subdivided into:

a. Alumina
b. Lime, clay & cement; sand, gravel & rock
c. Dry bulk other than the above

Alumina—In 1963, approximately 11 acres of terminal lands were used for handling five thousand tons of alumina resulting in a utilization rate of only 460 tons per acre annually. The Port of Tacoma's existing 50,000 ton alumina storage and handling facility occupies approximately 5.7 acres of land and can handle about one 50,000 ton vessel per month. Expansion of the port's facility is planned to provide a total of 150,000 tons of storage with total terminal lands of about 10.2 acres. Assuming a capacity of three 50,000 ton aluminum ore vessels per month, the annual utilization rate would be 176,000 tons/acre. This utilization rate was used to project future terminal land area requirements for alumina as tabulated below:

Other Dry Bulk

Alumina
Terminal Land Area Requirements

Year	Tons/Acre	Tonnage (1,000 Short Tons)	Terminal Area (Acres)
1980	176,000	2,300	13
2000	176,000	4,700	27
2020	176,000	10,500	60

Lime, Clay and Cement; Sand, Gravel and Rock—About 7,400,000 tons of these commodities were handled on 130 acres of terminal lands in 1963, providing a utilization rate of 57,000 tons per acre per year. Existing facilities can probably handle these cargoes at over twice the current annual rate. For purposes of forecasting future terminal land requirement a utilization rate of 120,000 tons per acre per year was used to translate projected tonnages into acres. The values derived are tabulated below:

Other Dry Bulk

Lime, Clay and Cement; Sand Gravel and Rock
Terminal Land Area Requirements

Year	Tons/Acre	Tonnage (1,000 Short Tons)	Terminal Area (Acres)
1980	120,000	16,800	140
2000	120,000	41,000	342
2020	120,000	100,000	834

Dry Bulk Other Than the Above—Approximately 3,600,000 tons of cargo composing this category were transferred over approximately 90 acres of terminal land in 1963, providing a utilization rate of 40,000 tons per acre per year. Existing facilities are estimated to be capable of handling at a rate at least 50 percent higher. For purposes of forecasting future terminal land requirements a utilization rate of 60,000 tons per acre per year was used to translate projected tonnages into acres. The required terminal areas are tabulated below:

Other Dry Bulk

Dry Bulk Other Than Above
Terminal Land Area Requirements

Year	Tons/Acre	Tonnage (1,000 Short Tons)	Terminal Area (Acres)
1980	60,000	7,200	121
2000	60,000	12,900	214
2020	60,000	18,100	302

Total Other Dry Bulk—Aggregating the needs for alumina; lime, clay and current; sand, gravel, rock and other, total other dry bulk terminal land area requirements are:

Other Dry Bulk

Terminal Land Area Requirements

Year	Tonnage (1,000 Short Tons)	Terminal Area (Acres)
1980	26,300	274
2000	58,600	583
2020	128,600	1,196

Other Liquid Bulk

Approximately 40 acres were used for handling 178,000 tons of other liquid bulk in 1963, providing a utilization rate of about 4,500 tons per acre per year. Existing facilities are estimated to be capable of handling at over twice this rate. For purposes of forecasting future terminal land requirements a utilization rate of 9,000 tons per acre per year was employed. The projected tonnages and land area requirements are:

Other Liquid Bulk
Terminal Land Area Requirements

Year	Tons/Acre	Tonnage (1,000 Short Tons)	Terminal Area (Acres)
1980	9,000	370	41
2000	9,000	890	100
2020	9,000	2,100	236

Ferry And Passenger Terminal—Commercial Vessel Moorage

In 1963, 84 acres of land were used for ferry and passenger traffic and 345 acres were used for moving of commercial vessels. The existing terminal areas are assumed adequate with modernization to meet 1980 needs. Beyond this date the land requirements are projected to grow at about the rate of 2.3 percent annually; the projected population growth for the Area. Future land terminal requirements for the Area are tabulated below:

Ferry and Passenger Terminal
and Commercial Vessel Moorage
Terminal Land Requirements

Year	Ferry & Passenger (Acres)	Commercial Vessel Moorage (Acres)
1980	84	345
2000	133	545
2020	210	860

TABLE 2-20. Puget Sound Area—terminal land requirements (acres)

	1963[1]	1980[2]	2000[2]	2020
General cargo	496	565	625	1,000
Bulk grain	30	30	30	41
Forest products	454	454	454	454
Petroleum	638	638	638	638
Other dry bulk	228	274	583	1,196
Other liquid bulk	40	41	100	236
Ferry & passenger	84	84	133	210
Commercial Vessel Moorage	345	345	545	860
Total	2,315	2,431	3,108	4,635

[1] Existing areas, including estimates for minor ports.

[2] Where projected land area needs are less than existing, the land area in use in 1963 are shown.

Total Terminal Land Requirements

Table 2-20 summarizes terminal land requirements exclusive of railroad and street rights-of-way, green belts, etc., for the Puget Sound Area.

WATER TRANSPORT-ORIENTED INDUSTRY LAND REQUIREMENTS

General

Waterfront terminal facilities serve an industrial complex which depends on waterborne commerce to enhance their competitive market positions. These industries are termed "Water-Transport-Oriented Industries." As previously discussed under the chapter on "Present Status", an estimate was made of the acres of land in use by these industries in 1963 on the basis of an inventory. The results of this inventory by industry and broad commodity groups are summarized as follows:

Industry	Broad Commodity Classification	Approx. Land in Use in 1963
Warehousing, storage, & heavy equipment	General Cargo	1,710
Lumber, wood products, pulp, paper, & allied products	Forest Products	1,040
Petroleum refining & related industries	Bulk Petroleum	1,250
Primary metals, dry chemicals, stone, clay, glass & cement	Other Dry Bulk[1]	690
Liquid chemicals & associated products	Other Liquid Bulk	130
Shipbuilding	Ship Repair & Construction	370
Total		5,190

[1] Excludes 2,440 acres in explosive manufacture.

Land Use Development Trends

Ideally, estimates of future water-transport industrial land needs should be based on detailed industry-by-industry investigations considering supply and demand for products on a worldwide scale. Lacking the resources needed for such an investigation, industrial land use trends were considered appropriate for projecting future acreage required for water-transport-oriented industries. For the purpose of this study, these trends provide a broad indicator of the lands that should be set aside for industry. Figures 2-34 and 2-35 show an inventory of suitable lands including areas already developed. Specific examples of land use development in the Puget Sound Area and related economic indicators are discussed in subsequent paragraphs.

Tacoma Port Industrial District—This district comprises 2919 acres of submarginal tidelands which were reclaimed by dredged fill and made accessible to waterborne traffic by waterways and terminals. The Port has restricted land sales to industries whose activities are oriented to water transportation. All sales agreements require development within one year of purchase. In the 16-year period from 1952 through 1968, the acreage sold increased from 984.6 acres to 1526 acres. The average annual compound rate of land absorption approximated 2.8%. This growth rate forecasts a full utilization of favorable industrial land by 1985. The actual utilization is likely to occur much earlier, since the recent growth rate has not kept up with more significant indicators, such as the tax base (6.4%) and terminal development (7.5%) as shown in the Table in a subsequent paragraph. Besides the rapid growth associated with development of the nearby industrial community, it is also likely that the "spill-over" from landlocking in more distant communities will contribute to the demand.

Appendix IV, Economic Environment—The economic study contained in Appendix IV provides long-term projections of output and employment. The tabulation below gives the average annual compound rate of growth for selected industrial trends judged to be most nearly representative of water-transport-oriented industrial growth.

Waterborne Commerce—The projections derived previously for Puget Sound Area waterborne commerce to year 2020 yield an average annual compound rate of growth of 3.4% as compared to a past trend of 2.5%.

Studies by Puget Sound Governmental Conference—Studies of the Puget Sound Governmental Conference provide a historical record of industrial land development in the counties of Snohomish, King, Pierce and Kitsap for the years 1961 and 1966. A review of their unpublished data revealed an average compound rate of growth of 5.4% between these dates, for select industries.

Trend Comparisons—The preceding specific examples of land use development in the Puget Sound Area and related economic indicators are summarized on the following page.

Commodity Classification	Industrial Categories	Average Compound Rate of Growth (1963 to 2020) Output	Employment
General Cargo	Wholesale & retail trade	3.2%	1.9%
Forest Products	Lumber, wood, paper & allied products	0.99%	-1.4%
Bulk Petroleum	Petroleum refining	3.8%	0.1%
Other Dry Bulk	Primary metals & construction	3.9%	1.4%
Other Liquid Bulk	Chemicals	3.1%	-1.5%
Shipbuilding	Shipbuilding	0.7%	0.9%
Composite trends of above		3.0%	1.5%

Parameter	Period	Average Annual Compound Growth Rate
Port of Tacoma industrial land sales	1952-1968	2.8%
Unpublished data of Puget Sound Governmental Conference	1961-1966	5.4%
Aggregated output of industrial sectors[1] judged to be representative of water-oriented industries	1963-2020	2.96%
Aggregated employment of industrial[1] sectors judged to be representative of water-oriented industries	1963-2020	1.5%
Population of Puget Sound Area[1]	1963-2020	2.31%
Past trend total Waterborne commerce Puget Sound Area	1952-1966	2.5%
Projected commerce Puget Sound Area	1980-2020	3.4%
Pierce County (Port of Tacoma) tax base	1949-68	6.4%
Port of Tacoma Terminal land use	1963-68	7.5%

[1] Source: Appendix IV, Economic Environment

Forecast of Land Use Trend—All of the foregoing trends can be identified to some extent with the future needs for land by water-transport-oriented industries. Even considering some deviations, a conclusion can be made that the mean range of long run trends would fall between 2 and 3% annually. Thus, for planning purposes, annual industrial land development can be approximated as 2.5%. Applying this rate to the existing base of 5,190 acres of land in use by these industries in 1963 reveals that about 61,000 acres would be in use in 100 years.

Alternative patterns of land use growth to reach this 61,000 acres in 2063 are:

Deferred Growth

$$y = 5190 \cdot 1.025x$$

Straight Line Growth

$$y = 5190 + \frac{56000x}{100}$$

Accelerated Growth

$$y = 5190 + \frac{\log e\,(x+1)}{4.61512}$$

Where:

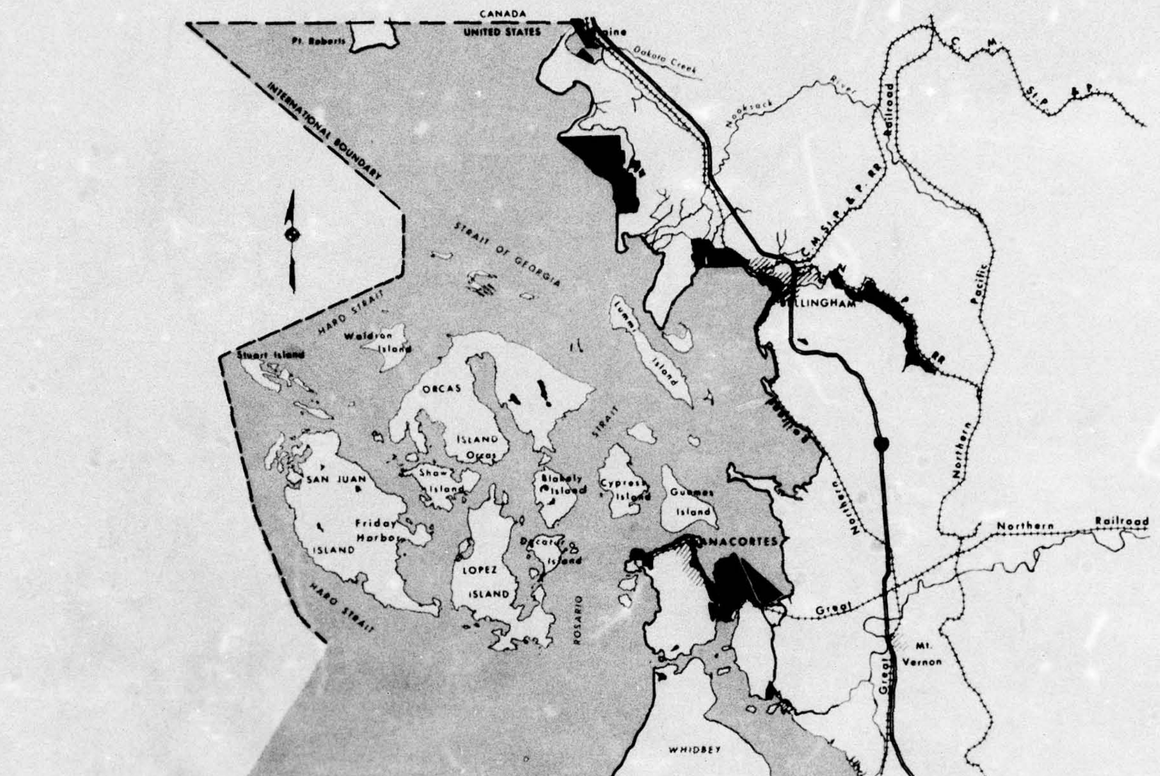
y = land requirements in acres
x = time in years beyond 1963
5190 = acres in use in 1963
56,000 = additional lands in use by water-transport-oriented industry by 2063
1.025 = compound growth factor
1/4.61512 = accelerated growth coefficient for 100 years

These trends are compared in Figure 2-36. Using the equations a range of land requirements was derived for the three target years of this study. The various forecasts are shown in Table 2-21.

TABLE 2-21. Puget Sound Area alternative land use projections, water-transport-oriented industries

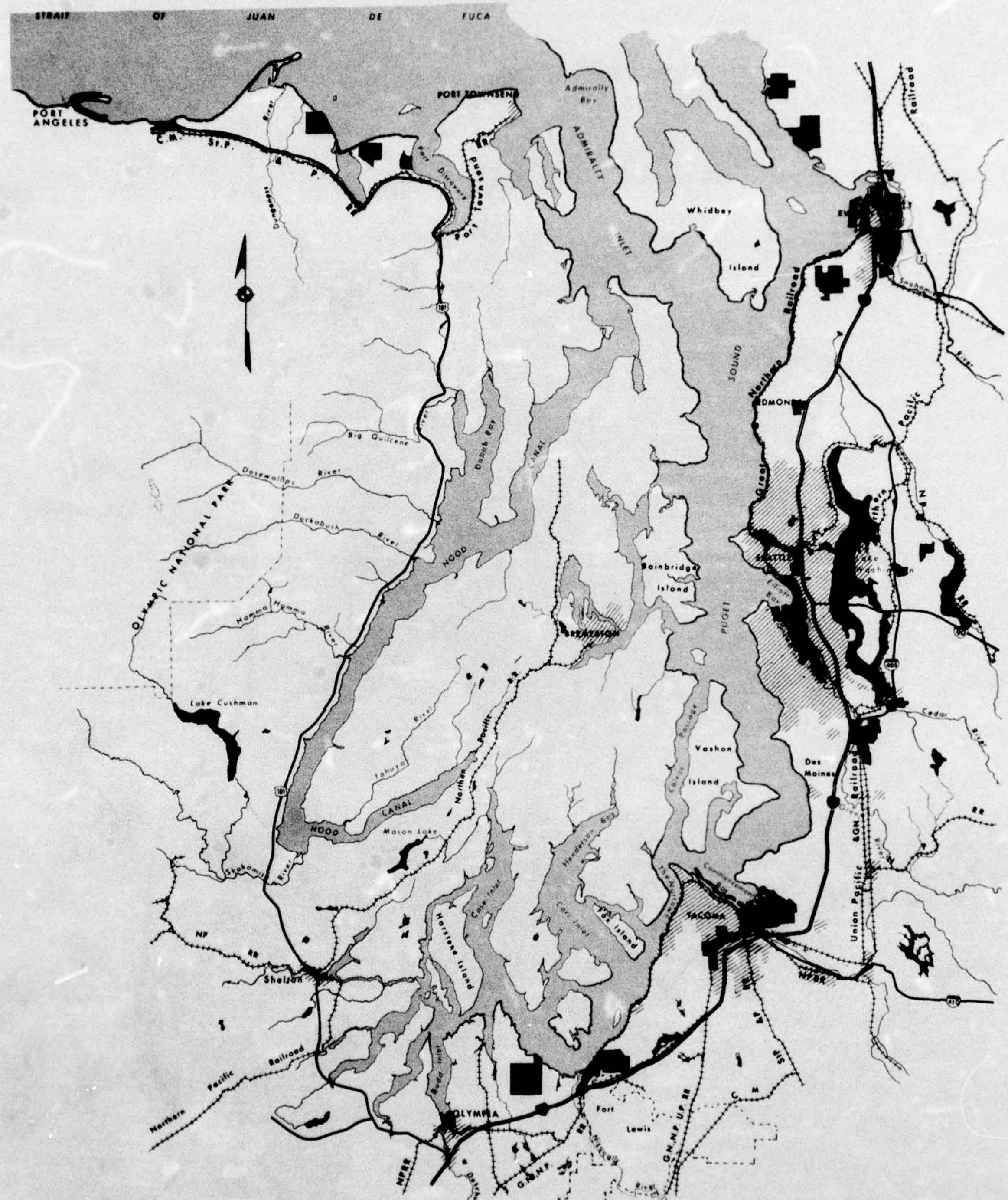
	Acres in Use			
	1963	1980	2000	2020
Deferred growth	5,190	7,900	13,000	21,200
Straight line growth	5,190	14,700	25,900	37,200
Accelerated growth	5,190	40,900	51,700	54,600

The rate of acquisition and use of land by water transport-oriented industries would be governed by demand, price and environmental conflicts. Prices rise as an area becomes more intensely developed with land put to a higher economic use. As environmental considerations become increasingly significant, requiring industries to provide space for aesthetic purposes, the demand for land is increased beyond that due to production and manufacturing needs alone. These factors would tend to favor an accelerated growth pattern over deferred growth with most future industrial land being acquired during the early years of the forecast period. However, using an accelerated growth forecast would result in an equivalent annual compound rate of growth of about 13%



PUGET SOUND-NORTH
WATER-ORIENTED INDUSTRY & WATERFRONT TERMINAL LANDS

FIGURE 2-34



LEGEND

Partially Developed Area

Undeveloped, Potential For Development

Scale in Miles 5 0 5 10

PUGET SOUND-SOUTH
WATER-ORIENTED INDUSTRY
& WATERFRONT TERMINAL
LANDS

FIGURE 2-35

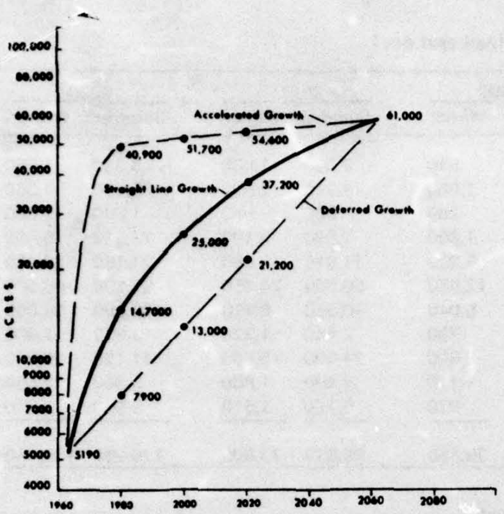


FIGURE 2-36. Puget Sound Area—Land Use Projection Water Transport-Oriented Industries.

TABLE 2-22. Puget Sound Area, Pleasure boat projections U.S. Coast Guard registered and documented craft

Basins	Number of Boats 1966	1980	2000	2020
Nooksack-Sumas	2,800	3,900	6,300	10,500
Skagit-Samish	2,000	2,800	4,600	7,600
Stillaguamish	600	900	1,800	3,600
Whidbey-Camano	700	1,000	1,700	2,800
Snohomish	5,700	9,400	18,300	35,800
Cedar-Green	31,300	51,700	100,700	196,900
Puyallup	10,400	17,100	33,400	65,300
Nisqually-Deschutes	2,400	2,800	2,700	6,500
West Sound	4,800	5,600	9,300	12,900
Elwha-Dungeness	800	1,000	1,800	2,300
San Juan Islands	200	300	400	600
Total	61,700	96,500	181,000	344,800

between 1963 and 1980; a rate not viewed as reasonable. For purposes of this study, straight-line growth was found to be the most appropriate projection pattern. This pattern has a decreasing percent increase over time, reflecting impacts of rising prices arising from competition for available lands suitable for industrial development and environmental quality needs.

SMALL BOAT HARBORS

General

The pleasure boat study, previously referenced, was the source of data summarized here on present and future needs.

Boat Projections

The future numbers of pleasure boats in the Puget Sound Area have been projected on the basis of annual growth rates which include projected population growth plus 1 percent, the latter attributed to increased disposable income and greater interest in boating. Table 2-22 shows projected number of registered and documented pleasure boats by basins for the years 1980, 2000, and 2020. Also shown are the estimated number of pleasure craft for 1966.

Pleasure Boat Moorage Demands

Responses to a questionnaire, sent out to a representative sampling of pleasure boat owners listed in the 1966 Coast Guard register, indicated that a large demand exists for rental moorages as well as for harbors of refuge, salt water camping, and picnicking, and boat launching facilities. From this questionnaire sampling and a base of the Puget Sound Area residents having registered or documented pleasure boats, estimates were made of the total Area demand for moorage facilities. Moorage needs were defined for both summer and winter seasons. The summer season is taken as mid-April to mid-September, and the winter season as mid-September to mid-April.

Moorage needs for each season were taken as the sum of permanent moorage demand and a percentage of temporary moorage demand with an allowance for sail boats without power, which use moorages, but are not registered with the Coast Guard. Permanent moorage is defined as moorage use for a period greater than one month and temporary demand as moorage use for one month or less.

Tabulated in Table 2-23 are the projected number of pleasure craft rental moorages required to meet existing (1966) and future (1980, 2000, and 2020) boater demand. Moorage demand was projected to grow at the same rates as pleasure boat ownership. The moorage needs are by season and include both wet and dry moorages. The questionnaire survey revealed that about 80% of total summer moorage demand is for wet moorages, dropping to about 60% for total winter moorage demand.

Table 2-24 summarizes the wet moorage needs.

Other Marine Facility Needs

The pleasure boat survey also provided a measure of demand for launching ramps, and salt-

TABLE 2-23. Puget Sound Area—total rental moorage needs (wet and dry)

Basins	1966 Summer	1966 Winter	1980 Summer	1980 Winter	2000 Summer	2000 Winter	2020 Summer	2020 Winter
Nooksack-Sumas	890	440	1,240	610	2,030	1,000	3,380	1,660
Skagit-Samish	2,140	1,140	3,000	1,600	4,910	2,620	8,170	4,360
Stillaguamish	310	180	500	290	960	560	1,880	1,090
Whidbey-Camano	3,320	1,320	4,720	1,890	7,870	3,180	13,360	5,450
Snohomish	3,780	3,820	6,150	6,220	11,910	12,080	23,150	23,450
Cedar-Green	8,390	7,640	13,670	12,450	26,500	24,150	51,500	46,900
Puyallup	3,340	3,100	5,440	5,040	10,560	9,770	20,500	19,000
Nisqually-Deschutes	1,250	620	1,460	730	2,440	1,220	3,370	1,680
West Sound	9,970	6,210	13,650	8,800	24,500	15,650	41,120	26,800
Elwha-Dungeness	1,220	950	1,430	1,110	2,400	1,860	3,300	2,550
San Juan Islands	2,510	660	3,510	920	5,750	1,510	9,560	2,510
Total	37,120	26,080	54,770	39,660	99,830	73,600	179,290	135,450

TABLE 2-24. Puget Sound Area—total rental wet moorage needs

Basins	1966 Summer	1966 Winter	1980 Summer	1980 Winter	2000 Summer	2000 Winter	2020 Summer	2020 Winter
Nooksack-Sumas	710	260	990	370	1,620	600	2,700	1,000
Skagit-Samish	1,720	690	2,400	960	3,930	1,570	6,540	2,620
Stillaguamish	250	110	400	170	770	340	1,500	650
Whidbey-Camano	2,660	790	3,770	1,130	6,300	1,910	10,690	3,270
Snohomish	3,020	2,290	4,920	3,730	9,530	7,250	18,520	14,100
Cedar-Green	6,710	4,570	10,920	7,470	21,200	14,500	41,200	28,200
Puyallup	2,670	1,860	4,350	3,030	8,450	5,860	16,400	11,400
Nisqually-Deschutes	1,000	370	1,170	440	1,950	730	2,700	1,010
West Sound	7,980	3,730	10,920	5,280	19,600	9,390	32,900	16,100
Elwha-Dungeness	980	670	1,140	670	1,920	1,110	2,640	1,530
San Juan Islands	2,010	390	2,810	550	4,600	910	7,650	1,500
Total	29,710	15,730	43,790	23,800	79,870	44,170	143,440	81,380

water camping and picnicking facilities. These pleasure boating related needs are discussed in Appendix X, Recreation.

Harbors of Refuge

Boaters were asked in the questionnaire survey to indicate areas where they need a harbor to flee heavy weather. A positive response of about 50 percent of those surveyed, reflecting nearly 30,000 boat owners, demonstrates definite interest in harbors of refuge. Harbors of refuge provide temporary havens for small craft in distress or seeking shelter from approaching storms, giving a place of rest and replenishment. A harbor of refuge must offer anchorage or moorage protected from waves of hazardous magnitude from any quarter, and may have access by land and a public landing.

No harbor located on Puget Sound and adjacent waters is presently designated as a harbor of refuge. Several of the larger marinas with anchorage basins are able to afford some protection to small craft, however space has not been set aside for this purpose. The growth of pleasure boat activity increases the peril as more boaters are subjected to adverse wave action during periods of sudden high winds. Uncertainty of weather conditions and the many miles of shoreline without these protected harbors tends to reduce the cruising radius of many boaters.

The expressed demand and recognized need to provide for boater safety and increased enjoyment of boating requires that further study be given to development of designated harbors of refuge.

SUMMARY OF NEEDS

The determination of navigation needs for the Puget Sound Area began with an examination of waterborne commerce and the projection of future tonnage by broad commodity groups. The commodity groupings were representative of the type of vessel and the terminal facilities required for shipment and receipt. Future terminal land requirements were projected using an inventory of terminal facilities and estimates of handling capacities considering future efficiency. Vessel trends in the world fleet were examined and from an analysis of these trends requirements for harbors and channels in terms of depth and widths were approximated for each type of carrier. These evaluations were followed by in-depth studies of pleasure boating from which the future needs were estimated. Water-transport-oriented industries, those plants in the Puget Sound Area which depend on waterborne commerce for their competitive position in the market place, were inventoried and historical growth patterns of these industries were analyzed. Projections of output and employment developed in Appendix IV, Economic Environment, were compared to historical experience and future growth rates were approximated. The acreage of future industrial land requirements were developed from these ranges of probable future growth as a guide for planning. The navigation needs of the Puget Sound Area developed by these studies are summarized in Table 2-25.

TABLE 2-25. Puget Sound Area—future navigation needs

Item		Unit	Needs By 1980	2000	2020
Waterborne Commerce					
General Cargo		1,000 short tons	6,800[1]	9,500	19,400
Bulk Grain			2,200	2,800	4,100
Forest Products			9,600	11,700	13,900
Bulk Petroleum			21,500	40,000	83,800
Other Dry Bulk			26,300	58,600	128,600
Other Liquid Bulk			370	890	2,100
Totals			66,770	123,490	251,900
Harbors & Channels Improvements		Feet			
Required[2] Depth and Width					
Freighters	Max.		44 x 200	46 x 220	46 x 220
	Ave.		32 x 120	32 x 120	32 x 120
Bulk Carriers	Max.		64 x 250	78 x 320	78 x 320
	Ave.		40 x 180	46 x 200	46 x 200
Tankers	Max.		106 x 420	112 x 450	112 x 450
	Ave.		52 x 230	54 x 240	54 x 240
Land Requirements		Acres			
Terminal Lands			2,430	3,110	4,640
Water-transport-oriented industry			14,700	25,900	37,200
Totals			17,130	29,010	41,840
Small Boat Harbors		Wet Moorages[3]	43,790	79,870	143,440

[1] Rounded off to the nearest 100,000 tons.

[2] Single lane channel for tug-assisted vessels.

[3] Taken as summer wet moorage needs.

MEANS TO SATISFY NEEDS

GENERAL

In the preceding chapters navigation in the Puget Sound Area has been examined with respect to the past and to its needs in the future. From past performance, the flow of waterborne commerce with associated industries and the growth of pleasure boating have contributed a large measure to the economy of the Area. An evaluation of needs of navigation yield the following general conclusions:

a. Waterborne commerce has increased from 31,000,000 tons in 1963 to almost 42,000,000 tons in 1966. By 2020, this tonnage is expected to reach about 252,000,000 tons.

b. The world fleet is changing in composition with large increases in the number and size of bulk carriers and tankers. These vessels are becoming giants of the world fleet with dead weights approaching one million tons for tankers and 400,000 tons for bulk carriers. Freighters are also experiencing growth in size, weight and length.

c. Harbors and channels of the Puget Sound Area are potential users of the full range of vessels of the world fleet. In 2020, the maximum depth and width of channels for single vessels would range from 46' X 220' for freighters, 78' X 320' for bulk carriers and 112' X 450' for tankers.

d. Terminal land areas to accommodate the projected waterborne commerce would increase from 2,325 acres in 1963 to 4,640 acres in 2020.

e. Waterfront terminal facilities are served by an industrial complex which depends on waterborne commerce for competition in the markets of the world. These water-transport-oriented industries occupied 5,190 acres on or adjacent to the waterfront in 1963. A projection based on relevant trends indicates that future land requirements for planning purposes would be 37,200 acres in 2020, and that the growth pattern would probably follow a straight line with a decreasing percent increase over time reflecting increasing land prices and environmental conflicts.

f. Registered pleasure boats in Puget Sound Area were estimated to increase from 61,700 in 1966 to 344,800 in 2020. In 1966 the total needs for rental moorages for pleasure boats were 37,120 spaces in summer and 26,080 in winter. The demand for these accommodations in 2020 are expected to be 179,290 spaces in summer and 135,450 spaces in winter.

OBJECTIVES

The general objective of this chapter is to develop a plan to meet the navigation needs of the Puget Sound Area for the years 1980, 2000 and 2020. This plan would embrace programs to meet land requirements and harbor and channel needs. A range of costs and benefits for harbor and channel improvements for the year 1980 would be included. For the years 2000 and 2020 only the range of costs would be estimated. Refinements in costs and benefits required to justify the expenditure of construction funds in the later period were left for further detailed studies.

METHODOLOGY

The inventory of existing waterborne commerce, land in use and available for terminal facilities and water-transport-oriented industries, and small boating followed by forecasts of navigation needs provided a base for developing a navigation plan for the Puget Sound Area and its river basins. The principal elements followed in the planning process are described below:

a. **Land requirements.**—The development of land available and favorable for terminals and water transport-oriented industries in each river basin was compared to land requirements for the year 2020 and land in use was estimated for that year. Land in use for the year 1980 was projected using the 1963 pattern. The estimated pattern for the year 2000 was developed from the difference between the years 1980 and 2020 recognizing the shift in industrial use as available land is developed in each basin.

b. **Waterborne Commerce.**—The flow and growth of waterborne commerce was examined for each of the general commodity groups to develop information on possible shifts between individual basins. A disaggregation of projected commerce into basins by general type of commodities was made for 1980 following the 1963 distribution. The commerce for the years 2000 and 2020 was estimated recognizing shifts in origin or destination resulting from industrial growth, land and backup area availability.

c. **Harbors and Channels.**—Using data developed previously on vessel trends, a program of channel and harbor projects in each basin were derived for the years 1980, 2000, and 2020 to meet the needs of future commerce. The range of costs and benefits was estimated for the year 1980; costs only were developed for 2000 and 2020.

d. **Small Boat Harbors.**—Moorage requirements for pleasure boats were accorded a special study bound separately as Exhibit 1 to this appendix. From information developed in this study, the needs and plans for meeting these needs were developed for each of the river basins.

SOLUTIONS TO NAVIGATION NEEDS

Land Requirements

The results of an inventory of favorable land areas for terminals and water transport-oriented industries are given in Table 2-10 of the chapter on Present Status. A comparison of these lands with the land needs for the year 2020 as derived in the preceding chapter reveals that land inventoried as favorable for either terminal or water transport-oriented industrial use is 41,501 acres as compared to a need for 41,840 acres. Since the two values are approximately the same, the land use plan for 2020 provides for the utilization of all land designated in this appendix as being favorable for terminal or water transport-oriented industrial use.

Alternate sites to those designated may be found on Indian Reservation. However, as discussed previously these lands were not included in the navigation study inventory of favorable sites due to the uncertainty of future availability. Current trends are for residential development on some reservation lands. Difficulty in achieving tribal approval for use of reservation lands and securing long-term lease agreements also diminish the attractiveness of these lands for industry.

Adequate land is available for the development of terminal facilities and water transport-oriented industries in each basin to meet the needs of commerce for the period of 1963-1980. Major shifts in commerce or development are not expected to occur. Therefore, the 17,130 acres of land estimated to be required in the Puget Sound Area in 1980 was disaggregated to river basins on the basis of the 1963 land use pattern. With substantially all available land assumed to be in use in the year 2020, the land use requirements by basin for the year 2000 were derived by proportioning changes in land use between 1980 and 2020 such that the sum of the individual basins would be equal to the projected total land needs for 2000. Table 2-6 gives the projected land needs in 1980, 2000, and 2020 as compared to the land use in 1963. The shift between basins appears logical on the basis of trends in land use. In order to insure that the above acreages are available for development, they should be held in reserve for future industrial use. However, this reservation need not preclude interim use for other purposes.

TABLE 2-26. Puget Sound Area, projected net land requirements (acres [2])

River Basins	Land in Use 1963	Needs for Land in Use 1980	2000	2020
Nooksack-Sumas	880	2,040	3,480	5,870
Skagit-Samish	1,260	2,920	4,050	5,910
Snohomish	700	1,600	5,640	12,330
Cedar-Green	2,810	6,550	7,300	7,300
Puyallup	1,300	3,010	4,950	4,950
Nisqually-Deschutes	130	310	2,550	3,760
Elwha-Dungeness	210	480	830	1,170
Minor Ports	210[1]	210[1]	210[1]	210[1]
Total	7,500	17,130	29,010	41,500

[1] Estimate of terminal lands only in use in 1963 for minor ports. Water transport-oriented industrial land use for 1963 was not inventoried for minor ports. However, sufficient land area is considered to be available.

[2] Land areas have been rounded off to the nearest 10 acres.

Waterborne Commerce

In the period of 1963 through 1980, the area of available land is adequate for continuation of present pattern of commerce and associated industrial development. Expanding petroleum refineries in the Nooksack-Sumas basins are the only major shift apparent during this period. Table 2-27 lists the historical total waterborne commerce in 1963 by river basins and by commodity groups and gives the projected commerce for the year 1980. The total waterborne commerce projected for the Puget Sound Area for year 1980 was disaggregated to river basins in proportion to the 1963 distribution except for the following adjustments which were made to reflect changes in petroleum traffic.

a. The 1963 petroleum commerce was held constant through 1980 for the Cedar-Green Basin. The shift from water transport to pipeline of refined oil products as reflected in the decreasing trend of domestic internal bulk petroleum tonnage justifies this modification.

TABLE 2-27. Puget Sound Area. Projection of waterborne commerce by river basins for year 1980. Waterborne commerce in 1,000 tons

River Basins	General Cargo 1963	General Cargo 1980	Bulk Grain 1963	Bulk Grain 1980	Forest Products 1963	Forest Products 1980	Bulk Petroleum 1963	Bulk Petroleum 1980	Other Dry Bulk 1963	Other Dry Bulk 1980	Other Liquid Bulk 1963	Other Liquid Bulk 1980	Total [2] 1963	Total [2] 1980
Nooksack-Sumas	170	270			410	500	70	2,040	810	2,930			1,450	4,740
Skagit-Samish	30	50			290	350	6,180	8,270	10	20			6,510	8,690
Snohomish	170	270			2,060	2,520	50	70	380	910			2,660	3,770
Cedar-Green	1,480	4,350 [1]	690	1,250	1,020	1,250	5,690	5,690	3,820	9,130	160	330	12,850	22,000
Puyallup	400	640	520	950	990	1,220	1,410	1,880	1,650	3,940	20	40	4,990	8,670
Nisqually- Deschutes	40	60			470	580	130	170	110	260			750	1,070
Elwha-Dungeness	390	620			510	630	200	270	90	210			1,180	1,730
Minor Ports	340	540			2,080	2,550	2,320	3,110	4,140	9,900			8,890	16,100
Total [2]	3,020	6,800	1,210	2,200	7,830	9,600	16,050	21,500	11,000	27,300	180	370	39,280	66,770

1 Increased by 2,000,000 tons to reflect accelerated growth of containerized freight

2 Tonnages have been rounded off to the nearest 10,000 tons

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b. The petroleum commerce of the Nooksack–Sumas Basins was increased from 70,000 tons in 1963 to 2,040,000 tons in 1980 to reflect new petroleum refinery capacity served by crude oil from Alaska.

Disaggregation of projected commerce to the various basins for the period 1980 to 2020 was generally based on land availability with the exception of the Elwha-Dungeness Basins and minor ports. The total waterborne commerce for the Elwha-Dungeness Basins is projected at an annual growth rate of 2.3% which is an extension of average growth forecast for the period 1963 through 1980. This rate is only slightly less than the 2.5% growth of Gross Regional Product projected in Appendix IV for the Western Division over the same period. Minor ports include the West Sound, Whidbey-Camano and San Juan Islands. The major tonnage in this group is handled in the latter two Basins. Commerce for these Basins is projected at an annual growth rate of 2.5% which is slightly less than the average annual historical growth from 1952 to 1964 and is consistent with economic growth projections for these Basins. Tabulated below are forecasts of waterborne commerce for the Elwha-Dungeness and Minor Ports.

Projected Waterborne Commerce for Elwha-Dungeness and Minor River Basins For Years 2000 and 2020

	Waterborne Commerce in 1,000 Tons	
River Basins	**2000**	**2020**
Elwha-Dungeness	2,700	4,200
Minor River Basins	26,500	43,000

In the remaining river basins along the eastern shoreline of Puget Sound, land could become a major restraint beyond 1980. The flow of commerce, particularly of bulk type, could be expected to shift in relation to land availability. Accordingly, these river basins were grouped into subareas most nearly fitting their spheres of influence. Table 2-28 compares these subareas in terms of percent distribution of waterborne commerce and land in use. An overview of these comparisons shows some relationship between land area and commerce for the years 1963 and 1980 and provides a basis for the approximate disaggregation of commerce between these river basins as described below and shown in Table 2-29.

a. The projected waterborne commerce for the Puget Sound Area for the years 2000 and 2020 was reduced by the tonnage forecast for the Elwha-Dungeness and minor river basins. The remaining 94,300 tons for 2000 and 204,700 tons for 2020 was distributed to subareas in proportion to the projected percent land in use given in Table 2-28.

b. In subarea 1, the dominant tonnage would be bulk petroleum. Considering the refinery complex soon to be developed in the Nooksack-Sumas Basins and the available land areas, the tonnage was equally divided between basins for the years 2000 and 2020.

c. In subareas 2 and 3 the existing ports of Seattle and Tacoma would be experiencing constraint on available land after 1980 causing shifts of commerce to neighboring basins. The following shifts of commerce were forecast within subareas 2 and 3:

	Percent Commerce 2000	Percent Commerce 2020
Subarea 2		
Snohomish	25	50
Cedar-Green	75	50
	100	100
Subarea 3		
Puyallup	75	50
Nisqually-Deschutes	25	50
	100	100

TABLE 2-28. Puget Sound Area, comparison of waterborne commerce and land in use by river basins

River Basins	1963 Commerce	1963 Land in Use	1980 Commerce	1980 Land in Use	2000 Land in Use	2020 Land in Use
Subarea 1						
Nooksack-Sumas	5.0	12.4	10.1	12.4	12.5	14.6
Skagit-Samish	22.2	17.8	18.5	17.8	14.4	14.8
	27.2	30.2	28.6	30.2	26.9	29.4
Subarea 2						
Snohomish	9.2	9.8	8.1	9.9	20.0	30.7
Cedar-Green	43.9	39.6	42.5	39.6	26.2	18.2
	53.1	49.4	50.6	49.5	46.2	48.9
Subarea 3						
Puyallup	17.1	18.5	18.5	18.4	17.7	12.3
Nisqually-Deschutes	2.6	1.0	2.2	1.9	9.2	9.4
	19.7	19.5	20.7	20.3	26.9	21.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 2-29. Puget Sound Area, projections of waterborne commerce for subareas 1, 2, and 3

River Basins	Waterborne Commerce (1,000 tons) 2000	2020
Subarea 1		
Nooksack-Sumas	12,700	30,100
Skagit-Samish	12,700	30,100
	25,400	60,200
Subarea 2		
Snohomish	10,900	50,000
Cedar-Green	32,600	50,000
	43,500	100,100
Subarea 3		
Puyallup	19,000	22,200
Nisqually-Deschutes	6,400	22,200
	25,400	44,400

The disaggregation of waterborne commerce to river basins summarized in Table 2-30 was made for planning purposes only and assumes that ports and industries involved pursue a successful course of active promotion and development to meet navigation needs. The estimates for the year 1980 fit past patterns and are reasonable on the basis of known facts. The long-range estimates for the years 2000 and 2020 can be considered only indicative of possible levels of future traffic because of the many variables which cannot be foreseen at this time. They do, however, reflect shifts in the industrial complex to meet the availability of suitable land for water transport-oriented industries and terminals.

TABLE 2-30. Puget Sound Area, projection of total waterborne commerce by river basins for years 1980, 2000, and 2020

River Basins	Total Waterborne Commerce (1,000 tons) [1] 1980	2000	2020
Nooksack Sumas	4,700	12,700	30,100
Skagit-Samish	8,700	12,700	30,100
Snohomish	3,800	10,900	50,000
Cedar-Green	22,000	32,600	50,000
Puyallup	8,700	19,000	22,200
Nisqually-Deschutes	1,100	6,400	22,200
Elwha-Dungeness	1,700	2,700	4,200
Minor Ports	16,100	26,500	43,000
Total	66,800	123,500	251,900

[1] Tonnages have been rounded to nearest 100,000 tons.

Harbors and Channels

General—The world fleet is potential users of the Puget Sound Area harbors and channels. The increasing size of these vessels requires improvements in the present controlling dimensions of harbors and channels. Such improvements are costly requiring advance planning and adequate financing to progressively meet navigation needs. With many ports having deep water, adequate depth can be easily obtained by extending the pier line or by filling behind bulkheads. At other ports, channel deepening would be necessary. The type and quantity of commerce expected to flow through each basin, as shown on Tables 2-27 and 2-30, provided a basis for forecasting the type and size of vessels to be serviced within each basin. The projected world fleet composition shown in Table 2-18 establishes guidelines for necessary harbor and channel improvements based on vessel operating characteristics. A review of vessel calls at Puget Sound Ports indicates that many of these vessels substantially exceed the world fleet average at the present time. Table 2-31 relates the size of vessels now calling in Puget Sound with world fleet averages. Projected relationships also are shown for 1980, 2000, and 2020 based on current experience and commerce forecasts. Subsequent paragraphs briefly discuss the rationale for these projections and the means to satisfy harbor and channel needs in each basin.

Nooksack-Sumas—Most of the waterborne commerce handled in this basin passes over terminal facilities located in Bellingham Bay, Blaine and Ferndale. The commerce forecast indicates substantial increases in general cargo, bulk petroleum and other dry bulk. The development of oil refineries in the basin north of Bellingham will generate port calls by large tankers; however, necessary facilities to accommodate these vessels are expected to be provided by each refinery company. Adequate water depths are available and offshore unloading of tankers is now technically and economically feasible. Freighters exceeding the world average now call at the Port of Bellingham, utilizing the Whatcom Creek Waterway. Deepening of this waterway for large freighters is required to meet current and future needs. Construction of a waterway near the Nooksack River Delta and use of dredged disposal for land fill will provide 2,400 acres of land necessary for bulk cargo shipments developing after 1980.

Skagit-Samish—Waterborne commerce in general cargo, dry bulk and petroleum is expected to increase significantly in the Skagit-Samish Basins.

TABLE 2-31. Puget Sound Area—existing and projected vessel calls

Basin	Existing Freighter	Existing Bulk Carrier	Existing Tanker	1980 Freighter	1980 Bulk Carrier	1980 Tanker	2000 Freighter	2000 Bulk Carrier	2000 Tanker	2020 Freighter	2020 Bulk Carrier	2020 Tanker
Nooksack-Sumas	+	O	+	+	A	+	+	+	+	+	+	+
Skagit-Samish	+	A	A	+	+	A	+	+	+	+	+	+
Snohomish	+	A	A	+	+	A	+	+	A	+	+	A
Cedar-Green	+	+	+	+	+	A	+	+	A	+	+	A
Puyallup	+	+	+	+	+	+	+	+	+	+	+	+
Nisqually-Deschutes	+	O	O	+	O	O	+	+	O	+	+	O
Elwha-Dungeness	+	O	A	+	O	A	+	O	-	+	O	-

Note: + Larger than average
A World fleet average
- Smaller than average
O No vessels of this type

Large tankers will continue to serve the two oil refineries located in the basin with greater quantities of bulk petroleum anticipated in the future, commensurate with growing needs of the Area for refined petroleum products. Dredging of Guemes Channel will be required. A channel into Padilla Bay and use of dredged material for fill will provide 3,000 acres of land suitable for other refineries or industries generating or receiving bulk or general cargo. The city of Anacortes has initiated development of an industrial park in Fidalgo Bay. A channel adequate to serve progressively larger barges and freighters would be required as industry develops and expands. Dredged material could be used to reclaim 600 acres in Fidalgo Bay.

Snohomish–Major increases in general and dry bulk cargo are expected in this basin. The East Waterway of the Port of Everett currently serves large freighters and with the completion of a 50,000 ton alumina storage facility will initiate service to large bulk cargo vessels. Cooperative planning by the Port, city and county envisions eventual development of the lower river to the U.S. Highway 99 bridge for large freighters. Above the Highway 99 bridge to the junction with Ebey Slough, industrial lands would be served by barges. The existing channel projects would require deepening to meet these needs with the dredged material used for land fill. Seaward of the existing training dike, dredged fill would be used to create 1,650 acres of land suitable for both bulk and general cargo handling. Berthing depths of 70 feet or over could easily be provided on the seaward of this proposed fill. Unlimited depths are available at potential industrial sites north of the city of Everett with any minor channel or harbor improvement required at these sites anticipated to be provided by the developer.

Cedar-Green–The Port of Seattle provides major terminal facilities for general and dry bulk cargo including grain. Due to a well-developed traffic base, significant increases in these commodity types are projected. The Port has energetically pursued a plan for rehabilitation and improvement of obsolete piers and terminal facilities to encourage traffic growth. These plans call for ultimate improvement of the East and West Waterways, and the Duwamish Waterway below the 8th Avenue bridge to provide for large freighters and average sized bulk carriers. Improvement of the Duwamish Waterway above the 8th Avenue bridge for large barges to serve the industrial complex in the Green River Valley also is contemplated. Dredged disposal can be used in some locations to reclaim land; however, much of the dredged material will probably be disposed of in deep water. Land fill for a bulk grain terminal recently has been placed between Piers 71 and 98. Natural berthing depths of 70 feet or more are attainable in this location. Large tankers may serve the Union Oil Company facility at Edmonds; however, natural berthing depths will preclude the necessity for any major channel improvement.

Puyallup–The Port of Tacoma is actively promoting traffic in general and bulk cargo including grain. Freighters, tankers and bulk cargo vessels exceeding the world average regularly call at this Port. Deepening of the Hylebos Waterway to serve large freighters and bulk carriers will be required. The Port Industrial Waterway also will serve large freighters and bulk carriers. The outer portion of Sitcum Waterway has been improved by the Port to serve large bulk carriers bringing alumina. Some dredged material may yet be used for land fill; however, a major portion will have to be disposed of in deep water. At the present rate of demand for terminal facilites, the potential of the Puyallup Delta will have been fully utilized by 1985. To accommodate further demand in the categories described above, the Port of Tacoma promulgated in 1965 an amendment to its Comprehensive Plan, providing for the development of a deep-water terminal in Nisqually Delta. This terminal will be on the east side of the Nisqually River, within the Port's present jurisdication. The project envisions 12 berths 1,000 feet long with depths from 55 to 85 feet, along with recreation facilities and conditions for restoring and maintaining environmental quality.

Nisqually-Deschutes–Within this basin are the existing facilities of the Port of Olympia and a potential harbor development on the Nisqually River Delta. Commerce in the Port of Olympia is expected to remain in the general cargo and forest product category normally transported by freighters. Freighters exceeding the world average currently call at the Port even though widths and depths of the existing channel and turning basin are substandard. Both the channel and turning basin should be improved to meet the needs of existing as well as projected large freighters. Additional industrial and terminal land could be created by improvement of the Government Waterway and use of dredged material for fill. Major projected increases in general and bulk commerce can be met by development of the Nisqually River Delta where maximum sized freighters and bulk carriers can

TABLE 2-32. Puget Sound Area, Harbor and channel improvements

Basin and Project	Feature Minimum Requirement (Ft)[1] Depth	Width	Length	Sequence By 1980	1980-2000	2000-2020
Nooksack-Sumas						
Whatcom Cr. W.W.	40	180	7,800	X		
Whatcom Cr. W.W.	46	200	9,500		X	
Nooksack Delta	46	200	5,400		X	
Skagit-Samish						
Guemes Channel	54	240	24,300	X		
Guemes Channel	78	320	25,000		X	
Fidalgo Bay	32	120	5,600	X		
Fidalgo Bay	40	180	6,100		X	
Fidalgo Bay	46	200	6,300			X
Padilla Bay	46	200	18,500		X	
Padilla Bay	54	240	19,100			X
Snohomish						
Upper River	20[2]	150	37,000		X	
Lower River	32	120	18,500	X		
Lower River	46	200	18,500		X	
East Waterway	46	200	3,500	X		
East Waterway	78	320	4,200		X	
Tract Q	78	Unlimited		X		
Cedar-Green						
East Waterway	54	750	6,300	X		
West Waterway	54	750	5,300	X		
Duwamish to 1st Ave. Bridge	46	220	13,500	X		
Duwamish to 8th Ave.	32	150	4,000	X		
Duwamish to Head Nav.	20[2]	150	9,500	X		
Puyallup						
Hylebos	46	220	14,800	X		
Seward 11th St. Bridge	78	320	7,500		X	
Port Industrial Waterway	52	300	10,200	X		
Seward 11th St. Bridge	106	600	3,500		X	
Sitcum	78	320	3,900	X		
Nisqually-Deschutes						
West Waterway	40	180	23,700	X		
West Waterway	46	220	29,300		X	
Government W.W.	46	220	6,800		X	
Nisqually Delta	78	320	3,000		X	
Elwha-Dungeness						
Port Angeles	46	Unlimited		X		

[1] Minimum channel dimension based on projected vessel size for single land tug-assisted traffic or existing condition.

[2] Barge waterway.

be served by a combination of dredging and land fill. Berthing depths in excess of 100 feet could be provided seaward of the land fill created terminal areas in the delta.

Elwha-Dungeness–The Port of Port Angeles is currently experiencing port calls from freighters exceeding the world average. Existing commerce consists of general cargo, forest products, bulk petroleum and dry bulk cargo. Harbor depths are adequate to serve large freighters and the tankers expected to call at the port. Piers and wharfs may require extension to reach required berthing depths.

West Sound–Many minor ports exist in the West Sound area. Traffic generally consists of forest products most of which is barged. Although, few harbor or channel improvements will be required if the present pattern of commerce and industrial development is maintained, a shortage of land in other basins may require investigation of the West Sound to meet the needs for water-oriented industrial land and terminal facilities. Such land development in the West Sound will produce ancillary requirements for harbor and channel improvement.

Harbor and Channel Improvements–Specific plans of improvement are identified by relating the forecast of vessel calls with the existing or potential harbor developments in each basin, as shown in Table 2-32.

Small Boat Harbors

In 1966 there were 21 public and 119 private marinas in the Puget Sound Area providing nearly 16,000 rental moorages available to the public. About 23 percent of these were dry moorages. All-year facilities amounted to nearly 95 percent of the total. A questionnaire survey of registered boat owners residing within the Area in 1966 revealed a large demand for rental moorages as well as other pleasure boating related facilities. This demand, when compared with the inventory conducted during 1966, indicated a need for nearly 11,000 additional winter (all-year moorages) moorages. Beyond the winter moorage needs about 10,000 additional moorages were required to provide summer only moorage space.

Future rental moorage needs were derived by assuming moorage demand would grow at the same rate as pleasurecraft ownership. Pleasurecraft were projected on the basis of annual growth trends developed from population forecasts for the Area plus 1.0%, the latter attributed to increased disposable income and greater interest in boating. Demand for both summer and winter moorages were projected and are tabulated in Table 2-23. These projections are all inclusive of both wet and dry moorage. About 80 percent of total summer moorage demand is for wet moorages, dropping to about 60 percent for total winter demand. As the scope of this study was limited to determining the needs and planning for small boat harbor development, dry moorage requirements were not investigated beyond recognizing that the total rental moorage demand not met by the small boat harbors would provide opportunities for private and public investment in these facilities. Summarized in Table 2-33 are projected demands for wet moorage by summer and winter season for each basin. Also shown are wet moorage available in 1966. The apparent magnitude of future demand for small boat harbors, demonstrates the importance of setting

TABLE 2-33. Puget Sound Area–Rental wet moorage

	Existing Facilities 1966		Future Demand 1980		2000		2020	
Basins	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Nooksack-Sumas	214	192	990	370	1,620	600	2,700	1,000
Skagit-Samish	555	555	2,400	960	3,930	1,570	6,540	2,620
Stillaguamish	0	0	400	170	770	340	1,500	650
Whidbey-Camano	102	86	3,770	1,130	6,300	1,910	10,690	3,270
Snohomish	864	774	4,920	3,370	9,530	7,250	18,520	14,100
Cedar-Green	5,701	5,687	10,920	7,470	21,200	14,500	41,200	28,200
Puyallup	1,348	1,348	4,350	3,030	8,450	5,860	16,400	11,400
Nisqually-Deschutes	519	519	1,170	440	1,950	730	2,700	1,010
West Sound	2,324	2,058	10,920	5,280	19,600	9,390	32,900	16,100
Elwha-Dungeness	275	275	1,140	670	1,920	1,110	2,640	1,530
San Juan Islands	395	210	2,810	550	4,600	910	7,650	1,500
Total	12,297	11,704	43,790	23,440	79,870	44,170	143,440	81,380

aside marine shoreline for this purpose in order to insure that the needs of the boating public are met.

For purposes of this study planning to meet the 1980 level of needs for wet moorages included provision for winter (all-year) moorages in most basins. The difference between summer and winter moorage demand represents requirements for facilities that would receive use only during the summer boating season. Currently revenues generated from only summer season occupancy are generally insufficient to make constructing expensive breakwater protected small boat harbors for this seasonal use economically feasible. Some of the natural harbors, inlets and bays within the Area can be further developed by private enterprise to meet a significant share of summer moorage needs as little breakwater protection is ordinarily required.

In the San Juan Basin public small boat harbor projects have been planned far in excess of winter moorage needs as summer moorage demand so greatly exceeds winter moorage demand that this appeared to be warranted.

After 1980 the assumption was made that most, if not all, of the naturally protected sites that can be developed for wet moorage by private interests will have been developed. The projected growth in wet summer moorage demands between 1980 and 2020 was assumed to be met by small boat harbor projects, undertaken by public bodies. Increasing per capita incomes are expected after 1980 to enable public marinas to charge moorage fees during the summer boating season sufficient to tolerate relatively high vacancy rates during the winter season.

The plan would add 27 small boat harbors by 1980 that would occupy nearly 10 miles of shoreline, assuming an average of 3 feet of waterfront per moorage (the average for existing marinas). By 2000 and 2020, twenty-nine and twenty-seven additional small boat harbors are proposed, respectively. Tables and figures listing and showing the sites of proposed and potential harbors are included in individual basin discussions of this appendix. Additional wet moorage called for by period for each basin are shown in Table 2-34.

Sitings of future small boat harbors have been located so as to meet the estimated demand in each river basin to the extent possible. However, because there are not sufficient sites to meet the demands of the more populated basins, use of sites in adjoining basins has been planned. Criteria considered in selection of small boat harbors include:

TABLE 2-34. Puget Sound Area—Additional wet moorage planned

Basins	Present to 1980 Wet Moorages	1980 to 2000 Wet Moorages	2000 to 2020 Wet Moorages
Nooksack-Sumas	870	550	1,150
Skagit-Samish	850	1,900	3,340
Stillaguamish	0	0	0
Whidbey-Camano	2,300	2,660	9,390
Snohomish	3,130	5,940	13,680
Cedar-Green	2,100	10,020	0
Puyallup	1,550	2,720	0
Nisqually-Deschutes	230	2,180	1,210
West Sound	4,310	8,710	13,220
Elwha-Dungeness	710	800	700
San Juan	1,480	1,800	3,040
Total	17,530	37,280	45,730

a. Avoid locations near commercial shipping terminals and traffic.

b. Avoid use or damage to sandy beach areas.

c. Provide boat harbors that can be utilized as harbors of refuge at not more than about ten miles apart, especially near exposed waters.

d. Select harbor areas with natural protection against waves and swells or provide breakwaters so that maximum waves in the moorage area will be less than one foot.

e. To avoid excessive breakwater costs, rubble mound breakwaters should generally be located where bottom is not more than 20 feet below mean lower low water.

All small boat harbor needs can be satisfied through 1980, consistent with boater demand for facilities in individual basins. By 2000, however, favorable harbor sites along the periphery of Puget Sound in the Cedar-Green and Puyallup Basins will become exhausted. Spillovers into adjacent basins are then necessary to satisfy area moorage demands. To meet wet moorage requirements between 2000 and 2020, the Snohomish and Whidbey-Camano Basins will need to accommodate major portions of the growth in Cedar-Green Basins demand as well as intra-basin needs. Further over-flow of Puyallup Basin moorage demands into the Nisqually-Deschutes Basins for satisfaction is also expected between 2000 and 2020.

The plan does not provide for wet moorage in Stillaguamish Basin, as no favorable small boat harbor sites were found. However, demand for this basin has been planned for in the Skagit-Samish Basins.

This study has shown that even with the development of all favorable sites the projected demands for small boat harbors on the east side of Puget Sound for 2000 and 2020 cannot be met.

Alternatively, a portion of the spillover demand from the larger populated basins may be met within the basins by greater use of dry moorage than anticipated. Boat hoists allow the use of shoreline sites for dry moorage where development of protected wet moorage is not economically feasible. Successful development of floating breakwaters may also provide additional sites for small boat harbors, enabling greater satisfaction of future intrabasin wet moorage needs.

The sites for the necessary dry moorage facilities to satisfy current and future demand have not been selected in the framework plan as these facilities are generally expected to be provided by private developments. These facilities would require a relatively small amount of waterfront and could use lands not necessarily favorable for wet moorages.

To accurately determine the order of development of boat harbors included in the framework plan requires more detailed information than is available at this time. However, tentative schedules of development have been provided in each of the basin discussions, together with estimates of benefits and costs. More accurate surveys of topography, hydrography and soil conditions as well as availability of rights-of-way are required. Because of the difficulties now foreseen to satisfy future demands, it is imperative that planning for present development recognize this and make necessary provisions for future expansion.

A number of sites are being considered for satisfying the immediate demands. Priority of development will largely depend upon detailed economic justification investigations, local interest and availability of investment capital.

Although not planned for in this study, the need for harbors of refuge is apparent from boater response to this question during the 1966 survey. Nearly 50 percent of those surveyed, representing approximately 30,000 pleasure craft owners indicated a need for harbors of refuge along the marine shoreline of the Puget Sound Area. Future small boat harbors should set aside anchorage space to specifically meet the refuge needs of small craft. Also, consideration should be given to constructing separate harbors of refuge with a study performed for this purpose.

NAVIGATION PLAN

General

The navigation planning process in the preceding paragraphs has developed the solutions to navigation needs. The forecast needs for terminal and water-transport-oriented land for the Puget Sound Area have been compared to the available lands and land utilization plans were derived by river basins as shown in Table 2-26. All available lands having a favorable potential for development were found to be required by 2020.

Waterborne commerce was distributed to river basins by commodity groups for 1980 and then by totals for the years 2000 and 2020 recognizing factors that would influence changes in the flow of commerce. Vessel trends were examined on a worldwide scale and from these analyses future channel depths and widths were determined. The channels now existing, or potential in each river basin, were evaluated in terms of prospective commerce and vessel trends, and plans of development formulated for 1980, 2000 and 2020. From an inventory of both the existing and potential small boat harbors and a forecast of future demands, the accommodation of pleasure boats was planned. The resultant plan is summarized in Table 2-35 and Table 2-36. Elements of the plan by basin are covered in more detail in the individual basin discussions. Derivation of costs, benefits, and accomplishments are presented in subsequent paragraphs.

Economic Analysis

General—An economic analysis of the navigation projects proposed for early action by 1980 is presented in the individual basin discussions. This analysis is based on single-purpose navigation benefits and costs. Cost estimates for harbor and channel projects and public small boat harbor developments are based on available office data including average unit cost derived from actual project costs and current project studies estimates. Dredging quantities were derived using hydrographic survey data.

Annual costs include interest and amortization of total investment (including interest during construction), average annual costs of operation and equivalent average annual cost of major replacements. An interest rate of 4-5/8 percent was used to

TABLE 2-35. Puget Sound Area—Navigation plan for structural measures

Navigation Features	Harbors and Channels Depth (ft)	Width (ft)	Length (mi)	Small Boat Harbors (Wet Moorages)	Schedule of Development By 1980	1980 2000	2000 2020	Approximate Development Cost
Nooksack-Sumas Basins								
Whatcom Creek								
Whatcom Waterway	40	200	1.5		X			$667,000
Whatcom Waterway	46	260	1.8			X		481,000
Nooksack Delta Channel	46	200	1.0			X		862,000
Bellingham Addition				430	X			875,000
Blaine Addition				440	X			891,200
Hale Passage-East Side				550		X		1,108,800
Hale Passage-East Side				1,150			X	2,326,500
Skagit-Samish Basins								
Guemes Channel	54	240	4.6		X			$612,000
Guemes Channel	78	320	4.7			X		4,082,000
Fidalgo Bay Channel	32	120	1.1		X			853,000
Fidalgo Bay Channel	40	180	1.2			X		942,000
Fidalgo Bay Channel	46	200	1.2				X	608,000
Padilla Bay Channel	46	200	3.5			X		4,423,000
Padilla Bay Channel	54	240	3.6				X	2,381,000
Anacortes Addition				600	X			1,212,000
LaConner-Indian Bay				250	X			501,600
LaConner-Indian Bay				250		X		501,600
Fidalgo Island-West				1,650		X		3,328,900
Fidalgo Island-West				1,120			X	1,285,000
Padilla Bay-William Pt.				1,120			X	1,285,000
Guemes Island Southwest				1,100			X	1,260,400
Stillaguamish Basin	No Development Planned							
Whidbey-Camano Islands								
Oak Harbor				500	X			$1,003,200
Oak Harbor				1,660		X		3,347,600
Langley				500	X			1,003,200
Point Partridge				1,300	X			2,641,600
Skagit-Bay-Utsalady				1,000		X		2,006,400
Skagit-Bay-Utsalady				1,060			X	2,120,000
Cultus Bay				2,060			X	4,240,000
Useless Bay-Maxwelton				1,370			X	2,710,000
Penn Cove-Coupeville				1,540			X	3,080,000
Skagit Bay-Dugualla Bay				1,540			X	3,080,000
Port Susan-Camanols				1,840			X	3,680,000
Snohomish Basin								
RM 0.0 to Hwy 99 Bridge	32	120	3.5		X			$1,921,000
RM 0.0 to Hwy 99 Bridge	46	200	3.5			X		3,511,000
East Waterway	46	200	0.7		X			279,000
East Waterway	78	320	0.8			X		1,872,000
Hwy 99 to RM 10.0	20	150	7.0			X		2,313,000
Track Q				2,000	X			4,000,600
Track Q				1,080		X		2,255,000
Meadowdale				1,130	X			2,306,200

TABLE 2-35. Puget Sound Area—Navigation plan for structural measures (Continued)

Navigation Features	Harbors and Channels Depth (ft)	Width (ft)	Length (mi)	Small Boat Harbors (Wet Moorages)	Schedule of Development By 1980	1980 2000	2000 2020	Approximate Development Cost
Priest Point West				5,140			X	$ 10,428,900
Big Gulch				1,310		X		2,620,000
Edmonds North				2,350		X		4,850,000
Tulalip				1,320			X	2,640,000
Tulalip				2,390			X	4,780,000
Mukilteo				1,100			X	2,200,000
Picnic Point North				1,730			X	3,460,000
Port Susan-Warm Beach				1,400			X	2,800,000
Mulkilteo South				880			X	1,760,000
Norma Beach North				920			X	1,840,000
Cedar-Green Basins								
West Waterway	54	750	1.0		X			$245,000
East Waterway	54	750	1.2		X			900,000
Duwamish Waterway (to First South Bridge)	46	220	2.6		X			1,715,000
Duwamish Waterway (First South to 8th Avenue)	30	150	0.8		X			279,000
Duwamish Waterway (8th Avenue to Head of Navigation)	20	150	1.8		X			640,000
Elliott Bay-Pier 54				290	X			500,000
Des Moines				670	X			1,340,000
Seacrest Marina Addition				1,140	X			2,299,500
Elliott Bay-Magnolia Bluff				1,910		X		3,820,000
Wells Pt. Edmonds				2,000		X		4,000,000
Golden Gardens-North				1,450		X		2,900,000
Fort Lawton-North				1,140		X		2,280,000
Fort Lawton-South				3,520		X		7,196,300
Puyallup Basin								
Hylebos Waterway	46	220	2.8		X			$1,742,000
Hylebos Waterway	78	320	1.4			X		2,406,000
Port Industrial Waterway	52	450	1.9		X			2,123,000
Port Industrial Waterway	106	600	0.7			X		2,082,000
Sitcum Waterway	78	220	0.7		X			1,565,000
Hylebos Waterway				890	X			1,800,400
Titlow-Day Island				660	X			1,320,400
Dumas Bay				2,720		X		5,491,000
Nisqually-Deschutes Basins								
West Waterway	40	340	3.8		X			$1,853,000
West Waterway	46	360	4.9			X		1,360,000
Government Waterway	46	220	1.0			X		2,353,000
Nisqually Delta Waterway	78	320	0.6			X		2,400,000 [1]
Olympia				230	X			459,000
Budd Inlet-East Side				1,000		X		2,000,000
Budd Inlet-East Side				680			X	1,060,000
Henderson Inlet				530			X	1,375,000
Nisqually Flats-East				1,180		X		2,386,800

[1] Three million dollars additional required for stabilization of 16,000 feet right bank of the Nisqually River (Flood Control)

TABLE 2-35. Puget Sound Area—Navigation plan for structural measures (Continued)

Navigation Features	Harbors and Channels: Depth (ft)	Width (ft)	Length (mi)	Small Boat Harbors (Wet Moorages)	Schedule of Development: By 1980	1980 2000	2000 2020	Approximate Development Cost
West Sound Basins								
Port Discovery-Beckett Pt.				250	X			$500,100
Sequim Bay-West				940	X			1,900,200
Port Townsend				890		X		1,800,000
Oak Bay				700		X		1,400,000
Sinclair Inlet-Annapolis				400	X			800,100
Kingston-Addition				740			X	1,499,000
Mats Mats				980	X			1,964,200
Brownsville				650	X			1,300,100
Hoodsport				160		X		350,000
Quilcene Bay-East Side				1,340			X	2,740,000
Manchester				220		X		450,000
Bainbridge Island-Murden Cove				1,860		X		3,759,000
Bainbridge Island-Lynwood Center				260		X		530,000
Bainbridge Island-Fletcher Bay				260			X	530,000
Dyes Inlet				1,090	X			2,220,200
Hood Canal-Coon Bay				1,090		X		2,220,000
Marrowstone Island-East Side				2,980			X	6,000,000
Hood Canal-Bywater Bay				2,500			X	5,000,000
Hood Canal-Thorndyke Bay				1,800			X	3,650,000
Hood Canal-Warrenville				1,980			X	3,980,000
Hood Canal-Anderson Cove				1,620			X	3,260,000
Hood Canal-Duckabush				1,360		X		2,780,000
Hood Canal-Union				2,170		X		4,300,000
Elwha-Dungeness Basins								
Port Angeles-Addition				150		X		$310,000
Elwha River-East				360	X			730,000
Elwha River-East				350		X		701,400
Dungeness River-East				300		X		601,400
Dungeness River-East				700			X	1,411,200
Dungeness-Sequim				350				701,400
San Juan Islands								
Stuart Island-Reid Harbor				240			X	$480,000
Waldron Island-Coulitz Bay				340		X		680,000
Sucia Island-Fossil Bay				240		X		480,000
Henry Island-Nelson Bay				340			X	680,000
San Juan Islands-Roche Harbor				190		X		380,000
San Juan Islands-Friday Harbor				460				911,400
San Juan Islands-False Bay				1,030		X		2,084,800
San Juan Islands-False Bay				940			X	1,880,000
San Juan Islands-Griffin Bay				1,180			X	2,380,400
Orcas Island-East Sound				340	X			680,000
Blakely Island-Armitage Island				340	X			680,000
Decatur Island-Fauntleroy Pt.				340			X	680,000
Lopez Island-MacKaye Harbor				340	X			680,000

TABLE 2-36. Puget Sound Area. Navigation plan for terminal and water transport oriented industrial lands.

Basin	Terminal and Water-Transport Oriented Industrial Lands[2] Acres 1980	2000	2020
Nooksack–Sumas	2,040	3,480	5,870
Skagit–Samish	2,920	4,050	5,910
Snohomish	1,610	5,640	12,330
Cedar–Green	6,550	7,300	7,300
Puyallup	3,010	4,950	4,950
Nisqually–Deschutes	310	2,550	3,760
Elwha–Dungeness	480	830	1,170
Other Minor Ports	210[1]	210[1]	210[1]
TOTAL	17,130	28,410	41,500

[1] Estimate of terminal lands only in use in 1963 for minor ports. Water-transport oriented industrial land in use for 1963 was not inventoried for minor ports. However, sufficient land area is considered to be available for expansion in these locations.
[2] Land areas have been rounded off to the nearest 10 acres.

compute interest during construction and the channel costs of interest and amortization. An economic life of 50 years was used for both the harbor and channel projects and the small boat harbor projects. Table 2-37 gives average annual costs and benefits for projects proposed by 1980. Navigation costs for the Area would be $50,615,600 by 1980. Average annual benefits for the 1980 projects total $4,459,600 for the Area as compared to average annual costs of $3,155,800. Net annual benefits, therefore, equal $1,303,800

Harbor and Channel Projects Benefits—Benefits for Harbor and Channel projects were derived by basin and for purposes of this study, consist of ranges used to determine general economic feasibility. The benefits are approximations to be refined by later project studies. The trends in vessel size and draft will require that many of the existing channels be dredged to greater depths to accommodate the larger and more efficient ships. Improvement of existing channels and the creation of new channels will be necessary for ports to remain competitive. Benefits derived from these projects will accrue to users as a result of reductions in delay time from waiting for high tides; enabling deeper draft vessels to load to capacity; and by allowing shippers to gain from cost savings on cargo that otherwise would be required to be carried over longer alternative routes at consequently, greater costs.

Preliminary estimates of deep draft navigation benefits were derived on the basis of vessels anticipated to be plying the Area's waters by 1980 (see Table 2-18). Operational savings to vessels from reductions in delay time were evaluated for projects in each basin by estimating the tonnages that would benefit from the channel projects. This was done by cargo grouping according to vessel type shown in Table 2-19. An average delay time of 3 hours per inbound or outbound vessel, representing a quarter tidal cycle was assumed for tonnages affected by the projects. Average in-port operating costs of $250 per hour, $220 per hour, and $300 per hour were used for freighters, bulk carriers and tankers, respectively. These values are averages of U.S. and foreign flag vessel operating costs, representative of vessels expected to be served by Area ports by 1980.

Other savings due to more efficient use of land and water transportation were not evaluated because of the detailed commodity by commodity analysis required.

Land enhancement benefits would accrue from most dredging projects with available large disposal areas nearby. Pipeline dredge disposal is generally the least cost alternative means for land filling waterfront areas located within a reasonable distance of the dredging operation. Terminal and water-transport oriented industrial sites can be developed economically by this method of fill as evidenced by Tacoma's port industrial area created in part from disposal of dredged material from the Hylebos and Port Industrial Waterways extensions.

Navigation benefits attributable to land enhancement from dredge land fill disposal were derived for each basin by examining the need for land fill. This need was met by a portion or all of the dredged material derived from the harbor and channel project. This method of land fill was assumed to be equal to the least cost alternative source of suitable

TABLE 2-37. Puget Sound Area—Cost and benefits of structural measures for 1980 portion of navigation plan

Navigation Feature	Investment Cost Range (Based on Area Average)	Preliminary Estimates of Annual Costs (Based on 1968 Prices)	Preliminary Estimates of Annual Benefits (Based on Area Average)
Nooksack-Sumas Basins			
Whatcom Creek Waterway	$667,000	$39,000	$42,000
Bellingham Addition	875,000	56,000	80,500
Blaine Addition	891,200	57,100	83,300
Total	$2,433,200	$152,100	$206,200
Skagit-Samish Basins			
Guemes Channel	$612,000	$33,600	$50,600
Fidalgo Bay Channel	853,000	54,000	54,500
Anacortes Addition	1,212,000	77,300	112,000
LaConner-Indian Bay	501,600	32,400	47,000
Total	$3,178,600	$197,300	$264,100
Stillaguamish Basin	None	None	None
Whidbey-Camano Islands			
Oak Harbor	$1,003,200	$64,800	$93,400
Langley	1,003,200	64,800	93,400
Point Partridge	2,641,600	158,000	244,000
Total	$4,648,000	$297,600	$430,800
Snohomish Basin			
Channel RM 0.0 to Hwy 99 Bridge	$1,921,000	$114,200	$138,300
East Waterway	279,000	16,600	34,100
Track Q	4,000,600	268,000	374,000
Meadowdale	2,306,200	135,800	210,900
Total	$8,506,800	$534,600	$757,300
Cedar-Green Basins			
West Waterway	$245,000	$15,600	$16,400
East Waterway	900,000	49,500	60,000
Duwamish Waterway (to 1st South Bridge)	1,715,000	93,500	153,700
Duwamish Waterway (1st South to 8th Avenue)	279,000	14,400	24,200
Duwamish Waterway (8th Avenue to Head of Navigation)	640,000	36,000	84,000
Elliott Bay-Pier 54	500,000	37,200	54,000
Des Moines	1,340,000	96,000	125,400
Seacrest Marina Addition	2,299,500	147,000	212,000
Total	$7,918,500	$489,200	$729,700

TABLE 2-37. Puget Sound Area—Cost and benefits of structural measures for 1980 portion of navigation plan (Continued)

Navigation Feature	Investment Cost Range (Based on Area Average)	Preliminary Estimates of Annual Costs (Based on 1968 Prices)	Preliminary Estimates of Annual Benefits (Based on Area Average)
Puyallup Basin			
Hylebos Waterway	$1,742,000	$108,000	$118,800
Port Industrial Waterway	2,123,000	123,000	151,600
Sitcum Waterway	1,565,000	87,000	118,400
Hylebos Water (Small Boat Harbor)	1,800,400	114,200	165,800
Titlow-Day Island	1,320,400	85,600	123,700
Total	$8,550,800	$517,800	$678,300
Nisqually-Deschutes Basins			
West Waterway	$1,853,000	$101,000	$138,400
Olympia Small Boat Harbor	459,000	29,400	42,600
Total	$2,312,000	$130,400	$181,000
West Sound Basins			
Port Discovery-Beckett Pt.	$500,100	$32,200	$46,600
Sequim Bay-West	1,900,200	121,000	175,000
Sinclair Inlet-Annapolis	800,100	51,500	74,700
Mats Mats	1,964,200	126,000	183,000
Brownsville	1,300,100	84,000	121,300
Dyes Inlet	2,220,200	141,400	205,000
Total	$8,684,900	$556,100	$805,600
Elwha-Dungeness Basins			
Elwha River-East	$730,000	$46,700	$67,500
Dungeness-Sequim	701,400	45,000	65,300
Total	$1,431,400	$91,700	$132,800
San Juan Islands			
San Juan Islands-Friday Harbor	$911,400	$47,900	$83,900
Orcas Island-East Sound	680,000	43,700	63,300
Lopez Island-Mackaye Harbor	680,000	43,700	63,300
Blakely Island-Armitage Island	680,000	43,700	63,300
Total	$2,951,400	$189,000	$273,800
Puget Sound Area	$50,615,600	$3,155,800	$4,459,600

fill with the increased market value of the filled land assumed to be greater than the cost of dredging. The representative annual yield derived from the land fill was taken as 8 percent, the current minimum rate of interest on risk capital for real estate investments in the Area.

Small Boat Harbor Benefits—Annual benefits for small boat harbor projects were based on the "Pleasure Boating Study, Puget Sound and Adjacent Waters," bound separately to this Appendix as Exhibit 1, and by standard methods employed by the Corps of Engineers for evaluating these projects. The benefit derivation recognized the types of craft expected to use wet moorages, and allowed for transient as well as permanent moorage use.

For purposes of this study the assumption was made that the proportion of moorages allocated for permanent and transient craft, 90 and 10 percent respectively, will remain the same from initial to capacity use. Capacity use of small boat harbor moorages was assumed to occur within ten years, with initial use taken as 70 percent of capacity.

Average annual benefits to each type of pleasure craft were computed on the premise that small boat navigation facilities increase the use and ownership of pleasure craft. A measure of the benefits a boat owner derives from his boat is the net return he would receive if he operated his boat on a for-rent basis. The ability of a boat to earn money from rental is directly related to its value. To attain an average annual benefit, the average value of a boat over its expected life must be determined. Fifty percent of a boat's new value was assumed to be representative of its average straight line depreciated value.

The net percent returns from capital investments for various boat types were selected from a range of percents, by types, determined from economic studies to be representative of the Area. These net percent returns are the results of national studies conducted by the Corps of Engineers. The product of a boat's average depreciated value and the selected net percent return gives the boat owner his complete ideal benefit realized from ownership. It was assumed that benefits to initial permanent moorage users is a gain of 40 percent in ideal benefits and to initial transient moorage users a gain of 5 percent (approximately one to two days increased use of their pleasure craft) in ideal benefits. New permanent moorage users will receive 100 percent of ideal benefits with new transient craft gain in ideal benefits remaining at 5 percent. Permanent moorage use was multiplied by 0.85 to adjust for about 15 percent of the time craft using these moorages are on extended cruises.

The benefits derived are merely ranges used to determine general economic feasibility with detailed studies required for project authorization. No land enhancement benefits were considered in the evaluation of small boat harbor projects, although in many cases they will exist.

Accomplishments

The potential accomplishments of the navigation plan for the Puget Sound Area are shown in Table 2-38. All needs for terminal and water transport-oriented industrial lands would be met by implementation of this plan. The needs for public small boat harbors as reflected by wet moorage demand by 1980 can be met within each basin. By 2000, favorable sites will have become exhausted in the Cedar-Green and Puyallup Basins. The residual need beyond 1980 can be satisfied by development in adjacent basins or greater use of dry storage.

Factors Influencing Implementation of Plans

Dislocations and Relocations—One of the major restraints on enlargement and extension of harbor and channel facilities are costs involved with relocations on dislocations. At many harbors throughout the United States, extensive developments have grown to the water's edge. In numerous cases, this growth has progressed to a point where removal or relocation of transportation facilities and industrial, commercial, residential structures must be accomplished at exorbitant cost if navigation needs are to be accommodated. Although not as acute a problem as at many other localities, the Puget Sound Area is approaching similar restraints with major highway bridges cutting off waterways and other developments proceeding in random patterns along the waterfront.

Changing Construction Conditions—Most of the Nation's harbors have been improved and deepened by removal of silt deposits. The bottom of soft material is being reached in many channels, particularly along the Atlantic Coast and further deepening must be made through rock at costs ranging from $15 to $25 a cubic yard. The continental shelf poses similar problems along the Gulf of Mexico with the natural 50-foot depth being from 2 to 14 miles offshore depending on location. With natural deep water, the Puget Sound Area is fortunate in not

TABLE 2-38. **Puget Sound Area–Accomplishments of navigation plan**

Item	Unit	1980 Needs	1980 Accomp	1980 Res.	2000 Needs	2000 Accomp.	2000 Res.	2020 Needs	2020 Accomp.	2020 Res.
Waterborne Commerce	1,000 short tons									
General Cargo		6,800	6,800	0						
Bulk Grain		2,200	2,200	0						
Forest Products		9,600	9,600	0						
Bulk Petroleum		21,500	21,500	0						
Other Dry Bulk		26,300	26,300	0						
Other Liquid Bulk		370	370	0						
TOTALS		66,770	66,770	0	123,500	123,500	0	251,900	251,900	0
Harbors & Channels Improvements	Miles	28.3	28.3	0	32.1	32.1	0	4.8	4.8	0
Terminal & Water-Transport-Oriented Industry Lands	Acres	17,130	17,130	0	29,010	29,010	0	41,500	41,500	
Small Boat Harbors	Wet Moorages	43,790	29,830	13,960[1]	79,870	79,860	0	143,440	126,790	16,650

[1] Residual needs for wet moorages projected for 1980 assumed to be satisfied by private developments or greater investments in public dry moorages.

having these almost insurmountable constraints. However, even with the relatively short channels required in Puget Sound to reach deep water, consideration should be given to the extension of earthfill or floating piers and wharves; or offshore cargo transfer systems to minimize costs.

Spoil Disposal–At numerous locations in the continental United States, the disposition of material excavated from harbors and channels, both in original construction and in maintenance, presents an increasingly serious problem which will be aggravated with further harbor widening and deepening. Port area residential and industrial development has already created an acute shortage of suitable, economical and aesthetically acceptable shore disposal areas. Aesthetic values are being assigned increasing weight by the public. Within 8 to 10 years, at present maintenance schedules, existing spoil disposal areas at many major ports will have been filled. Channel maintenance or further development thereafter in those ports will require new, acceptable disposal areas–a formidable challenge. Construction of new disposal areas through the building of retention dikes, where feasible, may offer relief. Dike construction, of course, will increase the cost of spoil disposal, and therefore impact on the feasibility of harbor channel deepening and widening.

An alternative to controlled land spoil is disposal in deep water. Yet, this option is also encountering difficulties. The cost of moving a million cubic yards of spoil just one mile by hopper dredge is approximately $50,000–and in maintaining the present channels of a port such as Philadelphia, disposal work involves over 8 million cubic yards a year. Beyond the increase in financial costs, spoiling in deep water is also becoming an ecological concern. Care must be taken in offshore disposal to avoid increasing water turbidity damaging to fish and wildlife habitat. Future quality standards for interstate and coastal waters may also constrain options for spoil disposal. In summary, the disposal taken from harbors or channels increasingly entails significant problems. While the Puget Sound Area with its deep waters and short channels has not yet experienced the problems of other regions, disposal problems will become increasingly serious and costly. Accordingly, port planners must consider long-range disposal programs. In some locations, consideration should be given to extending pierhead lines to permit filling behind bulkheads to reach deeper water rather than increase dredging.

Landside Transportation Requirements–Land distribution and "feeder" transportation networks including consolidation, distribution and warehousing facilities require thorough planning to insure properly timed receipt and prompt dispatch of huge commodity loads. The tremendous amount of cargo discharged by giant vessels must be handled efficiently if the transportation benefits (savings) made possible through large volume and containerized cargo movements are to be realized. A recent report by the Maritime Administration stated clearly that mere modernization of any given port will not in itself insure the economic feasibility of improvements:

> "More than ever before, other factors will determine the new traffic distribution patterns. Factors such as inland transportation facilities and highway systems, which are both beyond the immediate control of port officials, will influence the routing of containerized freight. On the seaward side of the marine terminal and wharf facilities, the economics of interoceanic container movements dictate that the new full containerships will call at an ever-decreasing number of ports. The very nature of containerization and intermodel transportation make it possible to handle cargo as a through service from an inland point of origin to an inland point of destination. This characteristic nullifies the principle that when modern terminal facilities are made available, the traffic is sure to follow."[1]

Provision for an efficient landside transportation system is the challenge facing Puget Sound ports and the State of Washington.

Environmental-Ecological Impacts–Major port and supporting navigation developments are in the coastal zone and estuarine environment. This zone has been defined as that part of the land which is affected by its proximity to the sea and that part of the ocean which is affected by its proximity to the land. Included are the inshore part of the continental shelf, ocean shoreline, and estuaries with their marginal shores. Tides, waves, and coastal currents mark this zone of frequently varying environment, which supports a multitude of plant and animal life.

The coastal estuaries are rich, biologically. In places, they are as productive as choice farmland. They are fertilized with inorganic nutrients which land runoff is continuously supplying, and are also enriched by the adjacent seas. The mixture of nutrients and salt and fresh water creates an environment conducive to the production of a great many species of aquatic life. Almost two-thirds of the United States harvest of commercial fisheries involve species that spend all or part of their lives in the estuaries. In addition to the commercial fish, shellfish and crustacean resources, estuaries and seashores support an abundance of fish and wildfowl species that provide an increasingly popular recreational harvest.

The estuaries and related shallows of the coastal zone are sensitive ecosystems. Knowledge is only gradually being developed about this complicated system involving the interaction of air, water, land and life. Current and future investigations of harbor and channel improvements must entail recognition of potential impacts on the ecological processes and wildlife resources. Potential adverse impacts can add greatly to the total estimated cost of improvements, either in financial outlays for mitigation or in the loss of significant wildlife resources. These considerations add substantially to the complex task of evaluating navigation improvements, as present tools for measuring impact on the environment are of limited utility.

Channel deepening in estuary areas can also risk intrusion of tidal salt water above those points where fresh water intakes draw water from channels for municipal or irrigation supplies. Engineering works that change significantly the channel dimensions or flow characteristics may cause an upstream movement of the saltwater wedge. Where such movement must be denied, control barriers, including navigation locks, may be required to forestall intrusion, adding to project cost and complicating shipping operations.

The National Council on Marine Resources and Engineering Development, among others, has recently pointed up the need for broader and more intensive research and action programs to preserve or enhance the resources of the Nation's estuaries. Council proposals related to inventory and analysis of estuarine resources and problems can be expected to produce distinct plans which will be recognized in transportation and waterfront renewal planning.

Already underway is the development of a complete study of Chesapeake Bay, authorized by the Congress in 1965, to provide prototype facilities for

[1] "Information and Preliminary Criteria on Planning Container Terminals," Maritime Administration, December 1967.

evaluation of estuarine resource problems. Development of a model-research facility was assigned to the Corps of Engineers, which is cooperating in the planning of the facility and its operations with eight other interested Federal agencies, four states and the District of Columbia. The Department of the Interior is already at work on a study of estuary pollution problems, authorized by the Clean Water Restoration Act of 1966 and was authorized in 1968 to undertake an inventory and study of the nation's estuaries and their natural resources. Development of the Chesapeake facility and conduct of research there, completion of the estuarine studies, and implementation of the National Science Foundation's "Sea Grant" program, should add greatly in the relatively near future to scientific capability for evaluating the ecological effects of harbor and port activities.

The Puget Sound Area contains a vast number of river estuaries having deltas which are biologically rich. Filling and dredging to develop harbors, channels and supporting facilities necessary to handle the commerce of the region, the Nation and the world must be planned to avoid, insofar as possible, significant adverse impacts or environmental conflicts. The proper consideration of environmental and ecological impacts in port planning and development require understanding and communication between all levels of public and private sectors to reach a balance between the needs of the economy and the essentials of environmental preservation. The accomplishment of this task represents a major problem to be resolved in making full use of the navigation resource of the Area.

Social and Aesthetic Values—The waterfront and harbor area was originally the economic key to the development of many communities and related interior lands. When American port cities were young, the waterfronts were living, dynamic areas which provided employment and recreation, market places and parks, warehouses and consumer outlets, and contact with nature at the water's edge. Today, many of these waterfronts are neither living nor dynamic, and nature has been crowded out or poisoned. Obsolete or abandoned piers, warehouses and hulks clutter many of our waterfronts. These characteristics are typical of the Puget Sound Area, and correction of the anachronisms is an important element of future development. There is a growing public awareness of the attraction of the waterfront. Ports are recognizing the public demands for use and access to waterfront areas for general viewing, fishing, relaxation, as well as pleasure boating. Growing recognition of these values is illustrated by the 7th Street Marine Terminal of the city of Oakland which has been placed in operation in 1968. The following excerpt from the January 1969 "Civil Engineering" describes public facilities included in this terminal.[1]

> "There is an increasing public demand to obtain access to waterfront areas for general viewing, fishing, and use of small boats. The Marine Terminal satisfies these desires with a wide range of facilities. Two fishing piers are provided with adjacent parking and viewing areas. An elevated revolving restaurant—similar in plan but lower in height than Seattle's famous Space Needle restaurant—provides a dramatic dining area with an unobstructed view of shipping activity as well as the entire Bay Area panorama. A second level below the main dining level provides the public with an excellent viewing area.
>
> All areas visible to the public including the restaurant, parking areas, viewing areas, and industrial structures will be extensively landscaped. This valuable recreational asset provides the Port with additional income as well as a chance to present a favorable image to the public."

In the Puget Sound Area, social and aesthetic values require more emphasis in planning and implementation of navigation plans. The existing environment with its scenic, natural attractions make these considerations more important than in those areas less richly endowed by nature.

Cooperative Planning and Development—Any concentrated effort at harbor, port and waterfront development and redevelopment entails a high degree of cooperation between ports, local governments, regional planning groups, private interests, and the several Federal agencies, and embraces a range of activities, from creation of entirely new port or waterfront complexes to rehabilitation and conversion of existing waterfront lands and facilities. An effective program would have the following related components:

[1] Article entitled, "Containerport Engineering for the Port of Oakland," by E.F. Nielsen, M. Asce, Project Engineer, Keiser Engineers, Oakland, California. Civil Engineering, January 1969.

Planning of Harbor-Port Requirements—A continuing planning program is required to determine the optimum number and spacing of ports, within the context of an integrated regional and national transportation system, and the harbor and specialized terminal facilities required at various ports. Such studies cannot be confined to harbor or port development only. They must involve undertaking detailed analyses of trends in industrial growth and location; commodity movements and fleet composition; identification of implications, by region, of projected economic activity, traffic movement and vessel size; analysis of port cargo handling and associated facilities, including all foreseeable technology required to accommodate prospective traffic; plus evaluation and recommendations for financial participation by states, local political entities, and commercial and industrial interests. The studies should explore fully all feasible technological alternatives to traditional harbor deepening, including installation of offshore transfer facilities or use of lightering vessels. The studies should lead to preparation of plans for orderly investment in navigation-transportation improvements.

Development of Action Plans for Harbor and Waterfront Area Renovation—As future transportation requirements become identified for individual harbor and port areas by comprehensive studies, companion plans need to be developed for renewal and rehabilitation of land areas adjacent to the harbor, including to the fullest extent feasible, consolidation and relocation of cargo handling and industrial facilities. The potential for offshore handling of petroleum and petroleum products coupled with the sharply rising use of containers, should provide many opportunities for land clearance and rehabilitation and thus more effective land utilization and improved tax base.

Planning of the magnitude just described is needed to guide the future of navigation on Puget Sound, but would have little meaning without means of implementation. This could be accomplished by centralized planning for the Area by an agency operating as a State agency or created by the State of Washington as a regional body. Port Districts would be required to prepare comprehensive plans for harbor and waterfront utilization. The regional planning agency would be charged with developing and maintaining a comprehensive navigation plan for the Area. By these measures, the local autonomy of Port Districts would be retained, a reasonable degree of competition would exist and an institutional framework would be developed which would make the best use of the navigation resources of the Puget Sound Area.

The ports are beginning to integrate environmental and social values into economic development as evidenced by the Port of Everett's participation in preparation of a comprehensive plan for development of the Snohomish River Delta. The plan presents opportunities for balanced use of the Delta and lands along the river to its head at the confluences of the Skykomish and Snoqualmie Rivers. Included are beach, park, and marine recreation facilities, additional deep water development taking advantage of the natural depths of Possession Sound, and creation of an extensive usable land area for a large port and industrial complex. Also provided for is a continuation of the existing greenbelt along the river through the urbanizing area. Floodways and flood plains afford recreational opportunities with portions of the Delta and a slough to remain in a natural state for wildlife preservation.

CONCLUSIONS

This study began with an inventory of navigation in the Puget Sound Area, including Pleasure Boating. Statistical analyses, comparisons and judgement were used to develop forecasts of land needs, commerce, vessel trends, and harbors and channel requirements. Plans were formulated to meet these needs and the factors affecting implementation were briefly reviewed.

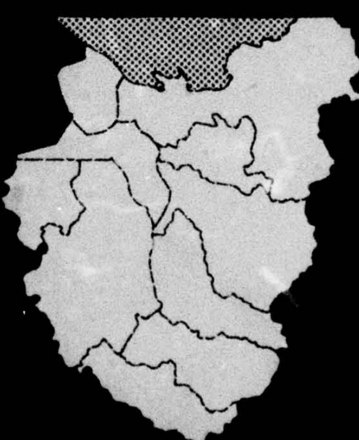
Washington economic prospects are dependent upon a well-planned water transportation system. Future waterborne traffic depends to a great extent on what the people themselves are willing to do and on what facilities they are willing to provide.

While the investigations contained in this appendix were limited by both available data and financial resources, the findings are sufficiently conclusive to bring out a program for progress. This study emphasizes the critical need for more detailed analysis of the competitive position of Puget Sound in relation to other ports on the West Coast and throughout the nation and in relation to patterns of world trade. Such analysis would permit refinement of commerce projections and provide a vastly improved base upon which to program public investment in port improvements.

A need also exists for additional investigations of terminal and water transport-oriented industrial sites particularly as the public need for all land uses evolves over time. The land inventory contained in this study was based principally on previous investigations by the State of Washington and the Bonneville Power Administration. However, this study should by no means be considered an exhaustive inventory of land available for development in the future when changing requirements may make alternative sites more desirable. Also, the actual growth patterns of land use in each basin may deviate from that projected herein, reflecting local economics and other factors.

Finally, planning for navigation needs must be a continuing and evolutionary process which identifies technological improvements in transportation, cargo handling and associated facilities, and industries and develops programs to meet the demands of the future. To be meaningful, this planning should be accomplished both on an individual port basis and from the overall standpoint of the Puget Sound Area. The high degree of required coordination and cooperation points toward the desirability of a single planning entity. The selection of such an organizational body requires a thorough evaluation of legal and political implications and the determination of the effectiveness and efficiency of a wide range of alternative methods. However, the navigation demands of the future, the long-term land shortage for water transport oriented industries and the needs for environmental, social and aesthetic considerations dictate that an early decision must be made on the path of future planning for navigation in the Puget Sound Area. The plans developed by this study provide a framework within which each port authority can work, until a formal area or state program can be established.

Nooksack-Sumas Basins



NOOKSACK-SUMAS BASINS

DESCRIPTION

Except for shallow draft vessels and logs on the lower reaches of the Nooksack River, the navigable waters of the Nooksack Basin are limited to the adjacent salt waters of the Strait of Georgia, Bellingham Bay, Drayton Harbor, Birch Bay, Lummi Bay and Hale Passage. The Strait of Georgia has depths of over 600 feet, but Drayton Harbor, Birch Bay, Lummi Bay and the head of Bellingham Bay have extensive tide flats. The Sumas Basin is drained by the Sumas River which discharges into Canada and is not navigable. The Port of Bellingham is the only major port district in the basins. Three transcontinental railroads serve the area. Interstate 5 and U.S. 99 are the major north-south highways. The eastern part of the basins is served by State Highway 542.

PRESENT STATUS

HARBORS AND CHANNELS

Bellingham is the principal harbor in these basins which is located at the head of Bellingham Bay, about 112 miles from the Pacific Ocean. Natural depths of over 60 feet are available in the bay but the flat slopes from shore require dredged channels to the wharfs. The status of the authorized Federal project for Bellingham Harbor is shown on Figure 3-1.

Blaine Harbor is on the east side of the entrance to Drayton Harbor, a small cove off Semiahmoo Bay. Blaine is 118 nautical miles from the Pacific Ocean. The Federal project as shown on Figure 3-2 provides a mooring basin for small boats having an area of 14.7 acres and an entrance channel with authorized depths of 12 feet. The condition survey in 1966 showed a minimum depth of 11.7 feet.

At Cherry Point about 2.4 miles north of Sandy Point and Lummi Bay at the south end of the Strait of Georgia, and six miles west of Ferndale are a petroleum loading wharf and an alumina ore handling wharf, each with a threstle extending 0.4 miles from shore. Depths alongside these wharves are 42 feet and 38 feet respectively.

Minor piers for small boats are located on Lummi Island, in Birch Bay and Lummi Bay.

WATERBORNE COMMERCE

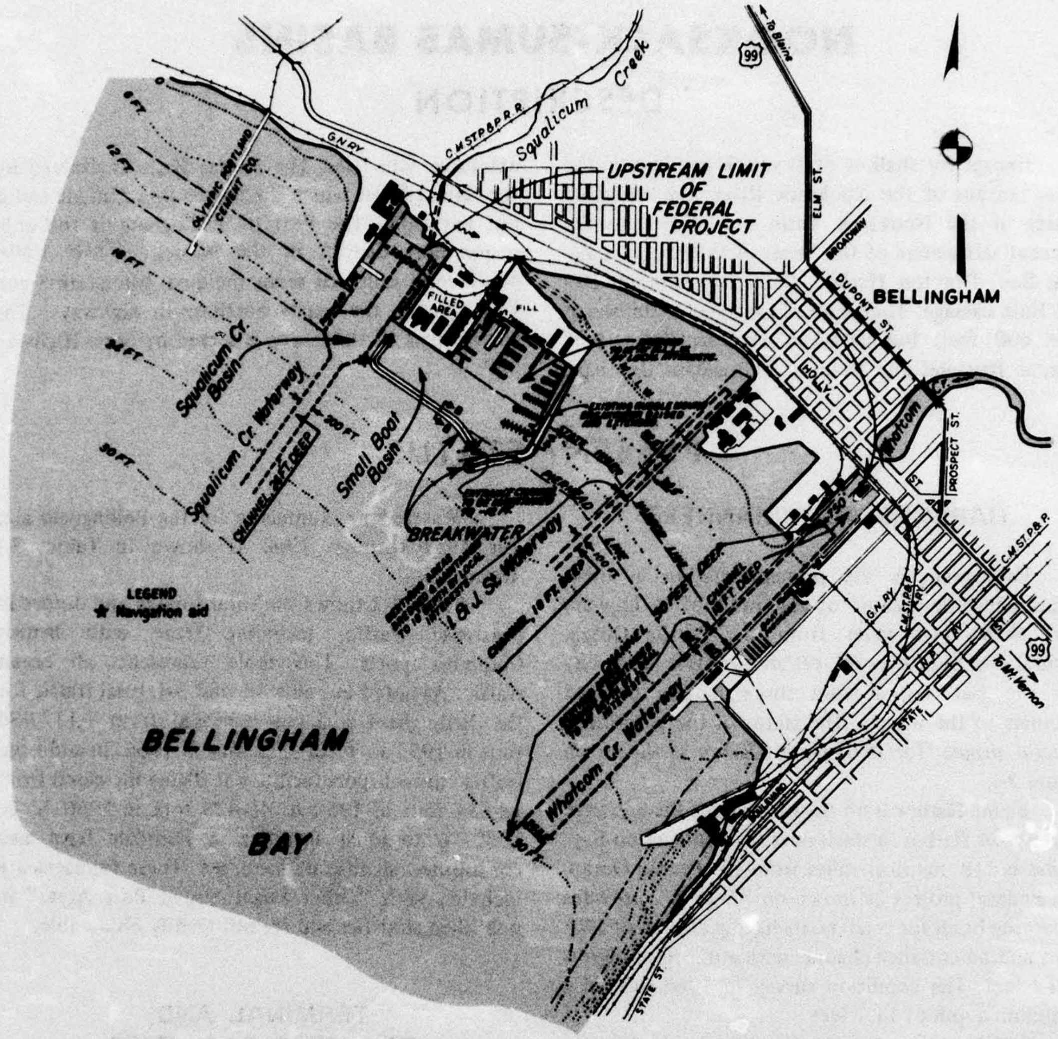
All of the waterborne traffic in the Nooksack Basin is handled through the Bellingham area, except for the traffic which goes through Blaine and Ferndale.

Waterborne commerce for the Bellingham area for 1952 through 1966 is shown in Tables 3-1 through 3-4.

Table 3-3 shows the total foreign and domestic coastwise traffic, including trade with British Columbia ports. This table represents all ocean traffic. As noted in Table 3-3 and 3-4, total traffic for the Bellingham area has increased from 1,117,936 tons in 1952 to 1,506,000 tons in 1966. In addition, traffic through port facilities at Blaine increased from 18,654 tons in 1952 to 40,423 tons in 1966. Since 1959, 6 terminal facilities at Ferndale have also contributed significant tonnages. These tonnages are included with "Other Puget Sound Port Areas" in published statistics and are not readily obtainable.

TERMINAL AND TRANSFER FACILITIES

Included in this area are port facilities in Bellingham Bay and along the shores adjacent to Ferndale as shown in Figure 3-3. The terminal facilities as of 1952 and 1963 are summarized in Tables 3-5 and 3-6, respectively. A comparison of these data shows that about 3,200 lineal feet of cargo berthing space was added between 1952 and 1963. Another 1,400 feet of berthing space was added by 1965. Although covered storage space remained essentially the same, open storage space was developed to give 4.5 acres in 1963, 12 acres by 1965 and 14 acres by 1967.



Improvement	AUTHORIZED Depth Feet	Width Feet	Length Feet	CONDITION IN 1967 Depth Feet	Width Feet	Length Feet
Whatcom Creek Waterway						
Inner Reach	18	363	750	15.3	200	750
Outer Reach	30	363	5600	23.0	200	5600
Squalicum Creek Waterway						
Entrance Channel	26	200	2100	24.4	200	2100
SE Half of Basin	26	295	1500	26.0 Except at edges		
Small-boat Basin Adjacent to Squalicum C. Waterway						
Entrance Ch.	12	90	400	12	90	400

BELLINGHAM HARBOR
WASHINGTON

SCALE IN FEET

1000 0 5000

Revised Sept, 1966

FIGURE 3-1

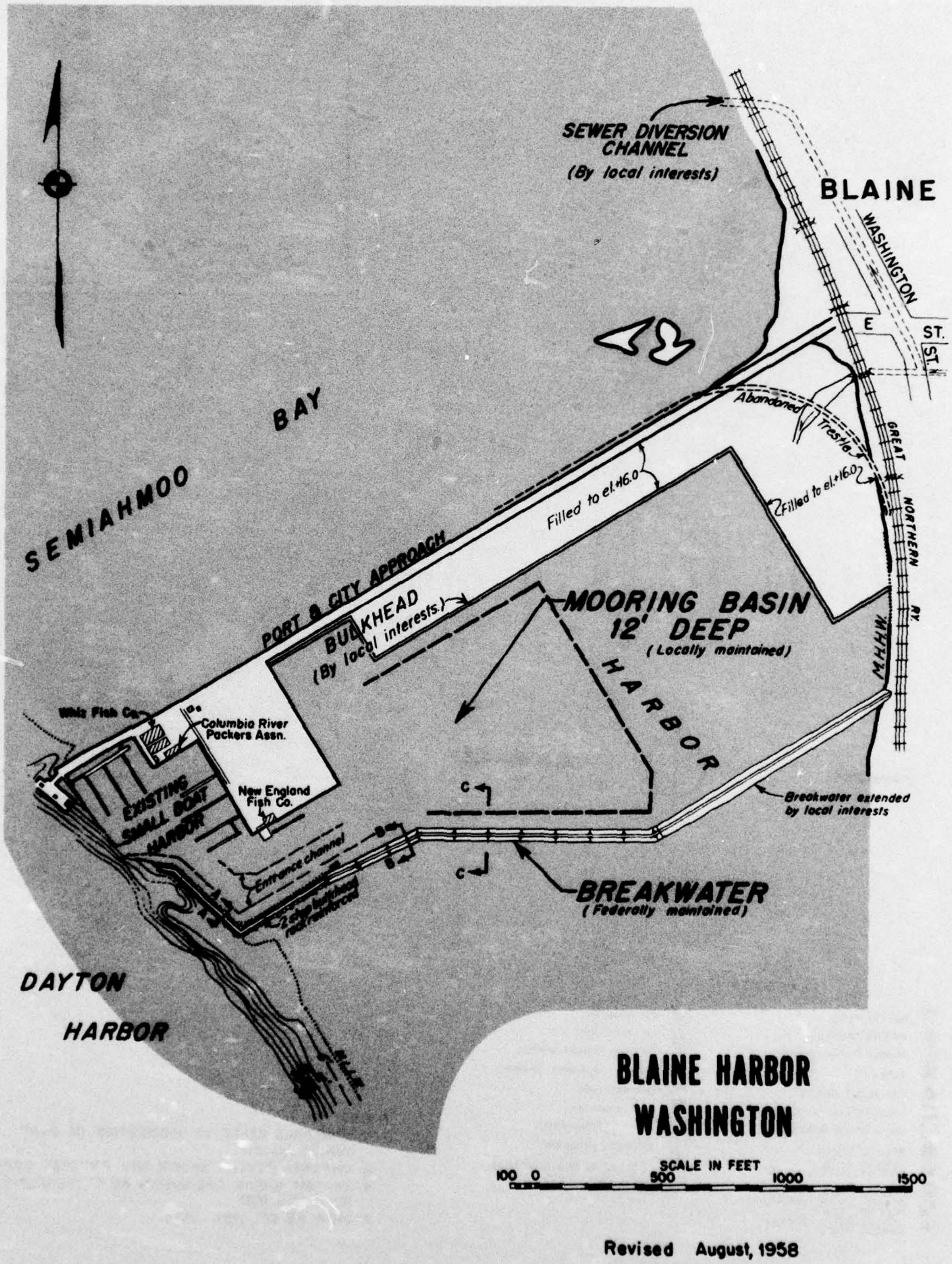
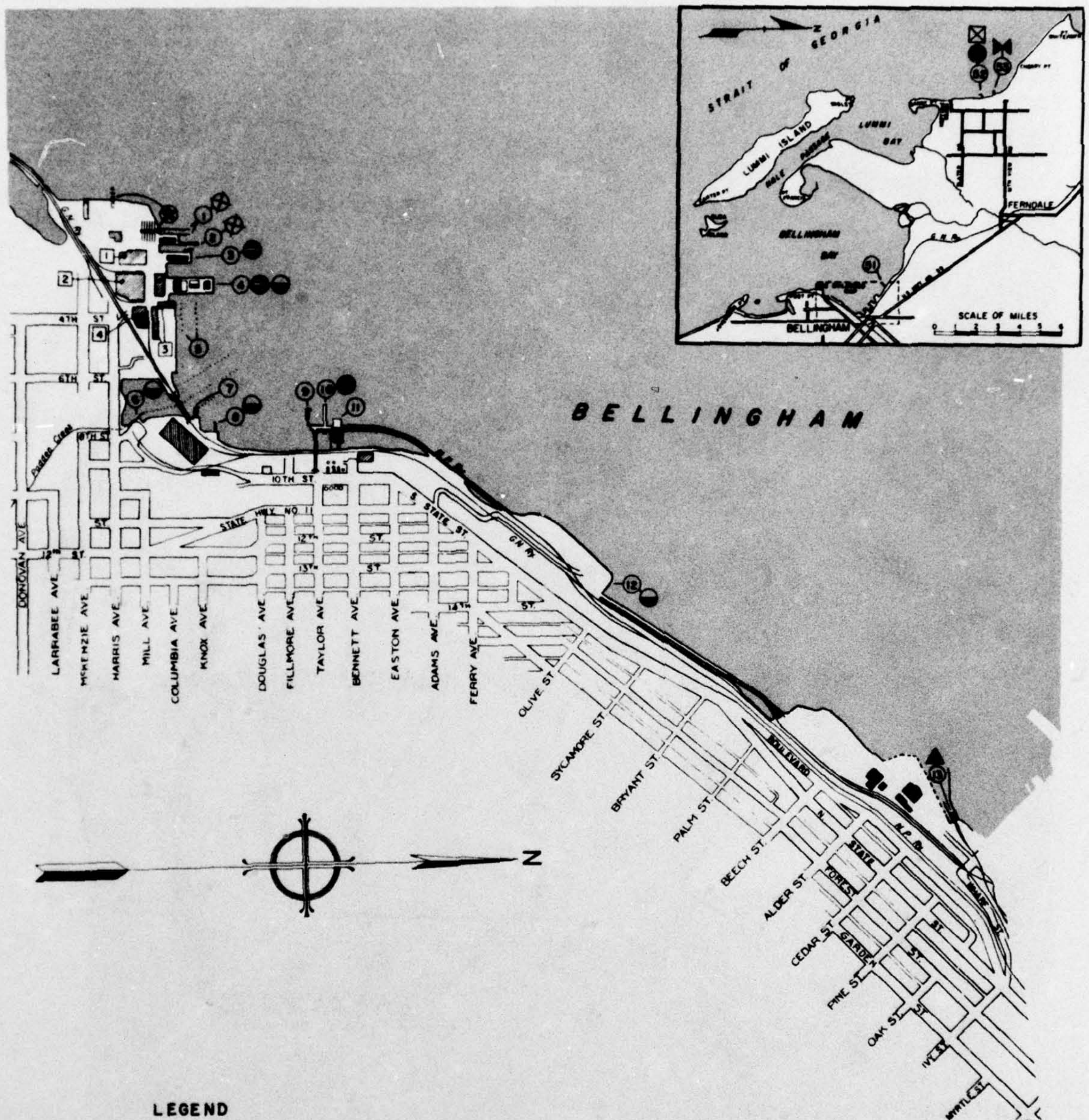

SEWER DIVERSION CHANNEL
(By local interests)
BLAINE
WASHINGTON
E
ST.
ST.
Abandoned
Trestle
GREAT
NORTHERN
RY.
SEMIAHMOO
BAY
Filled to el.+16.0
Filled to el.+16.0
PORT & CITY APPROACH
BULKHEAD
(By local interests.)
MOORING BASIN
12' DEEP
(Locally maintained)
HARBOR
M.H.H.W.
Columbia River
Packers Assn.
EXISTING
SMALL BOAT
HARBOR
New England
Fish Co.
Entrance channel
Breakwater extended
by local interests
BREAKWATER
(Federally maintained)
DAYTON
HARBOR
BLAINE HARBOR
WASHINGTON
SCALE IN FEET
100
0
500
1000
1500
Revised August, 1958

FIGURE 3-2



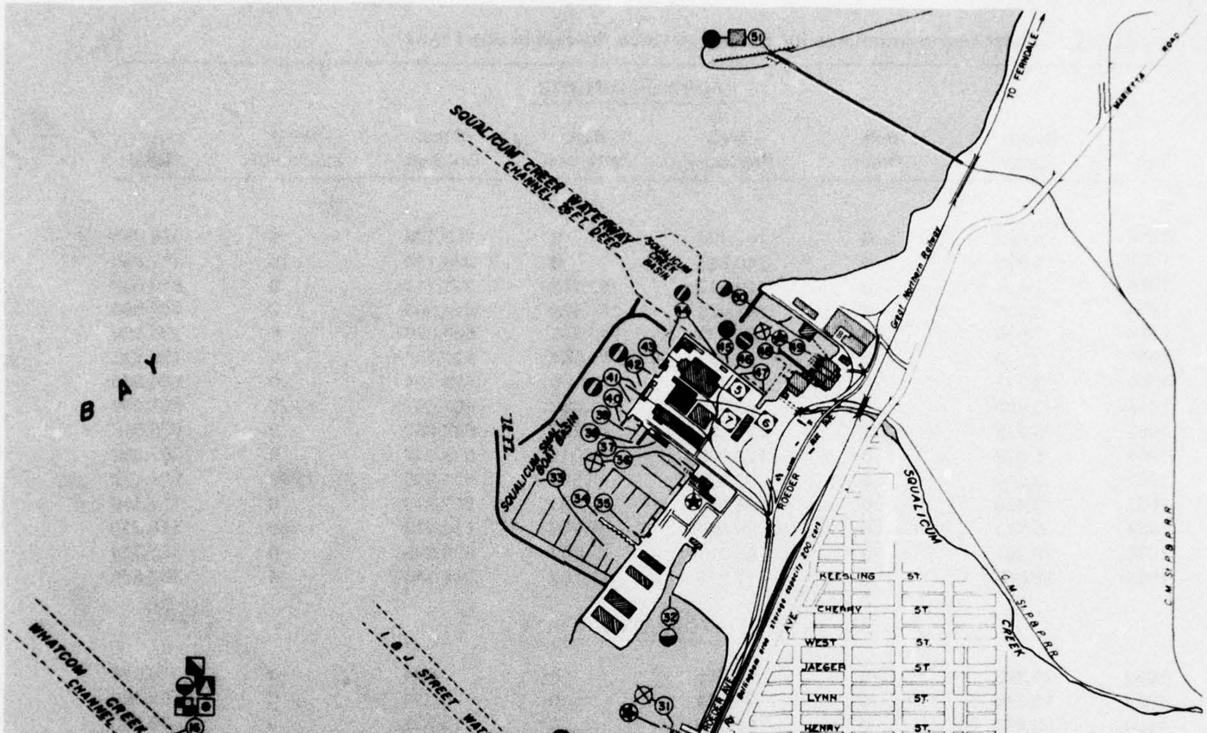
LEGEND

CUSTOM HOUSE	OIL HANDLING
MARINE RAILWAY	OIL BUNKERING
MARINE REPAIR PLANT	RAILWAY FREIGHT STATION
BOAT LIFT	RAILWAY PASSENGER STATION
CAR FLOAT BRIDGE	ORE HANDLING
COLD STORAGE WAREHOUSE	SALT HANDLING
DRY STORAGE WAREHOUSE	FERTILIZER HANDLING
GRAIN ELEVATOR	CHEMICAL HANDLING
LOGS, PILING & WOOD-PRODUCTS HANDLING	TERMINAL OF INLAND CARRIERS
FISH & SEAFOOD HANDLING	SAND, GRAVEL, CEMENT & LIMEROCK HANDLING
GENERAL CARGO TERMINAL DOMESTIC TRADE	
GENERAL CARGO TERMINAL FOREIGN TRADE	

NOTES:

1. NUMERALS REFER TO DESCRIPTION IN PORT SERIES NO. 37
2. CHANNEL DEPTHS SHOWN ARE PROJECT DEPTHS
3. TRANSIT SHEDS ARE SHOWN AS CROSSHATCHED BUILDINGS
4. DATA AS OF APRIL 1965

FIGURE 3-3L



PORT FACILITIES AT BELLINGHAM, WASH.

BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C.

SCALE OF FEET
500 0 500 1000 1500

FIGURE 3-3R

TABLE 3-1. Water-borne commerce for Bellingham area, foreign in short tons

FOREIGN IMPORTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	5,562	0	169,790	0	183,126	6	358,484
1953	13,870	0	240,855	0	233,120	15	487,860
1954	1,691	0	229,512	57,713	321,114	0	610,030
1955	3,395	0	101,435	107,528	474,606	0	686,964
1956	7,010	0	88,693	142,836	500,020	0	738,559
1957	3,743	0	100,509	56,584	627,737	0	788,573
1958	2,371	0	124,870	0	457,744	0	584,985
1959	3,993	0	92,056	1,693	401,602	1,925	501,269
1960	3,736	221	127,166	4,791	542,602	0	678,516
1961	5,928	0	128,343	93,042	679,777	0	907,090
1962	3,260	0	93,320	8,910	521,576	2,609	629,675
1963	3,493	0	106,091	9,633	597,919	0	717,136
1964	5,113	0	89,907	9,728	512,413	1,169	618,330
1965	10,681	0	64,991	10,807	338,895	0	425,374
1966	39,656	0	77,278	17,192	248,746	4	382,876
				FOREIGN EXPORTS			
1952	23,895	0	3,755	0	924	0	28,574
1953	18,316	0	35,994	0	6,876	0	61,186
1954	24,928	0	39,770	0	10,555	0	75,253
1955	23,012	0	9,418	19,805	4,401	0	56,636
1956	20,763	0	3,110	1,496	11,064	0	36,433
1957	28,173	0	22,335	21,517	1,184	117	73,326
1958	20,744	0	9,765	2,201	0	52	32,762
1959	62,432	0	21,286	28	1,420	52	85,218
1960	49,572	16	34,595	0	26	172	84,381
1961	52,609	0	94,871	0	5,638	544	153,662
1962	66,675	0	56,949	0	0	0	123,624
1963	53,521	0	140,307	0	3,360	0	197,188
1964	58,195	0	114,696	2,107	0	0	174,998
1965	42,253	0	96,775	3,183	5,282	0	147,493
1966	68,800	0	125,664	18,186	5,498	0	218,148

TABLE 3-2. **Water-borne commerce for Bellingham Area, domestic coastwise in short tons**

DOMESTIC COASTWISE RECEIPTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	23,566	0	0	0	11,683	0	35,249
1953	16,709	0	0	0	16,800	0	33,509
1954	18,211	0	0	0	14,026	0	32,237
1955	14,483	0	0	0	12,343	0	26,826
1956	18,066	0	534	0	12,544	0	31,144
1957	21,311	0	8,747	0	6,729	0	36,787
1958	27,949	0	0	5,128	8,871	0	41,948
1959	16,177	0	0	5,400	5,948	12	27,537
1960	21,676	0	0	0	4,464	39	26,179
1961	26,323	0	0	0	1,011	30	27,364
1962	21,687	0	0	0	1,132	18	22,837
1963	19,806	0	0	0	1,131	0	20,937
1964	15,755	0	0	0	564	733	17,052
1965	18,766	0	0	0	0	0	18,766
1966	27,982	0	0	0	60	0	28,042

DOMESTIC COASTWISE SHIPMENTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	17,450	0	8,277	434	671	0	26,832
1953	11,838	20	6,161	0	2,250	0	20,269
1954	7,658	0	1,901	7	53,817	0	63,383
1955	8,869	0	3,895	0	60,115	0	72,879
1956	8,907	0	2,663	0	20	0	11,590
1957	3,298	0	6,633	67	1,478	0	11,476
1958	10,632	0	1,382	0	6,588	0	18,602
1959	246	0	100	0	28,170	7,132	35,648
1960	2,728	0	26	0	49,218	10,643	62,615
1961	800	0	336	1,351	14,316	8,011	24,813
1962	611	0	517	821	10,721	2,584	15,245
1963	1,217	0	373	6	49,182	3,297	54,075
1964	3,767	0	851	0	112,418	3,112	120,148
1965	4,774	0	378	150	220,301	3,047	228,650
1966	35,521	0	382	104	117,171	10,153	163,331

TABLE 3-3. **Water-borne commerce for Bellingham Area, in short tons**

			FOREIGN & DOMESTIC COASTWISE				
Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	70,473	0	181,822	434	196,404	6	449,139
1953	60,733	20	283,010	0	259,046	15	602,824
1954	52,488	0	271,183	57,720	399,512	0	780,903
1955	49,759	0	114,748	127,333	551,465	0	843,305
1956	54,746	0	95,000	144,332	523,648	0	817,726
1957	56,525	0	138,224	78,168	637,128	117	910,162
1958	61,696	0	136,017	7,329	473,203	52	678,297
1959	82,848	0	113,442	7,121	437,140	9,121	649,672
1960	77,712	237	161,787	4,791	596,310	10,854	851,691
1961	85,660	0	223,549	94,393	700,742	8,585	1,112,929
1962	92,233	0	150,786	9,722	533,429	5,211	791,381
1963	78,037	0	246,771	9,639	651,592	3,297	989,336
1964	82,830	0	205,454	11,835	625,395	5,014	930,528
1965	76,474	0	162,144	14,140	564,478	3,047	820,283
1966	171,959	0	203,324	35,482	371,475	10,157	792,397

TABLE 3-4. **Water-borne commerce for Bellingham Area, in short tons**

			DOMESTIC INTERVAL				
Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	21,867	0	430,624	163,907	52,337	62	668,797
1953	25,423	0	414,082	159,802	47,706	0	647,013
1954	23,222	0	492,405	172,427	69,054	48	757,156
1955	19,233	5	467,169	199,410	18,345	67	704,229
1956	30,446	0	469,203	184,620	49,437	278	733,984
1957	56,140	0	252,367	116,290	150,728	494	576,019
1958	68,096	0	239,873	98,145	245,706	87	651,907
1959	66,060	0	342,271	93,867	144,693	95	646,986
1960	76,606	0	238,740	92,246	182,896	58	590,546
1961	53,817	0	161,955	83,252	159,247	0	458,271
1962	91,300	0	242,150	74,467	173,881	0	581,798
1963	67,876	0	159,293	61,651	154,086	0	442,906
1964	59,794	0	162,836	70,915	188,082	0	481,627
1965	16,789	0	215,252	87,758	379,461	0	699,260
1966	11,221	0	377,923	91,601	233,007	0	713,752

TABLE 3-5. Terminal facilities Bellingham Area 1952

Use	Depth 18' & Less: No. of Berths	Depth 18' & Less: Berth Space In Feet	Depth 18' - 40': No. of Berths	Depth 18' - 40': Berth Space In Feet	Depth 40' +: No. of Berths	Depth 40' +: Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	13	2,696	4	1,717	0	0	89,118	0
Bulk Grain	0	0	0	0	0	0	0	0
Forest Products	1	125	2	1,425	0	0	30,400	0
Bulk Petroleum	1	110	7	669	0	0	0	0
Other Dry Bulk	3	720	0	0	0	0	0	0
Other Liquid Bulk	0	0	0	0	0	0	0	0
Totals	18	3,651	13	3,811	0	0	119,518	0
Construction & Repair	5	1,075	1	295	0	0	0	0
Mooring	8	1,152	2	200	0	0	16,000	0

TABLE 3-6. Terminal facilities Bellingham Area 1963

Use	Depth 18' & Less: No. of Berths	Depth 18' & Less: Berth Space In Feet	Depth 18' - 40': No. of Berths	Depth 18' - 40': Berth Space In Feet	Depth 40' +: No. of Berths	Depth 40' +: Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	15	3,228	7	1,417	0	0	74,118	4.5
Bulk Grain	0	0	0	0	0	0	0	0
Forest Products	7	890	2	1,285	0	0	42,400	0
Bulk Petroleum	5	477	5	1,216	1	756	0	0
Other Dry Bulk	4	1,386	0	0	0	0	0	0
Other Liquid Bulk	0	0	0	0	0	0	0	0
Totals	31	5,981	14	3,918	1	756	116,518	4.5
Construction & Repair	0	1,990	0	0	0	0	0	0
Mooring	0	10,301	0	1,125	0	0	0	0

WATERFRONT AND INDUSTRIAL LAND

The existing and potential sites of water transport-oriented industries and terminal facilities in the Nooksack-Sumas Basins are indicated on Figure 3-4 and summarized in Table 3-7. In this table, the net areas are the gross areas less right-of-way for streets and highways. The following discussion refers to site numbers shown on reference figure and table:

Site No. 1 in Bellingham Bay includes the existing development of the Port of Bellingham, and its plan for future development which will make available a limited space for additional small industries. Additional dredging and filling is required for this development.

Site No. 2 in Drayton Harbor includes the existing port development at Blaine. The existing and limited space for industrial development in this area have not been evaluated.

Site No. 3 an area of about 800 acres near Ferndale has been partly developed by the Mobile Oil Company. In addition to the 600 acres in this tract that is undeveloped, it is possible that additional acreage can be annexed from the Lummi Indian Reservation to the south. Unlimited water depth is available along the waterfront.

Site No. 4 also near Ferndale has been partially developed since 1963 where about 1,420 acres have been acquired by Intalco and about 250 acres developed for their aluminum smelter. The remaining area of about 4,600 acres is suitable for heavy or light industry with unlimited depth along the waterfront.

Site No. 5 in Drayton Harbor would develop part of this shallow bay by dredging and filling. There are conflicts of interest with existing oyster beds and a proposed fish farm. Because of these conflicts and the high cost of development, this site is not considered very favorable.

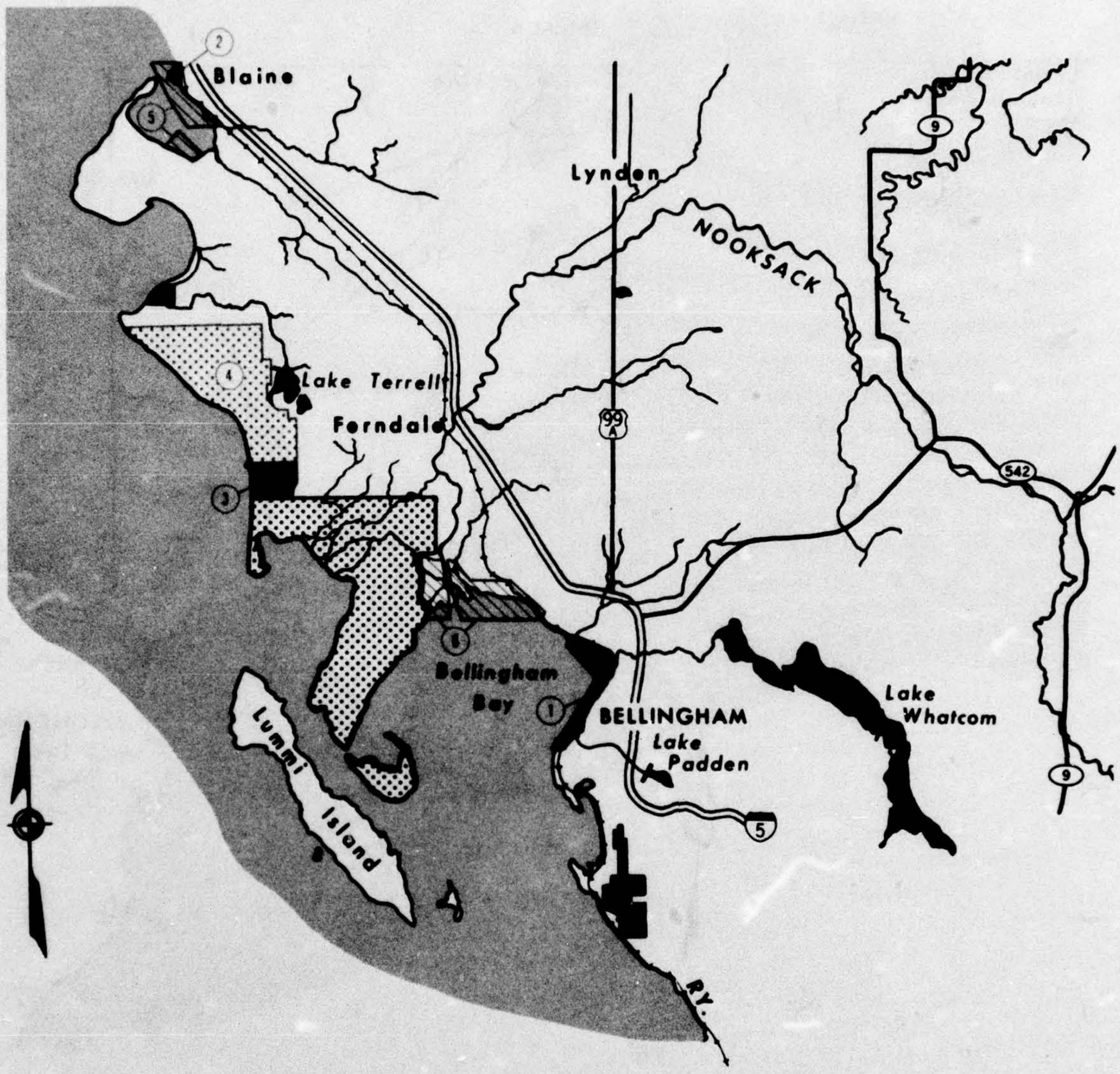
Site No. 6 at the mouth of the Nooksack River will require extensive dredging and filling but would be suitable for light or heavy industry. The development of this site must be coordinated with the flood control plan for the lower Nooksack River and will involve a silting problem.

SMALL BOAT HARBORS

Small boat facilities existing in 1966 on salt water are shown in Figure 3-5 and identified in Table 3-8. As shown in Figure 3-6, there are about 12 miles of shoreline that are considered suitable for potential marina development.

TABLE 3-7. Water front & industrial land—Nooksack-Sumas Basins—1963

		Acres in Use (Net)				Acres Potential			
			Vessel	Water		Favorable		Less Favorable	
Site Number	Location	Terminal Facilities	Repair & Construction	Oriented Industry	Totals	Gross	Net	Gross	Net
1.	Bellingham	122	12	180	314	420	315	0	0
2.	Blaine	20	0	30	50	0	0	0	0
3.	Mobile Oil Refinery	37	0	200	237	600	450	0	0
4.	Ferndale	0	0	280	280	5,600	4,220	0	0
5.	Drayton Harbor	0	0	0	0	0	0	1,000	750
6.	Nooksack Delta	0	0	0	0	0	0	2,400	1,800
	Total	179	12	690	881	6,620	4,985	3,400	2,550



LEGEND

- Indian Reservation
- Park
- Military Reservation
- Partially developed area
- Undeveloped area favorable
- Undeveloped area less favorable
- (0) Waterfront terminal and/or industrial site number

Scale in Miles

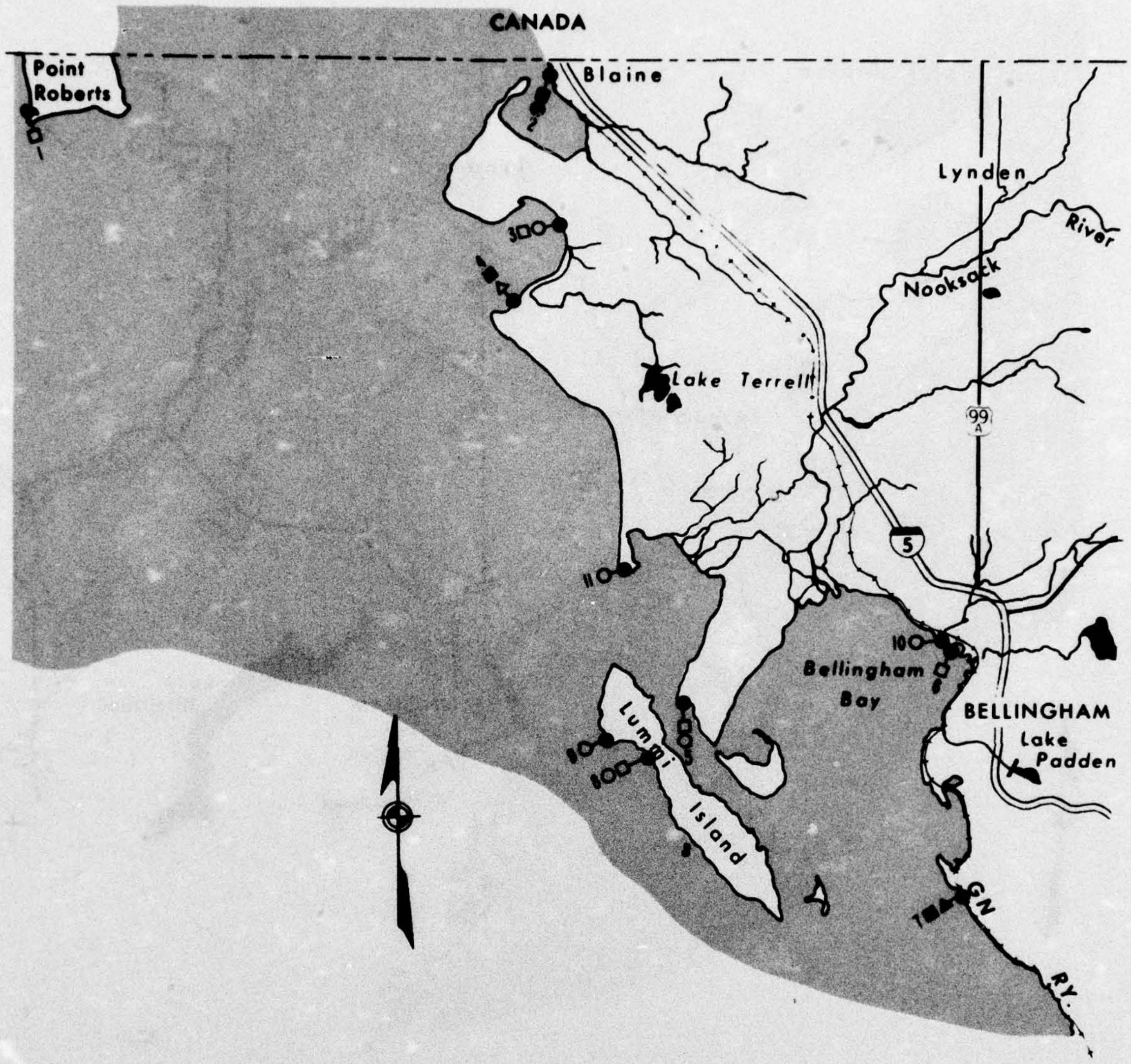
5 0 5 10

NOOKSACK-SUMAS BASINS

WATERFRONT TERMINAL & INDUSTRIAL SITES

1966

FIGURE 3-4



LEGEND

- △ State Park
- ▲ State Marine Park
- ○ Rental Moorage — Private
- ● Rental Moorage — Public
- ✱ Yacht Club
- □ Transient Boat Launching Ramp— Private
- ■ Transient Boat Launching Ramp —Public

Scale in Miles

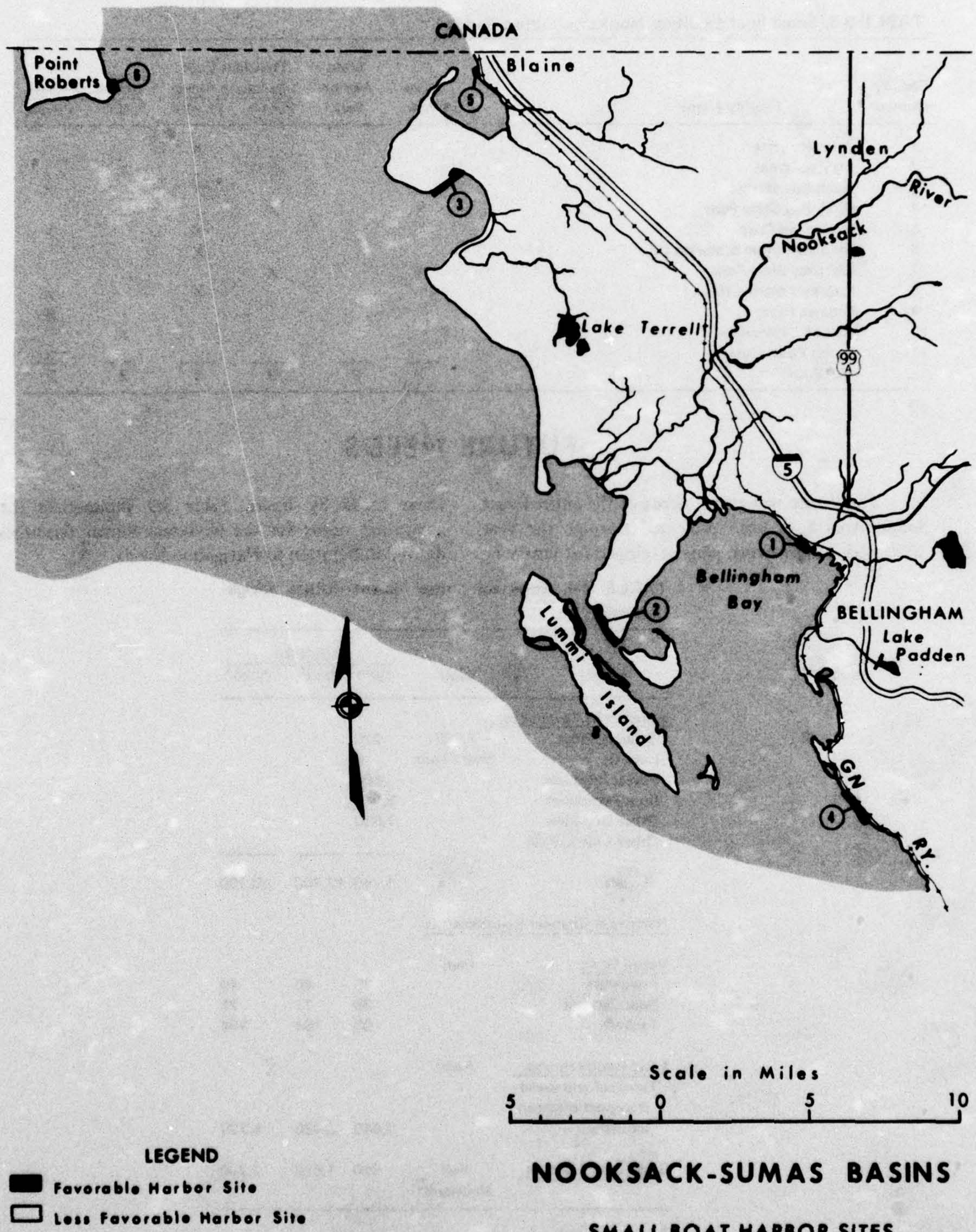
5 0 5 10

NOOKSACK-SUMAS BASINS

SMALL BOAT HARBORS

1966

FIGURE 3-5



NOOKSACK-SUMAS BASINS

SMALL BOAT HARBOR SITES

FIGURE 3-6

TABLE 3-8. Small boat facilities, Nooksack-Sumas Basins

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp Public	Transient Boat Launching Ramp Private	Rental Moorage Public	Rental Moorage Private
1	Point Roberts				X		
2	Blaine Marina			X		X	
3	Birch Bay Marina				X		X
4	Birch Bay State Park	X		X			
5	Fisherman Cove				X		X
6	Weldcraft Steel & Marine Co.				X		
7	Larrabee State Park	X		X			
8	Hawley's Marine Resort				X		X
9	Gramac Marina						X
10	Port of Bellingham					X	
11	Sandy Point Marina						X
	TOTALS	2	0	3	5	2	5

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 with a framework plan developed for satisfying these needs by basin. Table 3-9 summarizes the navigation needs for the Nooksack-Sumas Basins as derived in Solution to Navigation Needs.

TABLE 3-9. Nooksack-Sumas Basins—future navigation needs

Item	Unit	Needs By 1980	2000[1]	2020[1]
Waterborne Commerce				
General Cargo	1,000	270		
Bulk Grain	Short Tons	0		
Forest Products		500		
Bulk Petroleum		2,040		
Other Dry Bulk		1,930		
Other Liquid Bulk		0		
Totals		4,740	12,700	30,100
Harbors & Channel Requirements				
Vessel Draft	Feet			
Freighters		35	40	40
Bulk Carriers		35	71	71
Tankers		98	104	104
Land Requirements	Acres			
Terminal and water-transport-oriented industry		2,040	3,480	5,870
Small Boat Harbors	Wet Moorages[2]	990	1,620	2,700

1 Only aggregated tonnage projected after 1980.

2 Taken as summer wet moorage demand.

MEANS TO SATISFY NEEDS

Commerce forecasts indicate substantial increases in general cargo, bulk petroleum and other dry bulk. To meet projected traffic increases, terminal and industrial land development and harbor and channel improvement will be required. Also, construction of additional small boat facilities is vital, if basin needs are to be satisfied.

TERMINAL AND INDUSTRIAL LAND REQUIREMENT

As noted in Table 3-9, approximately 5,900 acres of terminal and industrial lands will be required to meet projected needs by 2020. This total includes 881 acres already developed for this purpose. Examination of Figure 3-4 and Table 2-10 reveals that these needs can be satisfied by development of favorable lands. However, it must be recognized that contrary to Table 2-10 some less favorable lands will have to be developed, particularly in the Nooksack delta area, to accommodate the projected increase in other dry bulk not readily accommodated in site No. 4. Figure 3-4.

HARBORS AND CHANNELS

Although Bellingham Bay has adequate depths in its center, harbor extensive tide flats require the dredging of channels to service terminal facilities to accommodate projected vessel drafts shown in Table 3-9. Whatcom Creek waterway should be modified as shown below:

During the period 1980-2000 a 46-feet deep channel in the Nooksack delta area should be developed. The cost of this channel is estimated at $862,000 with estimated average annual costs at $49,000. Vessels with drafts greater than 40-feet will most likely be of the super tanker and bulk cargo class carrying bulk petroleum and alumina. Existing depths to accommodate the vessels where these cargoes will be unloaded are adequate with very little modification of existing terminal facilities required.

SMALL BOAT HARBORS

Listed in Table 3-10 are the sites in the Nooksack-Sumas Basins considered suitable for development of small boat harbors. These sites are shown on Figure 3-6. Although alternative sites are also available the sites selected are believed to be the most favorable in this basin.

A tentative schedule of development to meet 1980, 2000 and 2020 needs is contained in Table 3-10. Benefits and costs for projects recommended to meet 1980 pleasure boating demand are also shown as are the estimated construction costs for additional projects required by 2000 and 2020. Costs shown are for general navigation facilities and navigation aids that may require Federal assistance in financing and construction. General navigation facilities consist of breakwaters, entrance channels, and turning basins and the navigation aids are normally lighted dolphins and breakwater lights. Costs are average values and are based on actual construction or detailed study

Period	Channel Depth	Estimated Construction Cost	Estimated Annual Costs	Estimated Benefits	Estimated Benefit-Cost Ratio
Prior to 1980	40-feet	$667,000	$39,000	$42,000	1.1
1980 to 2000	46-feet	$481,000	$26,500	*	*

*Not estimated.

TABLE 3-10. Small boat harbor sites—Nooksack-Sumas Basins

Site No.	Location	Wet Moorages	Water-Land Area-Acres[4]	Tentative Schedule of Development 1980	2000	2020
				Wet Moorages		
1	Bellingham Addition	430	36	430		
2	Hale Passage-East Side	1,700	142		550	1,150
3	Birch Bay	2,180	182			
4	Samish Bay-North End	2,020	168			
5	Blaine Addition	440	37	440[5]		
6	Point Roberts	800	67			
	Total	7,570	632	870	550	1,150

Summary of Benefits and Costs

1980 Construction Costs[3]	1980 Average Annual Costs[1&2]	1980 Average Annual Benefits	2000 Construction Costs[3]	2020 Construction Costs[3]
$1,766,200	$113,100	$163,800	$1,108,800	$2,326,500

[1] Annual interest and amortization charges of general navigation facility construction costs, including aids to navigation are computed for 50-year economic life at a rate of 4-5/8 percent.
[2] Includes allowance of $25 per wet moorage for annual maintenance and replacement costs.
[3] Includes allowance for Engineering, Design, Supervision and Administration costs.
[4] Using relationships based on Shilshole Marina wet moorage land and water area requirements are estimated at 0.056 acres of water area for moorage and maneuvering and 0.028 acres of land for parking and services per boat.

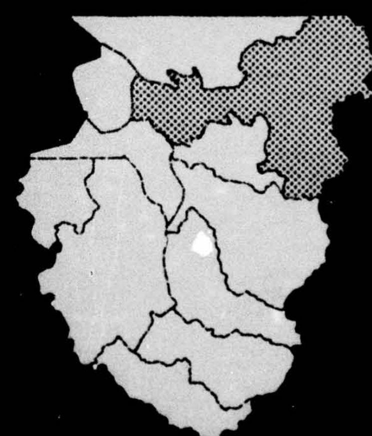
Note: Not contained in the area requirements are land needs for launching ramps which will generally be incorporated with moorage facilities. Launching facilities require about 1.5 acres of land for ramps and parking for each lane provided.

cost estimates for small boat harbor projects in the Area. Average benefit values were derived using standard methods employed by the Corps of Engineers, data from the "Pleasure Boating Study," and other studies performed for small boat harbor projects.

Factors Influencing Implementation of Plan

Due to the accumulation of pollutants in the inner portion of the Whatcom Creek Waterway, disposal of dredged spoil is a major problem. Suitable land area for terminal and industrial development is limited in the inner harbor. Implementation of the long-range plan for water transport-oriented industrial and terminal development at the mouth of the Nooksack River will be hampered by the extensive dredging and fill required and by the silt load from the Nooksack River. Breakwater design and construction for the Bellingham small boat harbor addition presents problems due to the unstable bottom material and the exposure to major storm wave activity.

Skagit-Samish Basins



SKAGIT — SAMISH BASINS

DESCRIPTION

These basins border the salt waters of Skagit Bay, Similk Bay, Rosario Strait, Bellingham Channel, Fidalgo Bay, Padilla Bay and Samish Bay and have about 186 miles of salt water shoreline. Fidalgo Island, Guemes and other Islands are close to natural deep water channels but all the shoreline along the mainland consists of extensive tide flats that require dredging for commercial vessels other than shallow draft barges and boats. Two port districts, Skagit County and Anacortes are included in these basins. Three transcontinental railroads service the basins. Interstate 5 and U.S. Highway 99 are the major north-south highway routes. Major east-west routes are State Highway 20 and 536.

PRESENT STATUS

HARBORS AND CHANNELS

The principal harbor in these basins is at Anacortes, located at the north end of Fidalgo Island, 93 nautical miles from the Pacific Ocean. The port has been developed on the south shore of Guemes Channel which has natural depths of over 50 feet. The only Federal project at this port, as shown on Figure 4-1, is a small mooring basin with breakwater and entrance channel along the Capsante Waterway.

Skagit River empties into the southeastern part of Skagit Bay where a Federal project authorized a reliable entrance channel through the delta by means of dikes and dredging. However, the project is only 46 percent complete and has been inactive for many years because of the impracticability of maintaining a reliable channel through the silt laden distributaries. As shown on Figure 4-2, entrance over the bar is restricted to high tide as the controlling depth at the mouth of the South Fork is about +2.5 feet and at the mouth of the North Fork about +2.3 feet, MLLW datum. Navigation on the Skagit River is limited to shallow draft barges, small boats and logs.

Swinomish Channel connects the waters of Skagit Bay with those of Padilla Bay. The Federal project shown on Figure 4-3 authorizes a channel 100 feet wide and 12 feet deep at MLLW by dredging, dike construction and removal of projecting rock points. The controlling depth May 1965 was 10.0 feet. The channel is used extensively for log tows and small boats. The wharfs at the town of LaConner are along the east bank of Swinomish Channel. The ferry landing on Guemes Island, across from Anacortes, is the only other significant harbor development in these basins.

WATERBORNE COMMERCE

Most of the waterborne traffic in the Skagit-Samish Basins is handled in the Anacortes area. Waterborne commerce statistics for this area from 1952 to 1966 are summarized in Tables 4-1 through 4-4. Other significant waterborne traffic in these basins consists of log rafts on the Skagit River. However, the Skagit River traffic has fallen off from 213,648 tons in 1952 to 22,734 tons in 1966.

TERMINAL AND TRANSFER FACILITIES

The Anacortes port facilities are on the northern portion of Fidalgo Island as shown on Figure 4-4. In 1952 only limited terminal facilities were existing but by 1963 facilities as summarized in Table 4-5 were available.

There are a number of ferry terminals and small boat landings for serving the internal traffic of the San Juans and Vancouver Islands.

WATERFRONT AND INDUSTRIAL LAND

The existing and potential sites of water-transport-oriented industries and terminal facilities in the Skagit-Samish Basins are indicated on Figure 4-5 and identified in Table 4-6.

TABLE 4-1. Water-borne commerce for Anacortes Area, foreign in short tons

FOREIGN IMPORTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	3,990	0	29,071	0	6,214	0	39,275
1953	2,703	0	26,604	0	379	3	29,689
1954	2,817	0	20,891	0	0	19	23,727
1955	915	0	0	0	0	67	982
1956	1,226	0	598	0	0	0	1,824
1957	726	0	6,905	0	0	0	7,631
1958	1,163	0	3,113	982,090	0	8	986,374
1959	669	0	2,221	2,494,110	0	0	2,497,000
1960	204	0	8,991	2,303,212	5,827	0	2,318,234
1961	108	0	40,151	1,128,140	41	0	1,168,440
1962	819	0	22,785	0	3,432	0	27,036
1963	435	0	16,918	385,659	0	0	403,012
1964	2,161	0	6,721	398,542	0	0	407,424
1965	707	0	15,485	630,222	14,838	0	661,252
1966	497	0	11,527	72,325	25,189	0	109,538

FOREIGN EXPORTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	200	0	11,990	0	0	0	12,190
1953	63	0	6,498	0	0	0	6,561
1954	2,301	0	2,565	0	0	0	4,866
1955	5,850	0	1,679	0	0	0	7,529
1956	225	0	6,248	12,594	0	0	19,067
1957	779	0	4,912	23,236	47	0	28,974
1958	3,200	0	8,651	0	30	0	11,881
1959	6,782	0	5,121	2,749	0	0	14,652
1960	2,800	0	1,248	9,588	49	1	13,686
1961	390	1,120	3,821	5,384	174	0	10,889
1962	538	0	16,208	7,653	0	0	24,399
1963	499	0	80,675	17,377	0	0	98,551
1964	8,595	0	111,122	5,650	0	0	125,367
1965	610	0	199,600	22,995	0	0	223,205
1966	9,340	0	128,014	6,459	0	0	143,813

TABLE 4-2. Water-borne commerce for Anacortes Area. Domestic coastwise in short tons

DOMESTIC COASTWISE RECEIPTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	94	0	0	0	1,792	0	1,886
1953	120	0	0	0	1,792	0	1,912
1954	1,071	0	0	0	897	0	1,968
1955	7,465	0	0	21,844	0	0	29,309
1956	6,764	0	0	19,328	0	0	26,092
1957	8,523	0	12,937	79,604	0	1,593	102,757
1958	17,891	0	0	1,213,234	0	0	1,231,125
1959	7,100	0	7,868	842,510	0	2,776	860,254
1960	4,663	0	0	1,192,274	0	4,171	1,201,108
1961	8,533	0	0	868,684	0	5,954	883,171
1962	8,449	0	0	898,036	0	6,662	913,147
1963	14,000	0	0	781,226	0	2,660	797,886
1964	11,259	0	0	609,488	0	0	620,747
1965	11,177	0	0	681,858	6,074	0	699,109
1966	26,234	0	0	828,492	0	0	854,816

DOMESTIC COASTWISE SHIPMENTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	22,294	0	613	0	0	0	22,907
1953	34,865	0	1,064	0	1,159	0	37,088
1954	44,541	0	463	0	0	0	45,004
1955	27,291	0	1,895	158,941	444	0	188,571
1956	907	0	373	1,104,030	0	0	1,105,310
1957	802	0	0	1,158,994	0	0	1,159,796
1958	0	0	0	1,237,647	0	0	1,237,647
1959	6,735	0	0	1,828,350	0	0	1,835,085
1960	7,429	0	0	2,309,811	13,860	0	2,331,100
1961	1,018	0	0	2,660,306	2,212	0	2,663,536
1962	107	0	0	3,021,052	2,487	0	3,023,646
1963	1,282	0	0	3,107,159	3,342	0	3,111,783
1964	13	0	0	3,618,201	0	0	3,618,214
1965	0	0	5	3,793,681	0	0	3,793,686
1966	55,369	0	0	2,982,237	91	0	3,037,697

TABLE 4-3. Water-borne commerce for Anacortes Area, in short tons

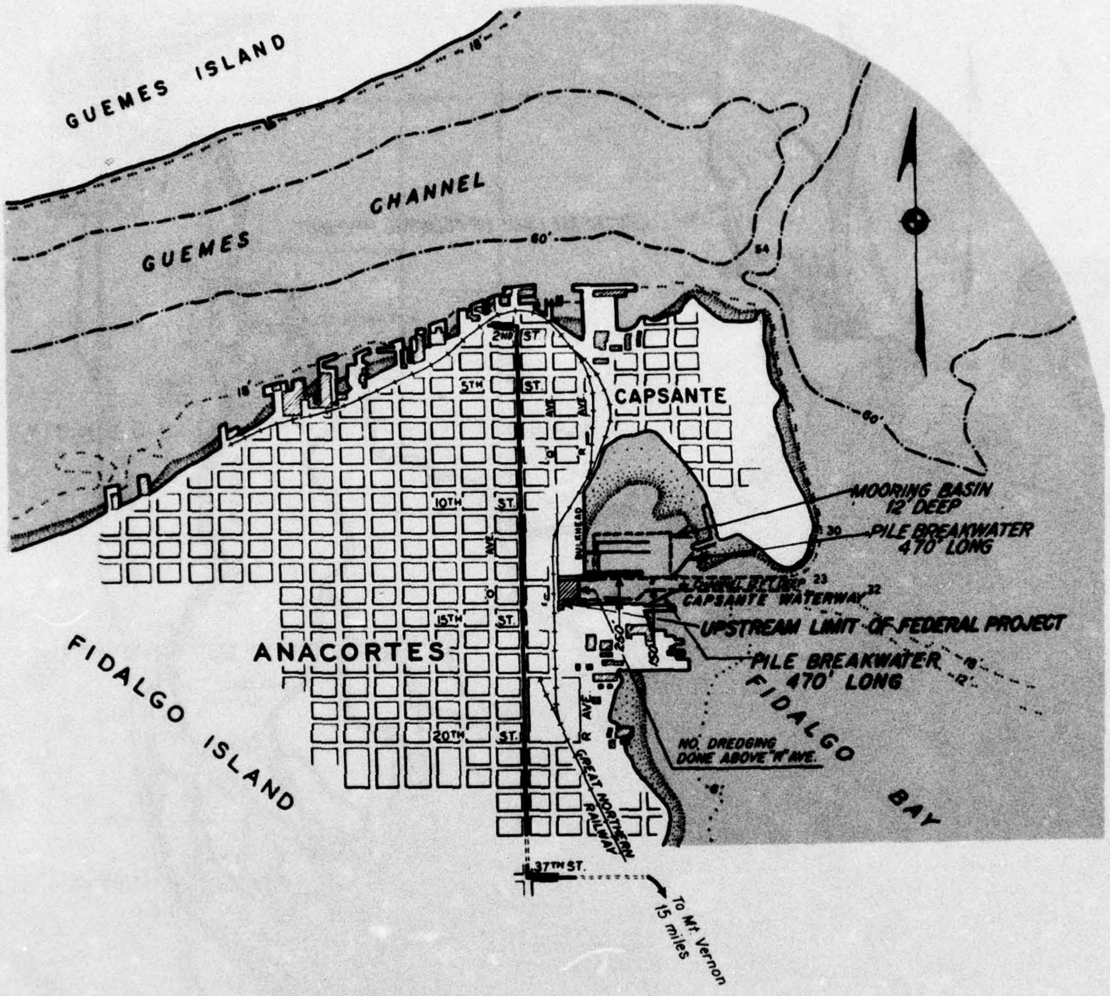
FOREIGN AND DOMESTIC COASTWISE

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	26,578	0	41,674	0	8,006	0	76,258
1953	37,751	0	34,166	0	3,330	3	75,240
1954	50,730	0	23,919	0	897	19	75,565
1955	41,521	0	3,574	180,785	444	67	226,391
1956	9,122	0	7,219	1,135,952	0	0	1,152,293
1957	10,930	0	24,754	1,261,834	47	1,593	1,299,158
1958	22,254	0	11,764	3,432,971	30	8	3,467,027
1959	21,286	0	15,210	5,167,719	0	2,776	5,206,991
1960	15,096	0	10,239	5,814,885	19,736	4,172	5,864,128
1961	10,049	1,120	43,972	4,662,514	2,427	5,954	4,726,036
1962	9,913	0	38,993	3,926,741	5,919	6,662	3,988,228
1963	16,216	0	97,593	4,291,421	3,342	2,660	4,411,232
1964	22,028	0	117,843	4,631,881	0	0	4,771,752
1965	12,494	0	215,090	5,128,756	20,912	0	5,377,252
1966	91,530	0	139,541	3,889,513	25,280	0	4,145,864

TABLE 4-4. Water-borne commerce for Anacortes Area, in short tons

DOMESTIC INTERNAL

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	11,631	0	580,714	22,203	10,745	728	626,021
1953	13,244	0	377,171	22,171	6,941	737	420,264
1954	12,746	0	317,578	24,511	15,125	599	370,559
1955	17,884	10	223,907	36,057	20,440	340	298,638
1956	16,725	0	413,289	93,146	14,281	0	537,441
1957	10,595	0	363,394	776,228	13,815	401	1,164,433
1958	21,917	0	237,189	805,462	11,500	454	1,076,522
1959	30,640	0	384,699	1,264,875	12,092	233	1,692,539
1960	9,041	0	271,627	1,535,931	9,670	0	1,826,269
1961	20,294	0	264,572	1,809,734	11,609	0	2,106,209
1962	8,177	0	282,478	2,045,346	10,176	0	2,346,177
1963	9,595	0	196,022	1,887,633	8,863	0	2,102,113
1964	16,839	0	213,974	2,219,241	9,498	78	2,459,630
1965	10,529	0	222,744	2,037,902	29,934	0	2,301,109
1966	13,715	0	287,492	1,138,688	26,531	0	1,466,426



Improvement	AUTHORIZED Depth Feet	AUTHORIZED Width Feet	AUTHORIZED Length Feet	CONDITION IN 1966 Depth Feet	CONDITION IN 1966 Width Feet	CONDITION IN 1966 Length Feet
Deepwater to breakwater	12	150	1750	8.9	130	1750
Entrance at breakwater	12	150	400	10.9	60	400
Inner channel	12	250	700	8.3	130	700
Mooring basin	12	570	960	6.1	570	800

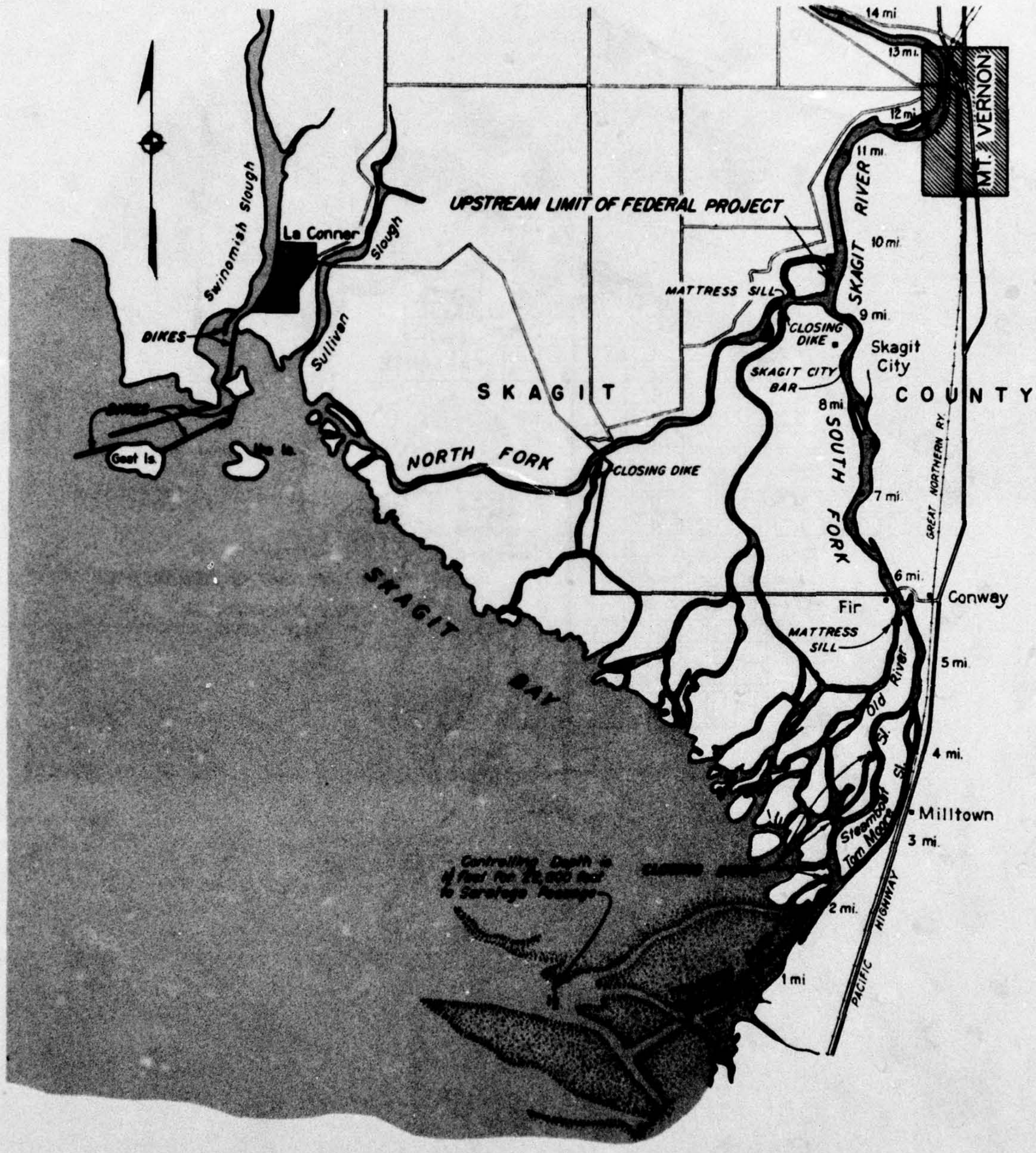
ANACORTES HARBOR WASHINGTON

SCALE IN FEET

1000 0 1000 2000 3000

Revised Sept. 1965

FIGURE 4-1



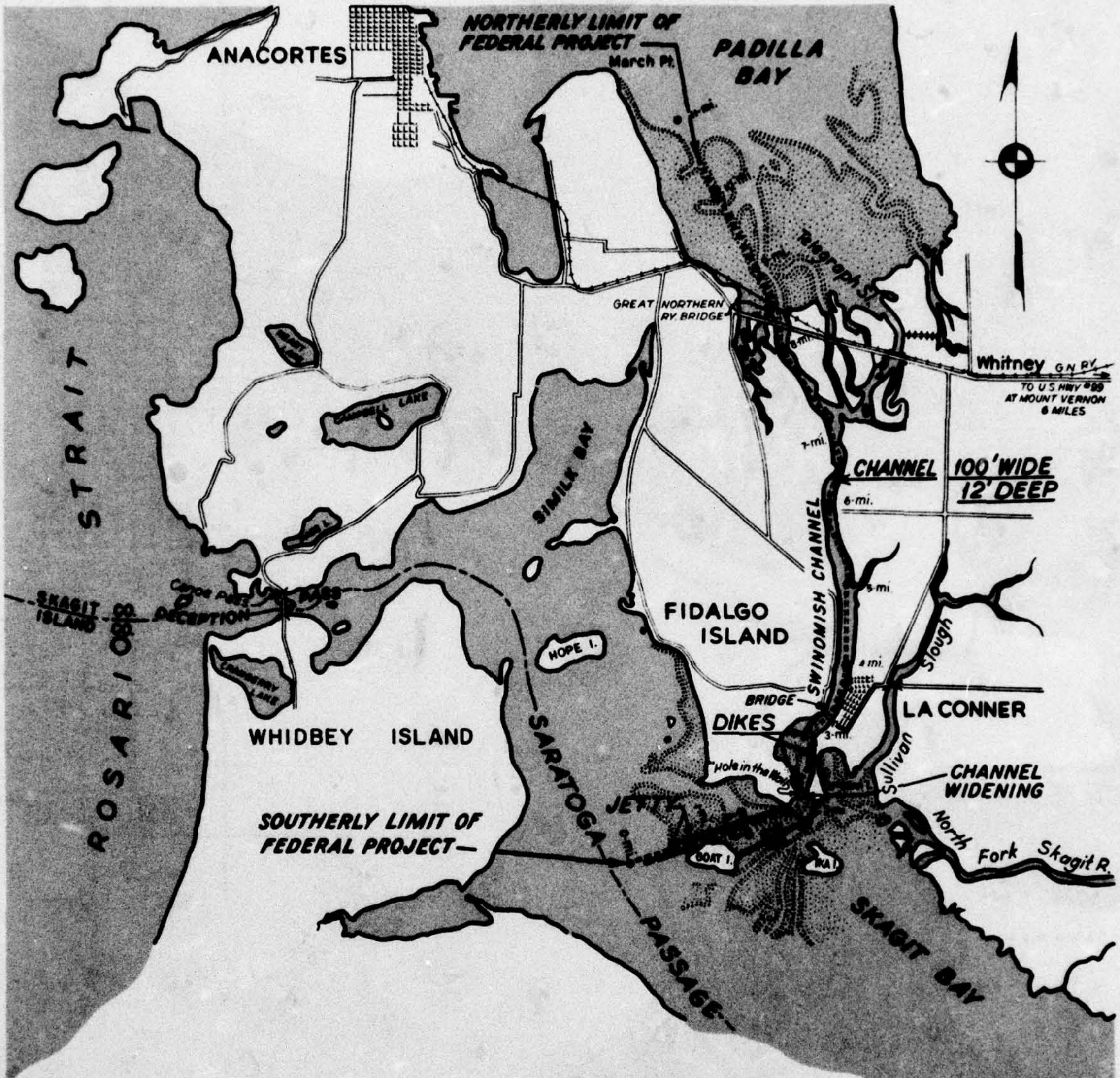
SKAGIT RIVER
WASHINGTON

SCALE IN FEET

5000 0 10 000 20 000

Revised July, 1959

FIGURE 4-2



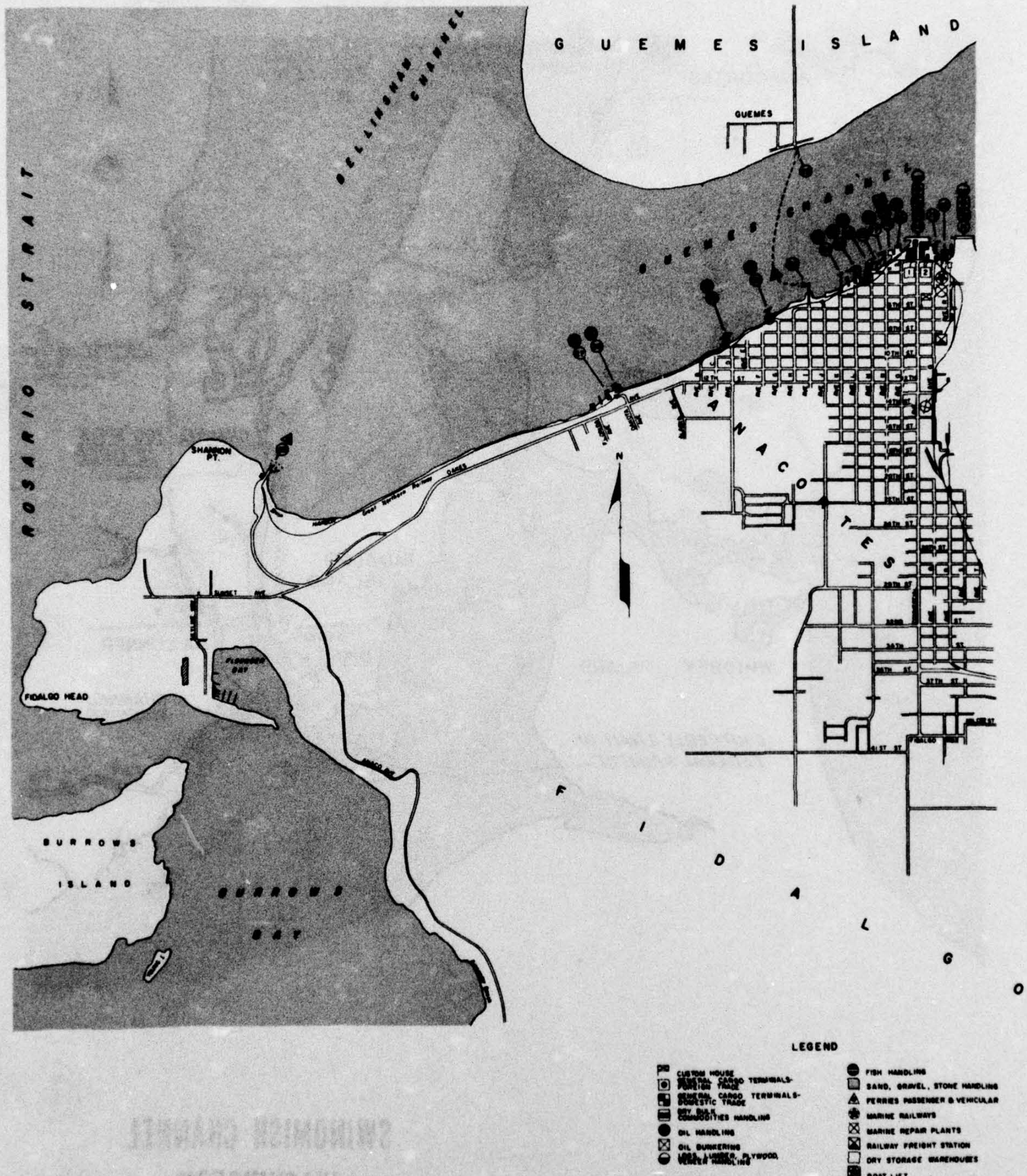
SWINOMISH CHANNEL
WASHINGTON

SCALE IN FEET

0 5000 10000 15000 20000 25000

Revised Sept. 1966

FIGURE 4-3



PORT FACILITIES AT ANACORTES, WASHINGTON

BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C.

SCALE OF FEET

NOTES:
1. NUMERALS REFER TO DESCRIPTIONS IN PORT SERIES NO. 37
2. CHANNEL DEPTHS SHOWN ARE PROJECT DEPTHS
3. TRANSIT SHEDS ARE SHOWN AS CROSSHATCHED BUILDINGS
4. DATA AS OF FEBRUARY 1968

FIGURE 4-4L

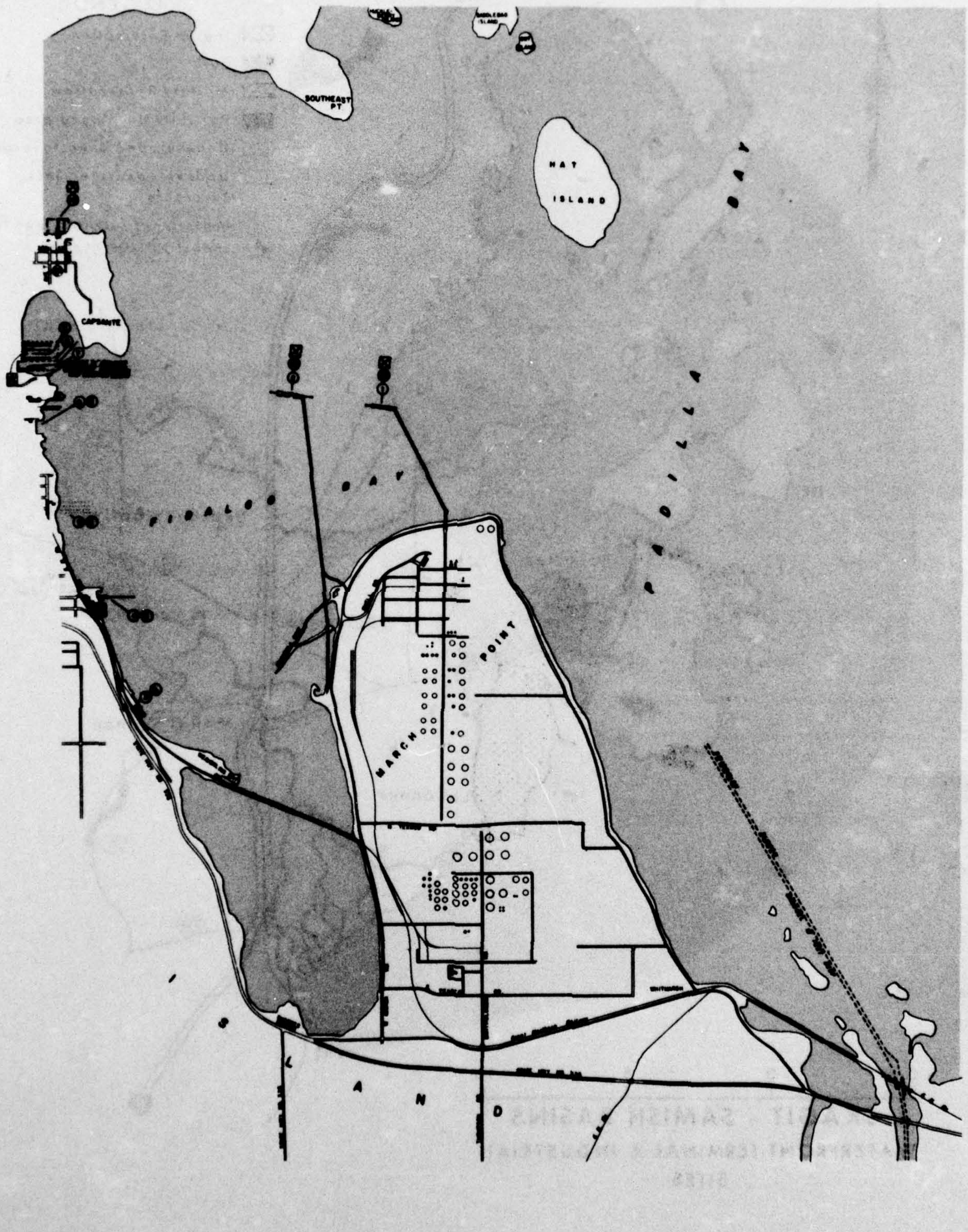
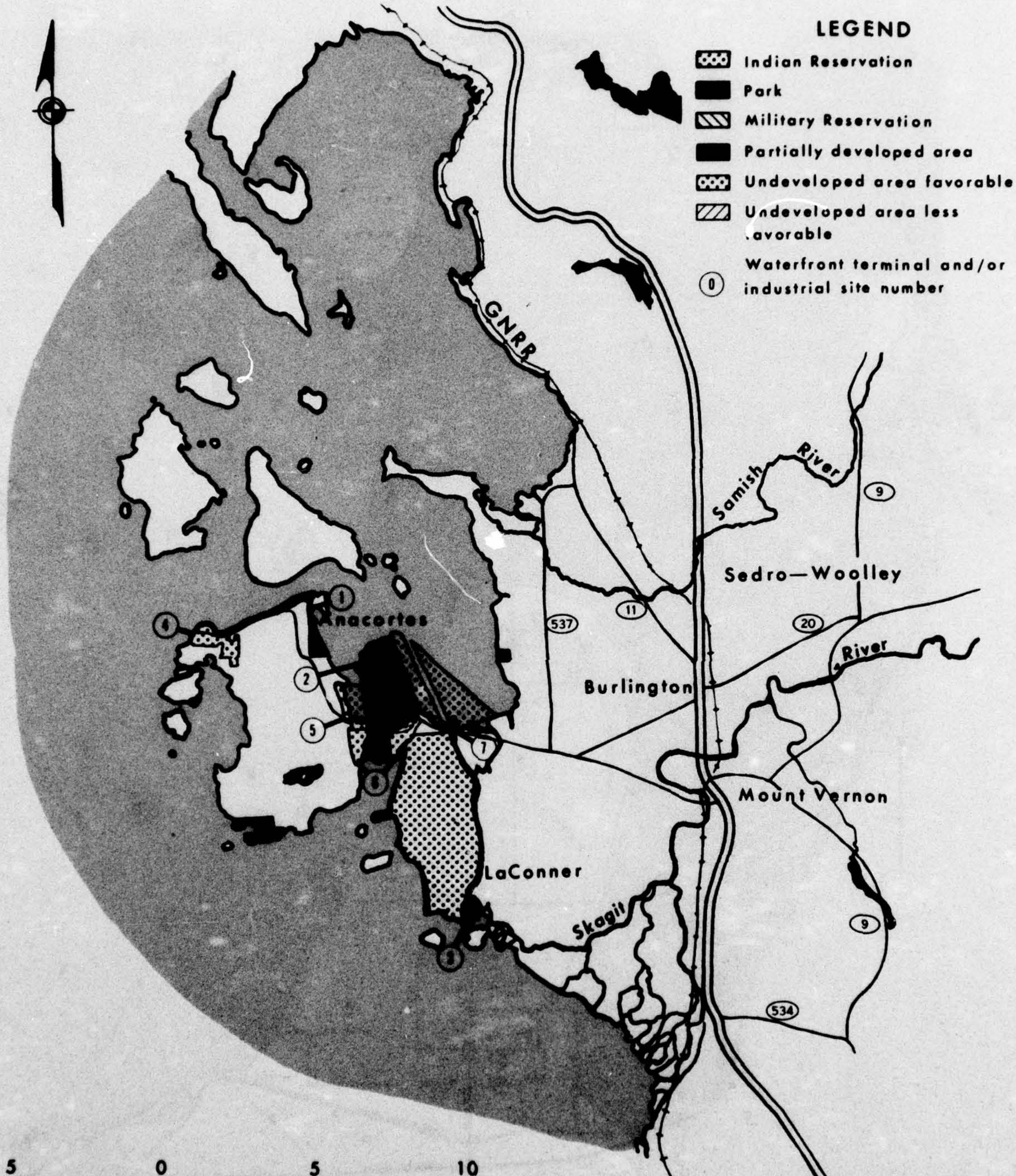

SOUTHEAST PT
HAT ISLAND
CAPSANTE
FIDALGO BAY
PADILLA BAY
MARCH POINT
ISLAND

FIGURE 4-4R



SKAGIT - SAMISH BASINS

WATERFRONT TERMINAL & INDUSTRIAL SITES

FIGURE 4-5

TABLE 4-5. Terminal facilities—Anacortes area 1963

Use	Depth 18' & Less No. of Berths	Depth 18' & Less Berth Space In Feet	Depth 18' - 40' No. of Berths	Depth 18' - 40' Berth Space In Feet	Depth 40' + No. of Berths	Depth 40' + Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	11	1,364	7	1,516	0	0	112,700	11.5
Bulk Grain	0	0	0	0	0	0	0	0
Forest Products	3	985	0	0	0	0	0	0
Bulk Petroleum	6	624	1	140	4	3,501	0	0
Other Dry Bulk	1	20	0	0	0	0	0	0
Other Liquid Bulk	0	0	0	0	0	0	0	0
Totals	21	2,983	8	1,656	4	3,501	112,700	11.5
Construction & Repair	0	772	0	0	0	0	0	0
Mooring	0	6,448	0	0	0	0	0	0

TABLE 4-6. Water front & industrial land—Skagit-Samish Basins—1963

Site Number	Location	Acres in Use (Net) Terminal Facilities	Vessel Repair & Construction	Water Oriented Industry	Totals	Acres Potential Favorable Gross	Favorable Net	Less Favorable Gross	Less Favorable Net
1.	Anacortes	125	9	45	179	200	150	0	0
2.	Marsh Point	270	0	800	1,070	800	600	0	0
3.	LaConner	10	0	0	10	220	165	0	0
4.	Shannon Point	5	0	0	5	380	285	0	0
5.	Fidalgo Bay	0	0	0	0	600	450	0	0
6.	Marsh Point Addition	0	0	0	0	1,000	750	0	0
7.	Padilla Bay-Westside	0	0	0	0	3,000	2,250	0	0
	Total	410	9	845	1,264	6,200	4,650	0	0

In this Table the net areas are the gross areas less rights-of-way for streets and highways. The following discussion refers to site numbers shown on referenced Figure and Table.

Site No. 1 includes the existing and planned developments of the Port of Anacortes as well as the city of Anacortes Industrial Park. The limited space available is only suitable for light industry and port facilities.

Site No. 2 on March Point is practically all taken up by the Shell Oil Refinery, the Texaco Oil Refinery, the Northwest Petrochemical Company and the Lone Star Cement Company holdings.

Site No. 3 is on the Swinomish Channel at LaConner. Only shallow draft is available and the site is suitable only for light industry.

Site No. 4 on Shannon Point is suitable for light or heavy industry but because there is considerable local opposition to its present zoning for industry, this may be changed.

Site No. 5 on Fidalgo Bay is suitable for light or heavy industry but would require extensive dredging and filling to develop.

Site No. 6 would be an extension of the existing developments on March Point. This site would be especially suitable for additional refinery or related chemical industry.

Site No. 7 on the west side of Padilla Bay would be suitable for light or heavy industry but would require extensive dredging and filling. An additional 6,000 acres on the east side of Padilla Bay has been considered for industrial development but has met with local opposition. Any development of the Padilla Bay tide flats must be coordinated with the outlet channel for the authorized Avon By-pass floodway channel, which has not been constructed. Navigation on the Skagit River is limited to shallow draft vessels and log rafts at times of high tide. As improvement of the Skagit River for increased navigation depths does not appear economically feasible in the foreseeable future, no significant potential for water-transport-oriented industry along the Skagit River is indicated. Development of the Skagit tide flats for industry and port facilities is a possibility, but would involve extensive dredging and filling as well as problems in maintaining adequate navigation channels.

A site of about 500 acres on Guemes Island has been zoned for industry and would be suitable for light or some heavy industries but because of regional as well as local opposition has not been included as a potential site.

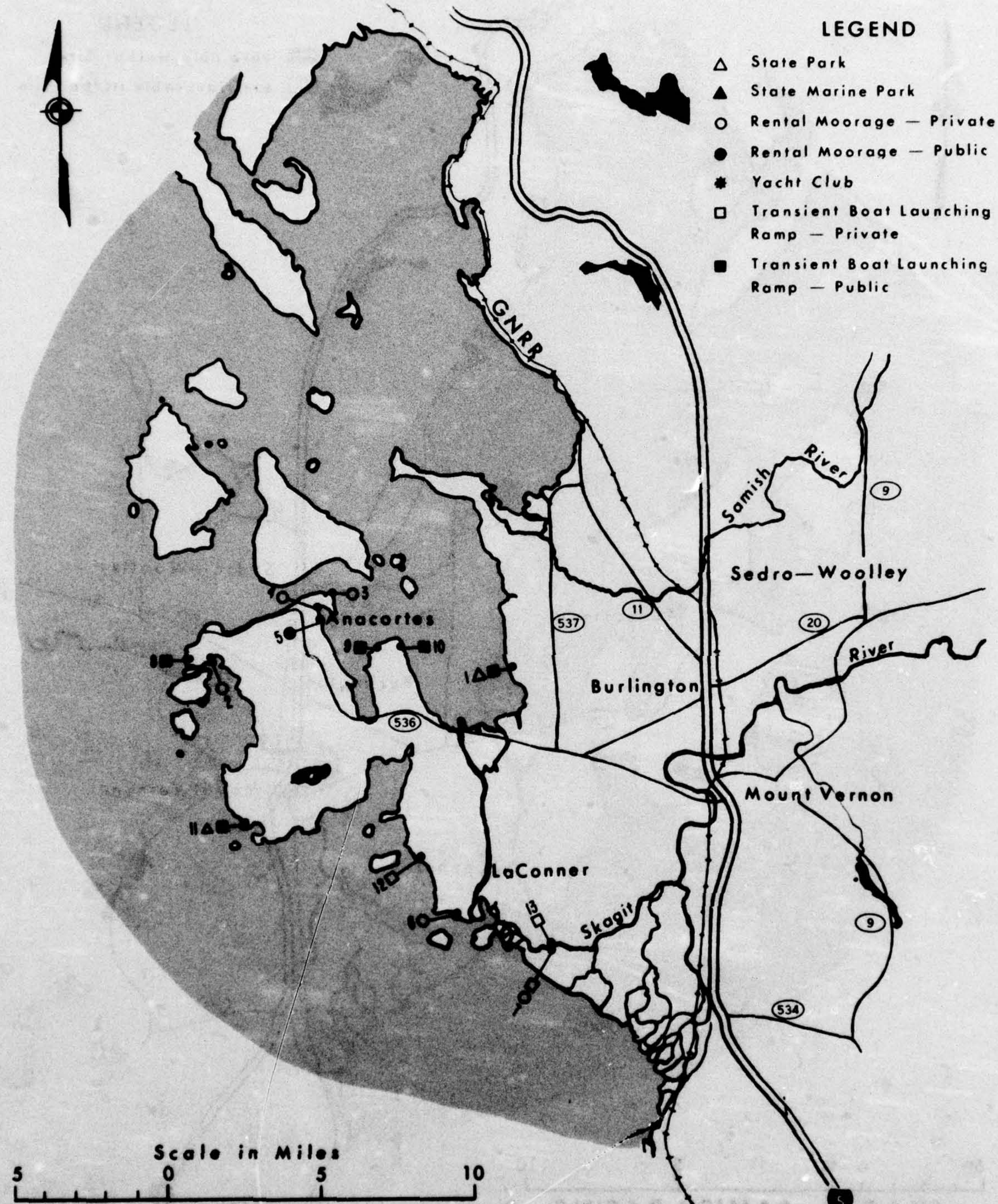
SMALL BOAT HARBORS

Existing small boat facilities on salt water as of 1966 are shown on Figure 4-6 and identified in Table 4-7.

Shown on Figure 4-7 are about seven miles of saltwater shoreline that are considered suitable for potential marina development.

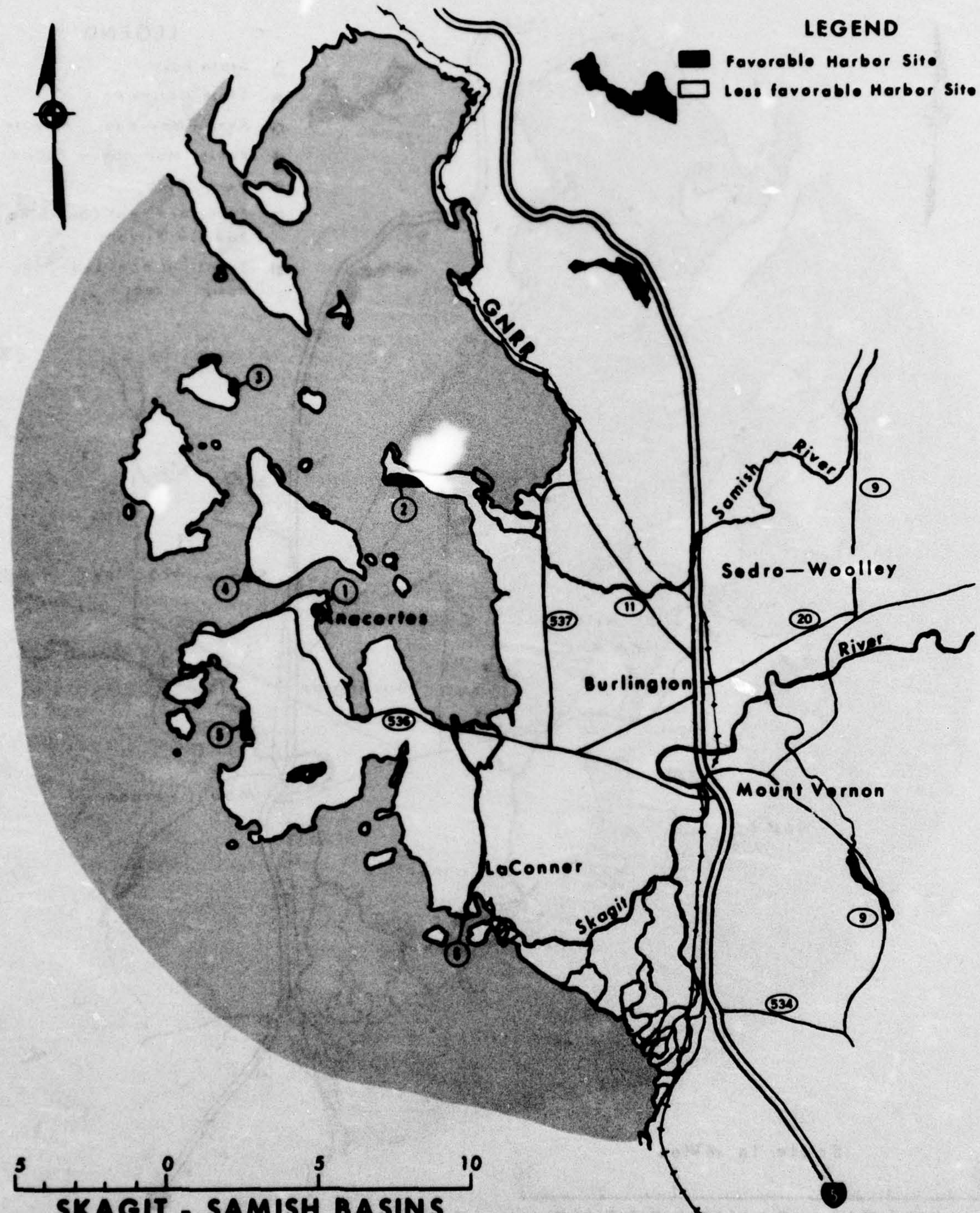
TABLE 4-7. Small boat facilities—Skagit-Samish Basins

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramps		Rental Moorages	
				Public	Private	Public	Private
1	Bay View State Park	X		X			
2	Skyline Marine Corp.						X
3	Gateway Marina Inc.						X
4	Bryants Marina						X
5	Port of Anacortes					X	
6	Otis Marina						X
7	Phil's Boat House				X		X
8	City of Anacortes			X			
9	March Point—State			X			
10	March Point—Public			X			
11	Deception Pass State Park			X			
12	Hope Island Fishing Resort				X		
13	Al's Landing				X		
	TOTALS	1	0	5	3	1	5



SKAGIT - SAMISH BASINS
SMALL BOAT HARBORS
1966

FIGURE 4-6



SKAGIT - SAMISH BASINS

SMALL BOAT HARBOR SITES

1966

FIGURE 4-7

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 with a framework plan developed for satisfying these needs by basin. Table 4-8 summarizes the navigation needs for the Skagit-Samish Basins as derived in Solutions to Navigation Needs.

TABLE 4-8. Skagit-Samish Basins—future navigation needs

Item	Unit	1980	Need By 2000[1]	Need By 2020[1]
Waterborne Commerce				
General Cargo	1,000	50		
Bulk Grain	Short Tons	0		
Forest Products		350		
Bulk Petroleum		8,270		
Other Dry Bulk		20		
Other Liquid Bulk		0		
Totals		8,690	12,700	30,100
Harbors & Channels Requirements				
Vessel Draft	Feet			
Freighters		39	40	40
Bulk Carriers		44	44	44
Tankers		45	71[3]	71[3]
Land Requirements	Acres			
Terminal and water-transport-oriented industry		2,920	4,050	5,910
Small Boat Harbors	Wet Moorages[2]	2,400	3,930	6,540

[1] Only aggregate tonnages projected after 1980.

[2] Taken as summer wet moorage demand.

[3] Draft of tankers projected to call in these Basins are expected to be comparable to maximum size bulk carriers.

MEANS TO SATISFY NEEDS

As elsewhere in the Puget Sound Area, waterborne commerce, particularly with respect to general cargo, dry bulk and petroleum, is expected to increase significantly in the Skagit-Samish Basins. Development of channels, industrial and terminal lands, and small boat facilities is vital to the well being of the Area as well as the Basins.

TERMINAL AND INDUSTRIAL LAND REQUIREMENTS

As noted in Table 4-8, approximately 5,900 acres of terminal and industrial lands will be required by 2020 to meet projected needs. This total includes 1,264 acres already developed for this purpose. Examination of Figure 4-5 and Table 2-10 shows that these needs can be satisfied by utilizing sites having a favorable potential for development.

HARBORS AND CHANNELS

To accommodate projected vessel drafts shown in Table 4-8, channel improvements should be made as shown below:

SMALL BOAT HARBORS

Listed in Table 4-9 are the sites in the Skagit-Samish Basins suitable for development of small boat harbors. These sites are shown on Figure 4-7. Although alternative sites are also available the sites selected are the most favorable in this Basin.

A tentative schedule of development to meet 1980, 2000 and 2020 needs is contained in Table 4-9. Benefits and costs for projects recommended to meet 1980 pleasure boating demand are also shown as are the estimated costs for additional projects required by 2000 and 2020. Costs shown are for general navigation facilities and navigation aids that may require Federal assistance in financing and construction. General navigation facilities consist of breakwaters, entrance channels, and turning basins and the navigation aids are normally lighted dolphins and breakwater lights. Costs are average values and are based on actual construction or detailed study cost estimates for small boat harbor projects in the Area. Average benefit values were derived using standard methods employed by the Corps of Engineers, data from the "Pleasure Boating Study," and other studies performed for small boat harbor projects. As no suitable sites were found for wet moorage development in the Stillaguamish Basin, with needs of that Basin met in planning for the adjacent Skagit-Samish Basins.

Period	Channel	Channel Depth In Feet	Estimated Cost	Estimated Annual Costs	Estimated Benefits	Estimated Benefit Cost Ratio
Prior to 1980	Guemes	54	$ 612,000	33,600	50,600	1.5
	Fidalgo Bay	32	853,000	54,000	54,500	1.0
1980-2000	Guemes	78	4,052,000	216,000	Not Est.	Not Est.
	Fidalgo Bay	40	942,000	50,000	Not Est.	Not Est.
	Padilla Bay	46	4,423,000	253,400	Not Est.	Not Est.
2000-2020	Fidalgo Bay	46	608,000	32,900	Not Est.	Not Est.
	Padilla Bay	54	2,381,000	125,900	Not Est.	Not Est.

TABLE 4-9. Small boat harbor sites—Skagit-Samish Basins

Site No.	Location	Wet Moorages	Water-Land Acre-Acres[4]	Tentative Schedule of Development: 1980	2000	2020
				Wet Moorages		
1.	Anacortes Addition	600	50	600		
2.	Padilla Bay—William Pt.	4,910	409			1,120
3.	Sinclair Island—East	320	27			
4.	Guemes Island Southwest	1,100	92			1,100
5.	Fidalgo Island—West	2,770	231		1,650	1,120
6.	LaConner—Indian Bay	500	42	250	250	
	Totals	10,200	851	850	1,900	3,340

Summary of Benefits and Costs

Construction Costs[3]	1980 Average Annual Costs[1,2]	Average Annual Benefits	2000 Construction Costs[3]	2020 Construction Costs[3]
$1,713,600	$109,700	$159,000	$3,830,400	$6,733,400

[1] Annual interest and amortization charges of general navigation facilitiy construction costs, including aids to navigation are computed for 50-year economic life at a rate of 4-5/8 percent.

[2] Includes allowance of $25 per wet moorage for annual maintenance and replacement costs.

[3] Includes allowance for Engineering, Design, Supervision and Administration costs.

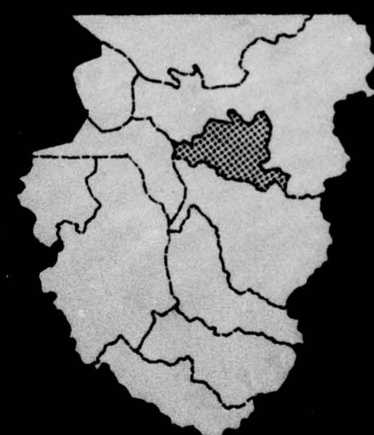
[4] Using relationships based on Shilshole Marina wet moorage land and water area requirements are estimated at 0.056 acres of water area for moorage and maneuvering and 0.028 acres of land for parking and services per boat.

Note: Not contained in the area requirements are land needs for launching ramps which will generally be incorporated with moorage facilities. Launching facilities require about 1.5 acres of land for ramp and parking for each lane provided.

Factors Influencing Implementation of Plan

The division of port authority within the Skagit-Samish Basins is the major problem with implementation of navigation improvements which require significant local contribution. The Ports of Anacortes and Skagit County both occupy portions of Skagit County, and as a result, share in the existing tax base from which development must be financed. Development of a terminal and water transport-oriented industrial site in Padilla Bay may be opposed by conservation interests.

Stillaguamish Basin



STILLAGUAMISH BASIN

DESCRIPTION

The 15 miles of salt water shore line of this basin is along the tide flats of Skagit Bay and the head of Port Susan. Access to deep water is by way of Port Susan and Saratoga Passage. No organized port district exists within this Basin.

PRESENT STATUS

HARBORS AND CHANNELS

There are no developed harbors with the Stillaguamish River which empties into the north end of Port Susan being navigable only at high tide. The Federal project as shown on Figure 5-1 authorizes dredging of the Stillaguamish River to a depth of 0.0 feet at mean lower low water with a channel 75 feet wide. The project is inactive because of the large volume of silt.

WATERBORNE COMMERCE

The only significant waterborne traffic in this basin is the movement of rafted logs on the Stillaguamish River which reached a maximum of 25,384 tons in 1963.

TERMINAL AND TRANSFER FACILITIES

There are only minor terminal facilities in this basin for fishing boats and forest products.

WATERFRONT AND INDUSTRIAL LAND

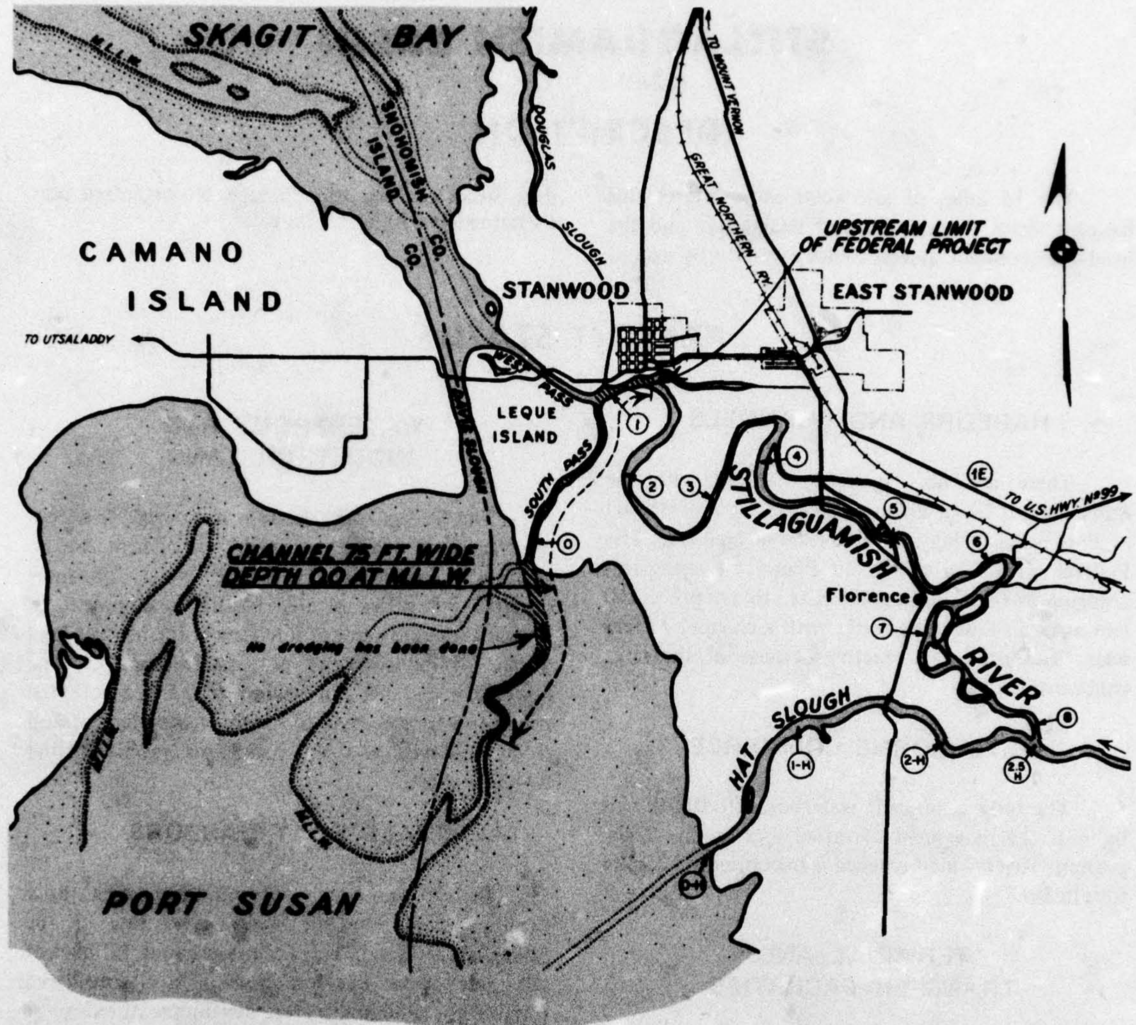
The Stillaguamish River is not navigable except on the lower reaches at high tide. There are no significant water terminals or water transport oriented industries in this basin. Development of several thousand acres of tide flats at the head of Port Susan for industry and port facilities might be a possibility, but has not been included as a potential site at this time because of the extensive dredging and filling involved and the major silt problems that would be faced.

SMALL BOAT HARBORS

In 1966 there were no significant small boat facilities along the salt water shore line of the Stillaguamish Basin. This basin has about 15 miles of salt water shore line but none of it is considered suitable for potential marina development, except as part of a major commercial development on the waterfront.

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 with a framework plan developed for satisfying these needs. Table 5-1 summarizes the navigation needs for the Stillaguamish Basin as derived in Solutions to Navigation Needs.



STILLAGUAMISH RIVER
WASHINGTON

SCALE IN MILES

Revised July, 1959
1966

FIGURE 5-1

TABLE 5-1. Stillaguamish Basin—Future navigation needs

Item	Unit	Needs by 1980	2000	2020
Waterborne Commerce			None Projected	
General Cargo	1,000			
Bulk Grain	Short Tons			
Forest Products				
Bulk Petroleum				
Other Dry Bulk				
Other Liquid Bulk				
Totals				
Harbors & Channels Requirements			None Projected	
Vessel Draft	(feet)		None Projected	
Freighters				
Bulk Carriers				
Tankers				
Land Requirements	Acres		None Projected	
Terminal and water-transport-oriented industry				
Small Boat Harbors	Wet Moorages[1]	400	770	1,500

[1]Taken as summer wet moorage demand.

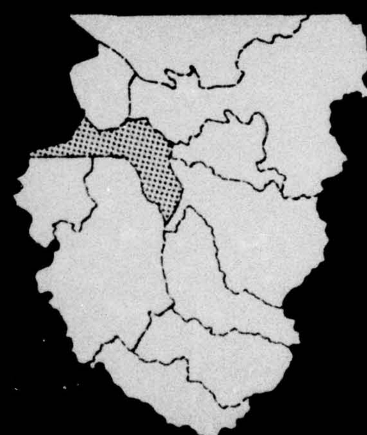
MEANS TO SATISFY NEEDS

As the shoreline of the Stillaguamish Basin is very unfavorable for deep water terminals, no significant development of water transport-oriented industries is expected.

SMALL BOAT HARBORS

The entire shoreline of the Stillaguamish Basin is composed of extensive tide flats that are considered unfavorable for development of small boat basins. As no suitable sites were found for wet moorage development, needs of this basin were considered to be met by planning for the Skagit-Samish Basins.

Whidbey-Camano Islands



WHIDBEY — CAMANO ISLANDS

DESCRIPTION

Whidbey Island, the second largest island in the conterminous United States, is bounded on the west by the Strait of Juan de Fuca and Admiralty Inlet; on the north by Deception Pass; on the east by Skagit Bay and Saratoga Passage; and on the southeast by Possession Sound. Access from Whidbey Island to the mainland is available by the highway bridge across Deception Pass. The Ports of Langley and Coupeville are the two organized port districts on Whidbey Island, encompassing all but the most northerly part of the Island.

Camano Island is bounded on the west and south by Saratoga Passage; on the north by Skagit Bay; and on the east by Port Susan. The island has a highway bridge connection to the mainland across West Pass in the vicinity of Stanwood.

Whidbey-Camano Islands have a combined total of about 221 miles of saltwater shoreline.

PRESENT STATUS

HARBORS AND CHANNELS

Whidbey Island has a number of minor harbors with ferry landings and/or piers for other local traffic, while there are no significant harbor developments on Camano Island.

Keystone Harbor, an improved part of Lake Crockett, lies just northeastward of Admiralty Head. A county ferry pier is maintained in the harbor. A Federal project at Lake Crockett consists of a mooring basin and entrance channel protected by a breakwater as shown on Figure 6-1. Other minor harbors on Whidbey Island are at Oak Harbor, Cresent Harbor, Coupeville, Columbia Beach, Juan de Fuca and Cornet Bay.

WATERBORNE COMMERCE

The waterborne traffic with these islands is not sufficient to be separately published but is included as part of the tonnage shown for "Other Puget Sound Area Ports" in Waterborne Commerce of the United States.

TERMINAL AND TRANSFER FACILITIES

Existing navigation terminal facilities on Whidbey Island include two ferry landings, a number of piers for fishing and other small boats, a few log dumps and facilities for the use of the military installations.

WATERFRONT AND INDUSTRIAL LAND

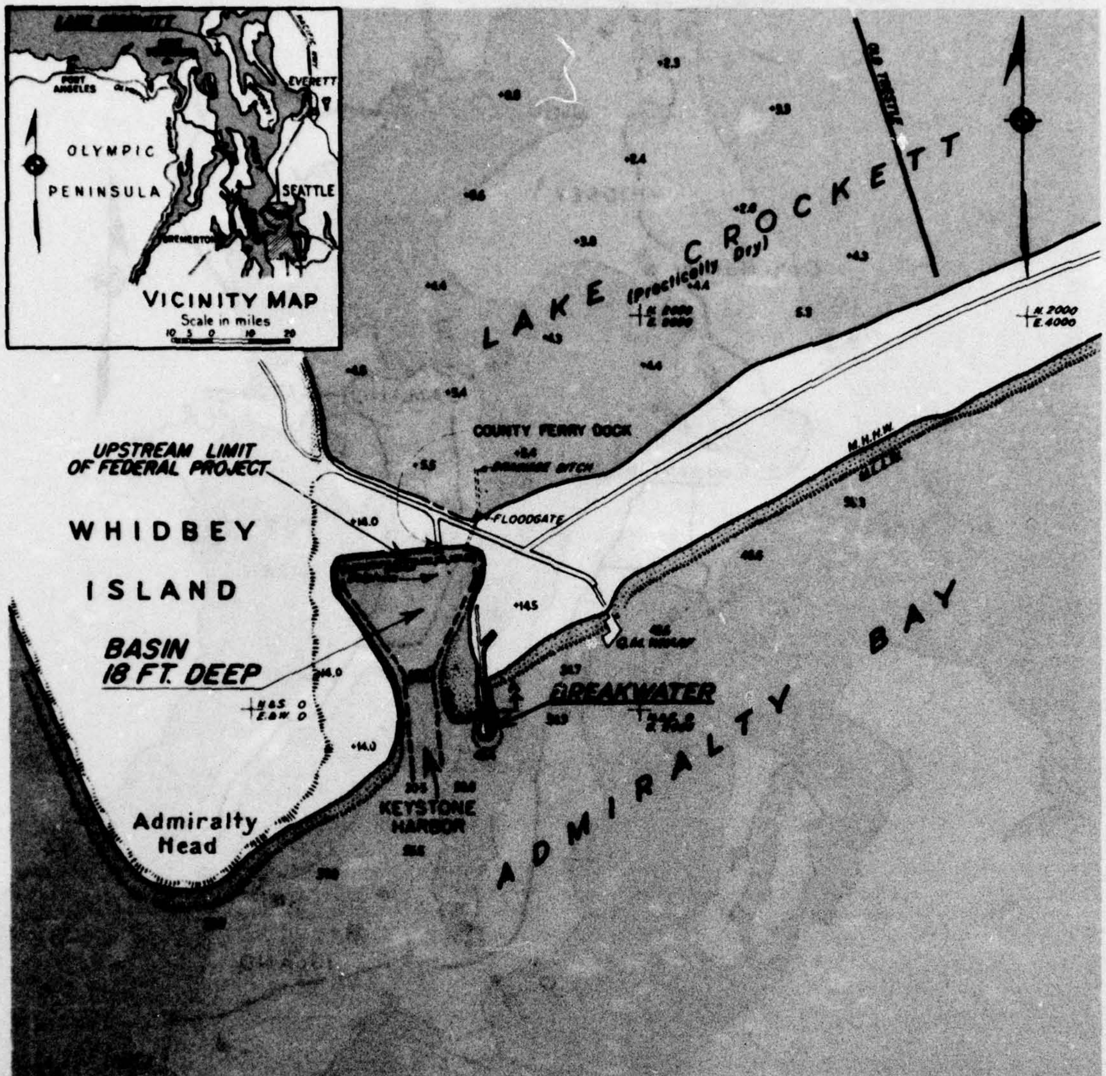
Water-transport-oriented industry is limited to two saw mills. As future development is expected to be mostly residential in support of the military installations, commuting industrial workers in adjacent basins and for retirement and recreation, no major industrial development is foreseen. However, there are several well protected harbor areas that could be developed as water terminals if needed to serve possible industrial plants. About 8,000 acres on Whidbey Island are being used for military purposes.

SMALL BOAT HARBORS

The small boat facilities existing on salt water in 1966 are shown on Figure 6-2 and summarized in Table 6-1. Shown on Figure 6-3 are about 21 miles of shoreline that are suitable for potential marina development.

TABLE 6-1. Small boat facilities—Whidbey-Camano Islands

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp		Rental Moorage	
				Public	Private	Public	Private
1	Deception Pass	X		X			
2	Cornet Bay State Marine Park		X	X			
3	Fort Casey	X					
4	South Whidbey	X					
5	Fort Ebey	X					
6	Mukilteo	X					
7	Camano Island	X		X			
8	Coronet Bay Marina				X		X
9	Whidbey Deception Pass Boat Club				X		
10	City of Coupeville			X		X	
11	Shore Meadows Resort						X
12	Sunrise Beach Resort						X
13	Langley Marina					X	
14	Lee Ora Del Mar, Inc.						X
15	Dugalla Bay				X		
16	Oak Harbor City Beach			X			
17	West Beach Road			X			
18	Island County Keystone Park (Lake Crockett)			X			
19	Holmes Harbor			X			
20	Langley City Dock			X			
21	Mutiny Bay Resort				X		
22	Camp Grande			X			
23	Maple Grove Resort				X		
24	Madrona Beach Resort				X		
25	Sunset Beach Resort				X		
	Total	6	1	10	7	2	4



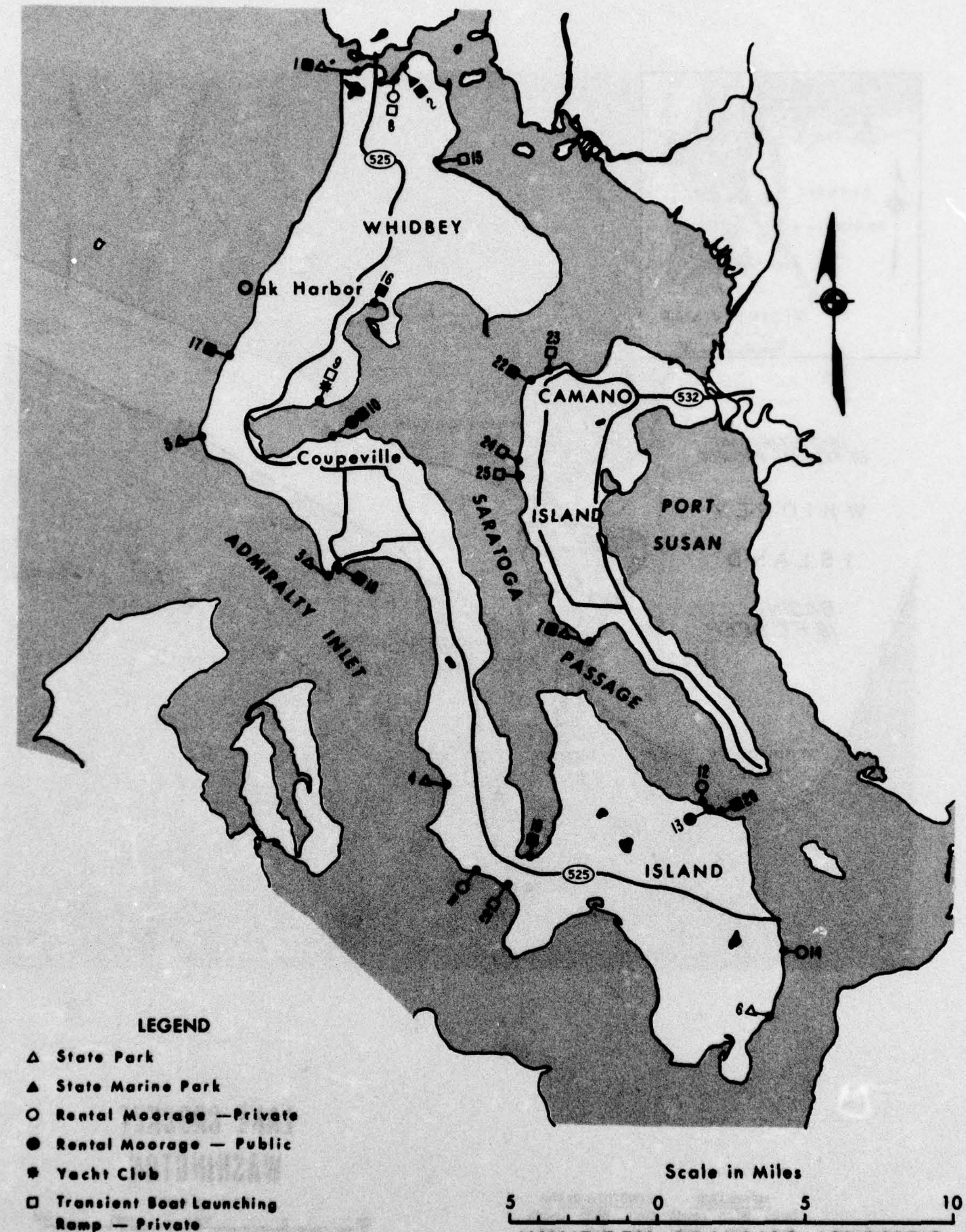
Improvement	AUTHORIZED Depth Feet	AUTHORIZED Width Feet	AUTHORIZED Length Feet	CONDITION IN 1966 Depth Feet	CONDITION IN 1966 Width Feet	CONDITION IN 1966 Length Feet
Mooring basin	18	6 Acres		17.6	except along edges	
Entrance Channel	18	150	500	18.2	140	500

LAKE CROCKET
WASHINGTON

SCALE IN FEET
500 0 500 1000 1500

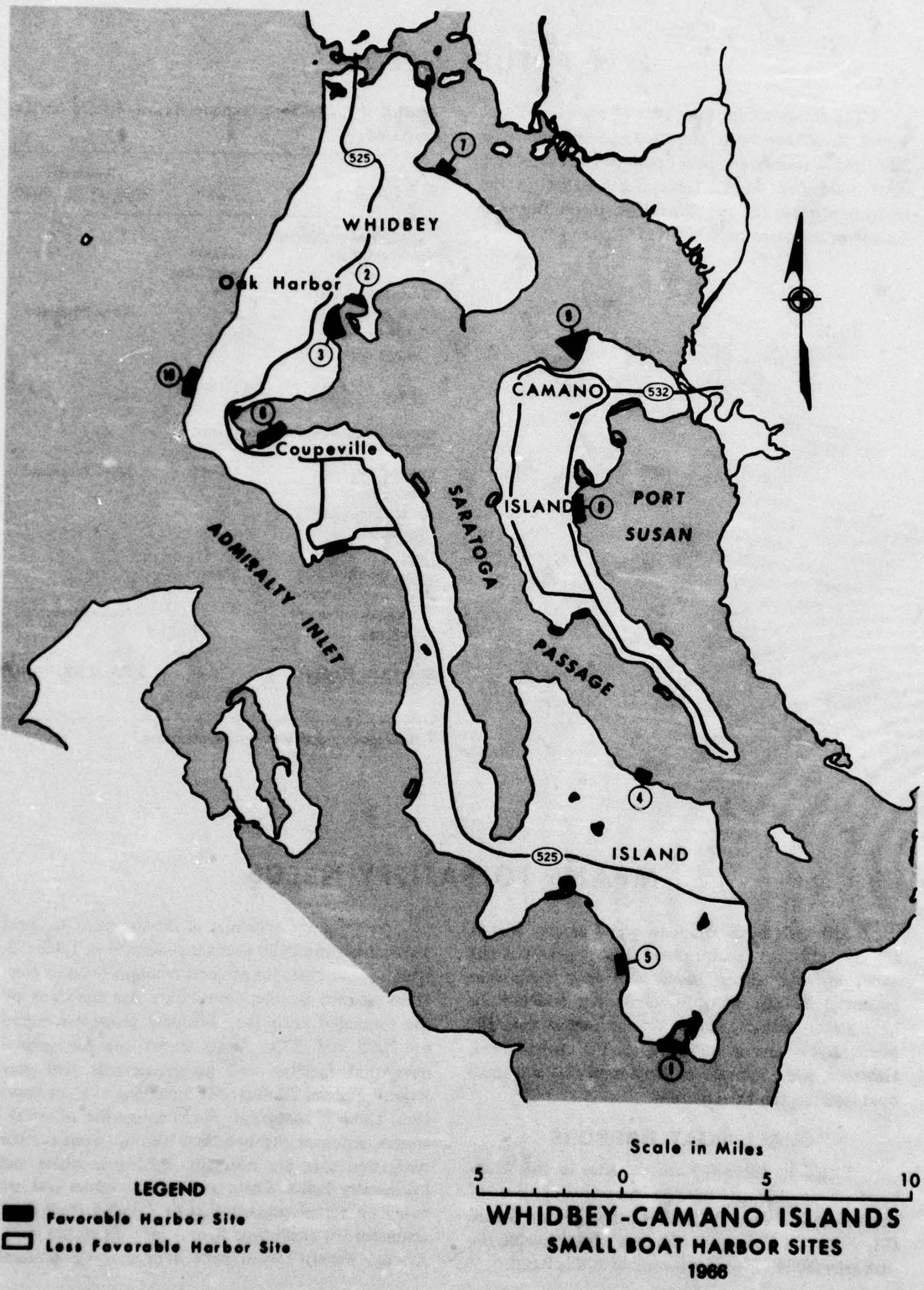
Revised Sept. 1962
1966

FIGURE 6-1



WHIDBEY-CAMANO ISLANDS
SMALL BOAT HARBORS
1966

FIGURE 6-2



WHIDBEY-CAMANO ISLANDS
SMALL BOAT HARBOR SITES
1966

FIGURE 6-3

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 and a framework plan developed for satisfying these needs by basin. Table 6-2 summarizes the navigation needs for the Whidbey-Camano Basins as derived in Solutions to Navigation Needs.

TABLE 6-2. Whidbey-Camano Basins—future navigation needs

Item	Unit	Needs By 1980	2000	2020
Waterborne Commerce				
General Cargo	1,000 Short Tons			
Bulk Grain				
Forest Products				
Bulk Petroleum		None Projected		
Other Dry Bulk				
Other Liquid Bulk				
Total				
Harbors & Channels Requirements				
Vessel Draft	Feet	None Projected		
Freighters				
Bulk Carriers				
Tankers				
Land Requirements	Acres			
Terminal and water-transport-oriented industry		None Projected		
Small Boat Harbors	Wet Moorages[1]	3,770	6,300	10,690

[1] Taken as summer wet moorage demand.

MEANS TO SATISFY NEEDS

Although both Whidbey and Camano Islands are connected to the mainland by bridges, it is not expected that either island will have significant industrial development. Residents are reluctant to have major industry locate on the islands with the possibility of major alterations in the environment. However, some increase in ferry terminals and small boat landings can be expected.

SMALL BOAT HARBORS

Listed in Table 6-3 are the sites in the Whidbey-Camano Islands suitable for development of small boat harbors. These sites are shown on Figure 6-3. Although alternative sites are also available the sites selected are the most favorable in this Basin.

A tentative schedule of development to meet 1980, 2000 and 2020 needs is contained in Table 6-3. Benefits and costs for projects recommended to meet 1980 pleasure boating demand are also shown as are the estimated costs for additional projects required by 2000 and 2020. Costs shown are for general navigation facilities and navigation aids that may require Federal assistance in financing and construction. General navigation facilities consist of breakwaters, entrance channels, and turning basins and the navigation aids are normally lighted dolphins and breakwater lights. Costs are average values and are based on actual construction or detailed study cost estimates for small boat harbor projects in the Area. Average benefit values were derived using standard

TABLE 6-3. Small boat harbor sites—Whidbey-Camano Basins

Site No.	Location	Wet Moorages	Water-Land Area-Acres[4]	Tentative Schedule of Development 1980	2000	2020
				Wet Moorages		
1.	Cultus Bay	2,050	171			2,050
2.	Oak Harbor—Phase I	500	42	500		
3.	Oak Harbor—Phase II	1,660	138		1,660	
4.	Langley	500	42	500		
5.	Useless Bay—Maxwelton	1,370	114			1,370
6.	Penn Cove—Coupeville	1,540	128			1,540
7.	Skagit Bay—Dugualla Bay	1,540	128			1,540
8.	Port Susan—Camanols	1,840	153			1,840
9.	Skagit Bay—Utsalady	2,050	171		1,000	1,050
10.	Pt. Partridge	1,300	108	1,300		
	Totals	14,350	1,195	2,300	2,660	9,390

Summary of Benefits and Costs

1980 Construction Costs[3]	1980 Average Annual Costs[1,2]	1980 Average Annual Benefits	2000 Construction Costs[3]	2020 Construction Costs[3]
$4,648,000	$297,600	$430,800	$5,354,500	$18,910,000

[1] Annual interest and amortization charges of general navigation facility construction costs, including aids to navigation are computed for 50-year economic life at a rate of 4-5/8 percent.

[2] Includes allowance of $25 per wet moorage for annual maintenance and replacement costs.

[3] Includes allowance for Engineering, Design, Supervision and Administration costs.

[4] *Using relationships based on Shilshole Marina wet moorage land and water area requirements are estimated at* 0.056 acres of water area for moorage and maneuvering and 0.028 acres of land for parking and services per boat.

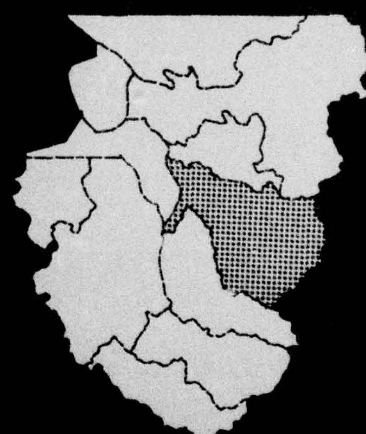
Note: Not contained in the area requirements are land needs for launching ramps which will generally be incorporated with moorage facilities. Launching facilities require about 1.5 acres of land for ramps and parking for each lane provided.

methods employed by the Corps of Engineers, data from the "Pleasure Boating Study," and other studies performed for small boat harbor projects. The number of wet moorages proposed in the basin plan for development after 2000 include provision for spillover demand from the Cedar-Green Basins.

Factors Influencing Implementation of Plan

Considerable public investment will be required to construct the many small boat harbors planned for the Whidbey-Camano Islands. However, existing authority is fragmented among several small ports which do not have adequate financial capability to undertake major projects. Integrated authority with all of Island County constituting a port district would provide an improved base for financing needed pleasure boating facilities.

Snohomish Basin



SNOHOMISH BASIN

DESCRIPTION

The 53 miles of salt water shoreline of this basin follows along Possession Sound and Port Susan. Most of this shoreline is backed by steep hillsides and bluffs except for the tide flats at the mouth of the Snohomish River. The Port of Everett is the only organized port district in the basin. The Basin is served by four transcontinental railroads. Interstate 5 and U.S. Highway 99 are the major north-south highways. U.S. Highway 2 is the major east-west highway.

PRESENT STATUS

HARBORS AND CHANNELS

The principal harbor development in the Snohomish Basin is Everett Harbor. Located on the east side of Port Gardner at the mouth of the Snohomish River, Everett Harbor is 117 nautical miles from the Pacific Ocean. Although the southerly portion of Port Gardner has depths of over 400 feet, the northeasterly portion is an extensive tidal flat. The Federal project for Everett Harbor and Snohomish River is shown on Figure 7-1. Beyond the upper limit of the Federal improvement on the Snohomish River navigation is limited to shallow draft barges, small boats and logs.

A minor harbor for small boats is located at Tulalip on Tulalip Bay, about 4 miles northwest of Everett.

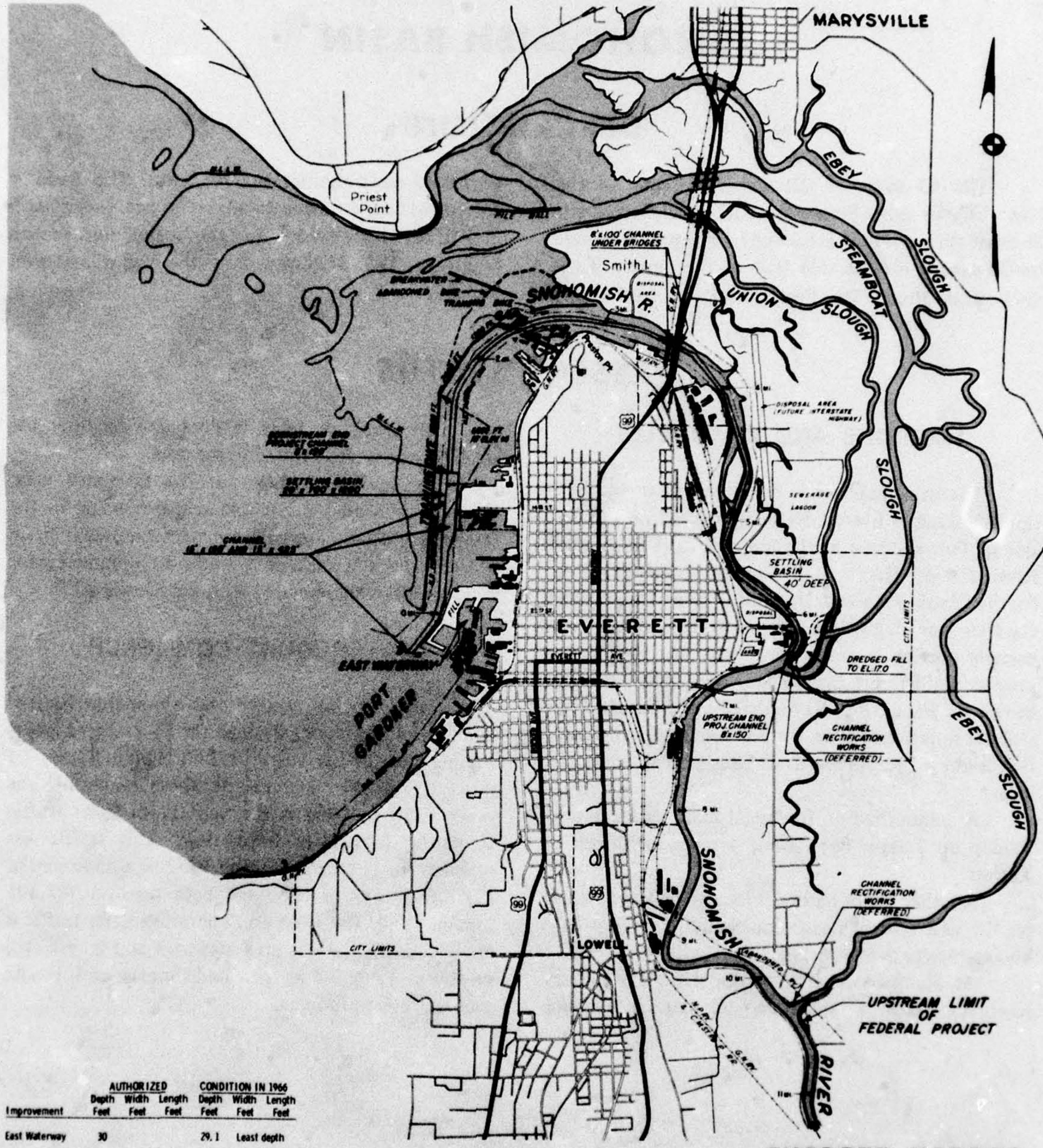
Another minor harbor is located at Meadowdale on the east side of Possession Sound in Brown Bay, known locally as Haines Wharf.

At Mukilteo on Elliot Point there is a military reservation with a tank farm and pier for handling bulk petroleum. A ferry landing and facilities for small boats are also located in the area.

The harbor facilities in the Edmonds area, although indicated on report maps as being in the Snohomish Basin, are included with the Cedar Basin because the statistics on waterborne commerce for these facilities are included with the Seattle area.

WATERBORNE COMMERCE

Practically all waterborne commerce for the Snohomish Basin goes through the Everett area and is summarized for the years 1952 to 1966 in Tables 7-1 through 7-4. Not included in these tables for the years 1952 to 1964 is the Snohomish River traffic consisting mostly of rafted logs. This traffic has varied from 1,882,998 tons in 1952 to a minimum of 1,088,085 tons in 1963 and back up to 1,347,301 tons in 1964. The 1965-66 Snohomish River traffic is included with Everett area statistics and is reflected mostly in Table 7-4 as increased tonnage of domestic internal forest products.



Improvement	AUTHORIZED Depth Feet	Width Feet	Length Feet	CONDITION IN 1966 Depth Feet	Width Feet	Length Feet
East Waterway	30			29.1	Least depth	
River Channel Lower Harbor to Settling Basin	15	150-425		11.1	125	
Settling Basin	20	700	2000	7.3	Least depth	
Settling Basin to G.N. Ry	8	150		6.9	130	
				CONDITION IN 1967		
From G.N. Ry. to upstream settling basin	8	150		7.3 ft. on centerline		
Upstream settling basin	1 million cu. yds			21.9 Least depth (500,000 cy. yds.)		
Upstream from settling basin	8	150		6.7 ft. on centerline		

EVERETT HARBOR & SNOHOMISH RIVER WASHINGTON

SCALE IN FEET

1000 0 5000 10000

Revised Sept, 1963

FIGURE 7-1

TABLE 7-1. Water-borne commerce for Everett Area. Foreign in short tons

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
FOREIGN IMPORTS							
1952	484	0	57,219	0	38,537	3,064	99,304
1953	3,026	0	68,754	0	34,514	1,310	107,603
1954	1,274	0	31,133	0	37,388	0	69,795
1955	4,242	0	24,621	85,402	20,420	0	134,685
1956	1,128	0	24,205	56,417	29,567	0	111,317
1957	783	0	39,197	70,310	22,612	0	132,902
1958	2,876	0	22,597	16,927	61,723	0	104,123
1959	2,554	0	10,181	0	57,941	0	70,676
1960	6,414	0	40,854	0	71,656	0	118,924
1961	6,650	0	49,900	0	93,343	0	149,893
1962	3,544	0	12,787	18,805	165,447	0	200,583
1963	4,914	0	34,449	23,159	183,256	0	245,778
1964	4,554	0	11,493	0	149,584	0	165,631
1965	2,624	0	2,557	0	175,555	0	180,736
1966	1,790	0	3,094	0	324,205	0	329,089
FOREIGN EXPORTS							
1952	5,227	0	9,600	0	0	0	14,827
1953	12,171	0	13,197	0	0	0	25,368
1954	18,163	0	11,230	0	0	0	29,393
1955	22,434	0	13,750	0	0	0	36,184
1956	18,227	0	4,604	0	0	0	22,831
1957	20,773	0	5,795	0	0	0	26,568
1958	30,424	0	3,279	0	0	0	33,703
1959	37,599	0	7,678	0	0	0	45,277
1960	94,581	0	11,501	0	0	0	106,082
1961	75,623	0	33,265	0	19,662	0	128,550
1962	110,293	0	67,820	0	16,771	0	194,884
1963	127,618	0	292,087	0	7,836	0	427,541
1964	90,090	0	222,900	0	51	0	313,041
1965	70,058	0	281,904	10	226	0	352,198
1966	94,681	16,464	336,079	0	16,500	0	463,724

TABLE 7-2. **Water-borne commerce for Everett Area. Domestic coastwise in short tons**

DOMESTIC COASTWISE RECEIPTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	37,603	0	0	0	0	0	37,603
1953	39,915	0	0	0	0	0	39,915
1954	42,372	0	0	0	0	0	42,372
1955	35,263	0	600	88,764	0	0	124,627
1956	42,319	0	1,600	114,684	0	0	158,603
1957	40,374	0	3,613	28,548	0	0	72,535
1958	29,415	0	568	12,207	0	0	42,190
1959	42,933	0	1,055	0	0	0	43,988
1960	45,670	0	1,178	0	0	0	46,848
1961	42,288	0	0	5,098	0	0	47,386
1962	0	0	0	4,300	17,583	0	21,883
1963	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0
1965	255	0	0	0	0	0	255
1966	2,619	0	739	0	0	0	3,358

DOMESTIC COASTWISE SHIPMENTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	22,757	0	523	939	1,851	0	26,070
1953	47,751	0	3,659	0	0	0	51,410
1954	68,576	0	5,714	0	0	0	74,290
1955	31,471	0	703	0	0	0	32,174
1956	61,719	0	84	0	2,073	0	63,876
1957	80,402	0	5,626	678	0	0	86,706
1958	72,940	0	2,900	594	0	0	76,434
1959	68,544	0	590	0	0	0	69,134
1960	69,812	0	5,338	564	590	0	76,304
1961	78,599	0	4,561	685	0	0	83,845
1962	49,755	0	1,054	1,982	3,002	0	55,793
1963	31,637	0	2,644	1,170	0	0	35,451
1964	1,816	0	3,668	165	0	0	5,649
1965	3,933	0	3,817	2,656	944	0	11,350
1966	4,252	0	10,262	0	0	0	14,514

TABLE 7-3. Water-borne commerce for Everett Area, in short tons

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	66,071	0	67,342	939	40,388	3,064	177,804
1953	102,862	0	85,610	0	34,514	1,310	224,296
1954	130,385	0	48,077	0	37,388	0	215,850
1955	93,410	0	39,674	174,166	20,420	0	327,670
1956	123,393	0	30,493	171,101	31,640	0	356,627
1957	142,332	0	54,231	99,536	22,612	0	318,711
1958	135,655	0	29,344	29,728	61,723	0	256,450
1959	151,630	0	19,504	0	57,941	0	229,075
1960	216,477	0	58,871	564	72,246	0	348,158
1961	203,160	0	87,726	5,783	113,005	0	409,674
1962	163,592	0	81,661	25,087	202,803	0	473,143
1963	164,169	0	329,180	24,329	191,092	0	708,770
1964	96,460	0	238,061	165	149,635	0	484,321
1965	76,870	0	288,278	2,666	176,725	0	544,539
1966	103,342	16,464	350,174	0	340,705	0	810,685

TABLE 7-4. Water-borne commerce for Everett Area, in short tons

			DOMESTIC INTERNAL				
Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	11,352	0	2,582,817	97,635	104,343	0	2,796,147
1953	11,177	0	2,468,884	116,456	126,238	0	2,722,755
1954	11,859	0	1,820,705	172,086	142,168	0	2,146,818
1955	16,882	0	2,746,157	108,375	99,700	0	2,971,114
1956	18,759	0	2,484,862	75,866	114,243	25	2,693,755
1957	22,589	0	2,328,994	43,356	126,107	0	2,521,046
1958	57,043	0	2,042,411	29,708	139,094	0	2,268,256
1959	12,359	0	2,295,095	27,566	183,972	0	2,518,992
1960	10,228	0	2,341,010	32,706	137,106	0	2,521,050
1961	14,133	0	1,528,992	24,511	76,872	0	1,644,508
1962	21,480	0	1,642,396	23,361	115,001	0	1,802,238
1963	8,794	0	696,417	19,749	133,902	0	858,862
1964	10,423	0	996,351	27,592	149,315	0	1,183,681
1965	6,458	0	1,537,495	53,581	237,467	0	1,835,001
1966	9,151	0	1,750,181	46,991	246,627	0	2,052,950

TERMINAL AND TRANSFER FACILITIES

As shown on Figure 7-2 major port facilities are situated on the east side of Port Gardner and the lower 19 miles of the Snohomish River. Terminal facilities as of 1952 and 1963 are summarized in Tables 7-5 and 7-6 respectively. A comparison of these data shows that about 2,400 lineal feet of cargo berthing space was added between 1952 and 1963. During the same period covered storage was increased from 90,000 square feet to 187,000 square feet and 2.7 acres of open storage was added. By 1967 there was added about 2 acres more of open storage area and the available depth at two more berths was increased to over 40 feet. By July 1969, the Port of Everett will have in operation a modern crane to serve all containerized and unitized cargo as well as a bulk unloading rate of 900 tons per hour. Included in the facility will be a bulk storage dome of 55,000 ton capacity and a 350 ton per hour car unloader. In the planning stage is the development of about 2,200 acres at the mouth of the Snohomish River, referred to herein as Snohomish Delta Plan 1.

TABLE 7-5. Terminal facilities Everett Area 1952

	Depth 18' & Less		Depth 18' - 40'		Depth 40' +			
Use	No. of Berths	Berth Space In Feet	No. of Berths	Berth Space In Feet	No. of Berths	Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	5	1,300	7	3,209	0	0	90,000	0
Bulk Grain	0	0	0	0	0	0	0	0
Forest Products	24	8,717	4	1,683	0	0	0	0
Bulk Petroleum	5	558	3	326	0	0	0	0
Other Dry Bulk	2	990	0	0	0	0	0	0
Other Liquid Bulk	0	0	0	0	0	0	0	0
Totals	36	11,565	14	5,218	0	0	90,000	0
Construction & Repair	5	1,320	11	3,715	1	480	0	0
Mooring	8	2,530	1	110	0	0	0	0

TABLE 7-6. Terminal facilities Everett Area 1963

	Depth 18' & Less		Depth 18' - 40'		Depth 40' +			
Use	No. of Berths	Berth Space In Feet	No. of Berths	Berth Space In Feet	No. of Berths	Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	4	378	8	3,677	1	140	146,378	2.7
Bulk Grain	0	0	0	0	0	0	0	0
Forest Products	19	10,443	7	2,692	0	0	40,700	0
Bulk Petroleum	4	675	3	476	0	0	0	0
Other Dry Bulk	2	505	0	0	0	0	0	0
Other Liquid Bulk	2	160	0	0	0	0	0	0
Totals	31	12,161	18	6,845	1	140	187,078	2.7
Construction & Repair	6	812	0	0	0	0	0	0
Mooring	0	4,240	0	2,342	0	0	0	0

WATERFRONT AND INDUSTRIAL LAND

The existing and potential sites of water transport oriented industries and terminal facilities in the Snohomish Basin are indicated on Figure 7-3 and summarized in Table 7-7. In this table the net areas are the gross areas less right-of-way for streets and highways. The following discussion refers to site numbers shown on reference figure and table.

Site No. 1 includes the partially developed lands along the Everett and Lowell waterfronts. Scattered in relatively small parcels these areas are suitable mostly for terminal facilities and light industries.

Site No. 2 is a small partially developed area in Marysville that is suitable for light to medium industry.

Site No. 3 at the mouth of the Snohomish River is being considered as Plan 1 for the development of the Snohomish delta area. This area is suitable for port terminal facilities and light and heavy industries. Unlimited depths are available for navigation but extensive dredging and filling are involved. Development must be coordinated with the flood control plan for the lower Snohomish.

Site No. 4 includes a land area that would be added to Plan 1 by Plan 2 for the development of the Snohomish delta area. This area is suitable for additional port facilities and light and heavy industries. This area involves additional dredging and filling as well as coordination with the flood control plan.

Site No. 5 includes a land area that would be added to Plans 1 and 2 by Plan 3 for the development of the Snohomish delta area. This area is suitable for light and heavy industries but the adjacent navigation channel would probably not be developed for anything but shallow drafts. Additional dredging and filling as well as coordination with the flood control plan are involved.

Site No. 6 located on Port Susan is owned by the Richfield Oil Company that has proposed to develop the site for an oil refinery. Unlimited depths are available for navigation.

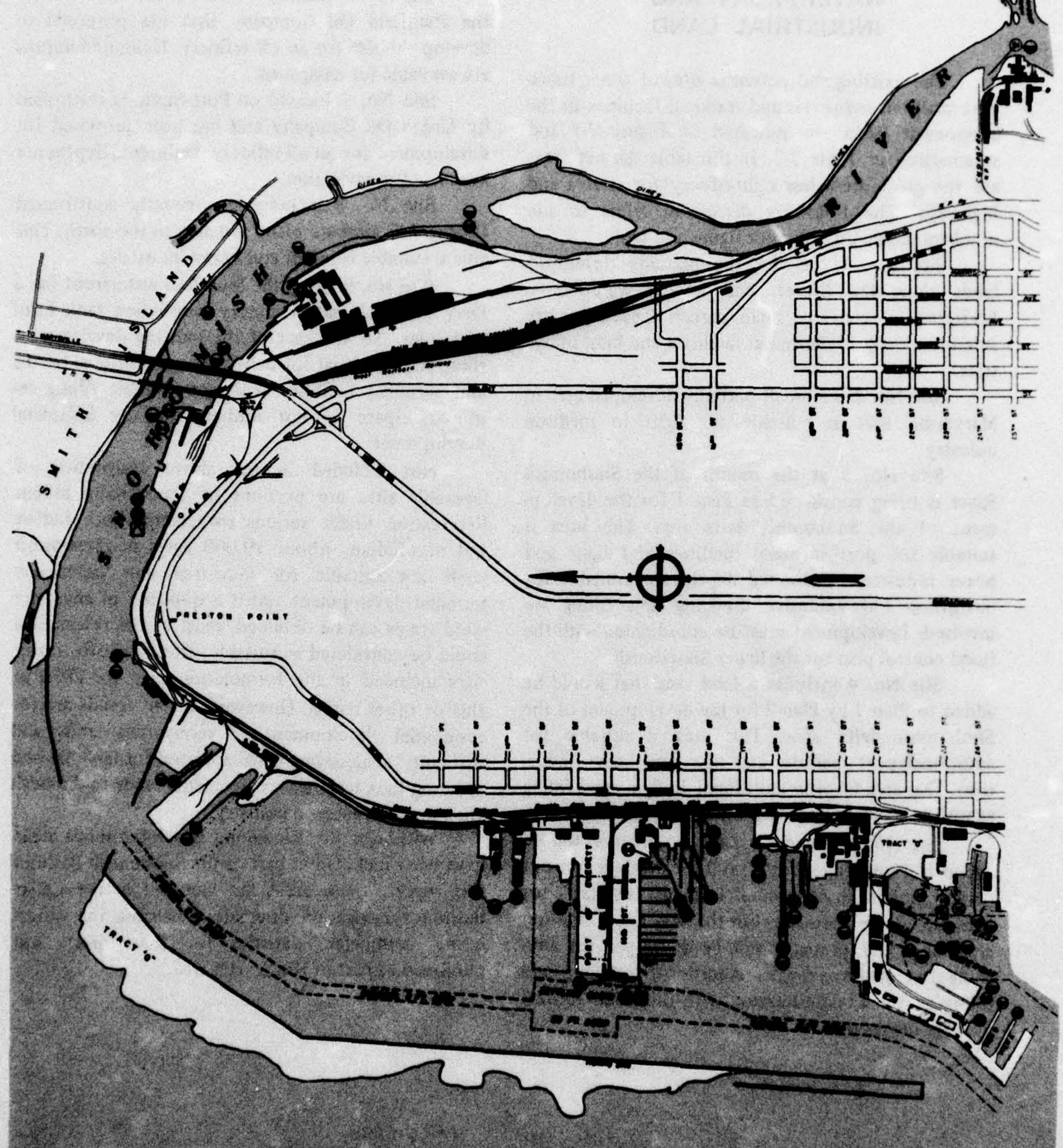
Site No. 7 located on Port Susan is controlled by Union Oil Company and has been proposed for development for an oil refinery. Unlimited depths are available for navigation.

Site No. 8 includes the recently constructed Boeing 747 airplane plant and area to the north. This area is suitable for light and heavy industries.

Site No. 9 along the Mukilteo waterfront has a ferry terminal and a military reservation tank farm with pier. To the east of the existing development there is a potential for constructing additional berths and terminal facilities with considerable filling required. Space is too limited for any industrial development.

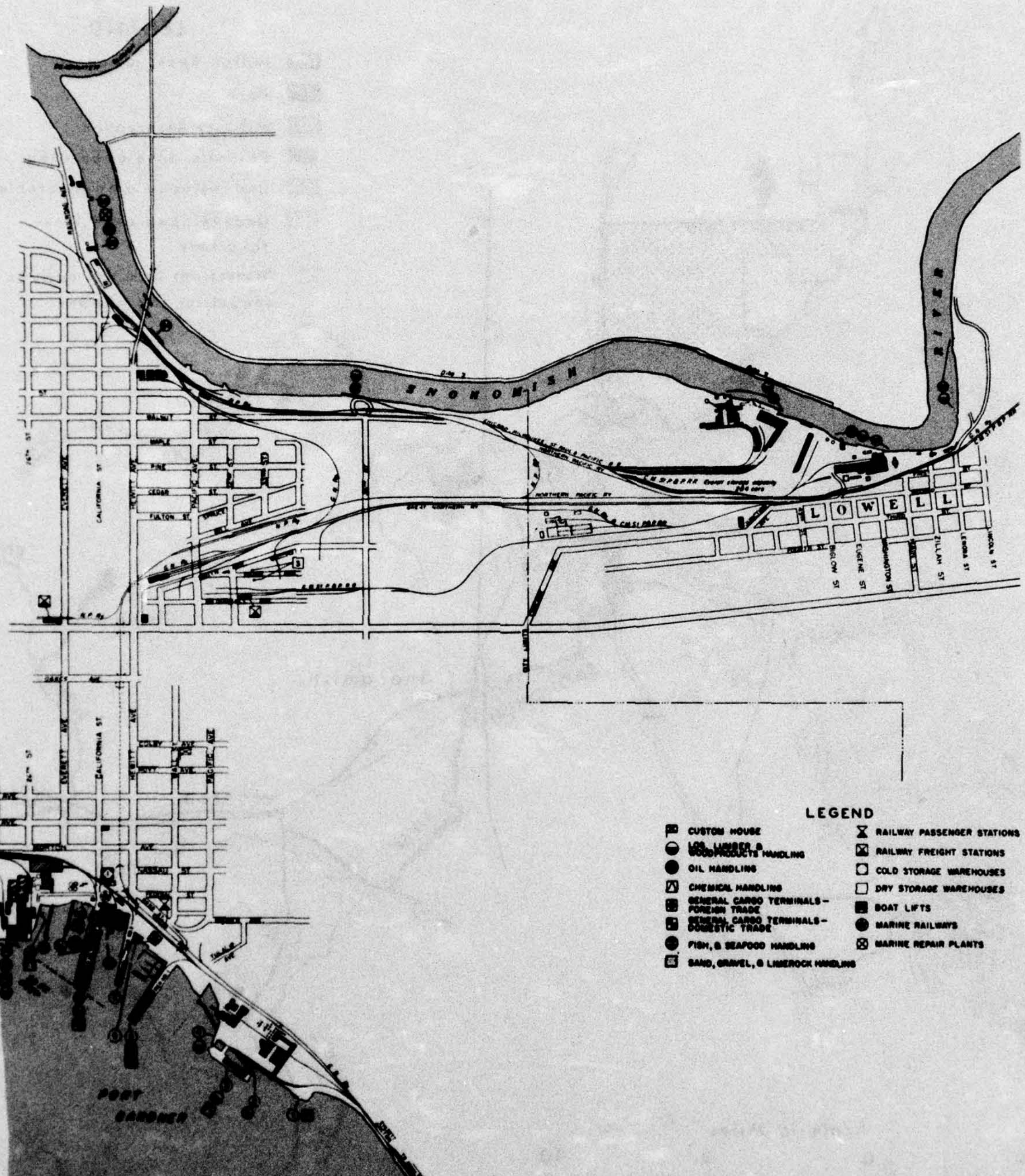
Not included in the above designation of favorable sites are portions of the Tulalip Indian Reservation under various ownerships both Indian and non-Indian. About 19,000 acres of reservation lands are suitable for industrial and waterfront terminal development and if acquisition of adequate sized tracts can be obtained, most of the reservation could be considered as suitable, alternative for many sites included in the formulation plan for 2020 in this or other basins. However, current trends are for residential development of reservation lands and difficulty in achieving tribal approval for land use and securing long-term lease agreements tends to diminish their attractiveness to industry.

Although the Richmond Beach-Edmonds areas have been included as part of the Snohomish Basin in this report, these areas are included in the Cedar Basin for navigation discussions because the waterborne commerce statistics for these ports are published as part of the Seattle area.



NOTES:
1. NUMERALS REFER TO DESCRIPTIONS IN PORT SERIES NO. 37
2. CHANNEL DEPTHS SHOWN ARE PROJECT DEPTHS
3. TRANSIT SHEDS ARE SHOWN AS CROSSHATCHED BUILDINGS
4. DATA AS OF MARCH 1965

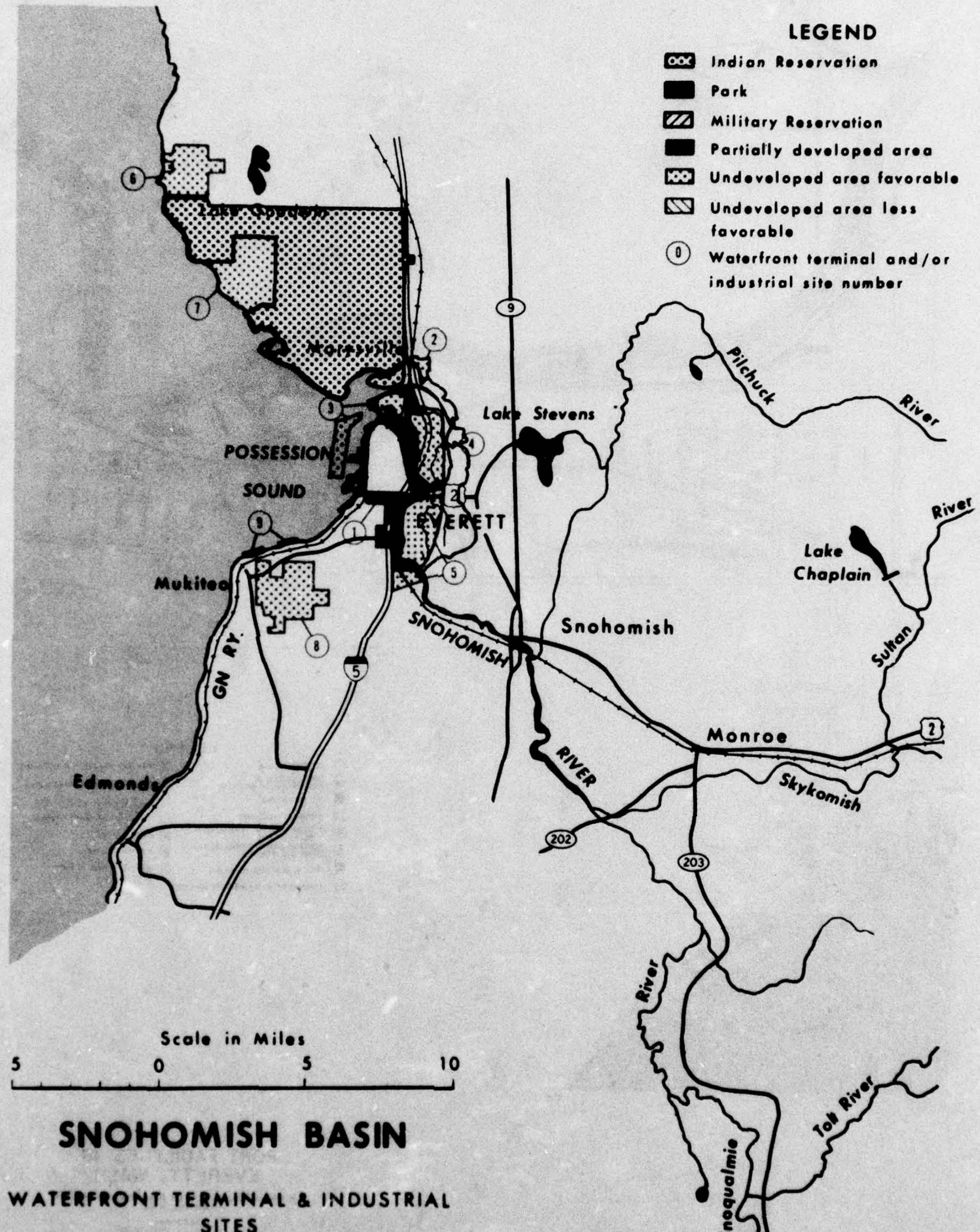
FIGURE 7-2L



PORT FACILITIES AT EVERETT, WASH.

BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C.

FIGURE 7-2R



SNOHOMISH BASIN

WATERFRONT TERMINAL & INDUSTRIAL SITES

FIGURE 7-3

TABLE 7-7. Water front & industrial land—Snohomish Basin—1963

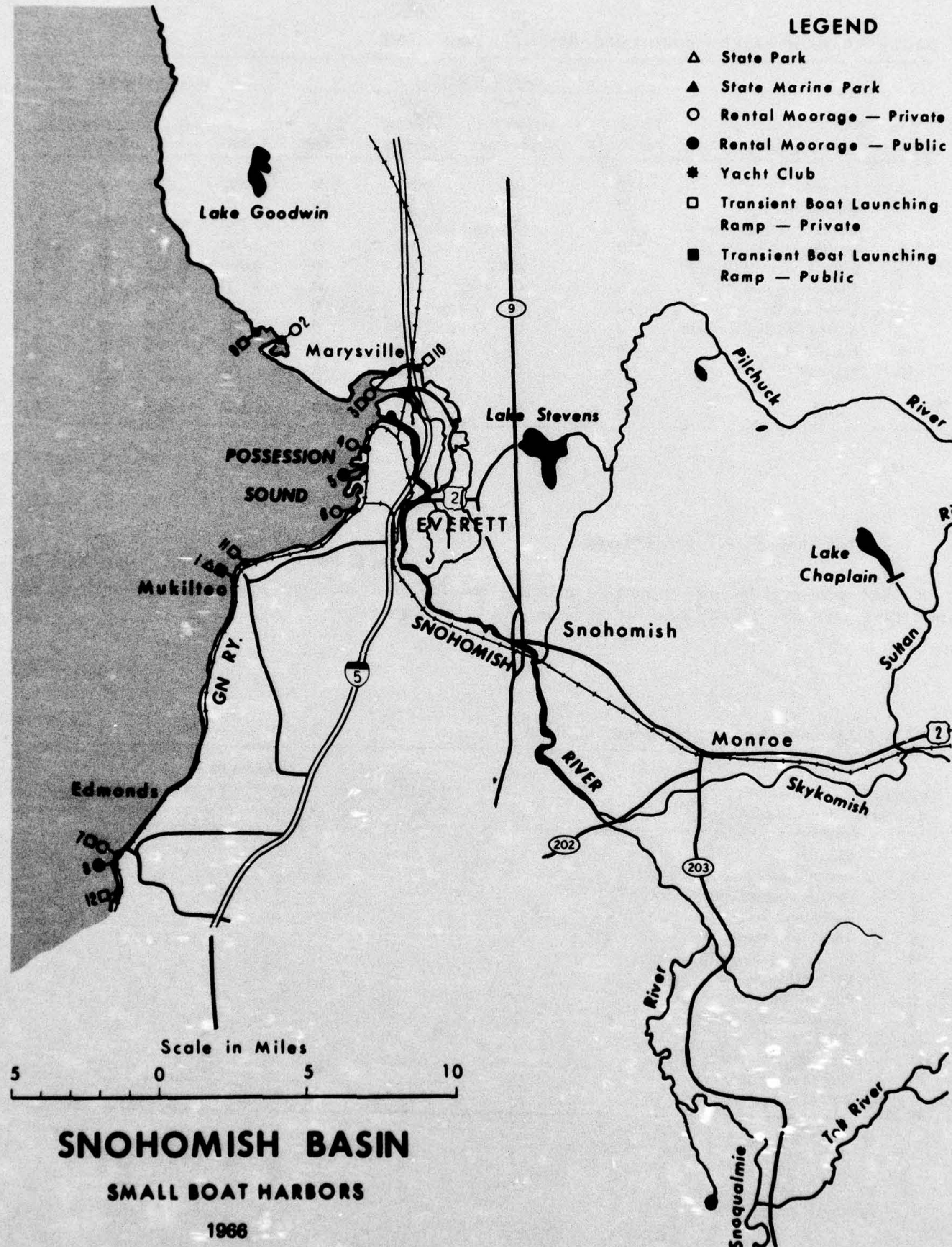
Site Number	Location	Acres in Use (Net): Terminal Facilities	Acres in Use (Net): Vessel Repair & Construction	Acres in Use (Net): Water Oriented Industry	Acres in Use (Net): Totals	Acres Potential: Favorable Gross	Acres Potential: Favorable Net	Acres Potential: Less Favorable Gross	Acres Potential: Less Favorable Net
1.	Everett	176	8	491	675	600	450	0	0
2.	Marysville	0	0	19	19	12	9	0	0
3.	Snohomish Delta Plan 1	0	0	0	0	2,200	1,650	0	0
4.	Snohomish Delta Plan 2	0	0	0	0	2,400	1,800	0	0
5.	Snohomish Delta Plan 3	0	0	0	0	3,600	2,700	0	0
6.	Richfield Oil Co.	0	0	0	0	2,000	1,500	0	0
7.	Union Oil Co.	0	0	0	0	2,240	1,680	0	0
8.	Boeing 747 Site & North	0	0	0	0	2,300	1,725	0	0
9.	Marysville	0	0	0	0	112	84	0	0
10.	Mukilteo	4	0	0	4	40	30	0	0
	Total	180	8	510	698	15,504	11,628	0	0

SMALL BOAT HARBORS

The small boat facilities existing on salt water are shown on Figure 7-4 and identified in Table 7-8. Shown on Figure 7-5 are about 23 miles of shoreline that are considered suitable for potential marina development.

TABLE 7-8. Small boat harbor, Snohomish Basin

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp: Public	Transient Boat Launching Ramp: Private	Rental Moorage: Public	Rental Moorage: Private
1	Mukilteo	X		X			
2	Totem Beach Resort						X
3	Geddes Marine Service				X		X
4	Robinson Marine						X
5	14th Street Marina					X	
6	Everett Boat House & Marina						X
7	Barton Marine, Inc.				X		X
8	Port of Edmonds					X	
9	Hermosa Beach Resort				X		
10	Ebey Slough				X		
11	Mukilteo Boat House				X		
12	Norma Beach Resort				X		
	TOTALS	1	0	1	6	2	5

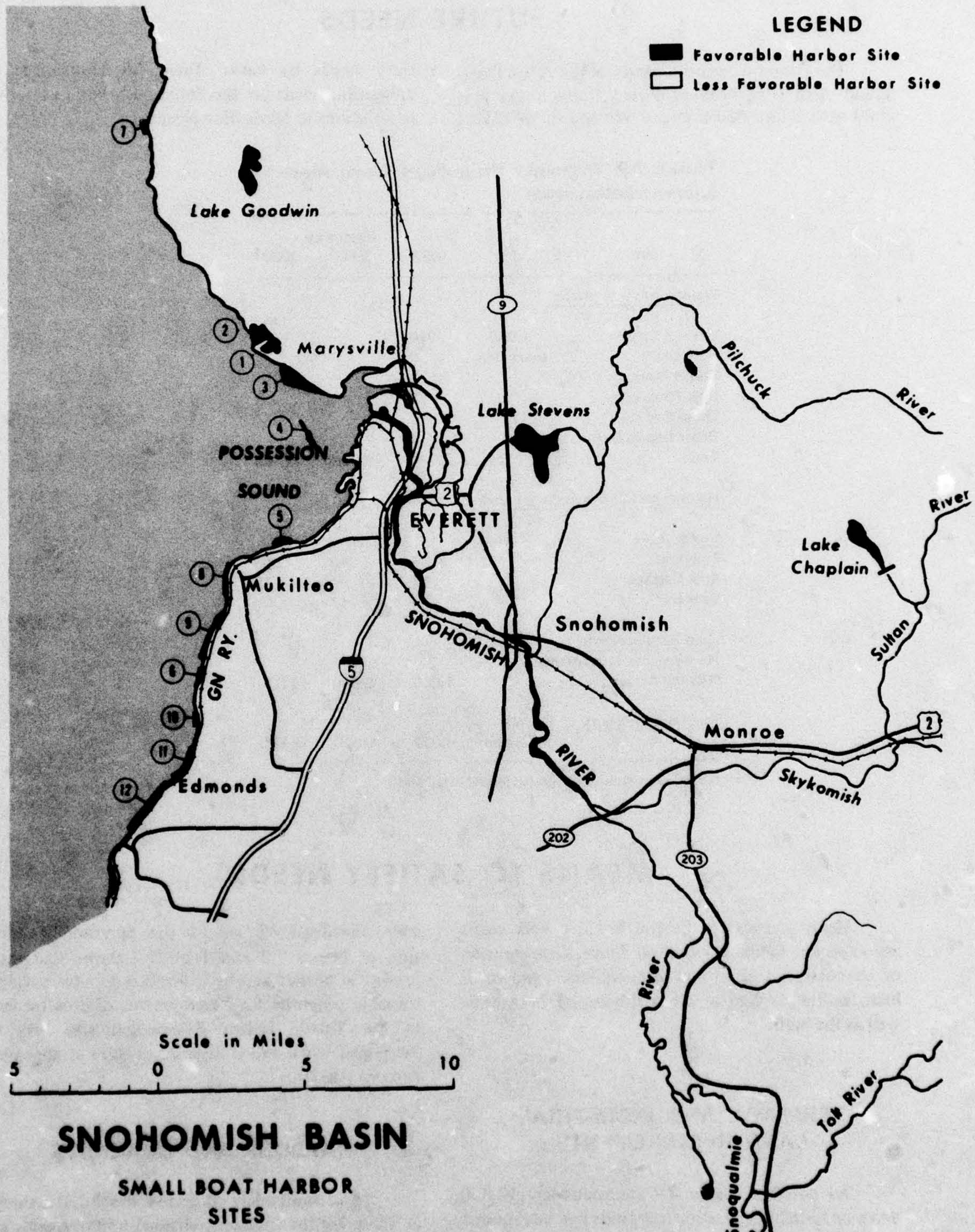


SNOHOMISH BASIN

SMALL BOAT HARBORS

1966

FIGURE 7-4



SNOHOMISH BASIN

SMALL BOAT HARBOR
SITES
1966

FIGURE 7-5

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 with a framework plan developed for satisfying these needs by basin. Table 7-9 summarizes the navigation needs for the Snohomish Basin as derived in Solutions to Navigation Needs.

TABLE 7-9. Snohomish Basin—Puget Sound Area—future navigation needs

Item	Unit	1980	Needs by 2000[1]	Needs by 2020[1]
Waterborne Commerce				
General Cargo	1,000	270		
Bulk Grain	short tons	0		
Forest Products		2,520		
Bulk Petroleum		70		
Other Dry Bulk		910		
Other Liquid Bulk		0		
Total		3,770	10,900	50,000
Harbors and Channels Requirements				
Vessel Draft	(feet)			
Freighters		39	40	40
Bulk Carriers		57	71	71
Tankers		45	47	48
Land Requirements	Acres			
Terminal and water-transport-oriented industry		1,610	5,640	12,330
Small Boat Harbors	Wet Moorages[2]	4,920	9,530	18,520

[1]Only aggregated tonnage projected after 1980.

MEANS TO SATISFY NEEDS

Major increases in general and dry bulk cargo are expected in the Snohomish Basin. Development of channels, industrial and terminal lands, and small boat facilities is vital to the well being of the Area as well as the basin.

TERMINAL AND INDUSTRIAL LAND REQUIREMENTS

As noted in Table 7-9 approximately 12,300 acres of terminal and industrial lands will be required by 2020 to meet projected needs. This includes 698 acres already developed for this purpose. Examination of Figure 7-3 and Table 7-7 shows that these needs can be satisfied by utilization of sites having a turnable potential for development. Alternative land in the Tulalip Indian Reservation also may be developed when and if disposal or lease arrangement become possible.

HARBORS AND CHANNELS

To accommodate projected vessel drafts shown in Table 7-9 the following channel improvements are required.

Period	Channel	Channel Depth in ft.	Estimated Construction Cost	Estimated Annual Cost	Estimated Benefits	Estimated Benefit/Cost Ratio
1980	Lower River Deep Water to Highway 99 bridge	32	$1,921,000	$114,200	$138,212	1.2
	East Waterway	46	279,000	16,600	34,100	2.1
	Tract Q	78		Existing Depths		
1980 to 2000	Upper River to head of Ebbey Slough-Barge Channel	20	2,313,000	137,400	Not Estimated	
	Lower River Channel	46	3,511,000	201,300	Not Estimated	
	East Waterway	78	1,872,000	110,700	Not Estimated	
2000 to 2020	None					

SMALL BOAT HARBORS

Listed in Table 7-10 are the sites in the Snohomish Basin suitable for development of small boat harbors. The sites shown on Figure 7-5 are the most favorable in this Basin.

A tentative schedule of development to meet 1980, 2000 and 2020 Basin needs as well as providing for spillover needs from the Cedar-Green Basins is contained in Table 7-10. Benefits and costs for projects recommended to meet 1980 pleasure boating demand are also shown as are the estimated construction costs for additional projects required by 2000 and 2020. Costs shown are for general navigation facilities and construction. General navigation facilities consist of breakwaters, entrance channels, and turning basins and the navigation aids are normally lighted dolphins and breakwater lights. Costs are average values and are based on actual construction or detailed study cost estimates for small boat harbor projects in the Area. Average benefit values were derived using standard methods employed by the Corps of Engineers data from the "Pleasure Boating Study," and other studies performed for small boat harbor projects.

TABLE 7-10. Small boat harbor sites—Snohomish Basin

Site No.	Location	Wet Moorages	Water-Land Area-Acres[4]	Tentative Schedule of Development 1980	2000	2020
				Wet Moorages		
1.	Tulalip Bay—1st Phase	1,320	110			1,320
2.	Tulalip Bay—2nd Phase	2,390	199			2,390
3.	Priest Pt. West	5,140	428			5,140
4.	Tract Q	3,080	257	2,000	1,080	
5.	Mukilteo	1,100	92			1,100
6.	Picnic Pt. North	1,730	144			1,730
7.	Port Susan—Warm Beach	1,400	117			1,400
8.	Mukilteo South	880	73			880
9.	Big Gulch	1,310	109		1,310	
10.	Norma Beach North	920	77			920
11.	Meadowdale	1,130	94	1,130		
12.	Edmonds North	2,350	196		2,350	
	Totals	22,750	1,896	3,130	4,740	14,480

Summary of Benefits and Costs

1980 Construction Costs[3]	1980 Average Annual Costs[1,2]	1980 Average Annual Benefits	2000 Construction Costs[3]	2020 Construction Costs[3]
$6,306,800	$403,800	$584,900	$9,725,000	$29,909,000

[1] Annual interest and amortization charges of general navigation facility construction costs, including aids to navigation are computed for 50-year economic life at a rate of 4-5/8 percent.

[2] Includes allowance of $25 per wet moorage for annual maintenance and replacement costs.

[3] Includes allowance for Engineering, Design, Supervision and Administration costs.

[4] Using relationships based on Shilshole Marina wet moorage land and water area requirements are estimated at 0.056 acres of water area for moorage and maneuvering and 0.028 acres of land for parking and services per boat.

Note: Not contained in the area requirements are land needs for launching ramps which will generally be incorporated with moorage facilities. Launching facilities require about 1.5 acres of land for ramps and parking for each lane provided.

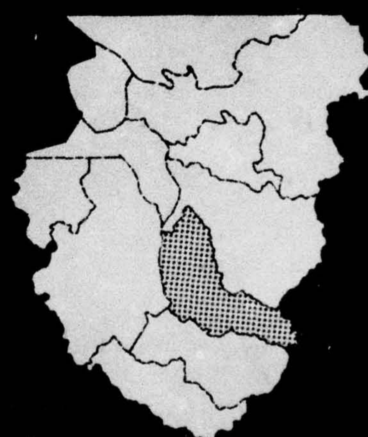
Factors Influencing Implementation of Plan

Flood control needs in the lower basin must be met before full improvement for navigation and related land development can be realized. The Port of Everett should expand its district boundaries to encompass all of Snohomish County in order to secure the necessary tax base for the major flood control and navigation improvements required. Cooperative development with the Port of Seattle also could provide a means of implementing projects in the plan.

Design and construction of channel improvements for flood control and navigation purposes will be difficult in the Snohomish River due to heavy silt loads. Design of economical rail and highway access to sites proposed for terminal and water transport-oriented industrial development will require study and coordination with companies and agencies representing these transportation sectors.

Facilitating development in the Snohomish delta will be the joint efforts that already have been undertaken by local interests in developing a comprehensive plan which provides for environmental as well as economic needs.

Cedar-Green Basins



CEDAR — GREEN BASINS

DESCRIPTION

The 64 miles of salt water shoreline of these basins extends along the east side of Puget Sound and East Passage. Also, the basin has about 90 miles of fresh water shoreline around Lake Washington and the Lake Washington Ship Canal. Navigable depths of over 100 feet exist along all the shoreline, but only in the Elliott Bay area is there sufficient lowland for major harbor development. The Ports of Seattle and Edmonds are the two organized port districts in the basin. The basin is served by four transcontinental railroads and numerous interstate and state highways. A major international airport also serves the area.

PRESENT STATUS

HARBORS AND CHANNELS

Seattle, the major port in Puget Sound, and in these basins is 124 nautical miles from the Pacific Ocean. The port has an outer salt water harbor and an inner fresh-water harbor. The outer harbor with depths of over 500 feet includes: Elliott Bay; the East, West and Duwamish Waterways; Shilshole Bay; and the waters of Puget Sound adjacent to West Seattle, Ballard, Richmond Beach and Edmonds. The Duwamish River by which the Green River discharges into Elliott Bay has been improved under a Federal project for Seattle Harbor as shown on Figure 8-1.

The Federal project for Shilshole Bay provides for construction of 4,400 feet of breakwater and a small boat harbor as shown on Figure 8-2.

Edmonds Harbor, owned and operated by the Port of Edmonds, is on the east side of Puget Sound midway between Everett and Seattle. The Federal project adopted in 1965, as shown on Figure 8-3, provides for maintenance of breakwaters and entrance channel for a small boat harbor which was completed by local interests in 1962.

The inner harbor of the port, as shown on Figure 8-4, consists of Lakes Union and Washington which are joined with each other and with Puget Sound by the Lake Washington Ship Canal and the "Hiram M. Chittenden" navigation locks.

WATERBORNE COMMERCE

All waterborne commerce for the Cedar-Green Basins is included in the statistics for the Seattle Area which includes both the inner and outer harbors as well as the Richmond Beach and Port of Edmonds terminals. These statistics are given in Tables 8-1 through 8-4 for the years 1952 through 1966.

TABLE 8-1. Water-borne commerce for Seattle Area. Foreign in short tons

FOREIGN IMPORTS

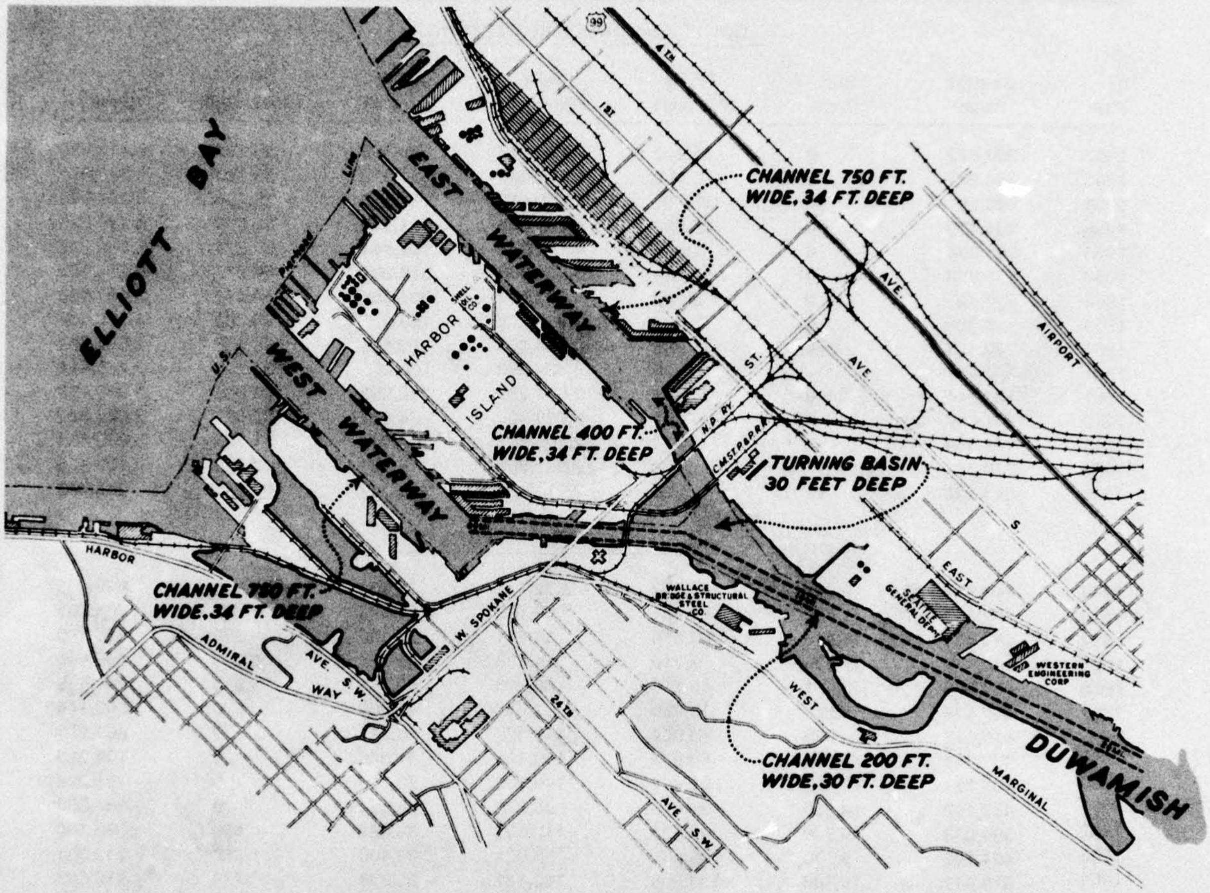
Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	183,747	0	36,786	0	35,732	28,772	285,037
1953	215,177	0	63,282	3,594	74,185	33,762	390,000
1954	212,225	0	78,002	609	121,242	33,521	445,599
1955	220,247	0	87,179	22,149	293,091	35,969	658,635
1956	249,085	0	71,116	52,229	281,808	21,212	675,450
1957	221,987	0	151,381	42,193	223,804	19,166	658,531
1958	251,694	0	244,484	36,505	194,658	9,940	737,281
1959	295,730	0	347,211	74,678	424,318	1,514	1,143,451
1960	297,479	0	231,334	38,445	405,336	2,048	974,642
1961	249,208	0	131,498	82,248	341,489	10,086	814,529
1962	285,150	0	197,446	112,099	394,521	5,493	994,709
1963	287,628	0	206,321	44,825	402,449	11,404	952,627
1964	299,004	552	221,690	0	545,218	20,076	1,086,540
1965	347,678	364	246,495	88,929	604,186	17,251	1,304,903
1966	430,593	941	297,925	115,144	582,018	13,814	1,440,435

FOREIGN EXPORTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	164,403	401,035	15,242	64,937	237,275	10,085	892,977
1953	184,552	325,519	19,850	48,196	46,298	18,602	643,017
1954	196,025	247,680	23,730	33,675	28,480	18,524	548,114
1955	168,871	349,797	33,612	16,634	111,229	18,248	698,391
1956	268,111	752,711	26,161	34,415	62,082	17,968	1,161,448
1957	213,487	1,071,094	31,899	48,012	158,657	20,715	1,543,864
1958	180,585	661,558	31,426	8,995	72,216	25,638	980,418
1959	218,448	638,891	23,989	12,902	202,265	30,040	1,126,535
1960	193,289	844,043	33,006	3,518	161,494	30,547	1,265,897
1961	170,879	805,021	52,926	6,513	104,823	29,383	1,169,545
1962	190,845	528,971	27,863	0	58,271	38,602	844,552
1963	240,223	673,359	52,417	2,290	42,004	37,024	1,047,317
1964	307,314	599,227	115,226	4,135	21,913	2,115	1,049,930
1965	284,634	798,645	84,459	6,188	44,690	26,923	1,245,539
1966	380,673	883,858	90,044	18,850	19,144	13,628	1,406,197

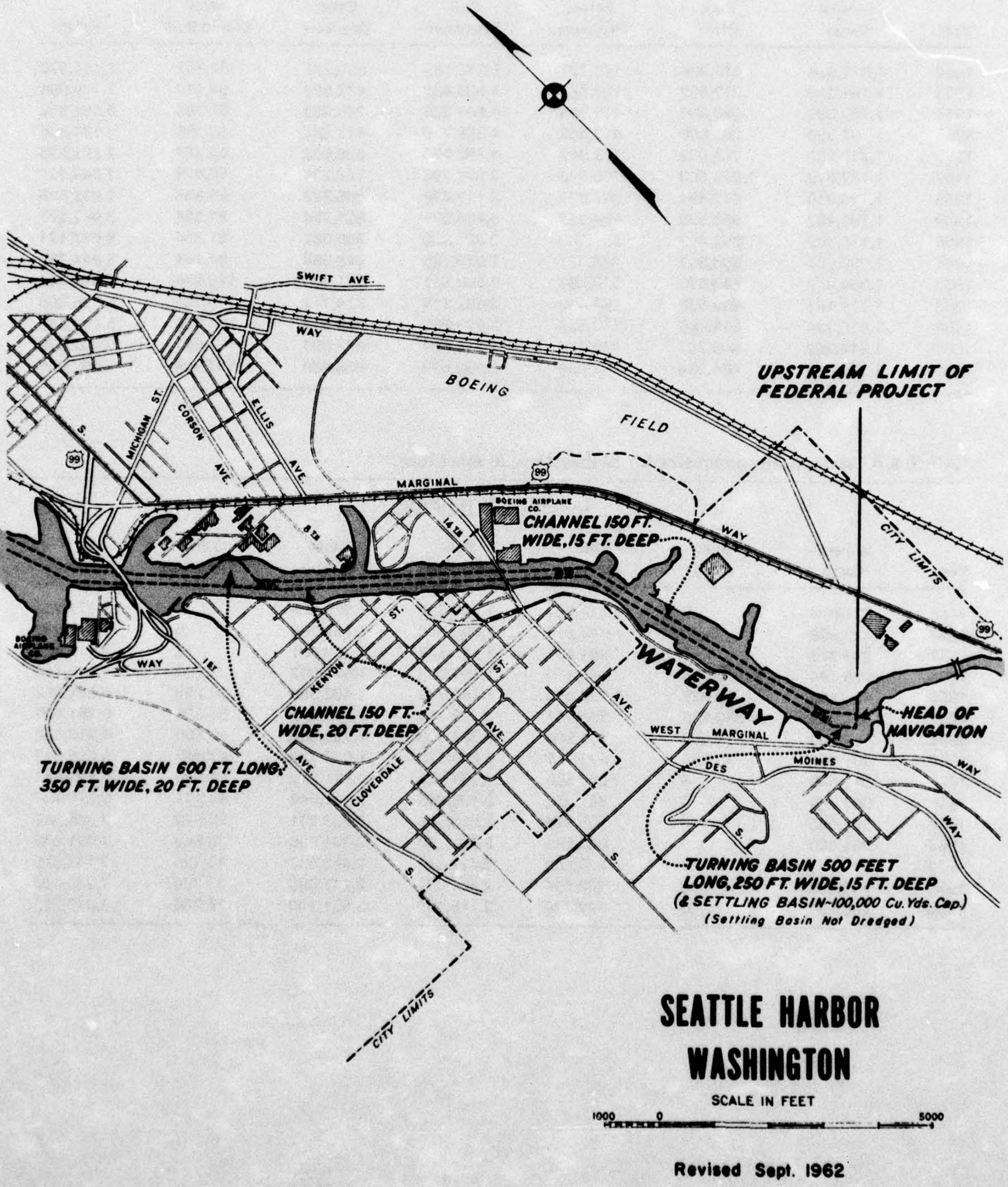
TABLE 8-2. Water-borne commerce for Seattle Area. Domestic coastwise in short tons

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
DOMESTIC COASTWISE RECEIPTS							
1952	260,672	0	15,227	5,106,077	208,402	20,115	5,610,493
1953	264,847	0	15,252	4,832,498	221,023	39,250	5,372,870
1954	298,491	0	10,146	4,765,811	131,655	25,455	5,231,558
1955	272,539	0	16,455	4,755,538	42,105	37,953	5,124,590
1956	295,690	0	5,870	4,719,084	209,444	50,274	5,280,362
1957	281,959	0	2,309	3,524,060	318,907	56,947	4,184,182
1958	277,425	0	2,923	2,922,611	354,664	50,277	3,607,900
1959	248,385	0	3,684	3,237,679	153,225	60,031	3,703,004
1960	230,147	0	1,988	3,134,000	130,403	28,769	3,525,307
1961	245,741	0	329	2,804,686	158,263	57,795	3,266,814
1962	184,644	0	431	2,674,250	148,892	67,566	3,075,783
1963	167,098	0	64	2,760,369	64,851	90,025	3,082,407
1964	191,399	2	312	2,506,597	107.040	81,103	2,886,453
1965	279,571	0	124	2,661,360	116,164	72,229	3,129,448
1966	295,626	21	58	2,711,153	168,047	108,141	3,283,046
DOMESTIC COASTWISE SHIPMENTS							
1952	408,514	9,249	79,472	72,171	98,862	8,195	676,463
1953	489,643	11,888	59,481	49,199	90,093	2,803	703,107
1954	473,554	11,416	67,616	45,161	34,556	4,285	636,588
1955	445,712	11,898	75,210	64,455	45,879	6,286	649,440
1956	497,203	9,311	65,755	86,296	82,188	3,913	744,666
1957	450,439	8,559	79,760	82,530	41,856	0	663,144
1958	416,612	10,936	45,004	149,327	45,341	0	667,220
1959	432,844	14,704	80,073	139,718	41,946	0	709,285
1960	455,787	18,410	92,852	145,900	38,329	0	751,278
1961	433,159	19,826	99,618	96,278	44,983	0	693,864
1962	394,033	14,905	93,823	112,602	69,582	4,155	689,100
1963	424,192	16,170	105,648	69,621	105,408	1,868	742,907
1964	518,677	15,705	123,005	162,821	95,676	734	916,618
1965	602,319	1,758	79,400	160,417	77,767	1,288	922,949
1966	602,503	164	54,932	147,382	70,275	2,121	877,377



Improvement	AUTHORIZED Depth Feet	Width Feet	Length Feet	CONDITION IN 1967 Depth Feet	Width Feet	Length Feet
West Waterway	34	750	5200	36	450	4700
East Waterway - 750 ft. Section	34	750	6500	33.6	525	6400
Duwamish Waterway From head of West Waterway to 1st Ave. So.	30	200	13,100	23.9	150	13,100
1st Ave. S. to 8th Ave S.	20	150	4000	16.1	130	4000
8th Ave. S. to 14th Ave. S.	15	150	2800	15.0	130	2800
14th Ave. S. to 4500' above 14th Ave. S.	15	150	4500	5.0	150	4500
From 4500' above 14th Ave. S. to turning basin	15	150	2000	0.5	150	2000
Least depth in turning basin just S. of 1st Ave. S. bridge	20	350	600	0.5	250	500
Turning basin at end of waterway	15	250	500	Not dredged		

FIGURE 8-1L



SWIFT AVE.
WAY
BOEING
FIELD
UPSTREAM LIMIT OF FEDERAL PROJECT
MICHIGAN ST.
CORSON AVE.
ELLIS AVE.
MARGINAL
WAY
BOEING AIRPLANE CO.
CHANNEL 150 FT. WIDE, 15 FT. DEEP
CITY LIMITS
WATERWAY
HEAD OF NAVIGATION
KENYON ST.
CHANNEL 150 FT. WIDE, 20 FT. DEEP
TURNING BASIN 600 FT. LONG, 350 FT. WIDE, 20 FT. DEEP
CLOVERDALE
WEST MARGINAL
DES MOINES
TURNING BASIN 500 FEET LONG, 250 FT. WIDE, 15 FT. DEEP
(& SETTLING BASIN-100,000 Cu. Yds. Cap.)
(Settling Basin Not Dredged)
CITY LIMITS
SEATTLE HARBOR
WASHINGTON
SCALE IN FEET
1000
0
5000
Revised Sept. 1962

FIGURE 8-1R

TABLE 8-3. Water-borne commerce for Seattle Area, in short tons

FOREIGN AND DOMESTIC COASTWISE

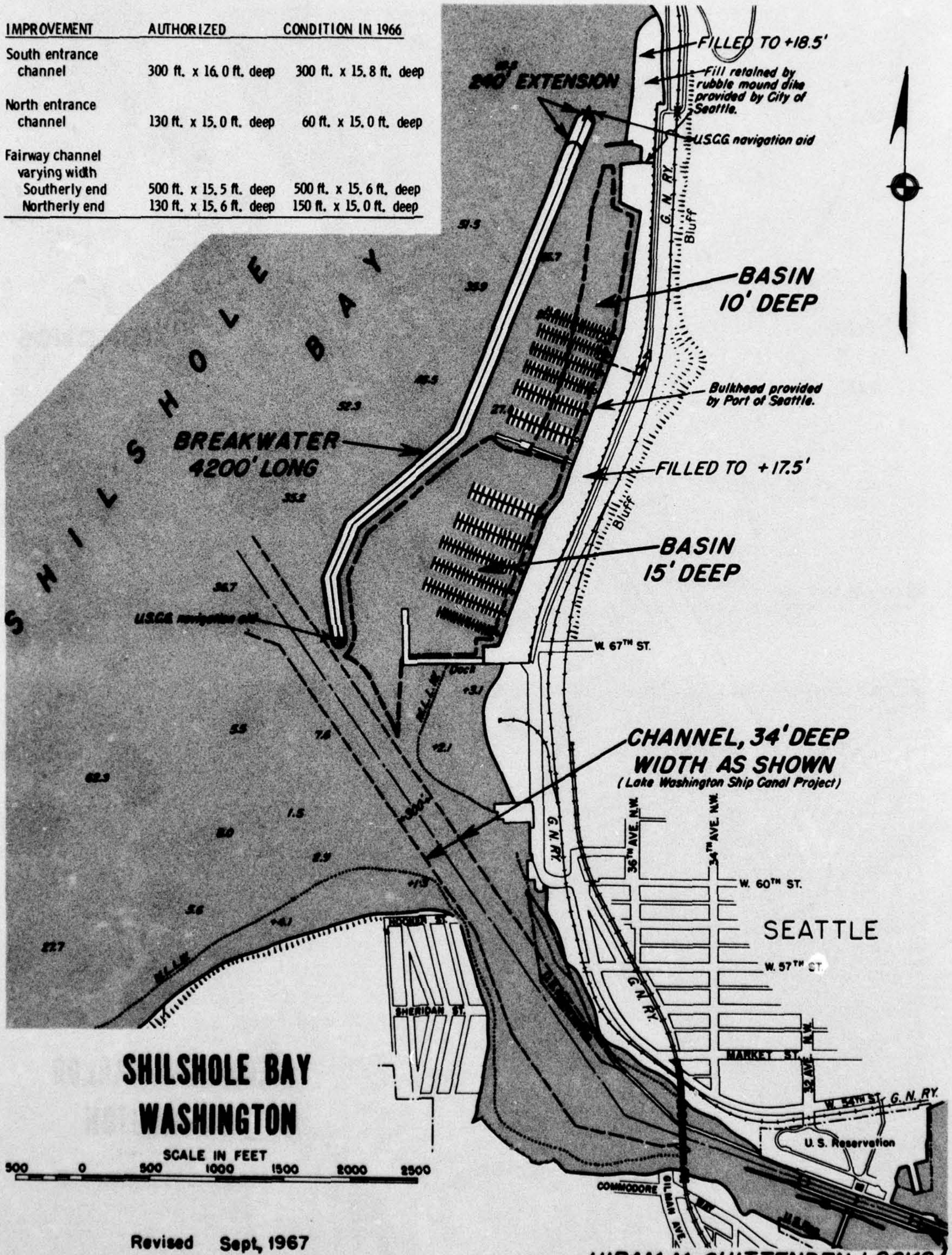
Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	1,017,336	410,284	146,727	5,243,185	580,271	67,167	7,464,970
1953	1,154,219	337,407	157,865	4,933,487	431,599	94,417	7,108,994
1954	1,180,295	259,096	179,503	4,845,256	315,933	81,785	6,861,868
1955	1,107,369	361,695	212,456	4,858,776	492,304	98,456	7,131,056
1956	1,310,089	762,022	168,902	4,892,024	636,522	93,367	7,861,926
1957	1,167,872	1,079,653	265,349	3,696,795	743,224	96,828	7,049,721
1958	1,126,316	672,494	323,837	3,117,438	666,879	85,855	5,992,819
1959	1,195,407	653,595	454,957	3,464,977	821,754	91,585	6,682,275
1960	1,176,702	862,453	359,180	3,321,863	735,562	61,364	6,517,124
1961	1,098,987	824,847	284,371	2,989,725	649,558	97,264	5,944,752
1962	1,054,672	543,876	319,563	2,898,951	671,266	115,816	5,604,144
1963	1,119,141	689,529	364,450	2,897,105	614,712	140,321	5,825,258
1964	1,316,394	615,486	460,233	2,673,553	769,847	104,028	5,939,541
1965	1,514,202	800,767	410,478	2,916,894	842,807	117,691	6,602,839
1966	1,709,395	884,984	442,959	2,992,529	839,484	137,704	7,007,055

TABLE 8-4. Water-borne commerce for Seattle Area, in short tons

DOMESTIC INTERNAL

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	221,818	0	1,112,257	1,133,652	1,254,525	0	3,722,252
1953	227,959	0	1,146,228	1,090,515	1,194,288	0	3,658,990
1954	244,215	0	904,607	1,185,638	1,377,961	0	3,712,421
1955	285,144	85,056	945,179	1,554,562	1,571,002	1,200	4,442,143
1956	405,406	56,038	1,127,042	1,744,879	1,460,365	28,252	4,821,982
1957	324,928	340,926	854,854	2,212,733	2,496,736	51,928	6,281,105
1958	187,300	14,000	778,900	2,094,100	1,795,300	46,400	4,916,000
1959	301,836	49,226	973,717	2,220,173	1,923,722	47,843	5,516,517
1960	312,635	0	867,580	2,368,339	2,121,283	52,850	5,722,687
1961	367,354	0	711,756	2,499,368	2,191,848	48,101	5,818,427
1962	361,043	0	905,824	2,850,554	3,233,701	15,620	7,366,742
1963	360,490	0	656,981	2,793,995	3,201,520	8,663	7,021,649
1964	337,032	0	830,850	3,479,874	2,480,333	15,426	7,143,515
1965	273,265	0	723,564	2,967,991	3,245,496	23,220	7,233,536
1966	265,621	0	782,776	2,115,462	3,631,100	15,266	6,810,225

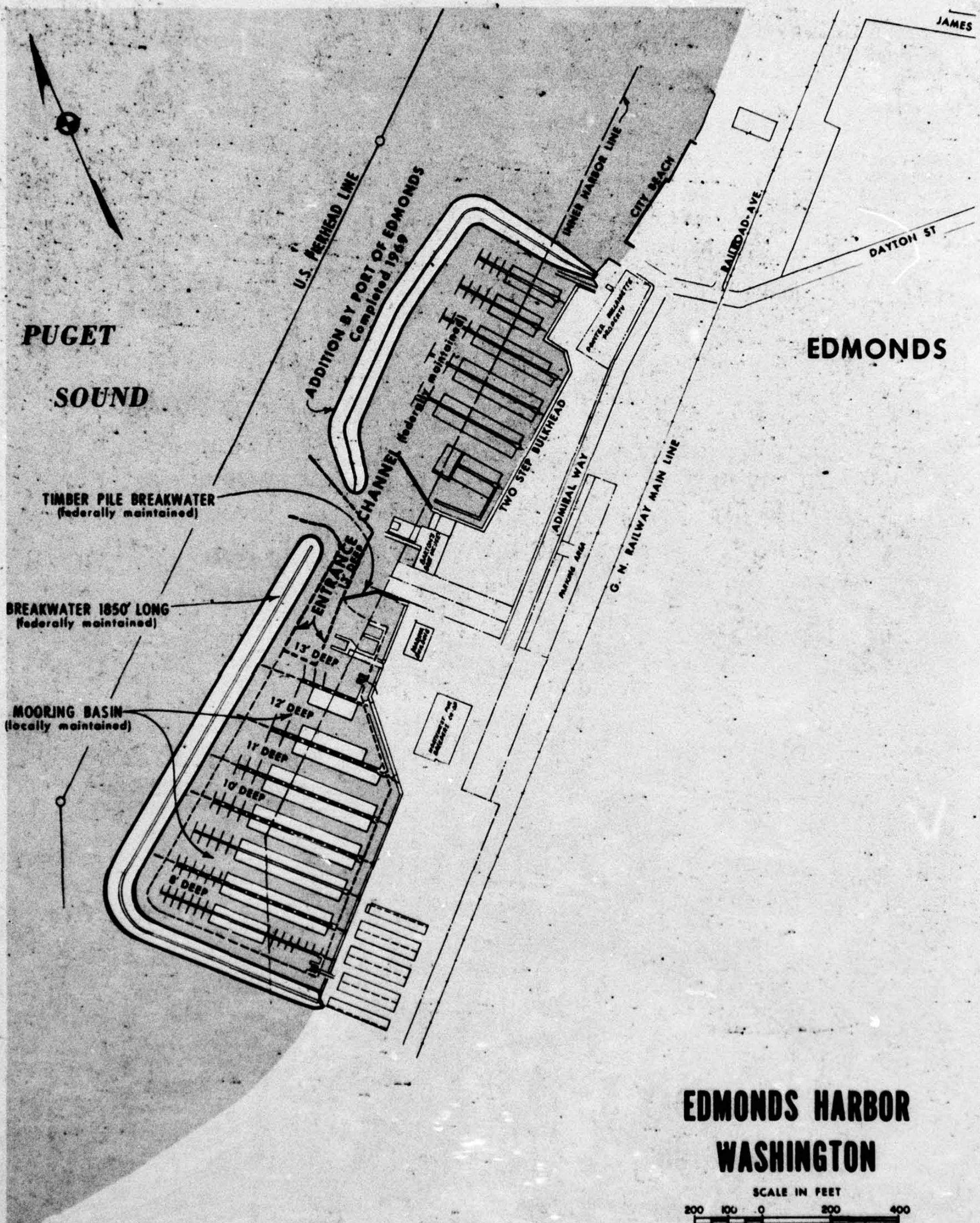
IMPROVEMENT	AUTHORIZED	CONDITION IN 1966
South entrance channel	300 ft. x 16.0 ft. deep	300 ft. x 15.8 ft. deep
North entrance channel	130 ft. x 15.0 ft. deep	60 ft. x 15.0 ft. deep
Fairway channel varying width		
Southerly end	500 ft. x 15.5 ft. deep	500 ft. x 15.6 ft. deep
Northerly end	130 ft. x 15.6 ft. deep	150 ft. x 15.0 ft. deep



Revised Sept, 1967

HIRAM M. CHITTENDEN LOCKS
(Lake Washington Ship Canal Project)

FIGURE 8-2



EDMONDS HARBOR
WASHINGTON

FIGURE 8-3

TERMINAL AND TRANSFER FACILITIES

Terminal facilities for the combined outer and inner harbor areas for 1952 and 1963 are summarized in Tables 8-5 and 8-6, respectively, and shown on Figures 8-5 and 8-6. During this period the total cargo berthing space in use on the inner harbor remained nearly constant at slightly over 12,000 feet but there was a reduction of about 3,000 feet being used for cargo on the outer harbor. While covered storage space was reduced by 284,000 square feet the open storage available was increased by 21.6 acres, all in the outer harbor. To facilitate the existing water-borne trade of the Seattle Harbor, to promote new ocean commerce and to attract port-oriented industry, the Port of Seattle Commission expended more than 32 million dollars during the period January 1963 and December 1967. The funds were spent for the improvement of present terminals, construction of new docks and cargo handling facilities, and in acquisition of land for industrial development. Since 1967 the Port of Seattle has continued improving facilities and acquiring additional land for terminals and industrial sites.

TABLE 8-5. Terminal facilities Seattle Area 1952

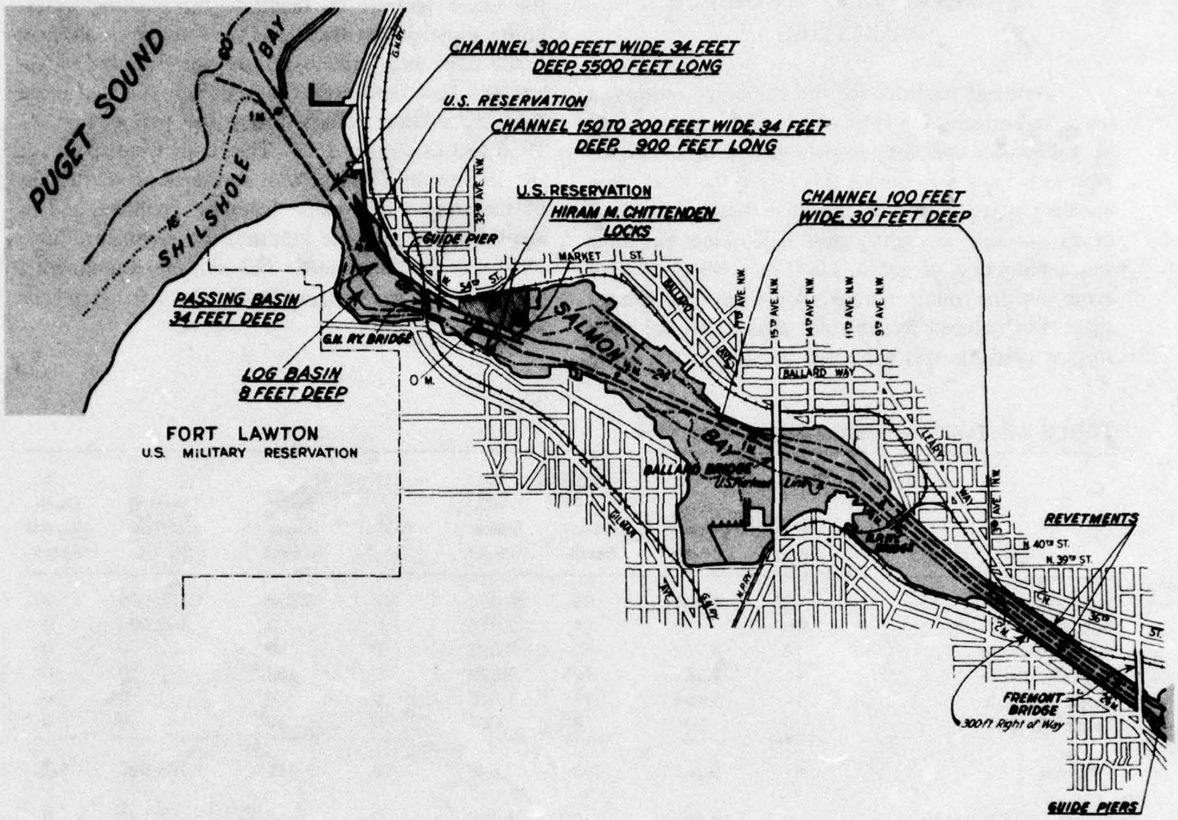
Use	Depth 18' & Less No. of Berths	Depth 18' & Less Berth Space In Feet	Depth 18' - 40' No. of Berths	Depth 18' - 40' Berth Space In Feet	Depth 40' + No. of Berths	Depth 40' + Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	6	1,248	69	28,694	12	2,862	1,320,690	1.7
Bulk Grain[1]	0	0	4	2,810	0	0	449,000	0
Forest Products	18	3,252	13	3,690	0	0	0	0
Bulk Petroleum	11	1,484	42	9,629	3	753	0	0
Other Dry Bulk	14	3,454	11	1,818	0	0	0	0
Other Liquid Bulk	2	303	4	907	0	0	0	0
Totals	51	9,741	143	47,548	15	3,615	1,769,690	1.7
Construction & Repair	0	8,742	0	21,136	0	0	0	0
Mooring	0	12,806	0	14,115	0	366	0	0

[1] Total storage capacity 5,916,000 bushels.

TABLE 8-6. Terminal facilities Seattle Area 1963

Use	Depth 18' & Less No. of Berths	Depth 18' & Less Berth Space In Feet	Depth 18' - 40' No. of Berths	Depth 18' - 40' Berth Space In Feet	Depth 40' + No. of Berths	Depth 40' + Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	9	1,486	44	23,851	9	3,350	1,485,605	23.3
Bulk Grain[1]	0	0	3	2,113	0	0	0	0
Forest Products	22	3,130	9	2,115	1	130	0	0
Bulk Petroleum	20	3,017	30	7,349	2	1,324	0	0
Other Dry Bulk	21	4,232	14	3,708	0	0	0	0
Other Liquid Bulk	2	200	3	1,607	0	0	0	0
Totals	74	12,065	103	40,743	12	4,804	1,485,605	23.3
Construction & Repair	0	19,266	0	19,556	0	0	0	0
Mooring	0	8,452	0	9,514	0	0	0	0

[1] Total storage capacity 8,308,000 bushels.


PUGET SOUND
SHILSHOLE
BAY
CHANNEL 300 FEET WIDE, 34 FEET DEEP, 5500 FEET LONG
U.S. RESERVATION
CHANNEL 150 TO 200 FEET WIDE, 34 FEET DEEP, 900 FEET LONG
U.S. RESERVATION
HIRAM M. CHITTENDEN LOCKS
CHANNEL 100 FEET WIDE, 30 FEET DEEP
GUIDE PIER
MARKET ST.
PASSING BASIN 34 FEET DEEP
G.N. RY. BRIDGE
LOG BASIN 8 FEET DEEP
SALMON
BAY
BALLARD WAY
BALLARD BRIDGE
FORT LAWTON
U.S. MILITARY RESERVATION
REVETMENTS
N. 40TH ST.
N. 39TH ST.
FREMONT BRIDGE
300 ft Right of Way
GUIDE PIERS

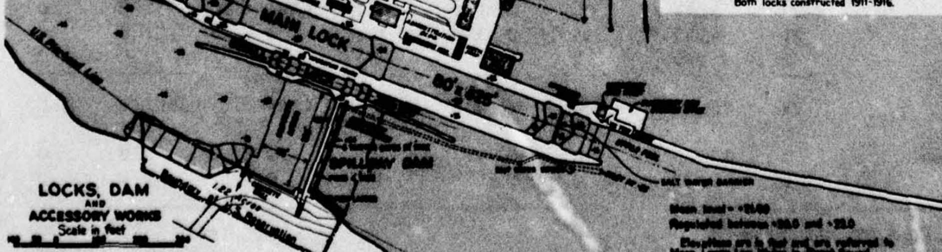
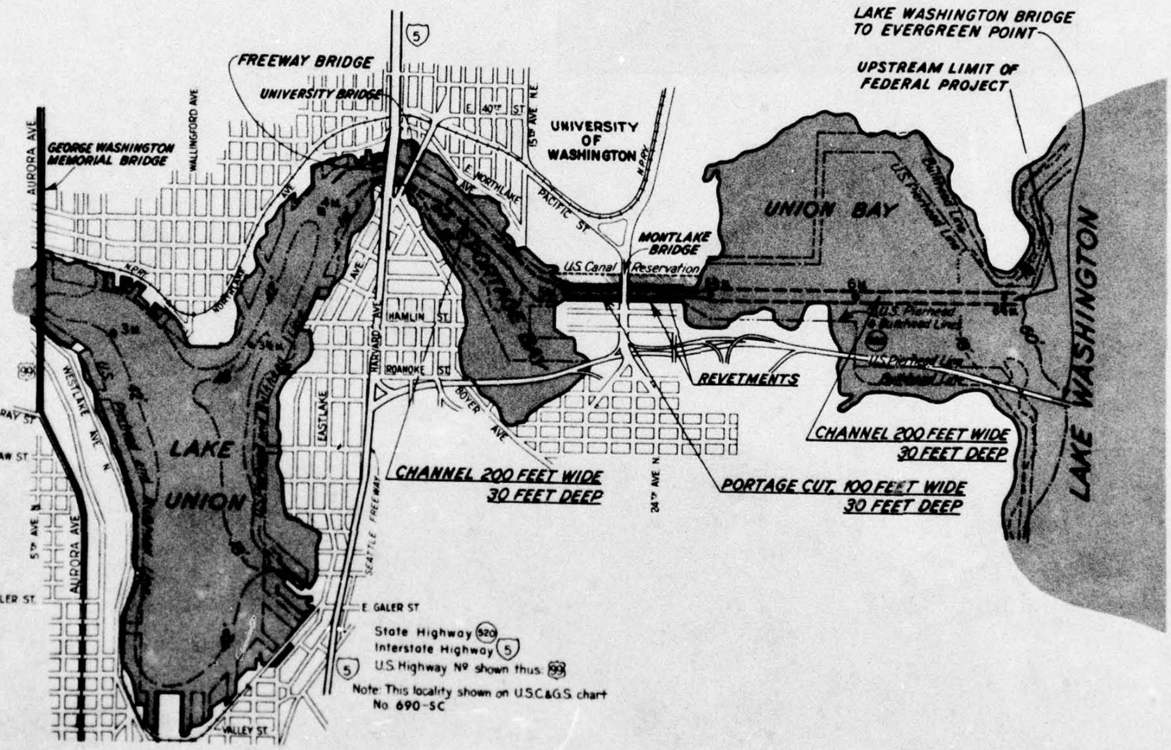

WEST
54TH ST.
GREAT NORTHERN
PUBLIC PARKING
Boundary of U.S. Reservation
16.23 Acres
DISTRICT ENGINEER'S RESIDENCE
MAIN LOCK
SPILLWAY DAM
MAIN LOCK
Available length 760 ft.
Available length east chamber 385 ft.
Available length west chamber 327 ft.
For square ends
Depth on Upper Mitre Sill 36 ft. at L.W.
Depth on Lower Mitre Sill 29 ft. at M.L.L.W. of Puget Sound.
SMALL LOCK
Available length 123 ft. for square ends
Depth on Upper Mitre Sill 16 ft. at L.W.
Depth on Lower Mitre Sill 16 ft. at M.L.L.W. of Puget Sound.
Both locks constructed 1911-1916.
LOCKS, DAM AND ACCESSORY WORKS
Scale in feet

FIGURE 8-4L

Improvement	AUTHORIZED Depth Feet	AUTHORIZED Width Feet	AUTHORIZED Length Feet	CONDITION IN 1967 Depth Feet	CONDITION IN 1967 Width Feet	CONDITION IN 1967 Length Feet
Shilshole Bay entrance to G.N. Ry. Bridge	34	300	5500	33.4	Along centerline	
G.N. Ry Bridge to Locks	34	150 to 200	900	33.4	"	"
Locks to Lake Union	30	100	6-1/2 miles	29.9	"	"
Lake Union to Portage Cut	30	200		28.8	"	"
Portage Cut	30	100		28.8	"	"
Portage Cut to Lake Washington	30	200		28.8	"	"



LAKE WASHINGTON SHIP CANAL WASHINGTON

SCALE IN FEET

U.S. Army Engineer District, Seattle, Wash.

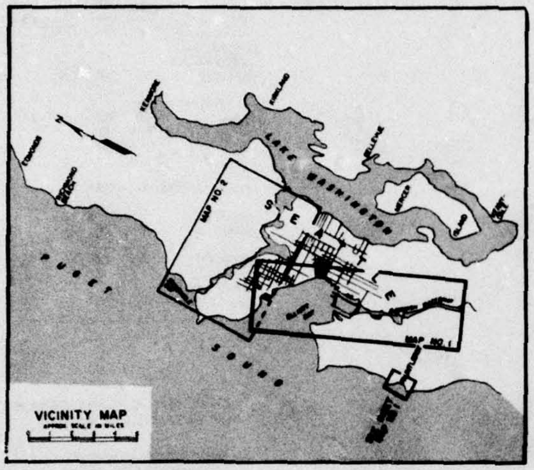
Revised September, 1967

FIGURE 8-4R

AD-A037 576 PACIFIC NORTHWEST RIVER BASINS COMMISSION VANCOUVER WASH F/G 8/6
COMPREHENSIVE STUDY OF WATER AND RELATED LAND RESOURCES. PUGET --ETC(U)
MAR 70 A T NEALE, L F KEHNE, F L NELSON

UNCLASSIFIED NL

3 OF 4
AD A037576


VICINITY MAP
LAKE WASHINGTON
PUGET SOUND
MAP NO 2
MAP NO 1

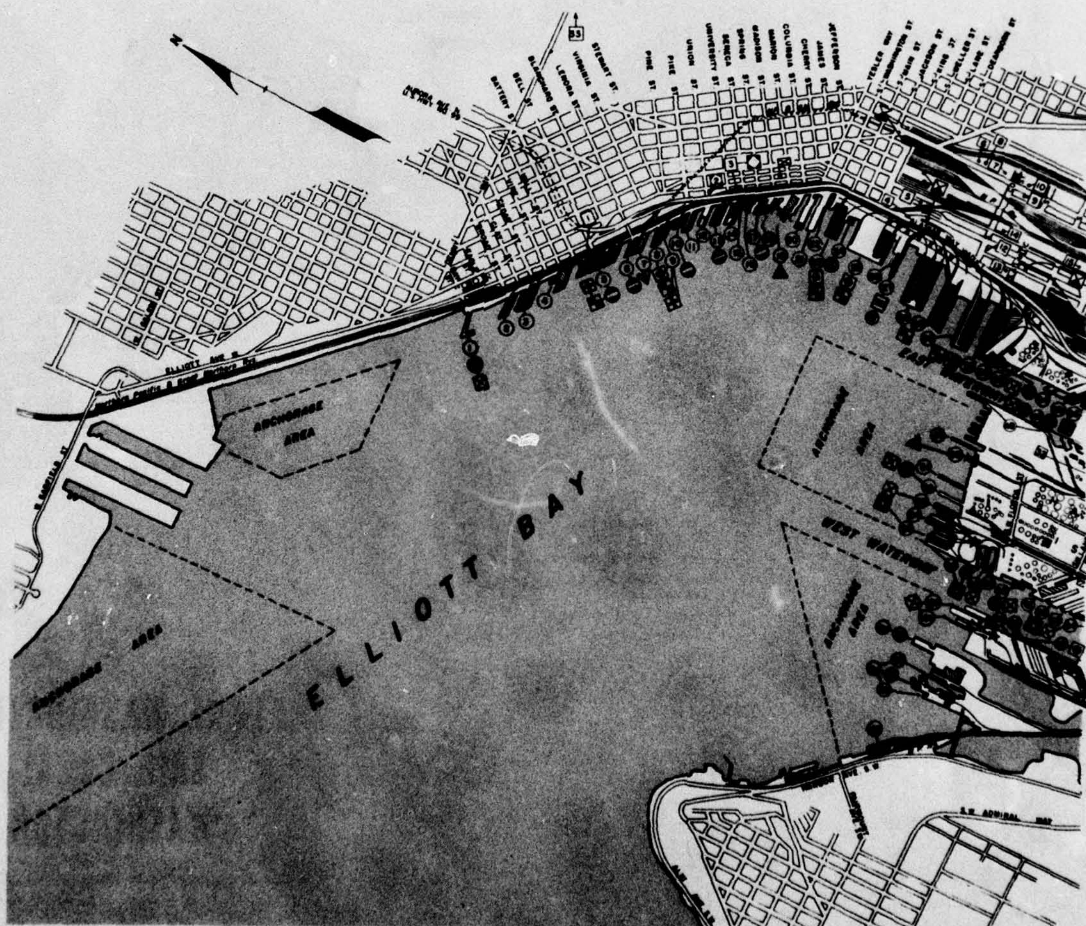
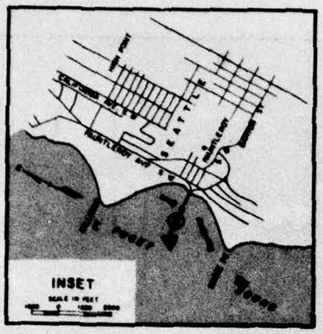

ELLIOTT BAY
ANCHORAGE AREA
WEST WATERWAY

FIGURE 8-5L

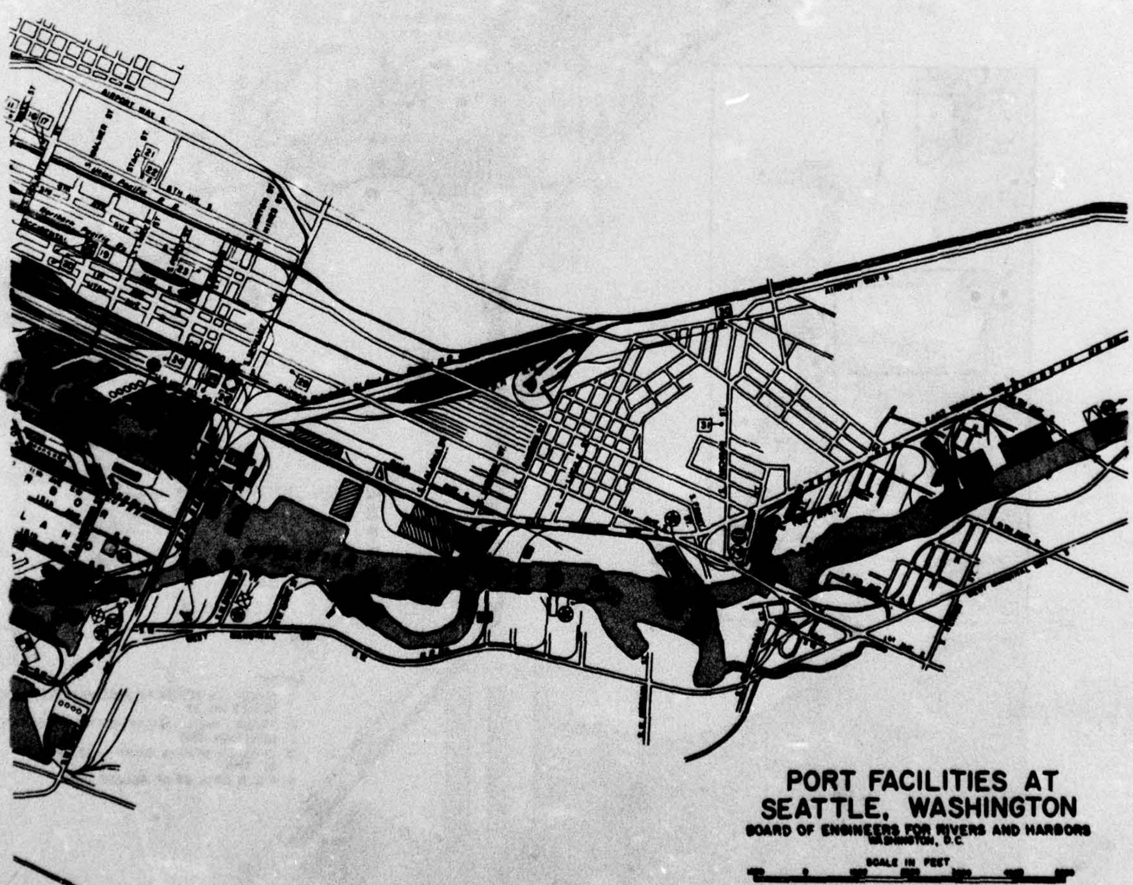


LEGEND

- CUSTOM HOUSE
- GENERAL CARGO TERMINALS–FOREIGN TRADE
- GENERAL CARGO TERMINALS COASTWISE & INTRACOASTAL TRADE
- TERMINALS OF INLAND CARRIERS
- CHEMICAL HANDLING
- IRON AND STEEL HANDLING
- OIL HANDLING
- BUNKER OIL
- LUMBER, LOGS & PILING HANDLING
- GRAIN HANDLING
- GRAIN ELEVATORS
- STORAGE WAREHOUSES
- COLD STORAGE WAREHOUSES
- BULK HANDLING, DRY AND LIQUID COMMODITIES
- MOLASSES HANDLING
- FERTILIZER HANDLING
- FISH & SEAFOOD HANDLING
- DRY DOCKS
- MARINE RAILWAYS
- MARINE REPAIR PLANTS
- SHIPBUILDING PLANTS
- RAILWAY PASSENGER STATIONS
- RAILWAY FREIGHT STATIONS
- CAR FLOAT BRIDGES
- FERRIES–PASSENGER & VEHICULAR
- SAND, GRAVEL & CEMENT
- VEGETABLE, FISH, & CHINA OIL HANDLING
- NEWSPRINT HANDLING
- COAL HANDLING

NOTES:

1. NUMERALS REFER TO DESCRIPTIONS IN PORT SERIES NO. 36
2. TRANSIT SHEDS ARE SHOWN AS CROSSHATCHED BUILDINGS
3. FIELD DATA AS OF AUGUST 1963



PORT FACILITIES AT SEATTLE, WASHINGTON

BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C.

SCALE IN FEET

OUTER HARBOR

FIGURE 8-5R

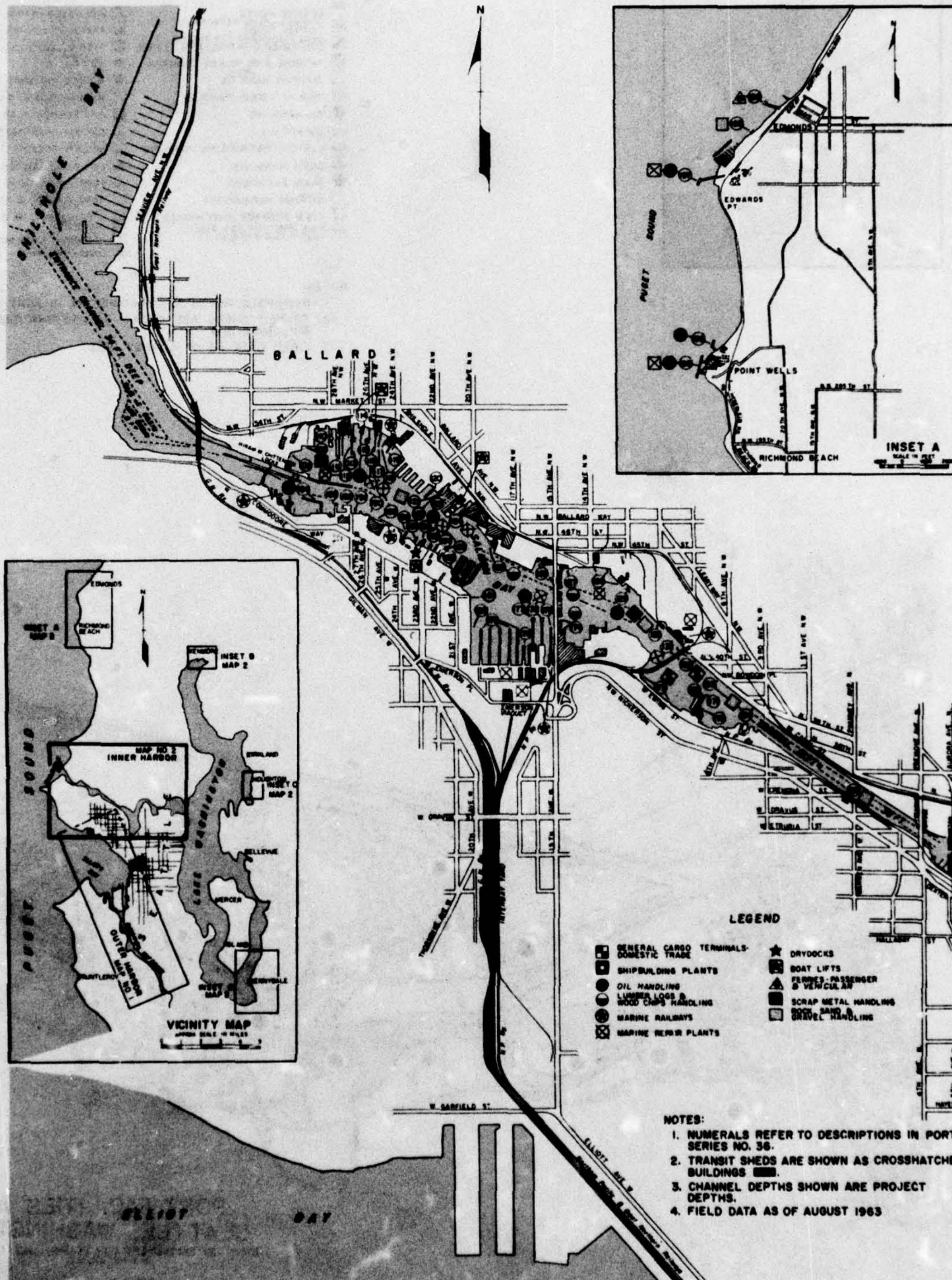

N
SHILSHOLE
BAY
BALLARD
INSET A
EDMONDS
EDWARDS PT
POINT WELLS
PUGET SOUND
RICHMOND BEACH
ELLIOT
BAY
W GARFIELD ST.
VICINITY MAP
MAP NO 1 INNER HARBOR
INSET B MAP 2
INSET C MAP 2
LAKE WASHINGTON
BELLEVUE
MERCER
LEGEND
GENERAL CARGO TERMINALS-DOMESTIC TRADE
SHIPBUILDING PLANTS
OIL HANDLING
LUMBER LOGS & WOOD CHIPS HANDLING
MARINE RAILWAYS
MARINE REPAIR PLANTS
DRYDOCKS
BOAT LIFTS
FERRIES-PASSENGER & VEHICULAR
SCRAP METAL HANDLING
ROCK, SAND & GRAVEL HANDLING
NOTES:
1. NUMERALS REFER TO DESCRIPTIONS IN PORT SERIES NO. 36.
2. TRANSIT SHEDS ARE SHOWN AS CROSSHATCHED BUILDINGS.
3. CHANNEL DEPTHS SHOWN ARE PROJECT DEPTHS.
4. FIELD DATA AS OF AUGUST 1963

FIGURE 8-6L

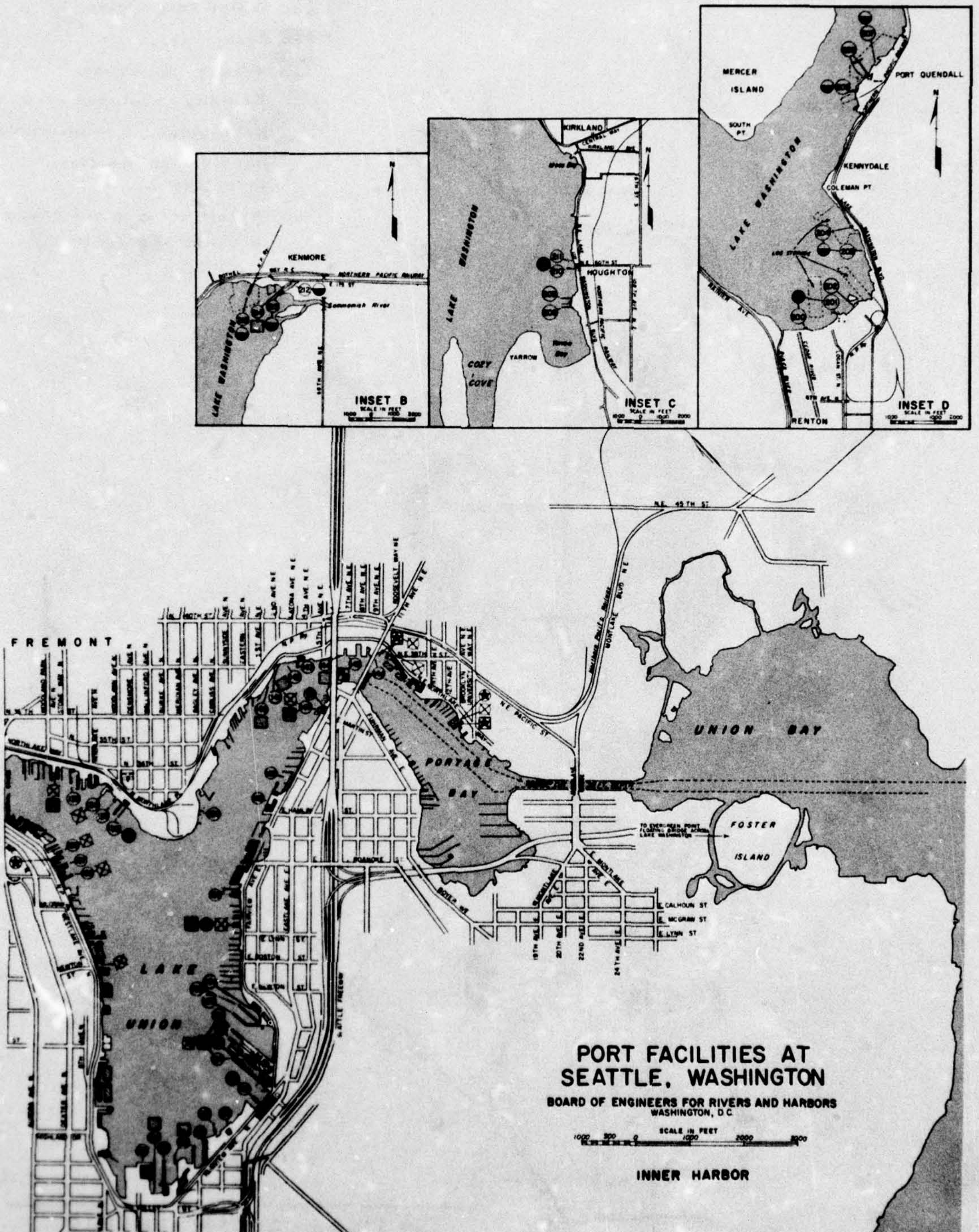
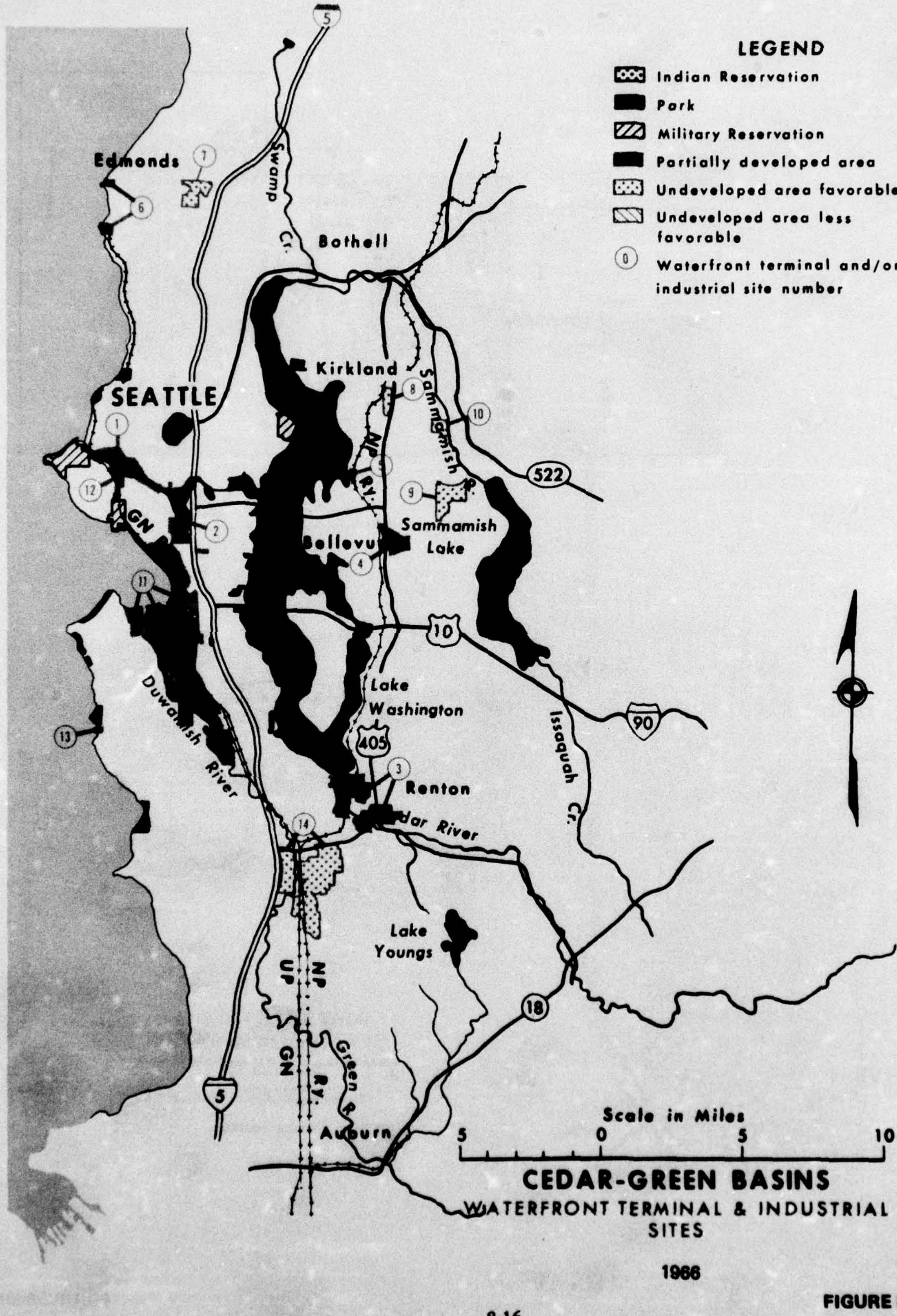

PORT FACILITIES AT
SEATTLE, WASHINGTON
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C.
SCALE IN FEET
INNER HARBOR
INSET B
INSET C
INSET D
KENMORE
KIRKLAND
HOUGHTON
YARROW
COZY COVE
MERCER ISLAND
SOUTH PT
PORT QUENDALL
KENNYDALE
COLEMAN PT
RENTON
LAKE WASHINGTON
FREMONT
LAKE UNION
PORTAGE BAY
UNION BAY
FOSTER ISLAND
N.E. 45TH ST.
E. CALHOUN ST
E. MCGRAW ST
E. LYNN ST

FIGURE 8-6R



CEDAR-GREEN BASINS
WATERFRONT TERMINAL & INDUSTRIAL SITES

1966

FIGURE 8-7

WATERFRONT AND INDUSTRIAL LAND

The existing and potential sites of water transport-oriented industries and terminal facilities in the Cedar-Green Basins are shown on Figure 8-7 and summarized in Table 8-7. In this Table the net areas are the gross areas less rights-of-way for streets and highways. The following discussion refers to site numbers shown on referenced Figure and Table.

Site No. 1 consisting of small parcels along the Lake Washington Ship Canal is mostly developed but has some potential sites for additional waterfront terminals and light industries.

Site No. 2 located at the south end of Lake Union includes a number of developed areas but also has a few small parcels suitable for light industries or waterfront terminals.

Site No. 3 located in and near Renton is partly developed but includes areas suitable for light industry.

Site No. 4 located near Bellevue is suitable for light industry.

Site No. 5 at Houghton is suitable for light industry.

Site No. 6 located along the Edmonds-Richmond Beach waterfront is essentially all developed.

Site No. 7 in the Mountlake Terrace area would be suitable for light industry.

Site No. 8 located near Kirkland is suitable for light industry.

Site No. 9 is near Sammamish Lake and is suitable for light industry.

Site No. 10 near Redmond would require major site preparation but would be suitable for light industry.

Site No. 11 includes the existing and planned future development by the Port of Seattle on the Elliott Bay waterfront and the adjacent industrial and commercial area. Although mostly developed, there are areas available, generally in less than 10 acre parcels, that are suitable for light and medium industries. Consolidation of these parcels is possible to meet larger land requirements. There is also waterfront available for terminal facilities some of which require dredging and filling.

Site No. 12 located in the Seattle Interbay area is partially developed but has some space suitable for light industry.

Site No. 13 located in the Seattle-Fauntleroy area is being used for a ferry slip and has no potential for other port facilities or industries.

Site No. 14 located in the Tukwila area is more than 5 miles from existing deep water terminals but is in an area being developed by various industries, some of which are water-transport-oriented. This area is considered suitable for light and medium industries.

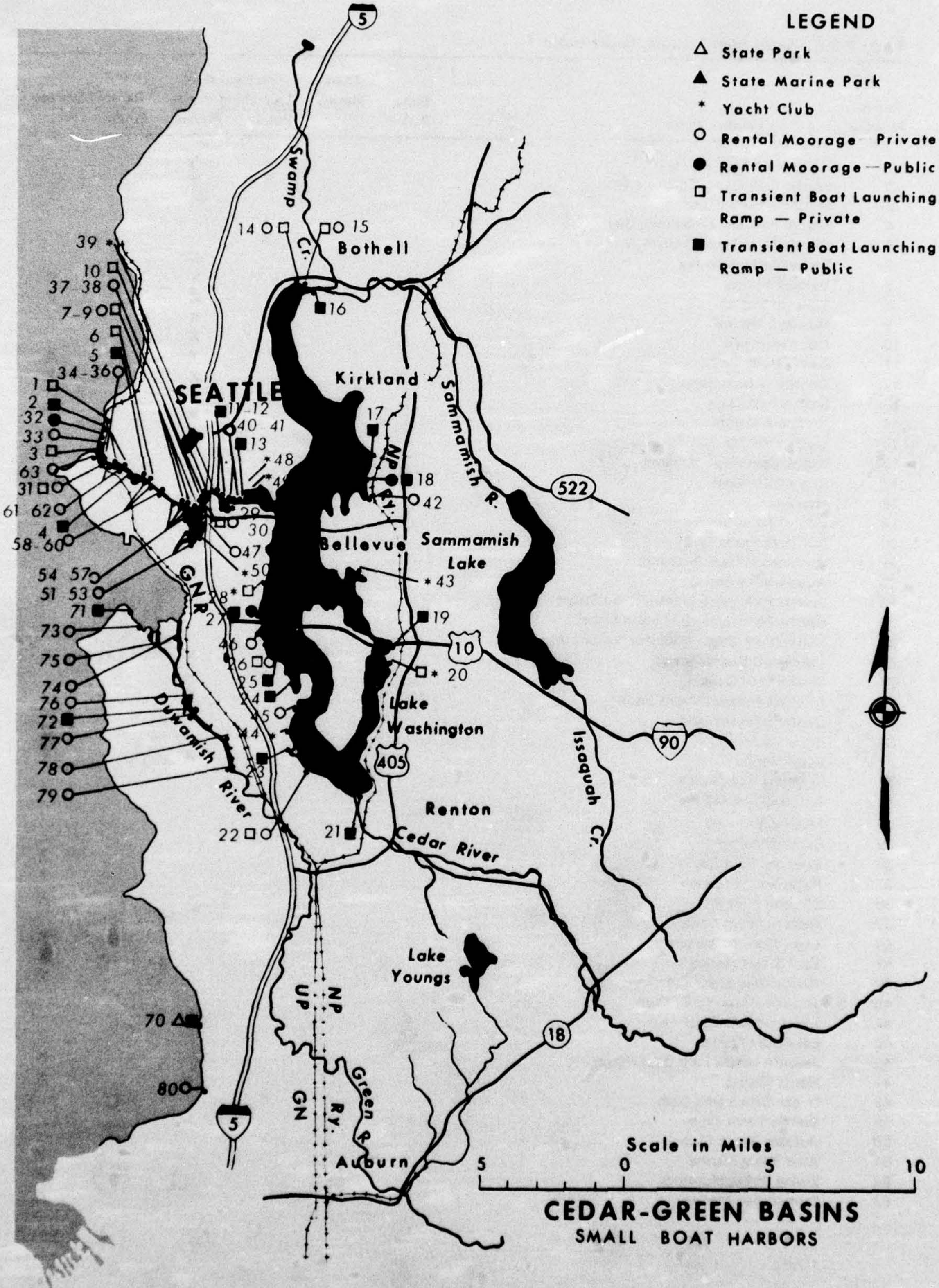
Site No. 15 is located in the Green River valley and generally more than 5 miles from existing deep water terminals are a number of parcels of land that would be suitable for light and medium industries. Although not specifically located on Figure 8-7, at least 800 acres is considered favorable for water-oriented industrial development.

TABLE 8-7. Waterfront and industrial land—Cedar-Green Basins—1963

		Acres in Use (Net)				Acres Potential			
						Favorable		Less Favorable	
Site No.	Location	Terminal Facilities	Vessel Repair Construction	Water Oriented Industry	Total	Gross	Net	Gross	Net
	Cedar Basin								
1	Lake Washington Ship Canal	135	73	39	247	64	48	0	0
2	Lake Union	32	9	16	57	24	18	0	0
3	Renton	9	0	287	295	452	339	0	0
4	Bellevue	0	0	76	76	220	165	0	0
5	Houghton	7	0	0	7	20	15	0	0
6	Edmonds-Richmond Beach	73	0	180	253	0	0	0	0
7	Mountlake Terrace	0	0	8	8	312	234	0	0
8	Kirkland	0	0	0	0	140	105	0	0
9	Sammamish Lake	0	0	0	0	460	345	0	0
10	Redmond	0	0	0	0	300	225	0	0
	Total Cedar Basin	256	82	606	943	1,992	1,494		0
	Green Basin								
11	Elliott Bay-Duwamish River	540	202	1,102	1,844	960	720	0	0
12	Interbay	0	0	10	10	20	15	0	0
13	Fauntleroy Ferry	11	0	0	11	0	0	0	0
14	Tukwila	0	0	0	0	2,220	1,665	0	0
15	Green River Valley	0	0	0	0	800	600	0	0
	Total Green Basin	551	202	1,112	1,865	4,000	3,000	0	0
	Grand Total—Cedar Green Basins	807	284	1,718	2,808	5,992	4,494	0	0

SMALL BOAT HARBORS

The small boat facilities existing in 1966 on salt water and on Lake Washington and along the Lake Washington Ship Canal are shown on Figure 8-8 and identified in Tables 8-8 and 8-9. Shown on Figure 8-9 are about seven miles of salt water shoreline that are considered suitable for potential marina development.



CEDAR-GREEN BASINS
SMALL BOAT HARBORS

FIGURE 8-8

TABLE 8-8. Small boat harbors, Cedar Basin

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp Public	Transient Boat Launching Ramp Private	Rental Moorage Public	Rental Moorage Private
1	Eddie Vine Boat Ramp				X		
2	Seattle Park Dept–Shilshole Bay			X			
3	Shilshole Marina, Inc.				X		X
4	Seattle Park Dept.–Salmon Bay			X			
5	Seattle Park Dept.–14th N.W.			X			
6	Rowe Machine Works				X		
7	Vesojas Marina				X		X
8	Tillicum Marina				X		X
9	Westlake Marina				X		X
10	Doc Freeman's				X		
11	Wies Marina				X		X
12	University Boat Sales				X		X
13	Seattle Park Dept			X			
14	Kenmore Marina				X		X
15	Uplake Marina				X		X
16	Washington Dept of Game			X			
17	City of Kirkland			X			
18	Houghton			X		X	
19	City of Bellevue			X			
20	Newport Yacht Basin				X		
21	Washington Dept of Game			X			
22	Aqua Marine Service				X		X
23	Seattle Park Dept–S Henderson Street			X			
24	Seattle Park Dept–S Hudson Street			X			
25	Seattle Park Dept–46th Avenue South			X			
26	Lakewood Boat Moorage				X		X
27	Seattle Park Dept–			X		X	
28	Lake Washington Yacht Basin				X		
29	Denny's Texas Marina				X		X
30	Bryant's, Inc.				X		X
31	Bergs Marina				X		X
32	Shilshole Bay Marina					X	
33	Golden Tides Marina						X
34	McGinnis Marina						X
35	Sagstad Marina						X
36	Fremont Boat Co.						X
37	Puget Sound Marina						X
38	Stimson Marina						X
39	Western yacht Basin						
40	Leger Marine Charters						X
41	Boat Street Marina						X
42	Yarrow Bay Marina						X
43	Meyden Bauer Yacht Club						
44	Rainier Yacht Club						
45	Lakeshore Marina						X
46	Seaborn Leschi Park Boat House						X
47	Houtz Marina						X
48	Queen City Yacht Club						
49	Seattle Yacht Club						
50	Webster Yacht Club						
51	West Shore Marina						X
52	Ewing Street Moorings						X
53	Salmon Bay Marina						X

TABLE 8-8. Small boat harbors, Cedar Basin (Continued)

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp		Rental Moorage	
				Public	Private	Public	Private
54	Gove's Cove						X
55	Washington Boat Center						X
56	Fairview Boat Service						X
57	Blanchard Boat Co.						X
58	Tom Wheeler Boat Sales						X
59	Seattle Marina, Inc.						X
60	Thunder Bird Marina						X
61	Lloyd Jett						X
62	Lockhaven Marina						X
63	Marina Mart						X
	TOTALS	0	0	13	18	3	38

TABLE 8-9. Small boat harbors, Green Basin

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp		Rental Moorage	
				Public	Private	Public	Private
70	Salt Water State Park	X		X			
71	Seattle Park Dept–SW Maryland Place			X			
72	Seattle Park Dept–S River Street			X			
73	Seacrest Marina						X
74	Pioneer Marina Ford						X
75	Triple & Everett						X
76	Nelsen & Hansen						X
77	Anchor Marina						X
78	Riverside Marina						X
79	South Park Boat Haven						X
80	Redondo Marina						X
	TOTALS	1	0	3	0	0	8

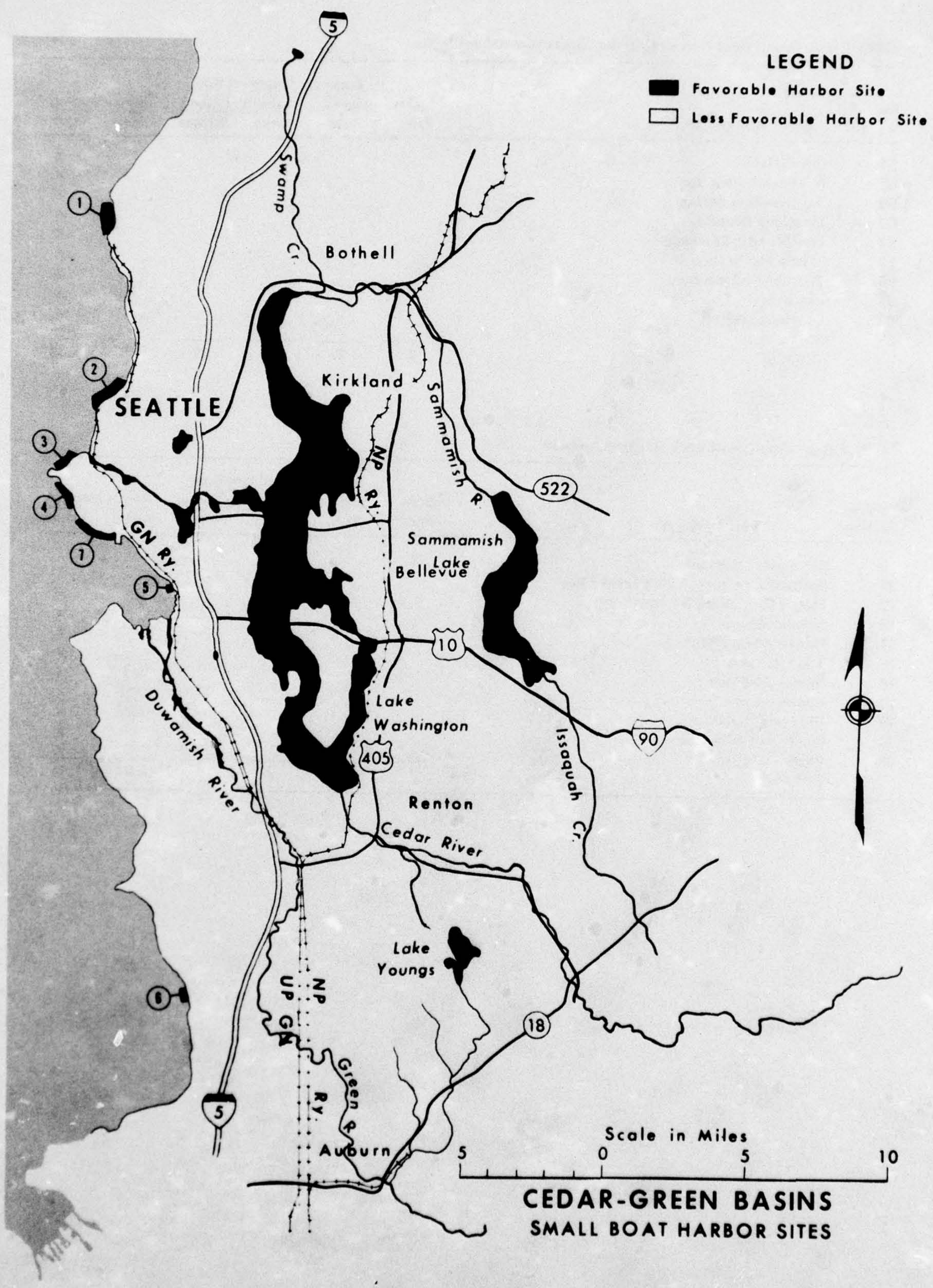

LEGEND
Favorable Harbor Site
Less Favorable Harbor Site
SEATTLE
Bothell
Kirkland
Bellevue
Renton
Auburn
Swamp Cr.
Sammamish R.
Sammamish Lake
NP Ry.
GN Ry
Lake Washington
Duwamish River
Cedar River
Issaquah Cr.
Lake Youngs
Green R.
NP
UP GA
Ry.
5
522
10
90
405
18
1
2
3
4
7
5
6
Scale in Miles
5 0 5 10
CEDAR-GREEN BASINS
SMALL BOAT HARBOR SITES

FIGURE 8-9

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 with a framework plan developed for satisfying these needs by individual basins. Table 8-10 summarizes the navigation needs of the Cedar-Green Basins as derived in Solutions to Navigation Needs.

TABLE 8-10. Cedar-Green Basins—future navigation needs

Item	Unit	1980	Needs By 2000[1]	Needs By 2020[1]
Waterborne Commerce				
General Cargo	1,000	4,350		
Bulk Grain	Short Tons	1,250		
Forest Products		1,250		
Bulk Petroleum		5,690		
Other Dry Bulk		9,130		
Other Liquid Bulk		330		
Totals		22,000	32,600	50,000
Harbors & Channels Requirements				
Vessel Draft	Feet			
Freighters		39	40	40
Bulk Carriers		57	71	71
Tankers		45	47	48
Land Requirements	Acres			
Terminal and water-transport-oriented industry		6,550	7,300	7,300
Small Boat Harbors	Wet Moorages[2]	10,920	21,200	41,200

1 Only aggregate tonnages projected after 1980.

2 Taken as summer wet moorage demand.

MEANS TO SATISFY NEEDS

The Port of Seattle should continue its pursuit of rehabilitation and development of new facilities if it is to continue to service a well-developed and diversified traffic base.

TERMINAL AND INDUSTRIAL LAND REQUIREMENTS

As noted in Table 8-10, approximately 7,300 acres of terminal and industrial lands will be required by the year 2000 to meet projected needs. This includes 2,808 acres already developed for this purpose. Examination of Figure 8-7 and Table 2-10 shows that these needs can be satisfied by full development of areas which are only partially developed and by utilization of certain undeveloped areas which show good potential for development. Table 8-10 shows continued growth beyond 2000. However, as available industrial and terminal lands become more intensely developed, the port will be required to handle cargo more efficiently or seek additional areas outside existing port boundaries.

Period	Channel	Channel Depth In Feet	Estimated Costs	Estimated Annual Costs	Estimated Benefits	Estimated Benefit Cost Ratio
1980	West Waterway	54	$ 245,000	$15,600	16,400	1.1
	East Waterway	54	900,000	49,500	60,000	1.2
	Duwamish Channel to 1st Ave. So.	46	1,715,000	93,500	153,700	1.6
	Duwamish 1st Ave. So. to 8th Ave.	30	279,000	14,400	24,200	1.7
	8th Ave. So. to Head of Nav.	20	640,000	36,000	84,000	2.3
1980-2000	None					
2000-2020	None					

HARBORS AND CHANNELS

To accommodate projected vessel drafts shown in Table 8-10 channel improvements should be made as shown above. The bulk grain terminal being constructed by the Port of Seattle will have access and berthing of unlimited depths to accommodate the current large bulk carriers and also meet future trends in vessel size.

SMALL BOAT HARBORS

Listed in Table 8-11 are the sites in the Cedar-Green Basins suitable for development of small boat harbors. The sites shown on Figure 8-9 are the most favorable in this Basin.

A tentative schedule of development to meet 1980, 2000 and 2020 needs is contained in Table 8-11. Benefits and costs for projects recommended to meet 1980 pleasure boating demand are also shown as are the estimated construction costs for additional projects required by 2000 and 2020. Costs shown are for general navigation facilities and navigation aids that may require Federal assistance in financing and construction. General navigation facilities consist of breakwaters, entrance channels, and turning basins and breakwater lights. Costs are average values and are based on actual construction or detailed study cost estimates for small boat harbor projects in the Area. Average benefit values were derived using the standard methods employed by the Corps of Engineers, data from the "Pleasure Boating Study," and other studies performed for small boat harbor projects.

By the year 2000, all salt water sites determined by this study to be favorable for development of wet moorage will be exhausted. Spillover into the Snohomish and Whidbey-Camano Basins is expected as well as a proportionate greater use of dry moorage than what boaters have indicated as desirable in order to satisfy future needs within these basins. Part of the demand may be satisfied by more intensive moorage development in Lakes Union and Washington. This, however, will increase traffic on the Lake Washington Ship Canal. Even with additional locks or other boat handling facilities a limit to this canal traffic is approached as conjestion increases.

TABLE 8-11. Small boat harbor sites—Cedar-Green Basins

Site No.	Location	Wet Moorages	Water-Land Area-Acres[4]	Tentative Schedule of Development 1980	2000 Wet Moorages	2020
1.	Wells Pt.—Edmonds	2,000	167		2,000	
2.	Golden Gardens—North	1,450	121		1,450	
3.	Fort Lawton—North	1,140	95		1,140	
4.	Fort Lawton-South	3,520	293		3,520	
5.	Elliott Bay—Pier 54	290	24	290		
6.	Des Moines	670	48	670		
7.	Elliott Bay—Magnolia Bluff	1,910	159		1,910	
8.	Seacrest Marina Addition[5]	1,140	121	1,140		
	Totals	12,120	1,028	2,100	10,020	

Summary of Benefits and Costs

1980 Construction Costs[3]	1980 Average Annual Costs[1,2]	1980 Average Annual Benefits	2000 Construction Costs[3]	2020 Construction Costs[3]
$4,139,500	$280,200	$391,400	$20,196,300	0

1 Annual interest and amortization charges of general navigation facility construction costs, including aids to navigation are computed for 50-year economic life at a rate of 4-5/8 percent.

2 Includes allowance of $25 per wet moorage for annual maintenance and replacement costs.

3 Includes allowance for Engineering, Design, Supervision and Administration costs.

4 Using relationships based on Shilshole Marina wet moorage land and water area requirements are estimated at 0.056 acres of water area for moorage and maneuvering and 0.028 acres of land for parking and services per boat.

5 *Private marina, shown* on Figure 8-7 as Site 73, proposed site for public marina with expansion planned by use of floating breakwater.

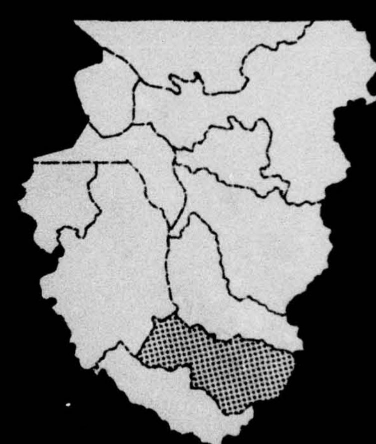
Note: Not contained in the area requirements are land needs for launching ramps which will generally be incorporated with moorage facilities. Launching facilities require about 1.5 acres of land for ramps and parking for each lane provided.

Factors Influencing Implementation of Plan

The major problem facing the development of the East, West and Duwamish Waterways for deep draft shipping is the navigation clearances afforded by existing bridges. The First Avenue Bridge limits the future upstream movement of deep draft vessels and the Spokane Street Bridge offers only minimal horizontal and vertical clearance. The proposed freeway bridge and expressway bridges will further compound the problem unless planned to meet the existing and future needs of deep draft navigation.

Coordination with companies and agencies representing rail and highway transportation sectors is necessary in order to provide an integrated land and sea transportation system which will facilitate handling of projected commerce for the Basin.

Puyallup Basin



PUYALLUP BASIN

The salt water boundary of this basin includes: East Passage, Poverty Bay, Commencement Bay, Dalco Passage, The Narrows and Cormorant Passage. There are depths of over 100 feet just offshore along the entire 48-mile shoreline but because of the steep slopes, only the shores in Commencement Bay are suitable for major harbor development. The Puyallup River is not navigable except in the tidal reach for shallow draft vessels. The Port of Tacoma is the only organized port district in the basin. Four transcontinental railroads serve the basin as well as numerous interstate and State highways. A major international airport also serves the area.

PRESENT STATUS

HARBORS AND CHANNELS

Tacoma Harbor is situated at the south end of Commencement Bay, 143 nautical miles from the Pacific Ocean. Commencement Bay has depths of over 500 feet but most of the harbor development is at the head of the bay on the Puyallup River Delta which requires dredging. The Federal project is shown on Figure 9-1.

Minor harbors included with this basin are the following:

Redondo on the east side of East Passage on Poverty Bay.

Dumas Cove or Bay two miles westerly of Redondo.

Titlow Beach or Day Island Anchorage is about 4.5 miles southward of Point Defiance.

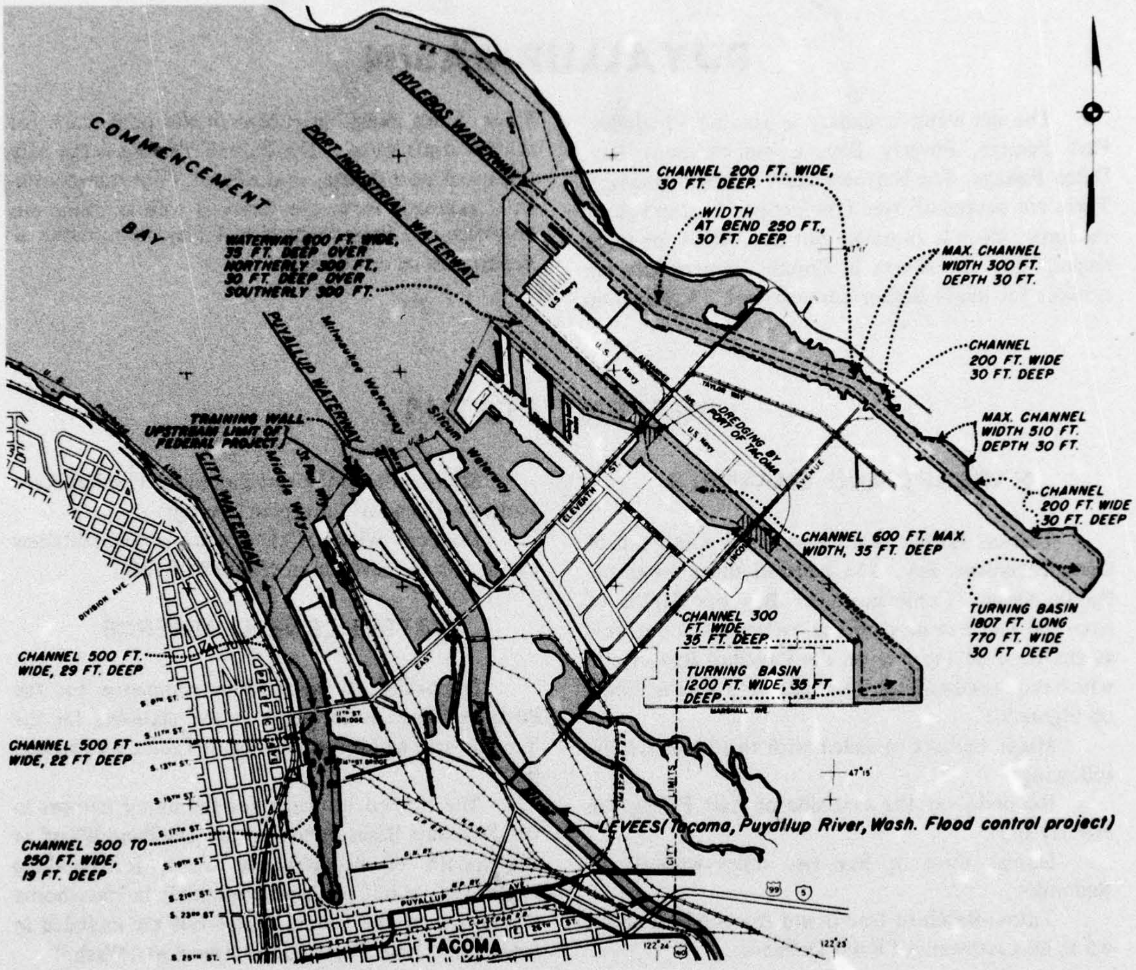
Steilacoom on the east shore near Gordon Point at the north end of Cormorant Passage.

Du Pont Wharf at the mouth of Sequalitchew Creek near the east end of Nisqually Reach.

WATERBORNE COMMERCE

Practically all waterborne commerce for the Puyallup Basin is included in the statistics for the Tacoma area and is summarized in Tables 9-1 through 9-4.

The limited tonnages for the minor harbors in the Puyallup Basin including the Du Pont Wharf at the mouth of Sequalitchew Creek for handling explosives are not published separately in Waterborne Commerce of the United States but are included in totals for "Other Puget Sound Area Ports, Wash."



Improvement	AUTHORIZED Depth Feet	Width Feet	Length Feet	Depth Feet	Width Feet	Length Feet
Hylebos Waterway:				CONDITION IN 1966		
Commencement Bay to E. 11th St.	30	200		29.0	180	
E. 11th St. to Bend below Lincoln Ave.	30	200		29.4	160	
Bend below Lincoln Ave. to downstream turning basin	30	200		30.0	280-160	
Downstream turning basin to upstream turning basin	30	200		30	200	
Upper turning basin	30	770	1807	30		
City Waterway:				CONDITION IN 1967		
Commencement Bay to S. 11th St. Bridge	29	500		26.2	440	
S. 11th St. to S. 14th St.	22	500		19.8	380	
S. 14th St. to 800 ft. Upstream	19	500		16.6	150	
800 ft. above S. 14th St. to head of waterway	17	500-250		14.2		
Port Industrial (Wapato) Waterway:						
Commencement Bay to E. 11th St.	30	S. 300		28.1	200	
Commencement Bay to E. 11th St.	35	N. 300		28.1	200	
At 11th St. Bridge				29.2	120	
E. 11th St. Lincoln Ave.	35	600		35.5		
Lincoln Ave. to turning basin	35	300		35.5		
Turning basin	35	1200		35.5		

TACOMA HARBOR WASHINGTON

SCALE IN FEET

1000 0 2000 4000 6000

Revised Sept., 1967

FIGURE 9-1

TABLE 9-1. Water-borne commerce for Tacoma Area. Foreign in short tons

FOREIGN IMPORTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	58,544	0	36,171	0	263,894	978	359,587
1953	50,862	0	37,934	0	412,204	1,729	502,729
1954	23,162	0	56,466	0	443,768	7,362	530,758
1955	27,591	0	69,874	772	341,381	781	440,399
1956	27,887	0	49,641	32,803	423,282	899	534,512
1957	24,561	0	38,116	126,911	455,773	831	646,192
1958	32,064	0	39,056	249,574	293,170	1,139	615,003
1959	38,104	0	35,569	78,066	281,546	0	433,285
1960	27,874	0	32,962	12,668	502,927	1,560	577,991
1961	36,053	0	24,437	14,635	421,483	2,430	499,038
1962	24,934	0	37,836	244,824	502,267	1,686	811,547
1963	28,654	0	32,951	287,172	958,811	0	1,307,588
1964	32,278	34	41,302	394,095	872,280	577	1,340,566
1965	45,939	105	60,277	442,758	824,506	2,124	1,375,709
1966	56,708	136	40,742	390,811	967,439	661	1,456,497

FOREIGN EXPORTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	109,750	546,148	44,816	0	84,366	1,224	786,304
1953	75,155	367,627	53,270	0	105,064	2,131	603,247
1954	146,112	297,352	38,028	0	136,452	1,660	619,604
1955	104,195	508,107	41,397	0	162,184	672	816,555
1956	124,866	769,894	42,940	0	212,304	844	1,150,848
1957	131,981	811,705	24,180	0	215,962	1,046	1,184,874
1958	149,522	413,313	49,117	0	104,482	621	717,055
1959	148,917	333,140	62,587	0	153,707	1,031	699,382
1960	148,418	827,188	57,771	0	167,781	1,266	1,202,424
1961	154,126	645,263	189,140	0	204,995	757	1,194,281
1962	112,170	425,344	237,479	0	215,503	846	991,342
1963	157,162	512,343	375,088	6,719	214,440	0	1,265,752
1964	155,444	395,943	428,709	84	192,514	126	1,172,820
1965	212,006	495,204	490,262	14,595	165,250	102	1,377,419
1966	165,844	493,036	765,897	104	101,427	48	1,526,356

TABLE 9-2. Water-borne commerce for Tacoma Area. Domestic coastwise in short tons

DOMESTIC COASTWISE RECEIPTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	18,639	0	0	553,614	221,067	0	793,320
1953	25,588	0	12,407	532,590	147,380	1,078	719,043
1954	22,381	0	6,748	497,131	147,781	17,975	692,016
1955	25,793	0	12,390	435,235	287,079	15,941	776,438
1956	2,363	0	14,756	380,198	316,461	10,125	723,903
1957	11,124	0	18,696	228,293	226,285	14,055	498,453
1958	23,083	0	15,758	233,169	196,809	11,862	480,681
1959	20,721	0	13,592	313,405	181,922	17,515	547,155
1960	54,059	0	16,416	596,622	0	9,892	676,989
1961	23,423	0	12,918	447,043	1,805	9,757	494,946
1962	98,058	0	4,993	243,771	12,113	6,673	365,608
1963	95,728	0	4,023	227,274	2,703	9,348	339,076
1964	63,839	0	2,891	125,652	563	9,713	202,658
1965	828	0	5,135	132,307	0	8,781	147,051
1966	93	0	2,489	110,478	442	4,422	117,924

DOMESTIC COASTWISE SHIPMENTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	100,005	5,458	107,748	1,900	6,704	685	222,500
1953	46,400	6,035	113,029	8,290	42,941	0	216,695
1954	37,456	5,636	62,893	620	55,591	0	162,196
1955	32,753	6,437	56,593	0	59,674	0	156,457
1956	39,568	6,463	51,843	537	62,361	0	160,772
1957	27,357	6,931	22,668	7,416	66,357	0	130,729
1958	21,259	7,060	40,690	55,891	64,407	0	189,307
1959	24,431	8,286	33,123	77,539	66,853	0	210,232
1960	18,000	4,438	22,197	131,872	77,676	0	254,183
1961	10,826	3,669	3,329	93,904	44,273	0	156,001
1962	7,292	2,743	1,383	11,172	48,547	0	71,137
1963	7,914	4,105	2,193	78,100	56,588	0	148,900
1964	851	115	2,195	83,701	92,580	0	179,442
1965	9,917	0	0	53,914	38,829	800	103,460
1966	39,580	0	10	46,091	72,736	0	158,417

TABLE 9-3. Water-borne commerce for Tacoma area, in short tons

	FOREIGN AND DOMESTIC COASTWISE						
Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	286,938	551,606	188,735	555,514	576,031	2,887	2,161,711
1953	198,005	373,662	216,640	540,880	707,589	4,938	2,041,714
1954	229,111	302,988	164,135	497,751	783,592	26,997	2,004,574
1955	190,332	514,544	181,254	436,007	850,318	17,394	2,189,849
1956	194,684	776,357	159,180	413,538	1,014,408	11,868	2,570,035
1957	195,023	818,636	103,660	362,620	964,377	15,932	2,460,248
1958	225,928	420,373	144,621	538,634	658,868	13,622	2,002,046
1959	232,173	341,426	144,871	469,010	684,028	18,546	1,890,054
1960	248,351	831,626	129,346	741,162	748,384	12,718	2,711,587
1961	224,428	648,932	229,824	555,582	672,556	12,944	2,344,266
1962	242,454	428,087	281,691	499,767	778,430	9,205	2,239,634
1963	289,458	516,448	414,255	599,265	1,232,542	9,348	3,061,316
1964	252,412	396,092	475,097	603,532	1,157,937	10,416	2,895,486
1965	268,690	495,309	555,674	643,574	1,028,585	11,807	3,003,639
1966	262,255	493,172	809,138	547,484	1,142,044	5,131	3,259,194

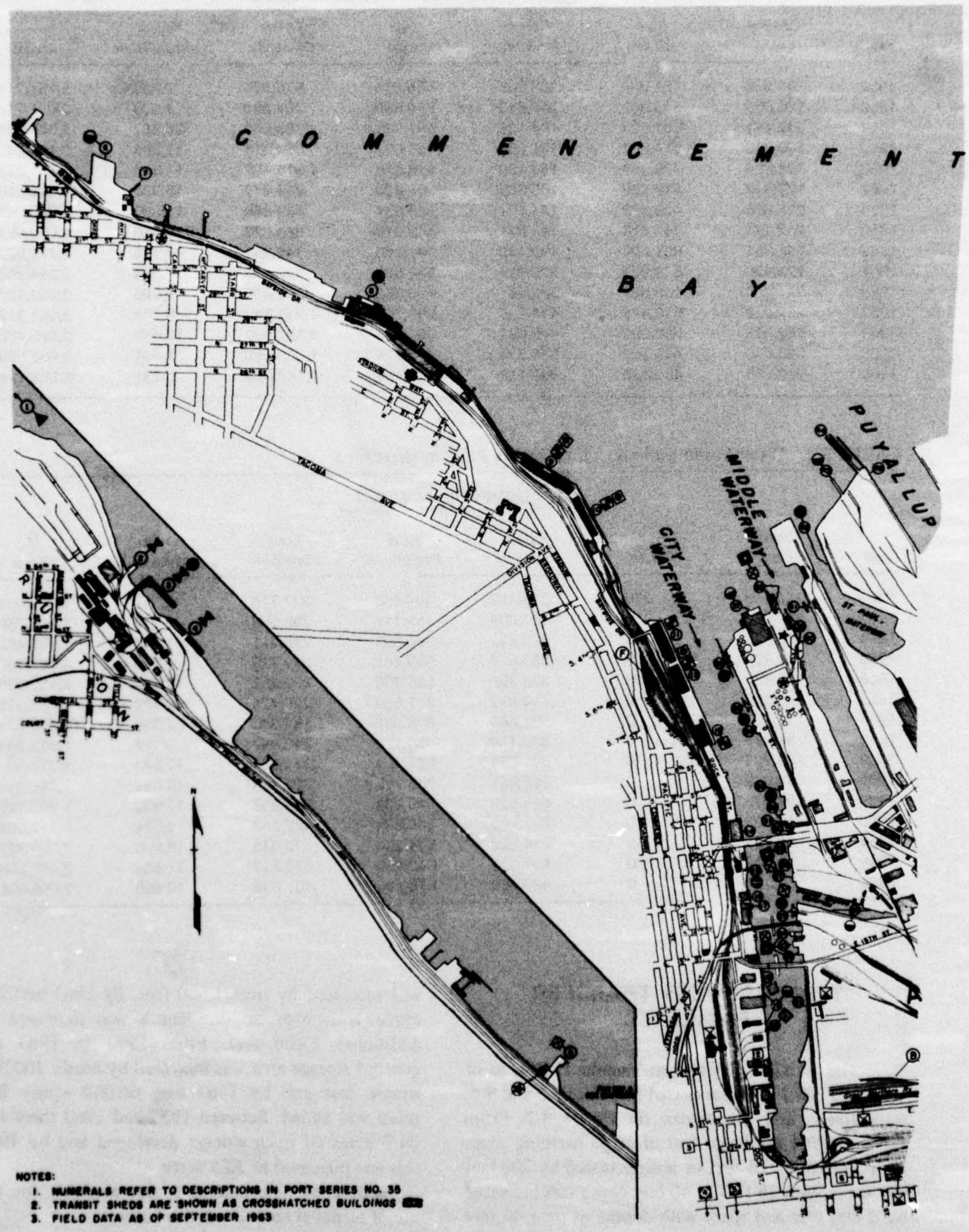
TABLE 9-4. Water-borne commerce for Tacoma Area, in short tons

	DOMESTIC INTERNAL						
Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	155,594	370	1,315,493	404,151	277,716	1,715	2,155,039
1953	119,363	322	1,183,204	355,111	298,666	0	1,956,666
1954	166,817	195	925,633	380,602	276,211	31	1,749,489
1955	171,426	71,530	1,088,628	590,497	319,713	1,266	2,223,060
1956	138,086	86	1,206,265	569,455	262,202	15,926	2,192,020
1957	95,128	0	700,811	607,550	228,724	21,102	1,653,315
1958	122,262	0	582,381	578,682	182,048	7,704	1,473,077
1959	84,319	0	885,110	650,172	243,042	3,151	1,865,794
1960	82,707	0	691,896	627,204	322,531	12,960	1,737,298
1961	88,035	0	735,881	776,198	332,183	13,952	1,946,249
1962	99,776	0	665,623	848,831	335,833	13,822	1,963,885
1963	110,133	0	576,780	808,335	422,242	9,574	1,927,064
1964	80,537	0	714,622	874,953	412,045	14,605	2,096,762
1965	78,449	0	891,032	840,950	576,312	21,565	2,408,308
1966	80,367	0	939,950	618,106	407,832	10,650	2,056,905

TERMINAL AND TRANSFER FACILITIES

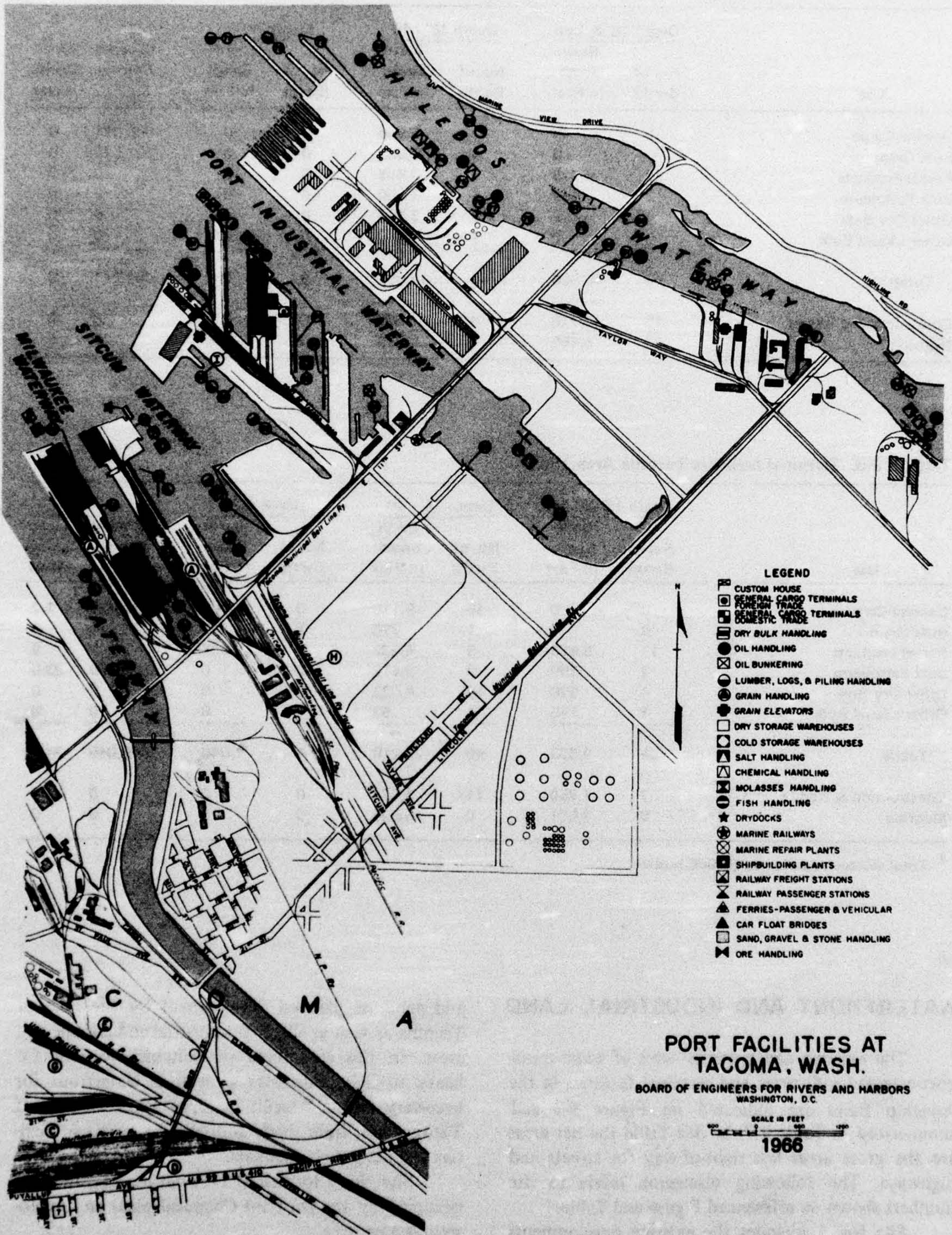
The terminal facilities at Tacoma Harbor as of 1952 and 1963 are summarized in Tables 9-5 and 9-6, respectively, and are shown on Figure 9-2. From 1952 to 1963 the lineal feet of cargo berthing space with a depth of 18 feet or less decreased by 700 feet but space with 18 feet to 40 feet depth was increased by 2,800 feet and space with depths of over 40 feet was increased by over 1,600 feet. By 1967 berthing space with over 40 feet depth was increased an additional 2,400 feet. From 1952 to 1963 the covered storage area was increased by nearly 100,000 square feet and by 1967 over 60,000 square feet more was added. Between 1952 and 1963 there was 24.7 acres of open storage developed and by 1967 this was increased to 33.5 acres.

Detailed information is not available for the minor terminal facilities in this basin.



NOTES:
1. NUMERALS REFER TO DESCRIPTIONS IN PORT SERIES NO. 35
2. TRANSIT SHEDS ARE SHOWN AS CROSSHATCHED BUILDINGS
3. FIELD DATA AS OF SEPTEMBER 1963

FIGURE 9-2L



PORT FACILITIES AT
TACOMA, WASH.

BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C.

1966

FIGURE 9-2R

TABLE 9-5. Terminal facilities Tacoma Harbor Area 1952

Use	Depth 18' & Less No. of Berths	Depth 18' & Less Berth Space In Feet	Depth 18' - 40' No. of Berths	Depth 18' - 40' Berth Space In Feet	Depth 40' + No. of Berths	Depth 40' + Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	1	45	17	9,256	0	0	603,321	0
Bulk Grain	0	0	4	1,552	0	0	101,520	0
Forest Products	32	9,215	7	2,555	0	0	0	0
Bulk Petroleum	3	449	6	1,390	0	0	0	0
Other Dry Bulk	4	826	8	2,164	0	0	0	0
Other Liquid Bulk	0	0	1	480	0	0	0	0
Totals	40	10,535	43	17,397	0	0	704,841	0
Construction & Repair	15	2,728	4	508	0	0	0	0
Mooring	27	5,455	7	1,928	0	0	0	0

TABLE 9-6. Terminal facilities Tacoma Area 1963

Use	Depth 18' & Less No. of Berths	Depth 18' & Less Berth Space In Feet	Depth 18' - 40' No. of Berths	Depth 18' - 40' Berth Space In Feet	Depth 40' + No. of Berths	Depth 40' + Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	0	0	16	9,118	0	0	657,425	1.7
Bulk Grain[1]	0	0	1	378	1	712	136,824	0
Forest Products	17	8,433	9	4,225	3	936	0	0
Bulk Petroleum	2	359	9	2,412	0	0	5,800	23.0
Other Dry Bulk	4	926	10	4,033	0	0	0	0
Other Liquid Bulk	1	115	1	53	0	0	0	0
Totals	24	9,833	46	20,219	4	1,648	800,049	24.7
Construction & Repair	7	1,750	11	1,574	0	0	0	0
Mooring	0	3,601	0	5,526	0	0	0	0

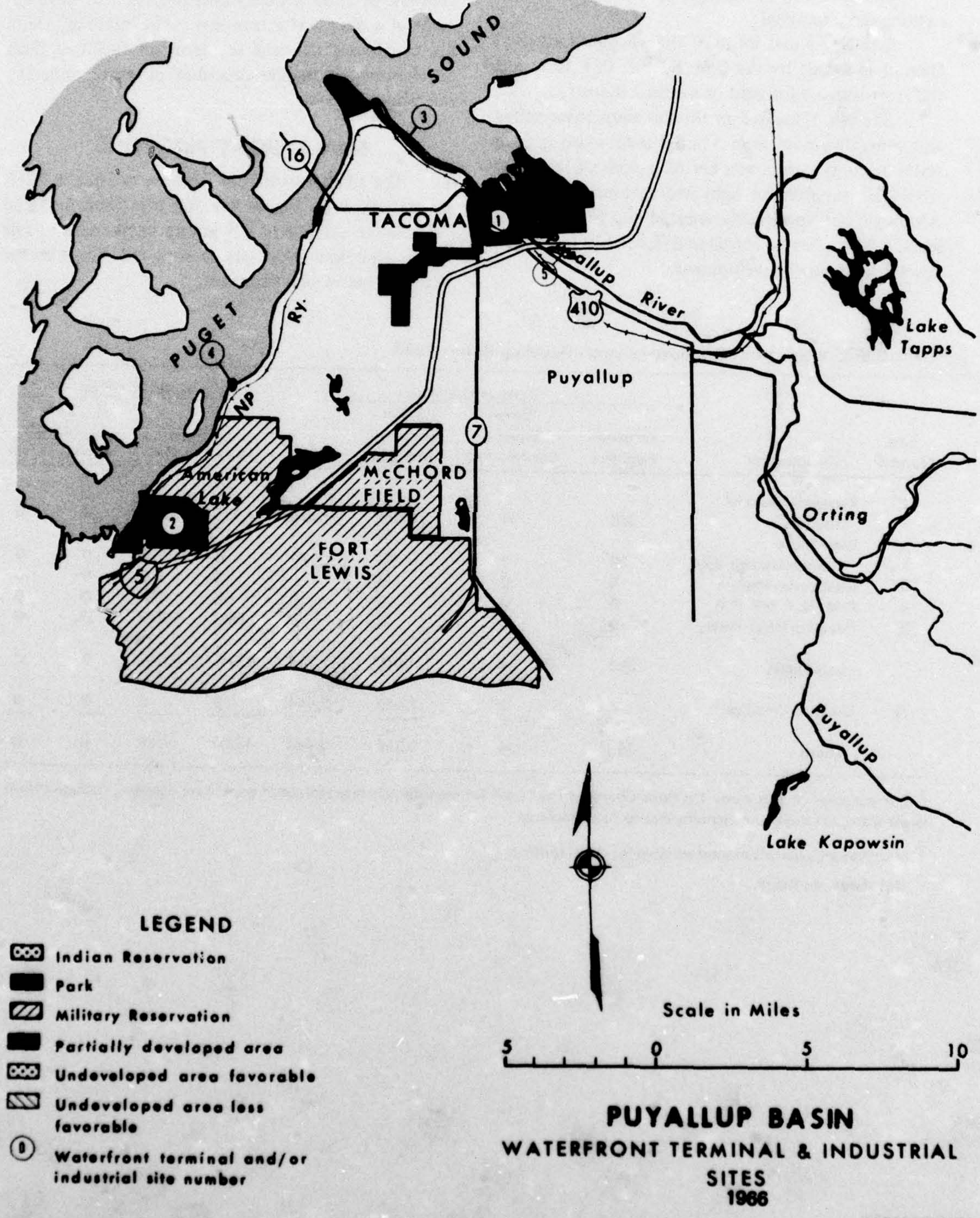
1 Total storage capacity 5,050,000 bushels.

WATERFRONT AND INDUSTRIAL LAND

The existing and potential sites of water-transport-oriented industries and terminal facilities in the Puyallup Basin are indicated on Figure 9-3 and summarized in Table 9-7. In this Table the net areas are the gross areas less right-of-way for streets and highways. The following discussion refers to site numbers shown on referenced Figure and Table.

Site No. 1 includes the existing developments and areas of planned development by the Port of Tacoma as well as adjacent industrial and commercial areas. In this area there are suitable locations for heavy to light industries as well as waterfront for necessary terminal facilities. Since 1963 the Port of Tacoma has made many additions to terminal facilities and navigation channels.

Site No. 2 located at Du Pont includes the area occupied by the Du Pont Chemical plant and explosives storage area.



PUYALLUP BASIN
WATERFRONT TERMINAL & INDUSTRIAL SITES
1966

FIGURE 9-3

Site No. 3 located on the west shore of Commencement Bay includes existing industries and related waterfront terminals but has no significant areas for additional developments.

Site No. 4 at Steilacoom is the location of the existing ferry terminal.

Site No. 5 just south of the Tacoma Industrial District is owned by the C.M. St. P.& P. R.R. and is the most suitable for light or medium industry.

Site No. 6 located in the Puyallup River valley and generally more than 5 miles from existing deep water terminals are a number of parcels of land that would be suitable for light and medium industries. Although not specifically located on Figure 9-5 at least 1,500 acres is considered favorable for water-oriented industrial development.

Several thousand additional acres up the Puyallup Valley could be favorable to water-oriented industry if a deep draft waterway was extended up the valley. As the potential of the Puyallup Basin will be fully utilized by about 1985, the Port of Tacoma adopted in 1965 a Comprehensive Plan for development of a deep water terminal in the Nisqually Delta for continuing demand for terminal facilities. This development is further described in the reference to the Nisqually Basin.

SMALL BOAT HARBORS

The small boat harbor facilities existing in 1966 are indicated on Figure 9-4 and identified in Table 9-8. Shown on Figure 9-5 are about 4 miles of salt water shoreline that are considered suitable for potential marina development.

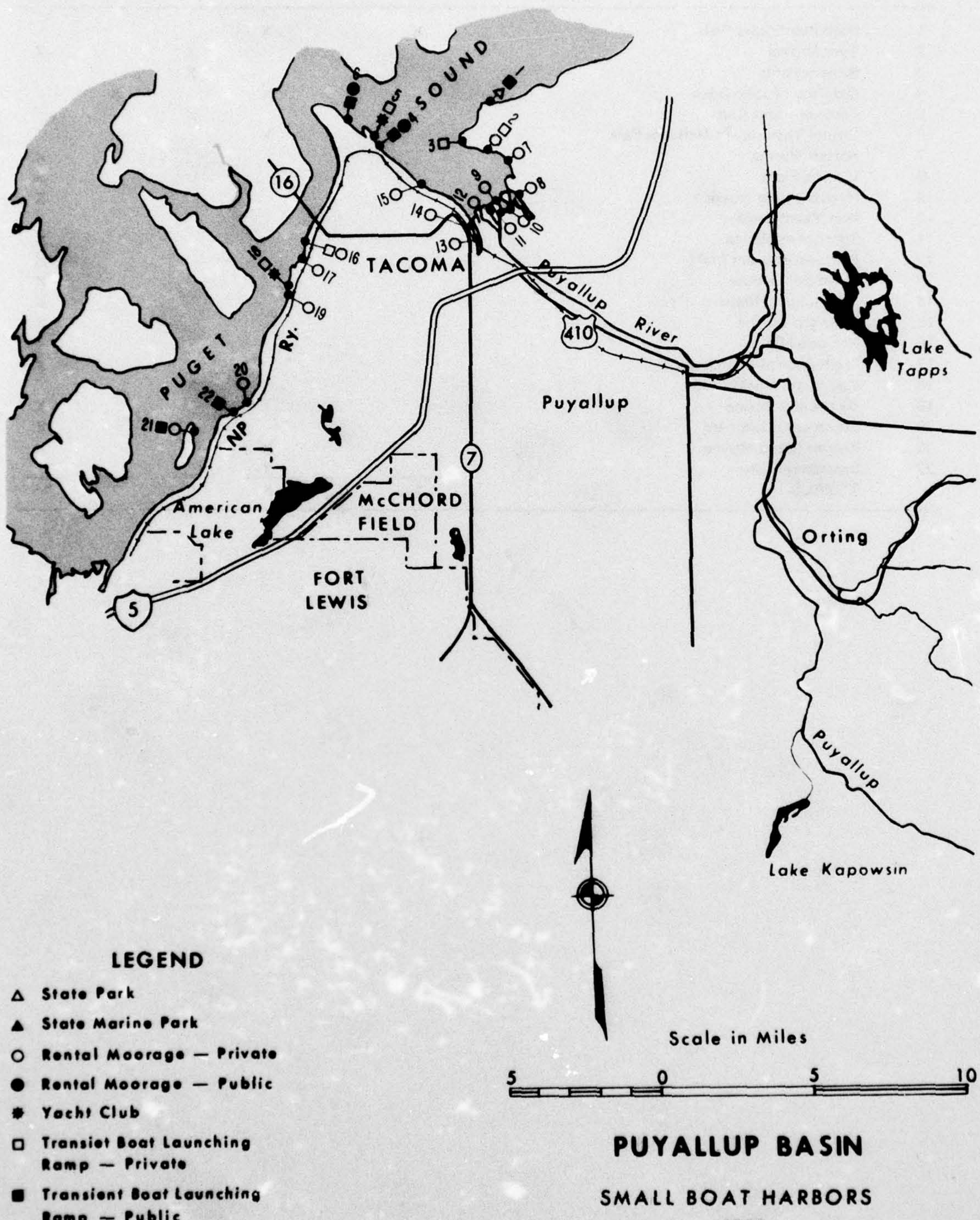
TABLE 9-7. Water front & industrial land—Puyallup Basin—1963

		Acres in Use (Net)				Acres Potential			
						Favorable		Less Favorable	
Site Number	Location	Terminal Facilities	Vessel Repair & Construction	Water Oriented Industry	Total	Gross	Net	Gross	Net
1.	Tacoma Industrial District	356	31	838	1,225	3,200	2,400	0	0
3.	West Shore Commencement Bay	28	3	43	74	0	0	0	0
6.	Steilacoom Ferry[3]	5	0	0	5	0	0	0	0
4.	C.M. St. P.& P. R.R.	0	0	0	0	60	45	0	0
5.	Puyallup River Valley[2]	0	0	0	0	1,600	1,200	0	0
	Sub-Totals	389	34	881	1,304	4,860	3,645	0	0
2.	Du Pont Chemical[1]	4	0	2,440	2,444	0	0	0	0
	Totals	393	34	3,321	3,748	4,860	3,645	0	0

[1] For purposes of this study Du Pont Chemical land used for manufacture and storage of explosives has been excluded from water-transport industrial planning due to its special use.

[2] Miscellaneous parcels of land suitable for development.

[3] Not shown on figure.



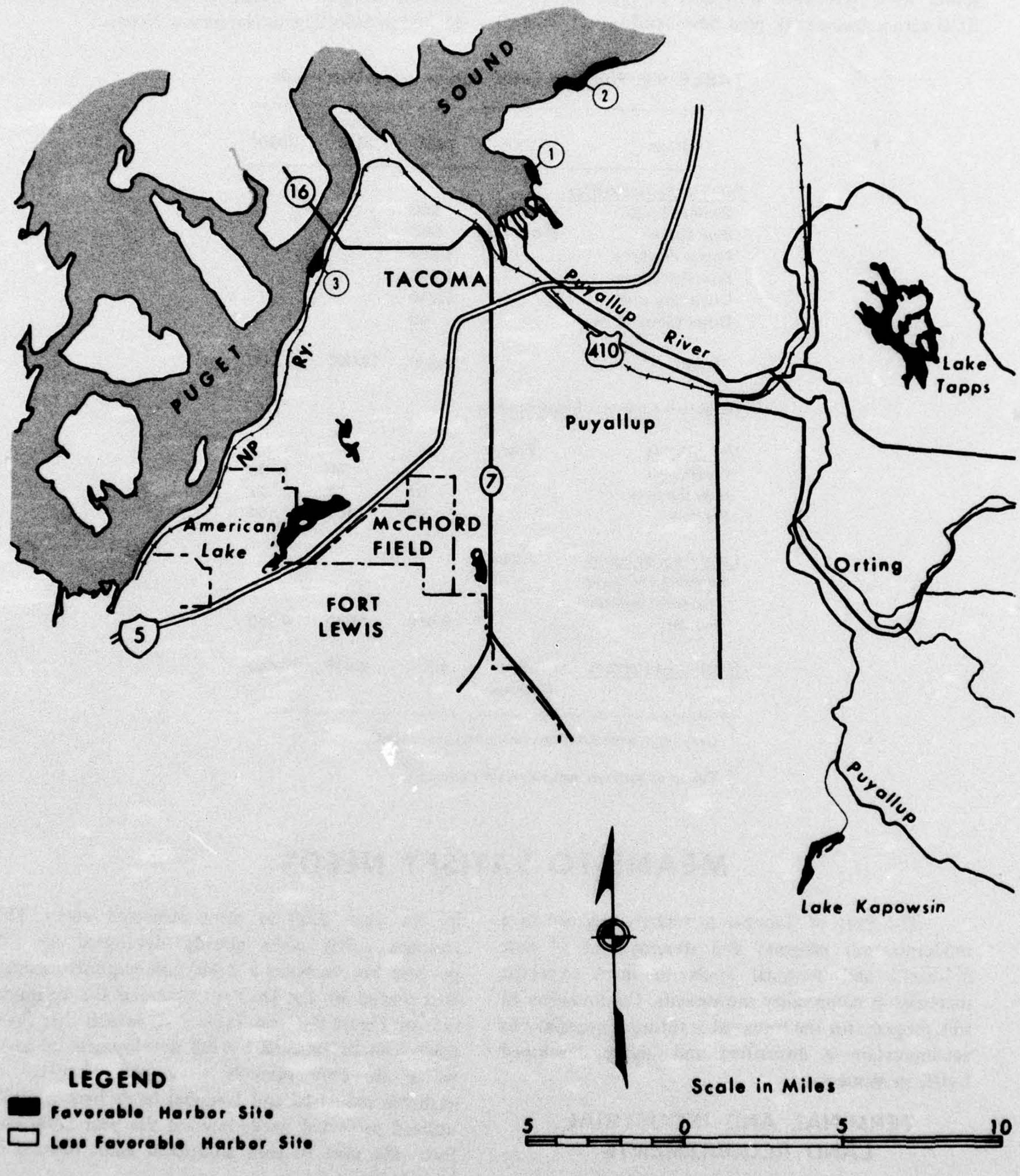
PUYALLUP BASIN

SMALL BOAT HARBORS
1966

FIGURE 9-4

TABLE 9-8. Small boat harbors, Puyallup Basin

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp: Public	Transient Boat Launching Ramp: Private	Rental Moorage: Public	Rental Moorage: Private
1	Dash Point State Park	X		X			
2	Tyee Marina				X		X
3	Browns Point				X		
4	Old Town Public Dock			X		X	
5	Tacoma Yacht Club				X		
6	City of Tacoma–Pt Defiance Park			X		X	
7	Harbor Marina						X
8	Lloyd's Float						X
9	Hylebo's Boat House						X
10	Port Yacht Basin						X
11	Sportsman Marina						X
12	Fairliner Pleasure Craft						X
13	Canal Boat House						X
14	Totem Boat Haven						X
15	Caddigan Marina						X
16	Narrows Marina				X		X
17	Sixth Avenue Boathouse						X
18	Day Island Yacht Club				X		
19	Day Island Marina						X
20	Steilacoom Outboard						X
21	Ketron Island Marina			X			X
22	Steilacoom City			X			
	TOTALS	1	0	5	5	2	15



PUYALLUP BASIN
SMALL BOAT HARBOR SITES

FIGURE 9-5

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 with a framework plan developed for satisfying these needs by individual basins. Table 9-9 summarizes the navigation needs of the Puyallup Basin as derived in Solutions to Navigation Needs.

TABLE 9-9. Puyallup Basin—future navigation needs

Item	Unit	1980	Needs By 2000[1]	Needs By 2020[1]
Waterborne Commerce				
General Cargo	1,000	640		
Bulk Grain	Short Tons	950		
Forest Products		1,220		
Bulk Petroleum		1,880		
Other Dry Bulk		3,940		
Other Liquid Bulk		40		
Totals		8,670	19,000	22,200
Harbors & Channels Requirements				
Vessel Draft	Feet			
Freighters		39	40	40
Bulk Carriers		57	71	71
Tankers		98	104	104
Land Requirements	*Acres*			
Terminal and water-transport-oriented industry		3,010	4,950	4,950
Small Boat Harbors	Wet Moorages[2]	4,350	8,450	16,400

[1] Only aggregate tonnages projected after 1980.

[2] Taken as summer wet moorage demand.

MEANS TO SATISFY NEEDS

The Port of Tacoma is actively engaged in a modernization program and development of new industrial and terminal lands to meet expected increases in commodity movements. Continuation of this program for the foreseeable future is necessary to accommodate a diversified and highly developed traffic movement.

TERMINAL AND INDUSTRIAL LAND REQUIREMENTS

As noted in Table 9-9, approximately 5,000 acres of terminal and industrial lands will be required by the year 2000 to meet projected needs. This includes 1,304 acres already developed for this purpose but excludes a 2,440 acre explosive storage area owned by the Du Pont Chemical Co. Examination of Figure 9-3 and Table 2-10 reveals that these needs can be fulfilled by full development of areas which are only partially developed. However, as available industrial and terminal lands become fully utilized projected needs beyond the year 2000 may force the port to seek additional lands beyond its boundaries.

HARBORS AND CHANNELS

To accommodate projected vessel drafts shown in Table 9-9, channel improvements should be made as shown below:

Period	Channel	Channel Depth In Feet	Estimated Costs	Estimated Annual Cost	Estimated Benefits	Estimated Benefit Cost Ratio
1980	Hylebos W.W.	46	$1,742,000	$108,000	118,800	1.1
	Port Industrial W.W.	52	2,123,000	123,000	151,600	1.2
	Sitcum W.W.	78	1,565,000	87,000	118,400	1.4
1980-2000	Hylebos W.W. Seaward 11th St. Bridge	78	2,406,000	140,000	Not Est.	Not Est.
	Port Industrial W.W. Seaward of 11th St. Bridge	106	2,082,000	114,000	Not Est.	Not Est.

SMALL BOAT HARBORS

Listed in Table 9-10 are the sites in the Puyallup Basin suitable for development of small boat harbors. The sites shown on Figure 9-5 are the most favorable in this Basin.

A tentative schedule of development to meet 1980, 2000 and 2020 needs is contained in Table 9-10. Benefits and costs for projects recommended to meet 1980 pleasure boating demand are also shown as are the estimated construction costs for additional projects required by 2000 and 2020. Costs shown are for general navigation facilities and navigation aids that may require Federal assistance in financing and construction. General navigation facilities consist of breakwaters, entrance channels, and turning basins and the navigation aids are normally lighted dolphins and breakwater lights. Costs are average values and are based on actual construction or detailed study cost estimates for small boat harbor projects in the Area. Average benefit values were derived using standard methods employed by the Corps of Engineers, data from the "Pleasure Boating Study," and other studies performed for small boat harbor projects.

By the year 2000 all saltwater sites determined by this study to be favorable for development of wet moorage will be exhausted. Spillover into the Nisqually-Deschutes Basins is expected as well as a proportionate greater use of dry moorage than what boaters have indicated as desirable in order to satisfy future needs within this basin.

TABLE 9-10. Small boat harbor sites—Puyallup Basin

Site No.	Location	Wet Moorages	Water-Land Area-Acres[4]	Tentative Schedule of Development — Wet Moorages 1980	2000	2020
1.	Hylebos Waterway	890	888	890		
2.	Dumas Bay	2,720	2,724		2,720	
3.	Titlow—Day Island	660	660	660		
	Totals	4,270	4,272	1,550	2,720	

Summary of Benefits and Costs

1980 Construction Costs[3]	1980 Average Annual Costs[1,2]	1980 Average Annual Benefits	2000 Construction Costs[3]	2020 Construction Costs[3]
$3,120,800	$199,800	$289,500	$5,491,600	0

[1] Annual interest and amortization charges of general navigation facility construction costs, including aids to navigation are computed for 50-year economic life at a rate of 4-5/8 percent.

[2] Includes allowance of $25 per wet moorage for annual maintenance and replacement costs.

[3] Includes allowance for Engineering, Design, Supervision and Administration costs.

[4] Using relationships based on Shilshole Marina wet moorage land and water area requirements are estimated at 0.056 acres of water area for moorage and maneuvering and 0.028 acres of land for parking and services per boat.

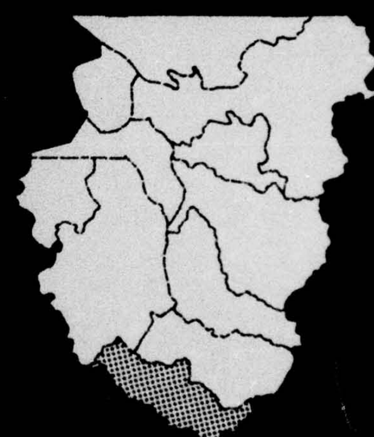
Note: Not contained in the area requirements are land needs for launching ramps which will generally be incorporated with moorage facilities. Launching facilities require about 1.5 acres of land for ramps and parking for each lane provided.

Factors Influencing Implementation of Plan

Land available for industrial and terminal development is limited. Port development is restrained by Interstate 5 to the south, the city of Tacoma to the west and undesirable terrain to the east. Early consideration must be given to relocating recreational small boat facilities to avoid conflict with industrial development and commercial shipping.

Air and water quality standards may constrain water transport-oriented industrial development in the Basin by placing operational restrictions on plants.

Nisqually-Deschutes Basins



NISQUALLY — DESCHUTES BASINS

DESCRIPTION

The saltwater boundary of the Nisqually Basin is along the Nisqually reach and the shoreline is essentially all along the Nisqually tide flats. The adjacent Nisqually reach has natural channel depths of about 200 feet.

The saltwater boundary of the Deschutes Basin is made up by the southerly arms of Puget Sound: Nisqually Reach; Henderson Inlet; Budd Inlet; and Eld Inlet. Dana Passage at the entrance to these three inlets has controlling depths of over 60 feet but natural water depths within the inlets is generally less than 30 feet. The Nisqually-Deschutes Basins have a total of about 75 miles of saltwater shoreline. The Port of Olympia is the only organized port district in the Deschutes Basin. In the Nisqually Basin, the Port of Olympia has jurisdiction in Thurston County, on the west side of the Nisqually River, and the Port of Tacoma has jurisdiction on the east side of the river.

PRESENT STATUS

HARBORS AND CHANNELS

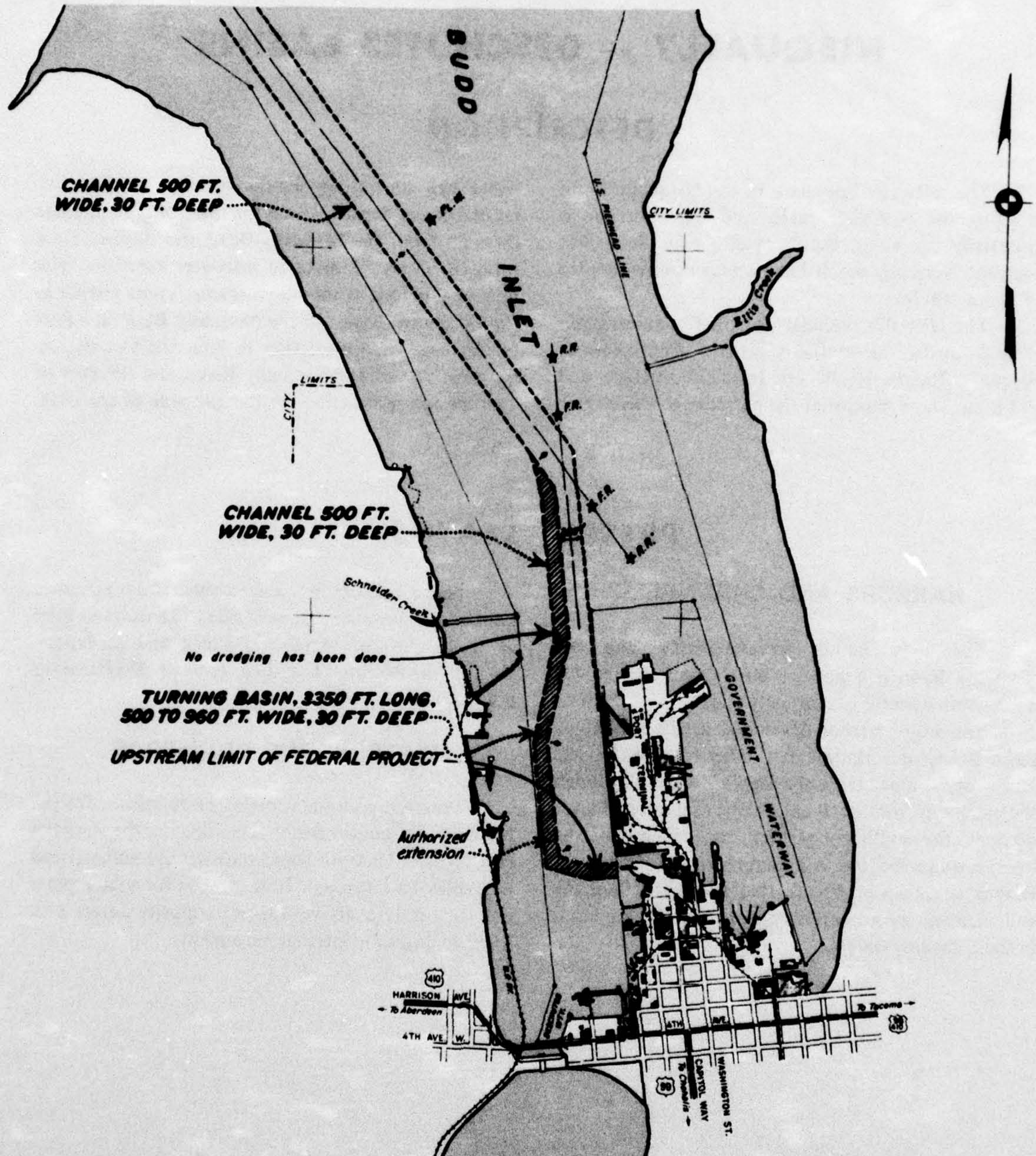
The only harbor development along the Nisqually Basin is a powder plant wharf located 1½ miles northwesterly of Nisqually Head.

The major harbor developed in the Deschutes Basin is Olympia Harbor at the head of Budd Inlet, 168 nautical miles from the Pacific Ocean. Although the northerly part of Budd Inlet has depths of over 40 feet, the southerly portion, at the head of the inlet, is quite shallow. A Federal project for Olympia Harbor as shown on Figure 10-1 authorizes dredging and maintaining an access channel and turning basin in these shallow waters.

Minor harbors in the Deschutes Basin include a railroad log dump on the west side of Henderson Inlet at the mouth of Woodward Creek and at Boston Harbor in Boston Cove just east of Dofflemeyer Point.

WATERBORNE COMMERCE

Practically all the waterborne commerce for the Nisqually-Deschutes Basins is included in the statistics for Olympia Harbor. These statistics are summarized in Tables 10-1 through 10-4. Traffic for minor ports not included in above Tables is mostly forest products in domestic internal movement.



Improvement	AUTHORIZED Depth Feet	AUTHORIZED Width Feet	AUTHORIZED Length Feet	CONDITION IN 1965 Depth Feet	CONDITION IN 1965 Width Feet	CONDITION IN 1965 Length Feet
Budd Inlet deep water to Buoy 6	30	500		30.0	320	
Buoy 6 to Port Terminal	30	500		30.0	300	
Turning Basin	30	500-960	3350	29.5	300-800	3350

OLYMPIA HARBOR
WASHINGTON

SCALE IN FEET

1000 0 2000 4000

Revised July, 1959

FIGURE 10-1

TABLE 10-1. Water-borne commerce for Olympia Area. Foreign in short tons

FOREIGN IMPORTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	597	0	0	0	0	0	597
1953	697	0	0	0	0	0	697
1954	646	0	0	0	0	0	646
1955	837	0	0	0	0	0	837
1956	407	0	0	0	0	0	407
1957	751	0	418	0	0	365	1,534
1958	618	0	0	0	0	1,968	2,586
1959	755	0	7	0	0	122	884
1960	779	0	0	0	0	0	779
1961	392	0	0	0	0	0	392
1962	259	0	3,605	0	0	0	3,864
1963	575	0	0	0	0	0	575
1964	1,258	0	9	0	0	0	1,267
1965	731	0	0	0	825	0	1,556
1966	0	0	0	1,622	0	0	1,622

FOREIGN EXPORTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	70	0	12,684	0	0	0	12,754
1953	10,905	0	9,433	0	0	0	20,338
1954	80	0	9,543	0	0	0	9,623
1955	2,771	0	6,609	0	0	0	9,380
1956	224	0	8,317	0	7,890	0	16,431
1957	781	0	7,875	0	20	0	8,676
1958	3,510	0	5,135	33	0	12	8,690
1959	7,166	0	12,289	0	0	30	19,485
1960	2,732	0	4,943	0	3,584	0	11,259
1961	1,794	0	47,179	0	0	0	48,973
1962	2,216	0	48,044	0	0	0	50,260
1963	1,489	0	63,405	0	0	0	64,894
1964	2,269	0	66,012	0	0	0	68,281
1965	2,916	0	106,589	0	1	0	109,506
1966	5,259	0	141,144	0	0	0	146,403

TABLE 10-2. Water-borne commerce for Olympia Area. Domestic coastwise in short tons

DOMESTIC COASTWISE RECEIPTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	616	0	0	13,999	24	0	14,639
1953	13	0	0	34,973	32	0	35,018
1954	0	0	0	31,898	0	0	31,898
1955	0	0	0	37,496	0	0	37,496
1956	1,293	0	2,873	29,695	0	0	33,861
1957	0	0	15,074	39,721	0	2,903	57,698
1958	0	0	58,889	7,919	0	1,340	68,148
1959	60	0	1,810	7,833	0	1,932	11,635
1960	973	0	259	144	0	0	1,376
1961	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0

DOMESTIC COASTWISE SHIPMENTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	510	0	117,105	0	0	0	117,615
1953	516	0	157,864	0	0	0	158,380
1954	0	0	160,138	0	0	0	160,138
1955	0	0	194,202	0	0	0	194,202
1956	0	0	223,837	572	0	0	224,409
1957	13,000	0	247,067	0	0	0	260,067
1958	14,325	0	238,110	0	15,792	0	268,227
1959	2,084	15	213,600	0	0	0	215,699
1960	694	0	215,626	0	174	0	216,494
1961	313	23	143,717	0	23	0	144,076
1962	0	0	80,608	0	0	0	80,608
1963	28,867	0	63,168	0	0	0	92,035
1964	15,954	0	68,430	0	0	0	84,384
1965	0	0	33,253	0	0	0	33,253
1966	125	0	15,930	0	0	0	16,055

TABLE 10-3. Water-borne commerce for Olympia area, in short tons

FOREIGN AND DOMESTIC COASTWISE

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	1,793	0	129,789	13,999	24	0	145,605
1953	12,131	0	167,297	34,973	32	0	214,433
1954	726	0	169,681	31,898	0	0	202,305
1955	3,608	0	200,811	37,496	0	0	241,915
1956	1,924	0	235,027	30,267	7,890	0	275,108
1957	14,532	0	270,434	39,721	20	3,268	327,975
1958	18,453	0	302,134	7,952	15,792	3,320	347,651
1959	10,065	15	227,706	7,833	0	2,084	247,703
1960	5,178	0	220,828	144	3,758	0	229,908
1961	2,499	23	190,896	0	23	0	193,441
1962	2,475	0	132,257	0	0	0	134,732
1963	30,931	0	126,573	0	0	0	157,504
1964	19,481	0	134,451	0	0	0	153,932
1965	3,647	0	139,842	0	826	0	144,315
1966	5,384	0	157,074	1,622	0	0	164,080

TABLE 10-4. Water-borne commerce for Olympia Area, in short tons

	DOMESTIC INTERNAL						
Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	42,878	0	735,058	117,698	77,710	0	973,344
1953	37,240	48	597,099	111,819	56,556	0	802,762
1954	54,244	0	557,888	104,974	73,601	0	790,707
1955	61,171	156,586	923,316	104,348	105,281	0	1,350,702
1956	69,336	56,038	824,273	111,879	136,218	0	1,197,744
1957	69,851	340,926	675,827	115,565	119,132	0	1,321,301
1958	55,414	13,970	508,994	104,562	109,718	18	792,676
1959	57,932	49,226	630,313	154,963	98,512	1,507	992,453
1960	13,225	0	495,908	133,426	95,560	2,390	740,509
1961	9,785	0	439,935	166,051	109,720	2,387	727,878
1962	9,328	0	415,777	139,408	126,190	2,636	693,339
1963	12,043	0	346,963	127,379	105,096	2,207	593,688
1964	12,477	0	425,414	131,658	113,242	743	683,534
1965	8,308	0	297,887	152,998	104,156	715	564,064
1966	12,410	0	206,647	100,268	77,316	0	396,641

TERMINAL AND TRANSFER FACILITIES

The terminal facilities at Olympia as of 1952 and 1963 are summarized in Tables 10-5 and 10-6, respectively, and are shown on Figure 10-2. From 1952 to 1963 there was a decrease of about 500 lineal feet of berthing space in use for cargo handling. During the same period the covered storage area remained about the same but 1.6 acres of open storage was added. By 1967 about 87,000 square feet of covered storage area and 12 acres of open storage had been added.

Detailed information is not available for the minor terminal facilities existing in these basins.

TABLE 10-5. Terminal facilities Olympia Area 1952

	Depth 18' & Less		Depth 18' - 40'		Depth 40' +			
Use	No. of Berths	Berth Space In Feet	No. of Berths	Berth Space In Feet	No. of Berths	Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	1	500	4	2,000	0	0	100,500	3.4
Bulk Grain	0	0	0	0	0	0	0	0
Forest Products	15	2,431	0	0	0	0	0	0
Bulk Petroleum	2	120	2	420	0	0	0	0
Other Dry Bulk	2	460	0	0	0	0	0	0
Other Liquid Bulk	0	0	0	0	0	0	0	0
Totals	20	3,501	6	2,420	0	0	100,500	3.4
Construction & Repair	1	250	0	0	0	0	0	0
Mooring	3	930	0	0	0	0	0	0

TABLE 10-6. Terminal facilities Olympia Area 1963

Use	Depth 18' & Less: No. of Berths	Depth 18' & Less: Berth Space In Feet	Depth 18' - 40': No. of Berths	Depth 18' - 40': Berth Space In Feet	Depth 40' +: No. of Berths	Depth 40' +: Berth Space In Feet	Covered Storage Sq. Ft.	Open Storage Acres
General Cargo	1	300	4	2,000	0	0	101,014	5.0
Bulk Grain	0	0	0	0	0	0	0	0
Forest Products	17	2,255	0	0	0	0	0	0
Bulk Petroleum	4	275	1	150	0	0	0	0
Other Dry Bulk	2	450	0	0	0	0	0	0
Other Liquid Bulk	0	0	0	0	0	0	0	0
Totals	24	3,280	5	2,150	0	0	101,014	5.0
Construction & Repair	0	290	0	0	0	0	0	0
Mooring	0	0	0	0	0	0	0	0

WATERFRONT AND INDUSTRIAL LAND

The existing and potential sites of water-transport-oriented industries and terminal facilities in the Nisqually-Deschutes Basins are indicated on Figure 10-3 and summarized in Table 10-7. In this Table the net areas are the gross areas less right-of-way for streets and highways. The following discussion refers to site numbers shown on referenced Figure and Table:

Site No. 1 in Budd Inlet includes the existing development of the Port of Olympia and its plan for future development which will make additional space suitable for light to medium industries as well as required terminal facilities. Additional dredging and filling will be required to develop this site.

Site No. 2 is located in the Hawk's Prairie area partly in the Deschutes Basin and partly in the Nisqually Basin. The property is available and suitable for light to heavy industry. Adjacent terminal facilities can be developed for any draft.

Site No. 3 at the mouth of the Nisqually River is suitable for development of deep draft terminal facilities and light to heavy industries. In 1965 the Port of Tacoma adopted a Comprehensive Plan for developing a deep-water terminal on the east side of the Nisqually River. The project would provide 12 berths 1,000 feet long with depths from 55 to 85 feet. A channel would be dredged 800 feet wide, 3,000 feet long, and 55 feet deep. In addition, the east bank of the Nisqually River would be stabilized through a distance of 16,000 feet, to preserve water quality by isolating the terminal. The west side of the river could remain as an undisturbed scenic and wildlife area. As the Nisqually River is the boundary line between Olympia and Tacoma port districts, this development is a possible joint venture.

SMALL BOAT HARBORS

The small boat facilities existing in 1966 on salt water are shown on Figure 10-4 and identified in Table 10-8. Shown on Figure 10-5 are about five miles of salt water shoreline that are considered suitable for potential marina development.

TABLE 10-7. Water front & industrial land—Nisqually-Deschutes Basins—1963

Site Number	Location	Acres in Use (Net): Terminal Facilities	Acres in Use (Net): Vessel Repair & Construction	Acres in Use (Net): Water Oriented Industry	Acres in Use (Net): Total	Acres Potential: Favorable Gross	Acres Potential: Favorable Net	Acres Potential: Less Favorable Gross	Acres Potential: Less Favorable Net
1.	Olympia	51	7	76	134	540	405	0	0
2.	Hawk's Prairie	0	0	0	0	3,000	2,250	0	0
3.	Nisqually Delta	0	0	0	0	1,300	975	0	0
	Total	51	7	76	134	4,840	3,630	0	0

TABLE 10-8. Small boat harbors—Nisqually-Deschutes Basins

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp		Rental Moorage	
				Public	Private	Public	Private
	DESCHUTES BASIN						
1	Puget Marina				X		X
2	Boston Harbor Marina				X		X
3	Bayside Beach				X		X
4	West Bay Marina				X		X
5	Sea Mart Marina				X		X
6	Olympia Marina				X		X
7	Olympia Yacht Club				X		
8	Johnson Point Marina				X		
9	Henry's Resort				X		
	NISQUALLY BASIN						
10	Luhr Beach Resort				X		
	TOTALS	0	0	0	10	0	6

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 with a framework plan developed for satisfying these needs by individual basins. Table 10-9 summarizes the navigation needs for the Nisqually-Deschutes Basins as derived in Solutions to Navigation Needs.

TABLE 10-9. Nisqually-Deschutes Basins—future navigation needs

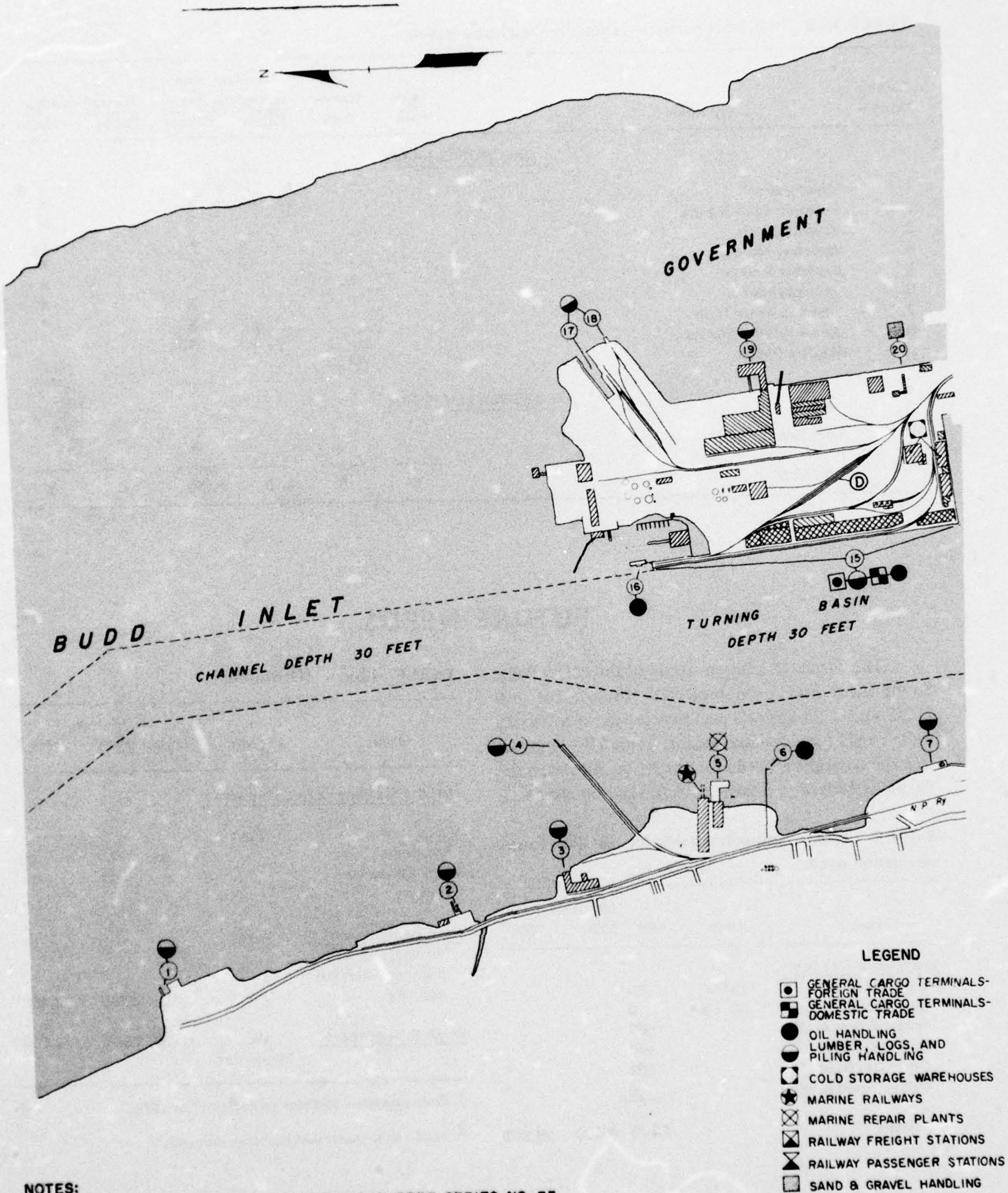
Item	Unit	1980	Needs By 2000[1]	2020[1]
Waterborne Commerce				
General Cargo	1,000	60		
Bulk Grain	Short Tons	0		
Forest Products		580		
Bulk Petroleum		170		
Other Dry Bulk		260		
Other Liquid Bulk		0		
Totals		1,070	6,400	22,200

TABLE 10-9. (Continued)

Item	Unit	1980	Needs By 2000[1]	2020[1]
Harbors & Channels Requirements				
Vessel Draft	Feet			
Freighters		35	40	40
Bulk Carriers			71	71
Tankers				
Land Requirements	Acres			
Terminal and water-transport-oriented industry		310	2,250	3,760
Small Boat Harbors	Wet Moorages[2]	1,170	1,950	2,700

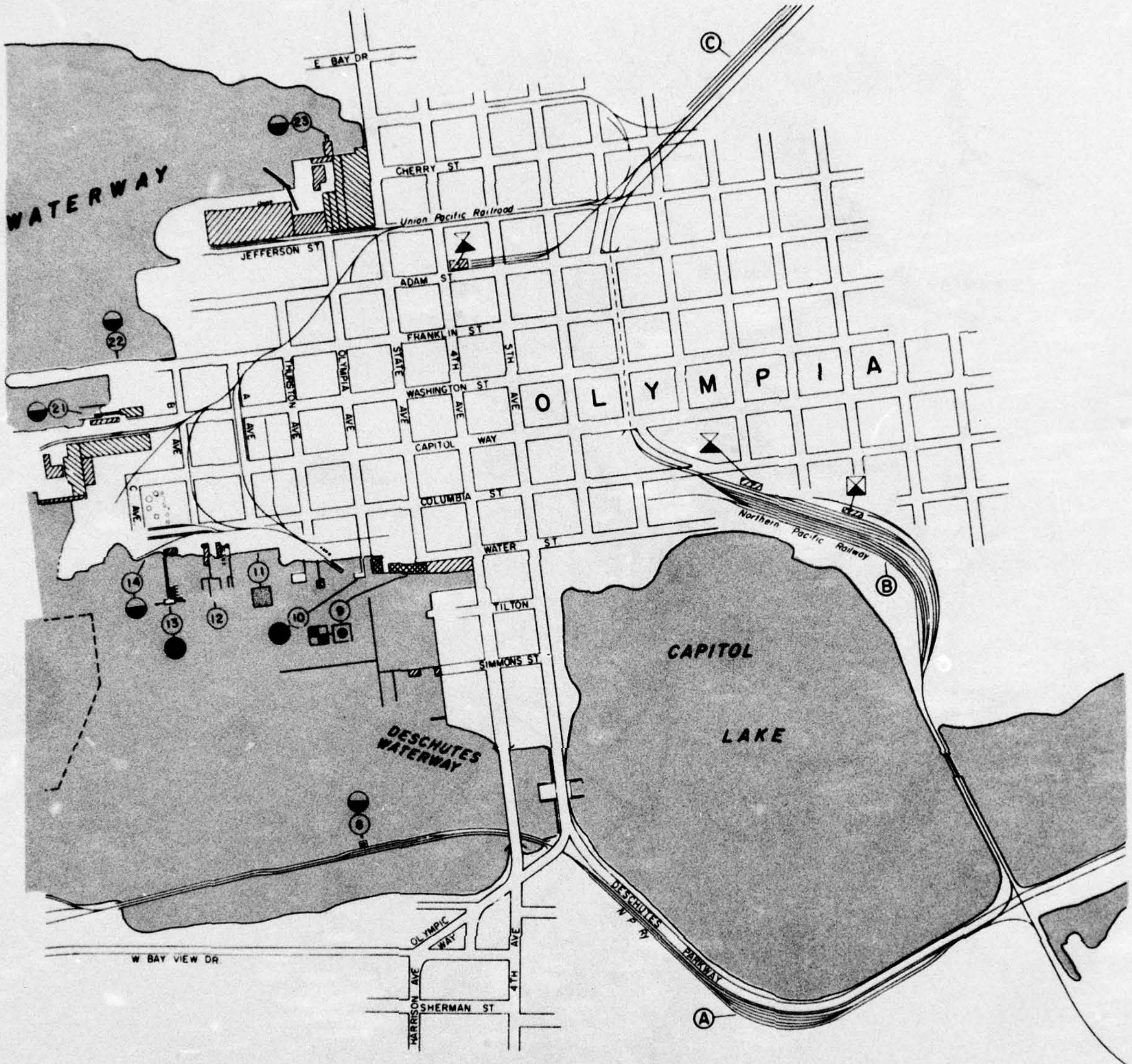
[1] Only aggregate tonnage projected after 1980.

[2] Taken as summer wet moorage demand.



NOTES:
1. NUMERALS REFER TO DESCRIPTIONS IN PORT SERIES NO. 35
2. CHANNEL DEPTHS SHOWN ARE PROJECT DEPTHS
3. TRANSIT SHEDS ARE SHOWN AS CROSSHATCHED BUILDINGS
4. FIELD DATA AS OF SEPTEMBER 1963

FIGURE 10-2L



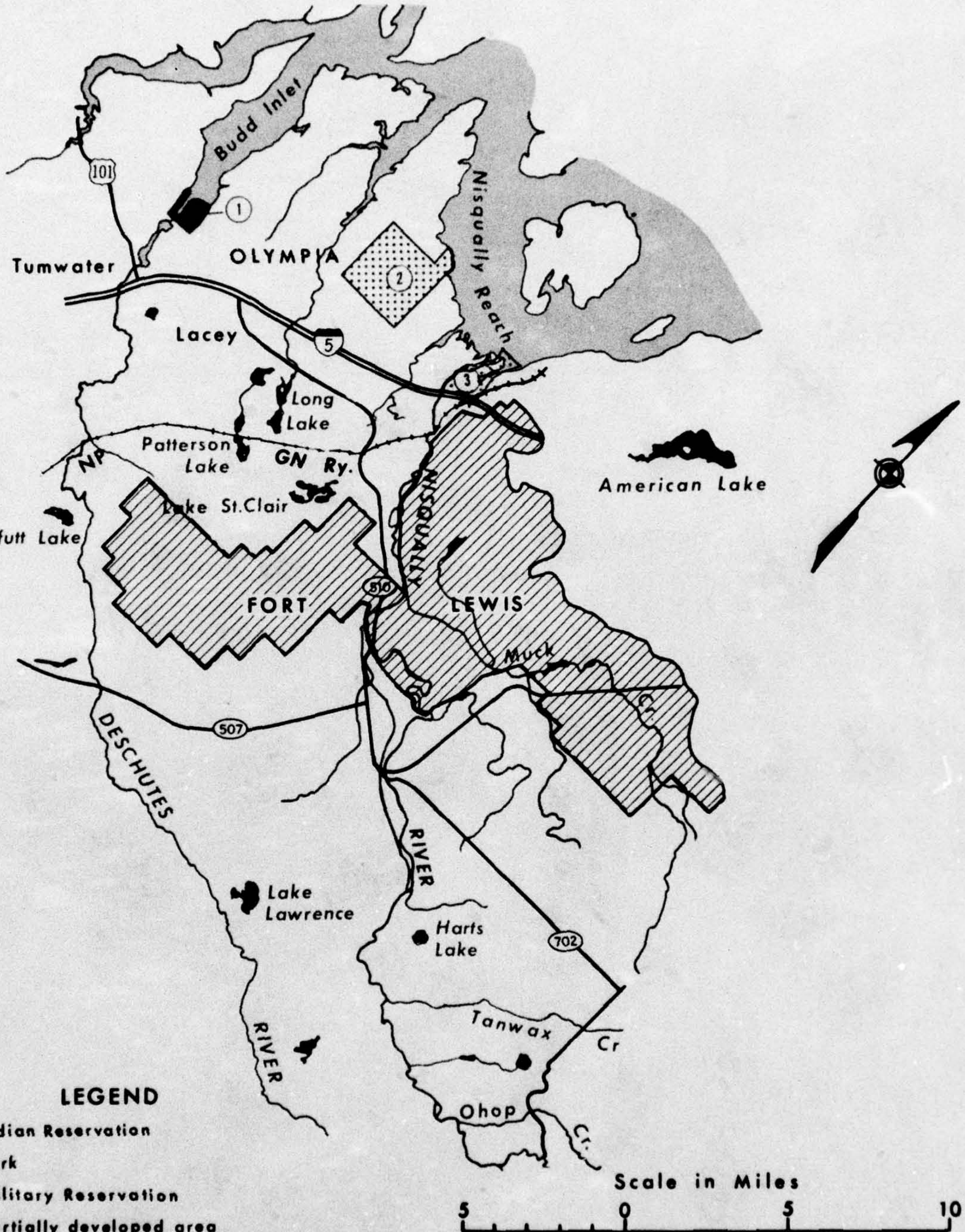
PORT FACILITIES AT OLYMPIA, WASHINGTON

BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C.

SCALE OF FEET
0 400 800 1200 1600

1966

FIGURE 10-2R

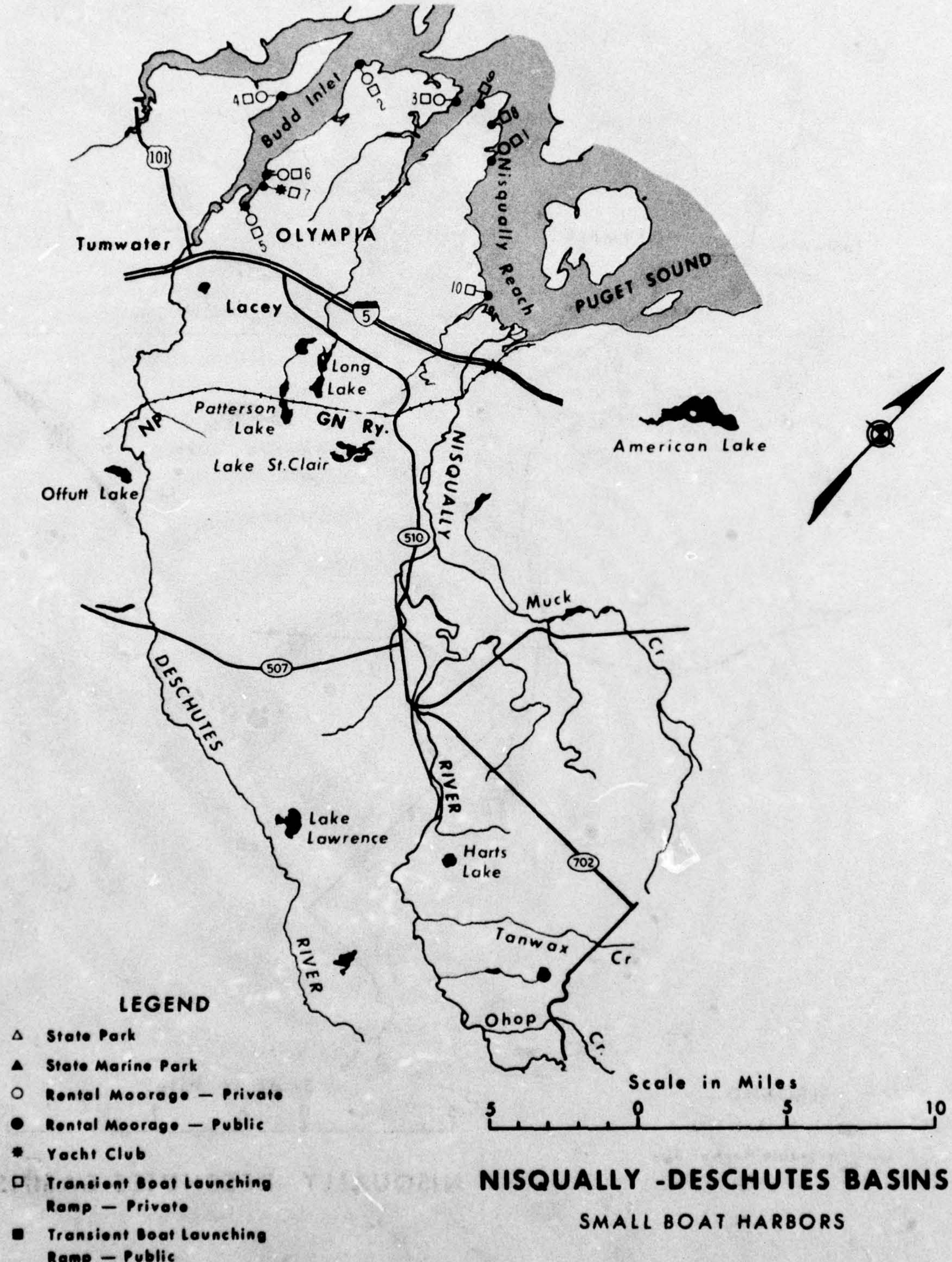


LEGEND

- Indian Reservation
- Park
- Military Reservation
- Partially developed area
- Undeveloped area favorable
- Undeveloped area less favorable
- (8) Waterfront terminal and/or industrial site number

NISQUALLY -DESCHUTES BASINS
WATERFRONT TERMINAL & INDUSTRIAL SITES

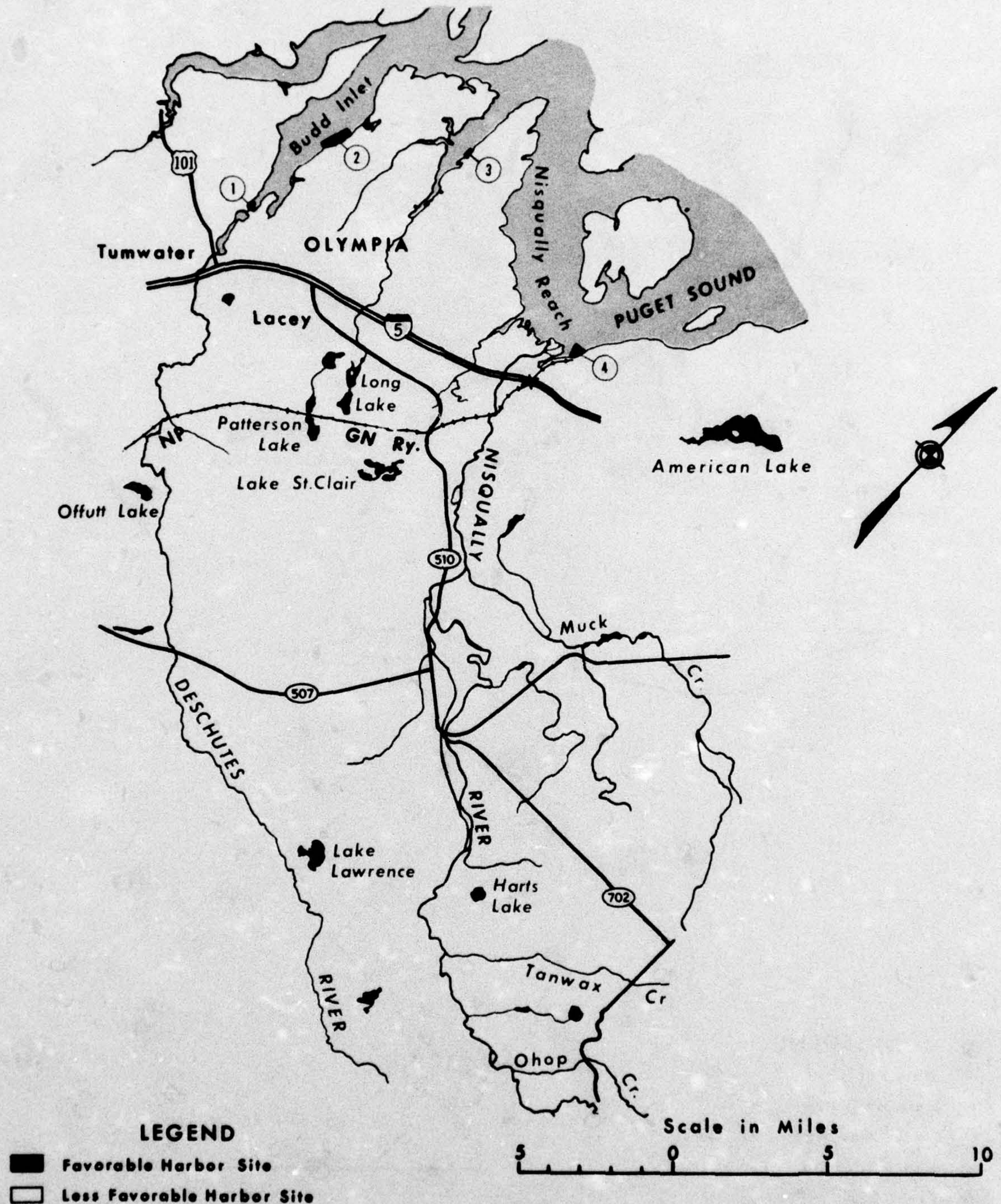
FIGURE 10-3



NISQUALLY -DESCHUTES BASINS

SMALL BOAT HARBORS

FIGURE 10-4



NISQUALLY -DESCHUTES BASINS
SMALL BOAT HARBOR SITES

FIGURE 10-5

MEANS TO SATISFY NEEDS

These basins are expected to experience a modest increase in general cargo and forest products. Improvement of existing facilities and development of additional areas in Budd Inlet will be required to meet these needs. Major developments to meet expected increases in bulk commodities will have to be made in the Nisqually River Delta area.

TERMINAL AND INDUSTRIAL LAND REQUIREMENTS

As noted in Table 10-9, approximately 4,800 acres of terminal and industrial lands should be developed by the year 2020 to meet projected needs. This includes 134 acres already developed for this purpose. Examination of Figure 10-3 and Table 2-10 shows that these needs can be satisfied in part by full development of partially developed areas in Budd Inlet. However, the majority of newly-developed lands is expected to occur in the Nisqually reach area.

HARBORS AND CHANNELS

To accommodate projected vessel drafts shown in Table 10-9, channel improvements should be made as shown below:

SMALL BOAT HARBORS

Listed in Table 10-10 are the sites in the Nisqually-Deschutes Basins suitable for development of small boat harbors. These sites are shown on Figure 10-5. Although alternative sites are also available the sites selected are the most favorable in this Basin.

A tentative schedule of development to meet 1980, 2000 and 2020 needs for these basins as well as spillover demand from the Puyallup Basin, is contained in Table 10-10. Benefits and costs for projects recommended to meet 1980 pleasure boating demand are also shown as are the estimated costs for additional projects required by 2000 and 2020. Costs shown are for general navigation facilities and navigation aids that may require Federal assistance in financing and construction. General navigation facilities consist of breakwaters, entrance channels, and turning basins and the navigation aids are normally lighted dolphins and breakwater lights. Costs are average values and are based on actual construction or detailed study cost estimates for small boat harbor projects in the Area. Average benefit values were derived using standard methods employed by the Corps of Engineers, data from the "Pleasure Boating Study," and other studies performed for small boat harbor projects.

Period	Channel	Channel Depths In Feet	Estimated Costs	Estimated Annual Costs	Estimated Benefits	Estimated Benefit Cost Ratio
1980	West W.W. Budd Inlet	40	$1,853,000	$101,000	138,400	1.4
1980-2000	West W.W.	46	1,360,000	75,000	Not Est.	Not Est.
	East W.W. (Govt. W.W.)	46	2,353,000	150,000	Not Est.	Not Est.
	Nisqually Delta [1]	55	2,400,000	160,000	Not Est.	Not Est.

[1] Approximately $3 million additional will be required for bank stabilization of 16,000 feet of the right bank of Nisqually River (Flood Control).

TABLE 10-10. Small boat harbor sites–Nisqually-Deschutes Basins

Site No.	Location	Wet Moorages	Water-Land Area-Acres[4]	Tentative Schedule of Development 1980	2000	2020
				Wet Moorages		
1.	Olympia	230	19	230		
2.	Budd Inlet–East Side	1,680	140		1,000	680
3.	Henderson Inlet	530	44			530
4.	Nisqually Flats–East	1,180	98		1,180	
	Total	3,620	301	230	2,180	1,210

Summary of Benefits and Costs

1980 Construction Costs[3]	1980 Average Annual Costs[1,2]	1980 Average Annual Benefits	2000 Construction Costs[3]	2020 Construction Costs[3]
$459,000	$29,400	$42,600	$4,386,800	$2,435,300

[1] Annual interest and amortization charges of general navigation facility construction costs, including aids to navigation are computed for 50-year economic life at a rate of 4-5/8 percent.

[2] Includes allowance of $25 per wet moorage for annual maintenance and replacement costs.

[3] Includes allowance for Engineering, Design, Supervision and Administration costs.

[4] Using relationships based on Shilshole Marina wet moorage land and water area requirements are estimated at 0.056 acres of water area for moorage and maneuvering and 0.028 acres of land for parking and services per boat.

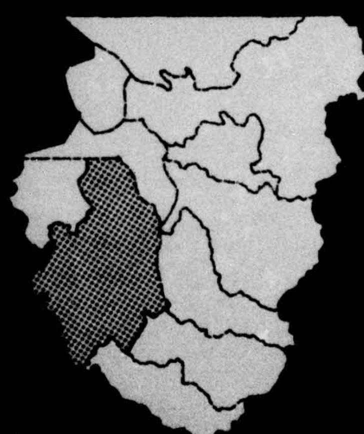
Note: Not contained in the area requirements are land needs for launching ramps which will generally be incorporated with moorage facilities. Launching facilities require about 1.5 acres of land for ramps and parking for each lane provided.

Factors Influencing Implementation of Plan

Conflicts with conservation interests regarding navigation development in the Nisqually Delta need to be resolved with balanced land use planning to meet, insofar as practicable, the needs of both interests. Improvements to the main stem of the Nisqually River are required for flood control, bank stabilization and for control of sedimentation the delta area in conjunction with navigation improvements.

Navigation development in the Nisqually-Deschutes Basins may be facilitated by cooperative efforts between the Port of Olympia and Port of Tacoma. The channel improvements planned for implementation prior to 1980 in the West Waterway of Budd Inlet will require the designation and retention of suitable disposal areas for this purpose.

West Sound Basins



WEST SOUND BASIN

DESCRIPTION

The saltwater boundary of these Basins is composed of all the many inlets and bays along the west side of Puget Sound and Admiralty Inlet together with Port Discovery and Washington Harbor to Sequim Bay along the Strait of Juan de Fuca. Most of these inlets and bays have natural depths of over 100 feet. Shallower waters and tide flats are generally found at the heads of these bays. The Basins have a total of about 953 miles of saltwater shoreline. There are several organized port districts in these Basins. For the most part, these port districts are small and provide mostly small boat facilities.

PRESENT STATUS

HARBORS AND CHANNELS

Port Townsend

Port Townsend is on the north shore at the entrance to Port Townsend Bay and 86 nautical miles from the Pacific Ocean. The bay has depths of over 70 feet but the depths at the wharves range from 12 to 20 feet along the faces. The Federal project as shown on Figure 11-1 authorizes construction of a mooring basin and breakwater; the basin with an area of 12½ acres and depths of 10 and 12 feet in the inner and outer sections, respectively, a gravel and rockfill breakwater 1,946 feet long and removal of a portion of the existing breakwater.

Shelton

Shelton is located at the west end of Oakland Bay and is connected to the waters of Puget Sound by way of Hammersley Inlet. A Federal project shown on Figure 11-2 authorized dredging of a channel 13 feet deep and 150 feet wide. The controlling depth in the project channel in March 1965 was 6.7 feet, but a channel 10.5 feet deep and 100 feet wide was available by deviating from the established channel.

Port Gamble

Port Gamble Harbor is on the western shore at the entrance of Port Gamble, a bay near the entrance to Hood Canal. Port Gamble is 104 nautical miles from the Pacific Ocean. The Federal project for Port Gamble Harbor shown on Figure 11-3 authorizes dredging of a deep water channel at the entrance to Port Gamble Bay. As of June 1965 the controlling depth of the channel was 27.7 feet for a width of 100 feet. The project is "inactive" because of lack of economic justification and local interest.

Port Orchard

Port Orchard Bay is on the southern shore of Sinclair Inlet at the south end of Port Orchard Channel. Connection to Puget Sound by way of Port Orchard Channel around the north end of Bainbridge Island has a controlling depth of about 20 feet but around the south end of Bainbridge Island by way of Rich Passage the available depth is over 50 feet. The Federal project for Port Orchard, shown on Figure 11-4, authorizes the removal of a shoal near Point Glover in Rich Passage to a depth of 40 feet. A depth of 41 feet was available in the shoal area in 1964.

Bremerton

Bremerton is on the northern shore of Sinclair Inlet, see description of Port Orchard Bay. Bremerton is 131 nautical miles from the Pacific Ocean.

Kingston

Kingston Harbor is on the northern side of Apple Tree Cove and the western side of Puget Sound. Offshore depths are over 100 feet. A Federal project at Kingston Harbor, shown in Figure 11-5, authorized construction of a breakwater and entrance channel which was completed in 1967.

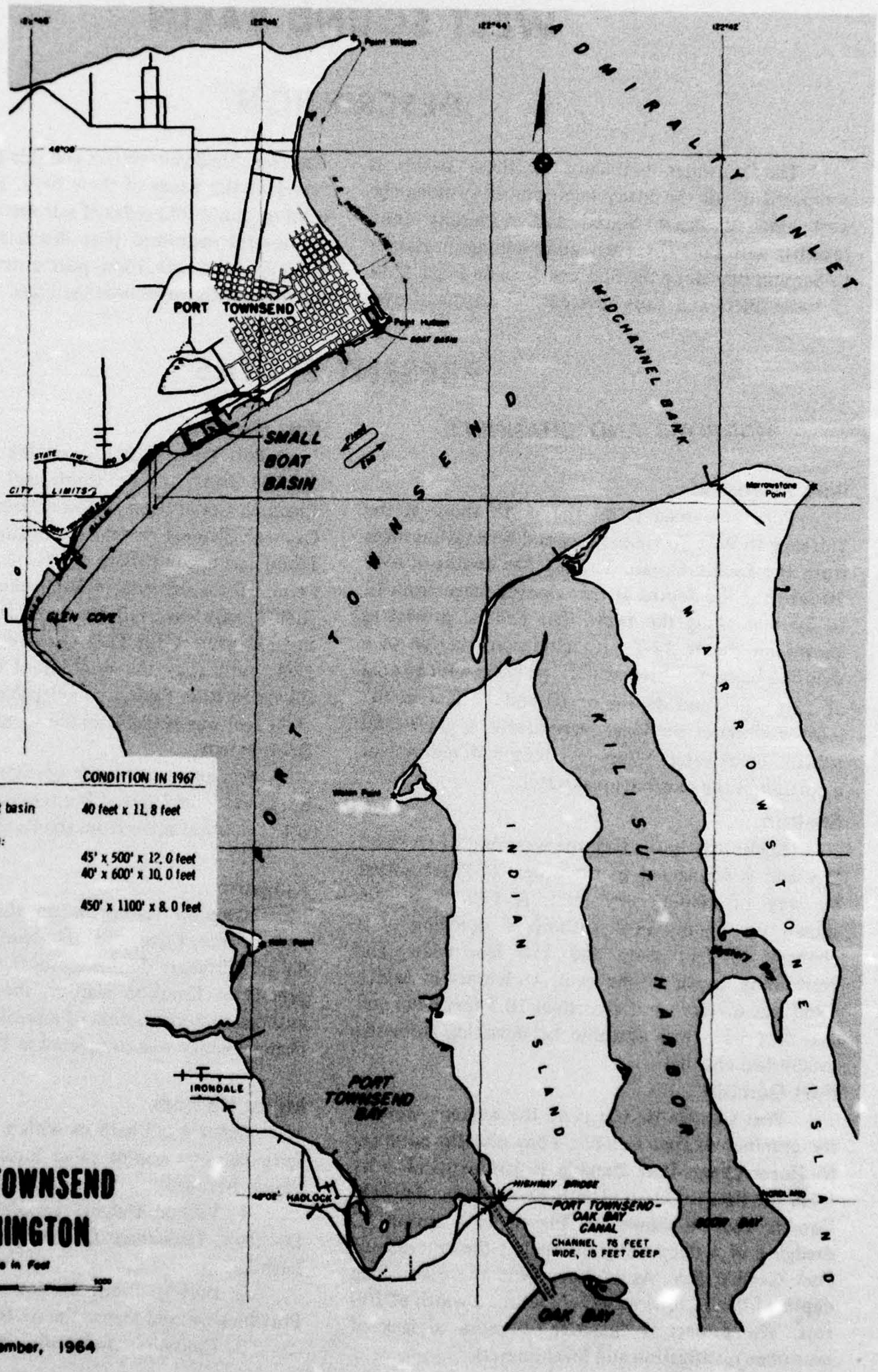
Minor Harbors

Other small harbors with wharves and piers for ferry landings and/or other local traffic in the West Sound Basins are:

1. Vashon Heights Landing, Portage, Burton, Dockton, Tahlequah, Lisabuela and Cove on Vashon Island.

2. Port Madison, Winslow, Creosote, Eagledale, Port Blakely, and Manzanita on Bainbridge Island.

3. Hansville, Indianola, Manchester, Harper,



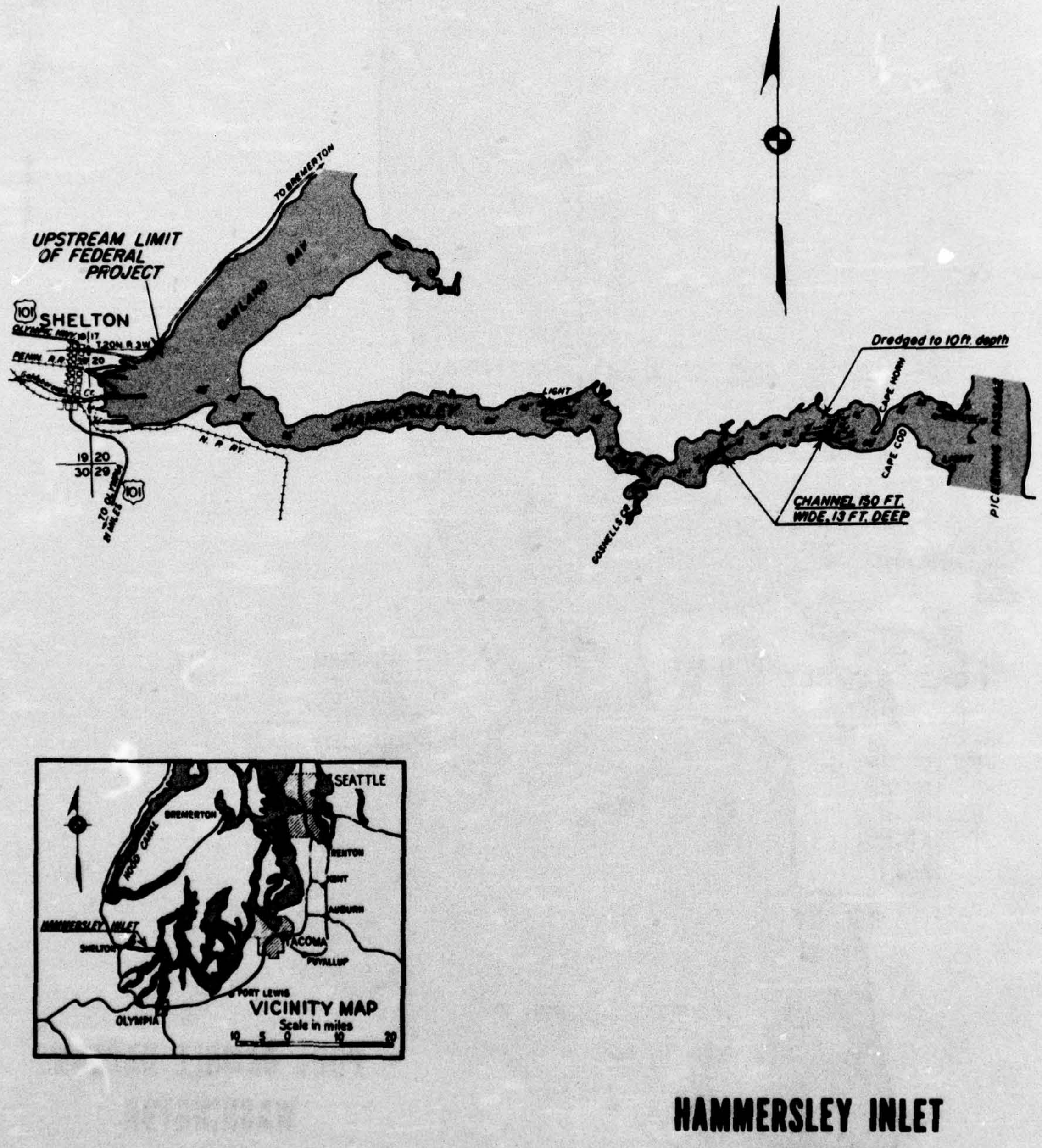
Improvement	CONDITION IN 1967
Channel from deepwater to boat basin	40 feet x 11.8 feet
Entrance channel in boat basin:	
Outer portion	45' x 500' x 12.0 feet
Inner portion	40' x 600' x 10.0 feet
Boat basin	450' x 1100' x 8.0 feet

PORT TOWNSEND
WASHINGTON

Scale in Feet

Revised September, 1964

FIGURE 11-1



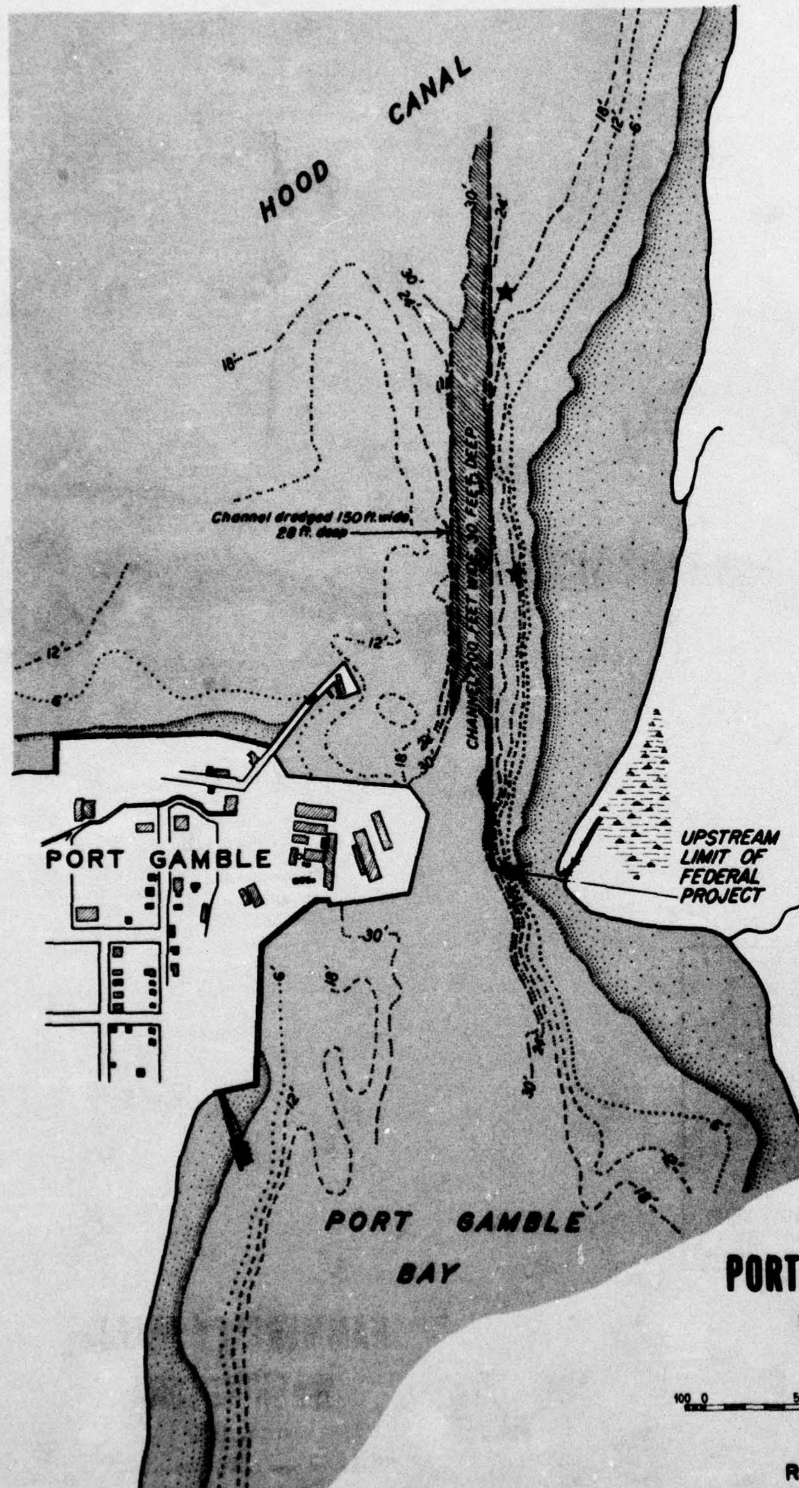
HAMMERSLEY INLET
WASHINGTON

SCALE IN FEET

1000 0 5000 10,000

Revised August, 1957.

FIGURE 11-2



PORT GAMBLE HARBOR
WASHINGTON

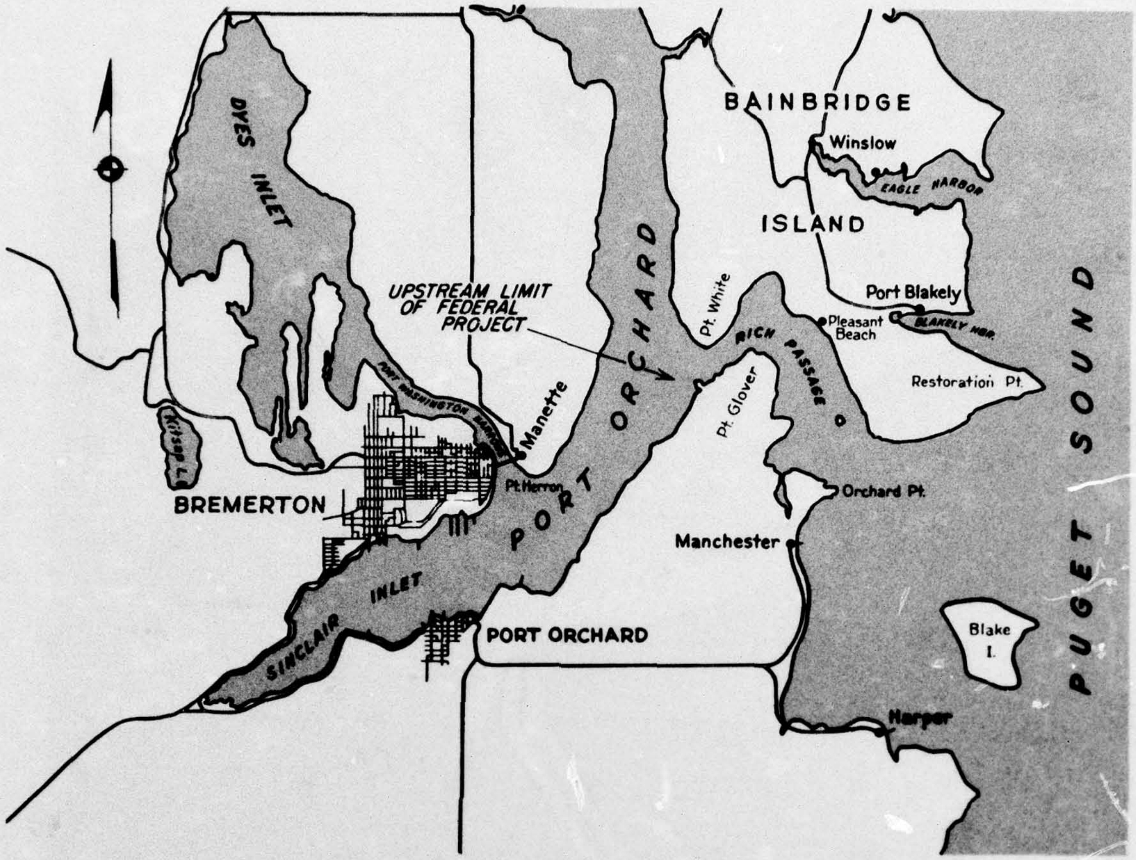
SCALE IN FEET

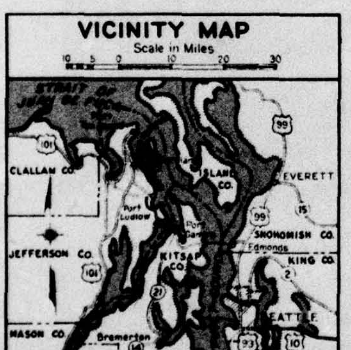
100 0 500 1000 1500 2000

Revised August, 1957.

1966

FIGURE 11-3



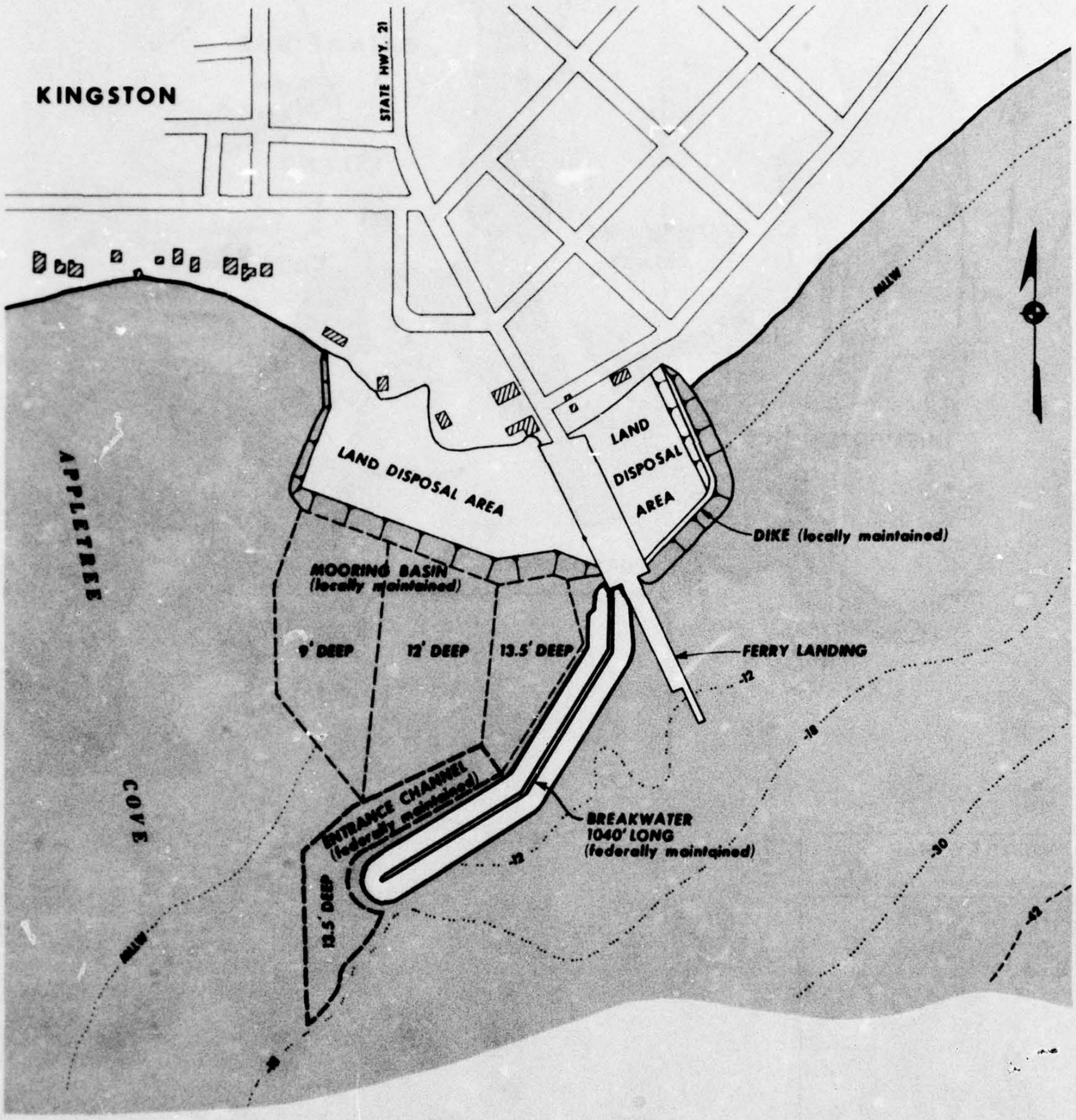


PORT ORCHARD BAY
WASHINGTON

SCALE IN FEET
5000 0 5000 10000 15000 20000

Revised August, 1955.
1966

FIGURE 11-4



KINGSTON HARBOR
WASHINGTON

Revised September 1966

FIGURE 11-5

Southworth on the west side of Puget Sound, Glen Cove.

4. Hadlock, Mats Mats and Port Ludlow on the west side of Admiralty Inlet.

5. Diamond Point and Blyn on south side of Strait of Juan de Fuca.

6. Bangor, Seabeck, Brinnon, Pleasant Harbor, Holly, Eldon, Hoodsport and Union on Hood Canal.

7. Ilahee, Keyport, Poulsbo, Brownsville on the west side of Port Orchard Channel.

8. Fragaria, Olalla, and Gig Harbor on the west side of Colvos Passage.

9. Sylvan on Fox Island.

10. Gertrude, Bee and McNeil Island Penitentiary on McNeil Island.

11. Vega on Anderson Island.

12. Horsehead Bay, Home, Lakebay, and Glencove on Carr Inlet.

13. Herron Island.

14. Allyn, Windy Bluff and Herron on Case Inlet.

15. Grant on Pickering Passage.

16. Carlyon Beach on Squaxin Passage.

17. Quilcene Boat Haven on Quilcene Bay.

18. Nordland on Marrowstone Island.

WATERBORNE COMMERCE

Separate statistics for waterborne commerce in the West Sound Basins are published only for the ports of Port Townsend, Port Gamble and Shelton, which is taken to be essentially the traffic through Hammersley Inlet. These statistics are shown in Table 11-1, 11-2, and 11-3, respectively. The traffic in the many minor ports in the West Sound Basins is lumped with total tonnages which was published for "Other Puget Sound Area Ports, Washington" but discontinued in 1965.

Table 11-4 shows the aggregate of all traffic for Port Townsend, Port Gamble and Shelton noted in Table 11-1, 11-2, and 11-3, respectively.

Table 11-5 showing the traffic for "Minor Puget Sound Ports" is included here as a substantial portion of this tonnage and is related to the many minor ports in the West Sound Basins.

TABLE 11-1. Water-borne commerce for Port Townsend, in short tons

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
			FOREIGN AND DOMESTIC COASTWISE				
1958	4,666	0	46,930	10,234	170,797	0	232,627
1959	3,761	0	46,643	13,734	169,088	0	233,226
1960	6,517	0	42,200	31,029	158,613	0	238,359
1961	6,630	0	41,799	14,582	162,529	0	225,540
1962	5,084	0	32,719	20,376	145,243	0	203,422
1963	14,380	0	26,099	9,246	108,515	0	158,240
1964	39,262	0	8,814	13,855	109,585	0	171,516
1965	8,145	0	60,882	7,115	25,541	0	101,683
1966	10,488	0	124,655	14,739	42,542	0	192,424
196							
1962			DOMESTIC INTERNAL				
1963							
1958	45,702	0	184,118	16,517	161,627	0	407,964
1959	50,877	0	211,804	17,483	159,132	0	439,296
1960	93,716	0	263,078	16,979	202,210	0	532,983
1961	53,000	0	223,101	18,134	266,044	0	575,983
1962	55,543	0	218,312	18,034	313,765	0	605,654
1963	67,029	0	197,951	20,674	307,825	0	593,479
1964	55,537	0	213,858	21,713	434,501	0	725,609
1965	59,122	0	273,000	36,959	381,872	0	750,953
1966	76,000	0	141,630	37,996	439,663	0	695,289

TABLE 11-2. Water-borne commerce for Port Gamble, in short tons

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
FOREIGN AND DOMESTIC COASTWISE							
1952	10	0	62,844	0	0	0	62,854
1953	11	0	66,464	0	0	0	66,475
1954	97	0	47,533	0	0	37	47,667
1955	339	0	70,284	0	0	0	70,623
1956	6	0	23,416	0	0	0	23,422
1957	10	0	41,089	0	0	1,098	42,197
1958	0	0	41,239	0	0	0	41,239
1959	20	0	40,510	0	107	0	40,637
1960	0	0	53,904	0	0	0	53,904
1961	10	0	47,885	0	0	0	47,895
1962	0	0	58,881	0	0	0	58,881
1963	8	0	51,392	0	0	0	51,400
1964	0	0	39,260	0	0	0	39,260
1965	0	0	39,264	0	0	0	39,264
1966	Not Segregated						
DOMESTIC INTERNAL							
1952	0	0	295,694	767	18,092	0	314,553
1953	0	0	292,148	3,378	22,118	0	317,644
1954	0	0	277,291	1,182	11,792	0	290,265
1955	350	0	296,199	2,180	42,967	0	341,696
1956	29,162	0	192,178	2,472	0	0	233,812
1957	29,090	0	158,696	0	0	1,430	189,216
1958	500	0	148,471	707	24,404	0	174,082
1959	1,608	0	167,324	0	69,779	0	238,711
1960	216	0	187,122	1,063	51,022	0	239,423
1961	274	0	155,971	0	44,487	0	200,732
1962	0	0	145,367	0	47,083	0	192,450
1963	80	0	124,426	0	0	0	124,506
1964	0	0	163,328	0	46,792	0	210,120
1965	0	0	171,057	999	50,037	0	222,093
1966	Not Segregated						

TABLE 11-3. Water-borne commerce for Shelton, in short tons

FOREIGN AND DOMESTIC COASTWISE

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952							
1953							
1954							
1955							
1956							
1957							
1958							
1959							
1960							
1961							
1962							
1963							
1964	14	0	802	0	0	0	816
1965	0	0	2,004	0	0	0	2,004
1966	2,101	0	0	0	0	0	2,101

DOMESTIC INTERNAL

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	100,470	0	412,038	63,899	24,735	0	601,142
1953	66,435	0	352,226	53,644	23,858	0	496,163
1954	93,256	0	674,774	61,808	22,716	0	852,554
1955	105,642	0	758,816	31,199	18,610	0	914,267
1956	123,019	0	491,795	42,771	10,362	0	667,947
1957	71,033	0	445,964	26,162	3,942	0	547,101
1958	2,633	0	266,590	15,998	74,954	0	360,175
1959	2,654	0	312,892	17,544	129,573	0	462,663
1960	180	0	266,142	15,464	98,653	0	380,439
1961	10	0	190,688	12,947	93,762	0	297,407
1962	0	0	179,078	13,897	80,765	0	273,740
1963	210	0	146,889	13,779	78,308	0	239,186
1964	120	0	114,915	13,984	117,822	0	246,841
1965	0	0	194,882	13,864	106,684	0	315,430
1966	0	0	187,119	13,634	100,250	0	301,003

TABLE 11-4. Water-borne commerce for West Sound Basins, in short tons

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
	INBOUND + OUTBOUND						
1952	144,682	0	1,078,047	127,737	495,330	0	1,845,796
1953	116,562	0	1,037,500	116,926	549,260	0	1,820,248
1954	162,059	0	1,236,083	125,879	439,986	37	1,964,044
1955	168,703	0	1,398,998	97,149	642,004	0	2,306,854
1956	383,351	0	845,602	129,885	421,033	0	1,779,871
1957	391,572	0	883,471	78,528	348,092	2,528	1,704,191
1958	53,501	0	687,348	43,456	431,782	0	1,216,087
1959	58,919	0	779,173	48,761	527,679	0	1,414,532
1960	57,629	0	812,446	64,535	510,498	0	1,445,108
1961	59,924	0	659,444	45,663	566,822	0	1,331,853
1962	60,627	0	634,357	52,307	586,856	0	1,334,147
1963	125,459	0	546,757	43,699	494,648	0	1,210,563
1964	94,933	0	540,977	49,552	708,700	0	1,394,162
1965	67,267	0	741,089	58,937	564,134	0	1,431,427
1966	147,563	0	600,182	66,369	590,187	0	1,404,301

TABLE 11-5. Water-borne commerce—minor Puget Sound Ports* in short tons

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
	INBOUND + OUTBOUND						
1952	32,868	0	2,156,564	223,818	2,211,490	9,383	4,634,123
1953	75,843	0	2,249,623	265,693	1,998,369	0	4,589,528
1954	60,509	0	1,925,520	396,639	2,102,830	0	4,485,498
1955	64,390	0	1,943,923	1,543,266	2,160,842	0	5,712,421
1956	40,319	0	2,108,489	1,667,371	2,117,583	0	5,933,762
1957	22,731	0	1,777,998	1,781,039	3,317,105	0	6,898,873
1958	16,777	0	1,606,633	2,964,678	2,648,943	0	7,237,031
1959	84,518	0	2,036,741	1,925,162	6,529,449	0	10,575,870
1960	36,352	0	1,887,410	2,083,322	5,091,780	0	9,098,864
1961	9,154	0	1,143,269	2,283,798	3,512,372	8,244	6,956,837
1962	59,657	0	1,782,250	2,292,899	3,759,842	1,213	7,895,861
1963	214,485	0	1,501,531	2,283,193	3,647,797	1,758	7,648,764
1964	323,916	7	1,479,660	2,636,995	3,017,638	1,095	7,459,311
1965							
1966							

* The following ports and rivers are not included: Bellingham, Anacortes, Everett, Seattle, Tacoma, Olympia, Port Angeles, Blaine, Port Townsend, Port Gamble, Shelton, Skagit River, Stillaguamish River.

TERMINAL AND TRANSFER FACILITIES

Although substantial port facilities have been developed at Port Townsend, Port Gamble and Shelton the detailed information on these facilities have not been assembled. Neither is there detailed information on the port facilities that have been developed in the many minor harbors in these basins.

WATERFRONT AND INDUSTRIAL LAND

West Sound Basins have a great number of small harbor facilities for local and internal traffic, mostly for forest products, bulk petroleum, fishing, sand, gravel and rock. The only harbors having significant ocean shipping are Port Townsend and Port Gamble. Information is not readily available as to the land areas being used for terminal facilities or for water transport-oriented industry in these basins. As the area has only limited railroad service, very little industrial development has occurred except at the Bremerton Naval Station, and little is expected until more favorable areas have been exhausted. Nearly 12,000 acres of land in the West Sound Basins are contained within U.S. Naval Reservations as shown in Figure 11-6. Other lands are held by Indian tribes in reservations. Also shown in Figure 11-6 are three alternative sites to Site No. 2 in the Elwha-Dungeness Basins under consideration by the Port of Port Angeles.

SMALL BOAT HARBORS

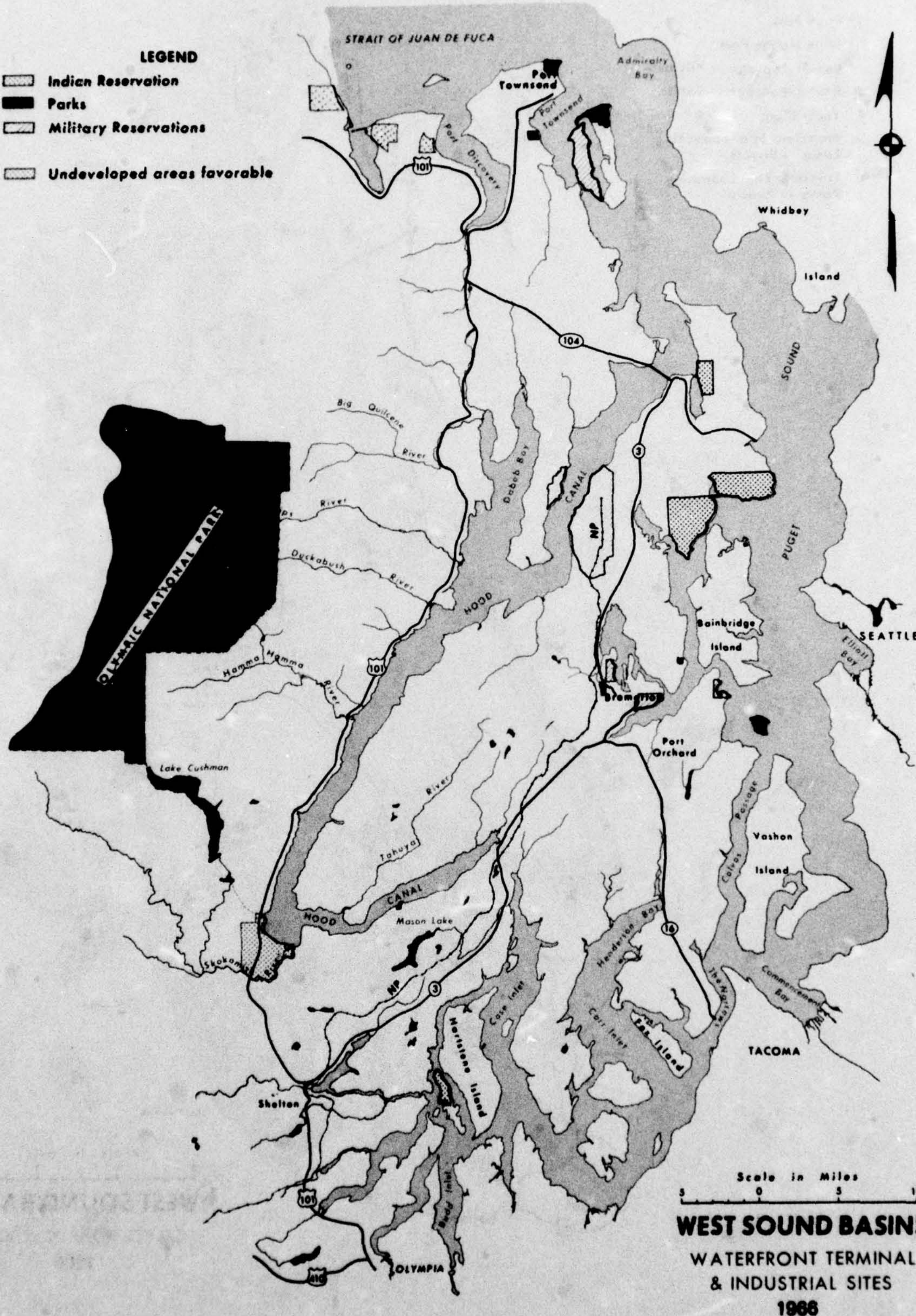
The small boat facilities existing in 1966 on salt water are shown on Figure 11-7 and identified in Table 11-6. Shown on Figure 11-8 are about 71 miles of saltwater shoreline that are considered suitable for potential marina development.

TABLE 11-6. Small boat harbors, West Sound Basins

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp: Public	Transient Boat Launching Ramp: Private	Rental Moorage: Public	Rental Moorage: Private
1	Port of Kingston					X	
2	City of Poulsbo			X		X	
3	Seattle Yacht Club						
4	Port of Brownsville			X		X	
5	Bainbridge Marine Service						X
6	Snug Harbor Marina						X
7	Bremerton Yacht Club						
8	Mannette Yacht Club						
9	Olympic Marina						X
10	Port Orchard Yacht Club						
11	Suldans Boat Works						X
12	Sebring Marina						X
13	Quarter Master Yacht Club						
14	Burk Worthington Marina						X
15	Larson Marina						X
16	Gig Harbor						X
17	Long Branch Marina						X
18	Peninsula Yacht Basin						
19	Triple TTT Marina						X
20	Long Beach Marina						X
21	Lake Bay Marina						X
22	Glen Cove Boat House						X
23	Fair Harbor Marina						X
24	Jarrels Cove						X
25	Fay Bainbridge	X		X			
26	Illahee	X		X			
27	Blake Island		X				
28	Lyles Resort				X		
29	Town of Suquamish			X			
30	Silverdale			X			
31	Chico Marina			X			

TABLE 11-6. Continued

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp Public	Transient Boat Launching Ramp Private	Rental Moorage Public	Rental Moorage Private
32	Tracyton			X			
33	Coal Dock			X			
34	Bremerton City Park			X			
35	State Dept. of Game			X			
36	Harper			X			
37	Southworth			X			
38	East Gig Harbor			X			
39	Kopachuck	X					
40	Penrose Point	X					
41	Squaxin Island		X				
42	Jarrells Cove		X				
43	Belfair	X		X			
44	Twanoh	X		X			
45	Potlach	X					
46	Pleasant Harbor		X			X	
47	Dosewallips River	X					
48	Kitsap Memorial	X					
49	Fort Flager	X		X			
50	Old Ft. Townsend		X				
51	Fort Warden	X					
52	Sequim Bay	X		X			
53	Sequim Bay		X				
54	Shelton Port Commission			X		X	
55	Hood Canal Marina				X		X
56	Alderbrook Inn						X
57	Hoodsport Marina						X
58	Seabeck Outboard Service						X
59	Trader Mac's Marina				X		X
60	Quilcene Boat Haven			X		X	
61	South Point Marina						X
62	Mats Mats Bay Marina			X		X	
63	Port Townsend Boat Haven			X		X	
64	Point Hudson Marina-County			X		X	
65	Arcadia Point				X		
66	Graham—County			X			
67	Harstine Island			X			
68	McLane Cove			X			
69	Grapeview			X			
70	Reach Island Boat Haven				X		
71	Allyn			X			
72	Union			X			
73	Restwhile Park, Inc.				X		
74	Mike's Beach Resort				X		
75	Miami Beach Resort			X			
76	State Dept of Game			X			
77	Rainbow Lodge				X		
78	Shine			X			
79	Twin Spits Resort				X		
80	Marrowstone Resort				X		
81	Mystery Bay				X		
82	Point Hudson Marina			X			
83	Rhode-Drona Resort				X		
84	Gardiner—County			X			
85	Haques Point Mobile Park				X		
	TOTALS	12	6	34	13	9	21



WEST SOUND BASINS

WATERFRONT TERMINAL
& INDUSTRIAL SITES
1966

FIGURE 11-6

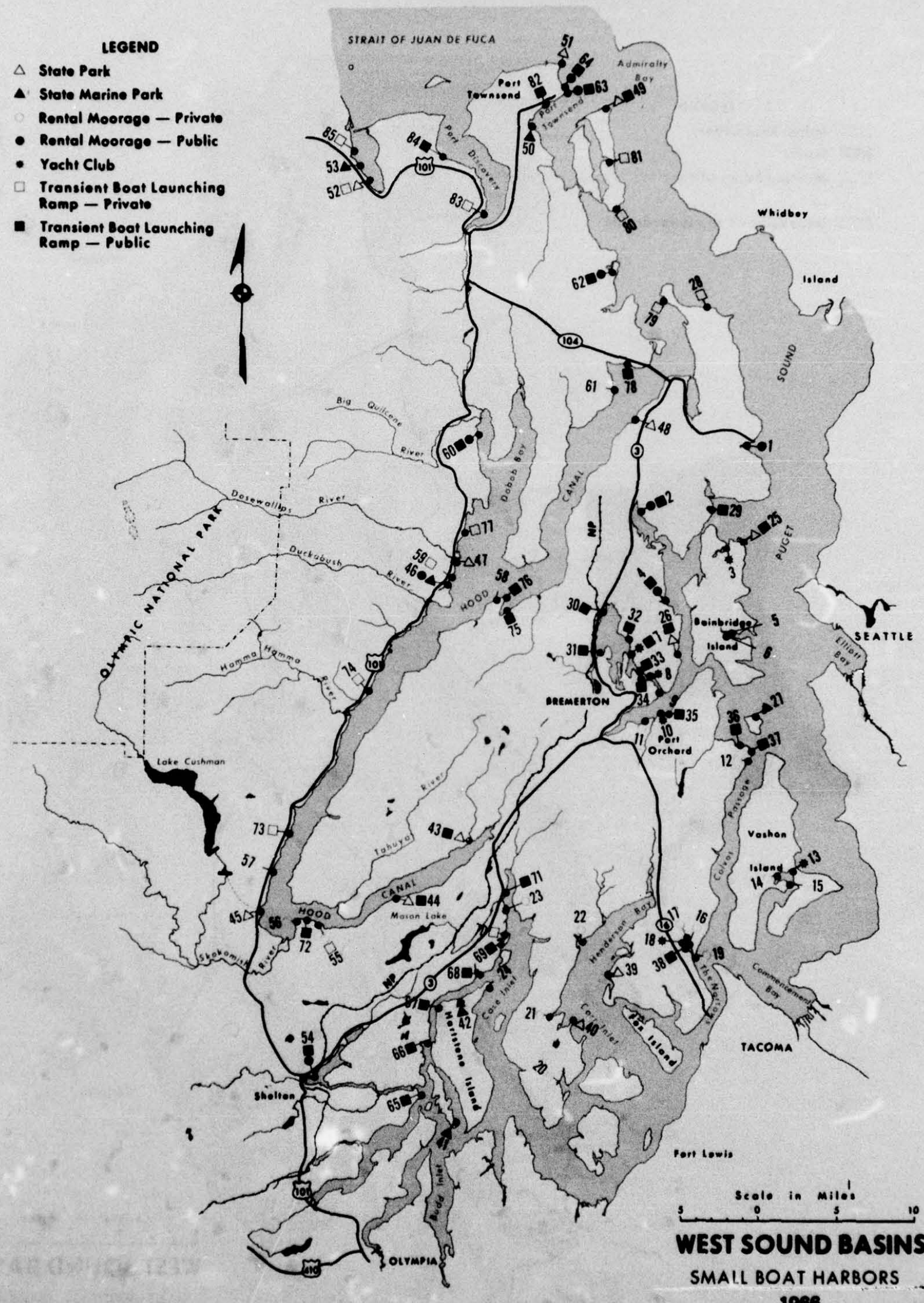
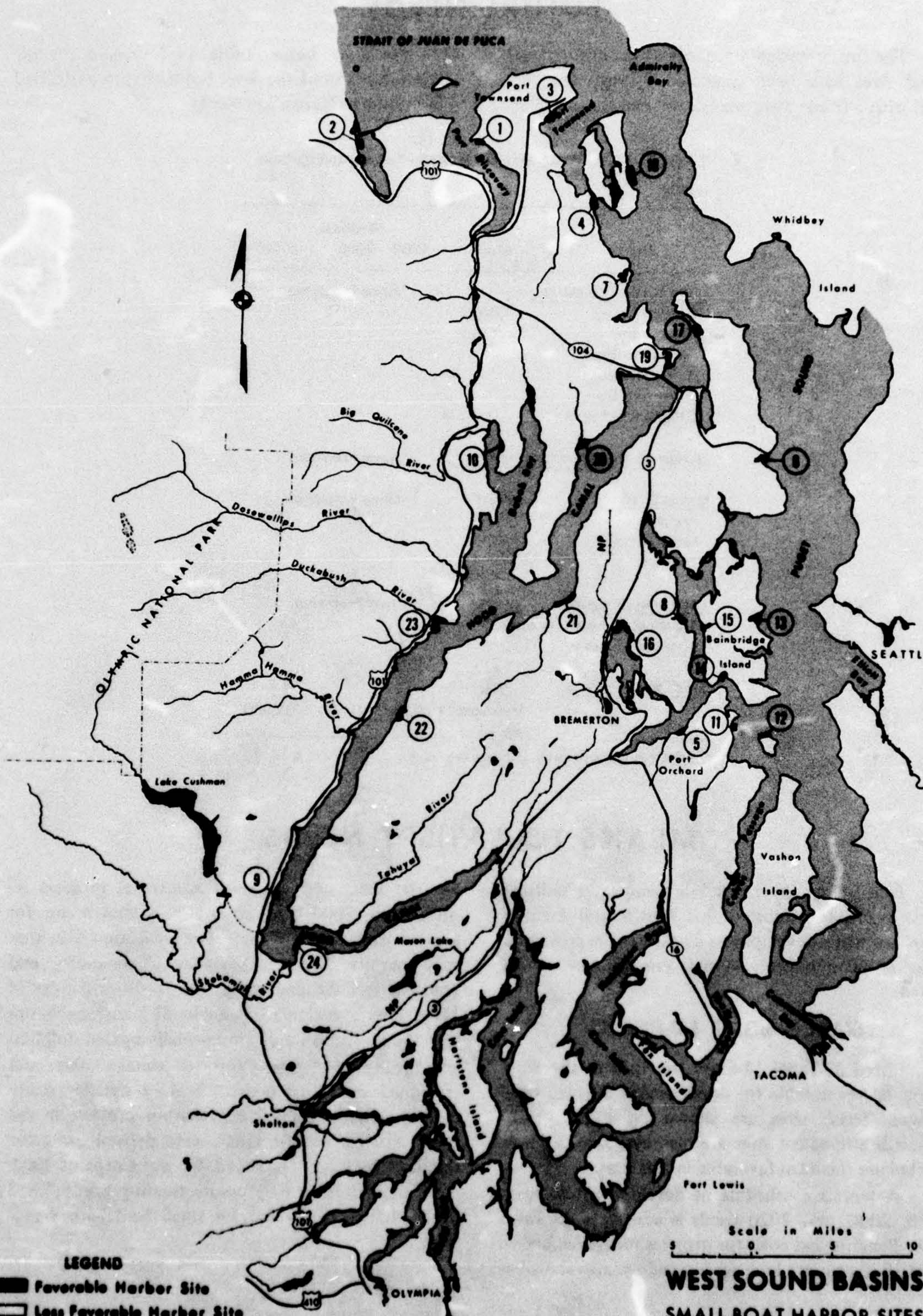

LEGEND
State Park
State Marine Park
Rental Moorage — Private
Rental Moorage — Public
Yacht Club
Transient Boat Launching Ramp — Private
Transient Boat Launching Ramp — Public
STRAIT OF JUAN DE FUCA
Port Townsend
Admiralty Bay
Whidbey Island
SOUND
PUGET
SEATTLE
Elliott Bay
Bainbridge Island
BREMERTON
Port Orchard
Vashon Island
TACOMA
Commencement Bay
Fox Island
Henderson Bay
Carr Inlet
Case Inlet
Harstene Island
Budd Inlet
OLYMPIA
Shelton
Fort Lewis
Mason Lake
Lake Cushman
OLYMPIC NATIONAL PARK
HOOD CANAL
Dabob Bay
Big Quilcene River
Dosewallips River
Duckabush River
Hamma Hamma River
Tahuya River
Skokomish River
Scale in Miles
5 0 5 10
WEST SOUND BASINS
SMALL BOAT HARBORS
1966

FIGURE 11-7



WEST SOUND BASINS

SMALL BOAT HARBOR SITES
1966

FIGURE 11-8

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 with a frame work plan developed for satisfying these needs by basin. Table 11-7 summarizes the navigation needs of the West Sound Basins as derived in Solutions to Navigation Needs.

TABLE 11-7. West Sound Basins—future navigation needs

Item	Unit	Needs by 1980	2000	2020
Waterborne Commerce			None Projected	
General Cargo	1,000			
Bulk Grain	short tons			
Forest Products				
Bulk Petroleum				
Other Dry Bulk				
Other Liquid Bulk				
Harbors & Channels Requirements			None Projected	
Vessel Draft	(feet)		None Projected	
Freighters				
Bulk Carriers				
Tankers				
Land Requirements	Acres		Not Projected	
Terminal and water-transport-oriented industry				
Small Boat Harbors	Wet Moorages[1]	10,920	19,600	32,900

[1]Taken as summer wet moorage demand.

MEANS TO SATISFY NEEDS

Because of the limited highway and railroad access available in most of the West Sound Area no major industrial development or substantial growth in water borne commerce at any one location is expected.

SMALL BOAT HARBORS

Listed in Table 11-8 are the sites in the West Sound Basins suitable for development of small boat harbors. These sites are shown on Figure 11-8. Although alternative sites are also available the sites selected are the most favorable in this Basin.

A tentative schedule of development to meet 1980, 2000, and 2020 needs is contained in Table 11-8. Benefits and costs for projects recommended to meet 1980 pleasure boating demand are also shown as are the estimated costs for additional projects required by 2000 and 2020. Costs shown are for general navigation facilities and navigation aids that may require Federal assistance in financing and construction. General navigation facilities consist of breakwaters, entrance channels, and turning basins and the navigation aids are normally lighted dolphins and breakwater lights. Costs are average values and are based on actual construction or detailed study cost estimates for small boat harbor projects in the Area. Average benefit values were derived using the standard methods employed by the Corps of Engineers data, from the "Pleasure Boating Study," and other studies performed for small boat harbor projects.

TABLE 11-8. Small boat harbor sites—West Sound Basins

Site No.	Location	Wet Moorages	Water-Land Area-Acres[4]	Tentative Schedule of Development 1980	2000 Wet Moorages	2020
1	Port Discovery-Beckett Point	250	21	250		
2	Sequim Bay—West	940	78	940		
3	Port Townsend	890	74		890	
4	Oak Bay	700	58		700	
5	Sinclair Inlet—Annapolis	400	33	400		
6	Kingston	740	62			740
7	Mats Mats	980	82	980		
8	Brownsville	650	54	650		
9	Hoodsport	160	13		160	
10	Quilcene Bay—East Side	1,340	112			1,340
11	Manchester	220	18		220	
12	Bainbridge Island—Murden Cove	1,860	155		1,860	
13	Bainbridge Island—Lynwood Center	260	22		260	
14	Bainbridge Island—Fletcher Bay	260	22			260
15	Dyes Inlet	1,090	91	1,090		
16	Hood Canal—Coon Bay	1,090	91		1,090	
17	Marrowstone Island—East Side	2,980	248			2,980
18	Hood Canal—Bywater Bay	2,500	208			2,500
19	Hood Canal—Thorndyke Bay	1,800	150			1,800
20	Hood Canal—Warrenville	1,980	165			1,980
21	Hood Canal—Anderson Cove	1,630	135			1,620
22	Hood Canal—Duckabush	1,360	113		1,360	
23	Hood Canal—Union	2,170	181		2,170	
	Total	26,250	2,186	4,310	8,710	13,220

Summary of Benefits and Costs

1980 Construction Costs[3]	1980 Average Annual Costs[1&2]	1980 Average Annual Benefits	2000 Construction Costs[3]	2020 Construction Costs[3]
$8,684,900	$556,100	$805,600	$17,539,000	$26,650,600

[1]Annual interest and amortization charges of general navigation of facility construction costs, including aids to navigation are computed for 50-year economic life at a rate of 4-5/8 percent.

[2]Includes allowance of $25 per wet moorage for annual maintenance and replacement costs.

[3]Includes allowance for Engineering, Design, Supervision and Administration costs.

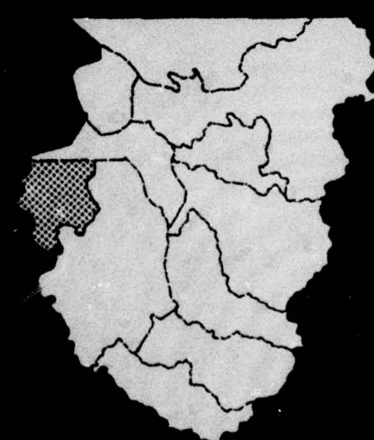
[4] Using relationships based on Shilshole Marina wet moorage land and water area requirements are estimated at 0.056 acres of water area for moorage and maneuvering and 0.028 acres of land for parking and services per boat.

Note: Not contained in the area requirements are lane needs for launching ramps which will generally be incorporated with moorage facilities. Launching facilities require about 1.5 acres of land for ramp and parking for each lane provided.

Factors Influencing Implementation of Plan

Considerable public investment will be required to construct the many small boat harbors needed in the West Sound Basins. However, existing authority is fragmented among numerous small ports which do not have adequate financial capability to undertake major projects. Integrated authority with Kitsap and Mason Counties constituting port districts would provide an improved basis for financing needed pleasure boating facilities. The pollution aspects of small boat concentrations near prime shellfish rearing areas must be resolved.

Elwha-Dungeness Basins



ELWHA-DUNGENESS BASINS

DESCRIPTION

These Basins border the south side of the Strait of Juan de Fuca including Port Angeles, Freshwater Bay and Dungeness Bay and have about 56 miles of saltwater shoreline. The Port of Port Angeles is the only organized port district. U.S. Highway 101 is the main route through these basins.

PRESENT STATUS

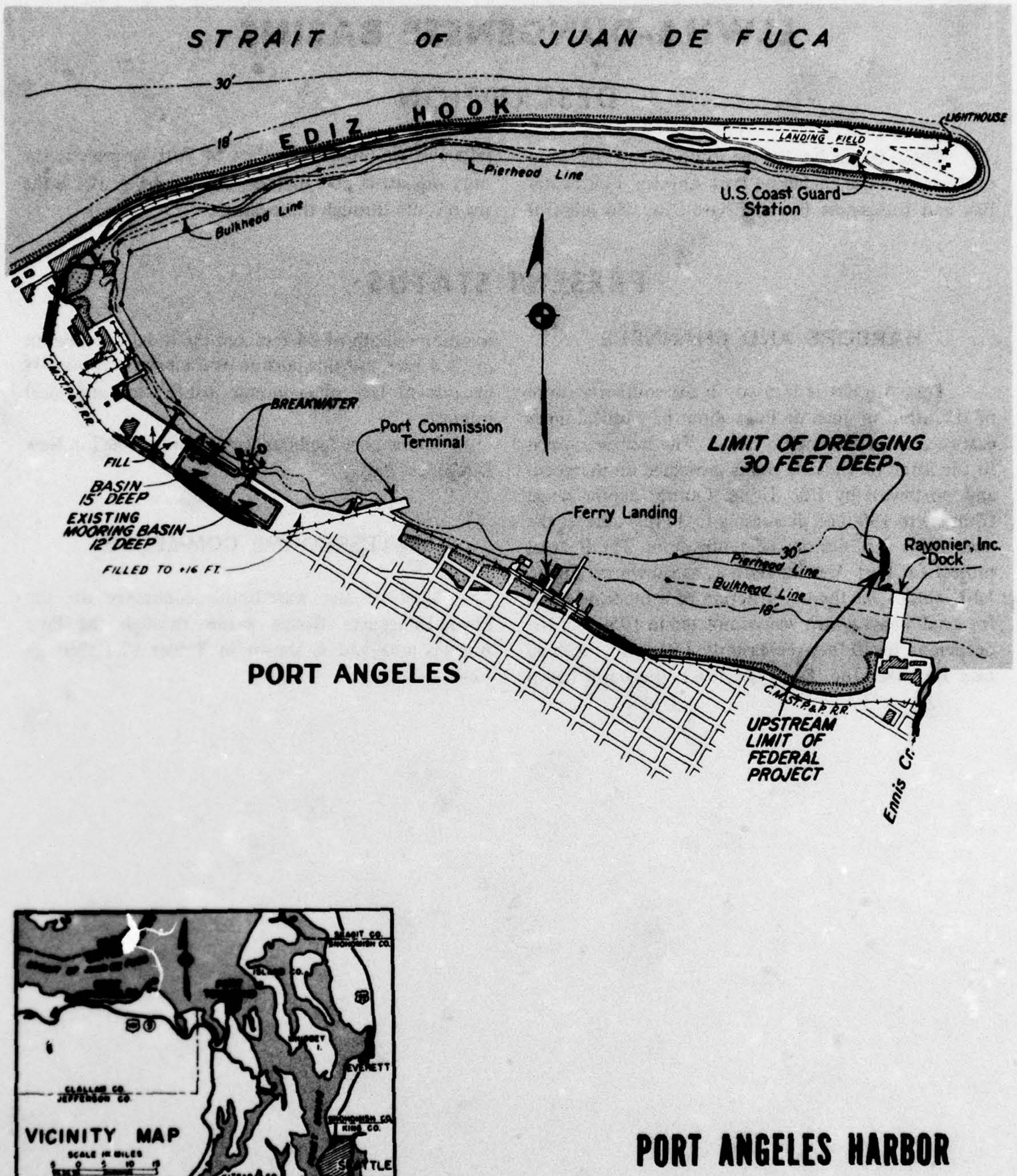
HARBORS AND CHANNELS

Port Angeles is located on the southerly shore of the Strait of Juan de Fuca about 62 nautical miles eastward from the Pacific Ocean. The harbor is open to the Strait on the east and is protected on the north and northwest by Ediz Hook. Central depths range from 90 to 180 feet, decreasing to 30 feet abreast the waterfront facilities on the south shore. The Federal project for Port Angeles Harbor, as shown on Figure 12-1, authorizes the construction of a mooring basin for small boats which was completed in 1959 and the deepening to 30 feet the easterly 150 feet of a shoal near Rayonier Inc. Dock. In 1962, the basin had a minimum depth of 14 feet and the shoal had a depth of 25.4 feet, but this portion of the project is inactive because of lack of economic justification and local interest.

Minor port facilities have been provided in New Dungeness Bay.

WATERBORNE COMMERCE

Most of the waterborne commerce for the Elwha-Dungeness Basins passes through the Port Angeles area and is shown in Tables 12-1 through 12-4.



PORT ANGELES HARBOR
WASHINGTON

SCALE IN FEET

1000 500 0 1000 2000 3000 4000 5000

Revised Sept. 1961
1966

FIGURE 12-1

TABLE 12-1. Water-borne commerce for Port Angeles Area, in short tons

FOREIGN IMPORTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	726	0	54,174	0	45,864	0	100,764
1953	274	0	44,767	0	29,284	0	74,325
1954	153	0	116,242	0	31,957	0	148,352
1955	207	0	26,177	0	37,772	0	64,156
1956	198	0	19,104	0	36,420	0	55,722
1957	1,062	0	19,871	0	25,385	0	46,318
1958	608	0	73,231	0	28,358	0	102,197
1959	995	0	86,124	0	42,086	1	129,206
1960	10,964	0	99,864	0	86,808	15	197,651
1961	7,209	0	66,528	0	126,134	16	199,887
1962	5,265	0	5,683	0	77,477	0	88,425
1963	56,350	0	20,984	0	29,907	0	107,241
1964	22,344	0	112	0	71,945	0	94,401
1965	41,165	0	2,561	0	13	0	43,739
1966	40,844	0	8,686	0	91,547	0	141,077

FOREIGN EXPORTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	7,862	0	258	0	0	0	8,120
1953	16,001	0	16,541	9	42	6	32,599
1954	31,095	0	18,641	8	6,690	2	56,436
1955	43,935	0	31,426	5	1,360	3	76,729
1956	43,924	0	20,597	10	521	0	65,052
1957	38,084	0	2,762	0	413	0	41,259
1958	30,335	0	14,904	0	377	10	45,626
1959	51,164	0	15,254	2	187	18	66,625
1960	42,888	8	6,984	4	91	35	50,010
1961	43,390	0	57,411	104	99	400	101,404
1962	32,889	0	91,381	4	56	216	124,546
1963	82,567	0	190,230	54	0	0	272,851
1964	66,937	0	208,894	0	0	34	275,865
1965	80,000	129	289,039	3	789	38	369,998
1966	76,507	0	436,872	292	94	77	513,842

TABLE 12-2. Water-borne commerce for Port Angeles Area. Domestic coastwise in short tons

DOMESTIC COASTWISE RECEIPTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	236	0	0	109,449	19,217	0	128,902
1953	186	0	0	105,511	18,352	0	124,049
1954	377	0	0	113,545	23,844	0	137,766
1955	652	0	0	114,464	19,340	0	134,456
1956	226	0	734	112,038	20,821	0	133,819
1957	165	0	0	102,447	9,739	0	112,351
1958	319	0	0	82,731	16,682	0	99,732
1959	128	0	1,005	81,251	14,946	0	97,330
1960	17	0	0	200,199	5,173	0	205,389
1961	0	0	0	151,797	0	0	151,797
1962	0	0	0	131,117	0	0	131,117
1963	0	0	0	113,644	0	0	113,644
1964	0	0	0	116,112	0	0	116,112
1965	0	0	9,190	61,298	0	0	70,488
1966	109	0	431	83,461	0	0	84,001

DOMESTIC COASTWISE SHIPMENTS

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	98,760	0	0	0	0	0	98,760
1953	64,692	0	389	0	0	0	65,081
1954	122,775	0	0	0	0	0	122,775
1955	79,510	0	0	0	0	0	79,510
1956	86,418	0	0	0	0	0	86,418
1957	88,938	0	1,947	0	0	0	90,885
1958	49,712	0	2,638	0	0	15	52,365
1959	39,280	0	31,539	0	0	0	70,819
1960	5,436	0	15,952	0	0	0	21,388
1961	0	0	15,257	0	0	0	15,257
1962	0	0	20,239	0	0	0	20,239
1963	1,508	0	35,035	0	0	0	36,543
1964	500	0	41,398	0	0	0	41,898
1965	0	0	31,547	0	0	0	31,547
1966	0	0	20,501	0	0	0	20,501

TABLE 12-3. Water-borne commerce for Port Angeles Area, in short tons

FOREIGN AND DOMESTIC COASTWISE

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	107,584	0	54,432	109,449	65,081	0	336,546
1953	81,153	0	61,697	105,520	47,678	6	296,054
1954	154,400	0	134,883	113,553	62,491	2	465,329
1955	124,304	0	57,603	114,469	58,472	3	354,851
1956	130,766	0	40,435	112,048	57,762	0	341,011
1957	128,249	0	24,580	102,447	35,537	0	290,813
1958	80,974	0	90,773	82,731	45,417	25	299,920
1959	91,567	0	133,922	81,253	57,219	19	363,980
1960	59,305	8	122,800	200,203	92,072	50	474,438
1961	50,599	0	139,196	151,901	126,233	416	468,345
1962	38,154	0	117,303	131,121	77,533	216	364,327
1963	140,425	0	246,249	113,698	29,907	0	530,279
1964	89,781	0	250,404	116,112	71,945	34	528,276
1965	121,165	129	332,337	61,301	47,402	38	562,372
1966	117,460	0	466,490	83,753	91,641	77	759,421

TABLE 12-4. Water-borne commerce for Port Angeles Area, in short tons

DOMESTIC INTERNAL

Year	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Totals
1952	73,733	0	631,856	62,725	77,297	0	845,611
1953	88,894	0	897,708	65,988	95,270	0	1,147,860
1954	111,758	0	494,745	60,082	76,989	0	743,574
1955	132,227	0	579,143	63,299	92,844	0	867,513
1956	157,682	0	699,258	63,033	61,302	0	981,275
1957	152,545	0	597,421	60,125	50,660	0	860,751
1958	152,294	0	472,218	52,243	86,387	0	763,142
1959	153,208	0	690,232	59,340	142,408	0	1,045,188
1960	191,567	0	422,135	60,097	124,083	0	797,882
1961	193,328	0	457,639	62,563	106,319	0	819,849
1962	204,581	0	345,196	72,696	142,930	0	765,403
1963	245,943	0	260,900	85,832	57,872	0	650,547
1964	227,801	0	283,770	325,083	82,899	0	919,553
1965	239,361	0	332,414	134,015	167,669	0	873,459
1966	225,538	0	679,442	132,663	107,363	0	1,145,006

TERMINAL AND TRANSFER FACILITIES

Port facilities development in these basins has been limited to the Port Angeles area as shown on Figure 12-2. Terminal facilities as of 1952 and 1963 are summarized in Tables 12-5 and 12-6, respectively.

From 1952 to 1963 there was a reduction of 200 feet in berth space with less than 18 feet depth but an increase of about 200 feet in berths with over 18 feet depth. During the same period the covered storage area was decreased by about 18,500 square feet. By 1967 about 700 feet of berth space with 30 feet depth was added.

TABLE 12-5. Terminal facilities Port Angeles Area 1952

Use	Depth 18' & Less		Depth 18' - 40'		Depth 40' +		Covered Storage Sq. Ft.	Open Storage Acres
	No. of Berths	Berth Space In Feet	No. of Berths	Berth Space In Feet	No. of Berths	Berth Space In Feet		
General Cargo	2	1,425	9	2,337	0	0	24,990	0
Bulk Grain	0	0	0	0	0	0	0	0
Forest Products	5	1,765	2	625	0	0	0	0
Bulk Petroleum	2	200	1	150	0	0	0	0
Other Dry Bulk	2	330	0	0	0	0	0	0
Other Liquid Bulk	0	0	0	0	0	0	0	0
Totals	11	3,720	12	3,112	0	0	24,990	0
Construction & Repair	0	0	0	0	0	0	0	0
Mooring	10	920	3	560	0	0	0	0

TABLE 12-6. Terminal facilities Port Angeles Area 1963

Use	Depth 18' & Less		Depth 18' - 40'		Depth 40' +		Covered Storage Sq. Ft.	Open Storage Acres
	No. of Berths	Berth Space In Feet	No. of Berths	Berth Space In Feet	No. of Berths	Berth Space In Feet		
General Cargo	4	1,092	7	1,991	0	0	6,500	0
Bulk Grain	0	0	0	0	0	0	0	0
Forest Products	4	1,090	0	0	0	0	0	0
Bulk Petroleum	0	0	3	1,340	0	0	0	0
Other Dry Bulk	4	515	0	0	0	0	0	0
Other Liquid Bulk	1	830	0	0	0	0	0	0
Totals	13	3,527	10	3,331	0	0	6,500	0
Construction & Repair	0	5,222	0	0	0	0	0	0
Mooring	0	935	0	282	0	500	0	0

WATERFRONT AND INDUSTRIAL LAND

The existing and potential sites of water-transport-oriented industries and terminal facilities in the Elwha-Dungeness Basins are indicated on Figure 12-3 and summarized in Table 12-7. In this Table the net areas are the gross areas less rights-of-way for streets and highways. The following discussion refers to site numbers shown on referenced Figure and Table.

Site No. 1 in the Port Angeles Harbor area includes the existing development by the Port of Port Angeles and private interest as well as areas available for future development. Much of the presently undeveloped area included in Site No. 1 will probably be taken up by expansion of existing industries but some space may be available for additional light industries.

Site No. 2 located at Green Point a few miles east of Port Angeles is a potential site for light to heavy industries. This site is adjacent to deep water.

Although not located in the Elwha-Dungeness Basins three alternative sites to Site No. 2 are under consideration by the Port of Port Angeles. These are shown in Figure 11-6, West Sound Basins.

SMALL BOAT HARBORS

The small boat facilities existing in 1966 on salt water are shown on Figure 12-4 and identified in Table 12-8.

Shown on Figure 12-5 are about 7 miles of salt water shoreline that are considered suitable for potential marina development.

TABLE 12-7. Water front & industrial land—Elwha-Dungeness Basins—1963

		Acres in Use (Net)				Acres Potential			
						Favorable		Less Favorable	
Site Number	Location	Terminal Facilities	Vessel Repair & Construction	Water Oriented Industry	Total	Gross	Net	Gross	Net
1.	Port Angeles Harbor	87	15	105	207	1,000	750	0	0
2.	Green Point	0	0	0	0	280	210	0	0
	Total	87	15	105	207	1,280	960	0	0

TABLE 12-8. Small boat harbors existing, Elwha-Dungeness Basins

				Transient Boat Launching Ramp		Rental Moorage	
Facility Number	Facility Name	State Park	State Marine Park	Public	Private	Public	Private
1	Dungeness Spit		X	X			
2	Thunderbird				X		X
3	Port Angeles Boat Haven					X	
4	Dungeness County			X			
	TOTALS	0	1	2	1	1	1

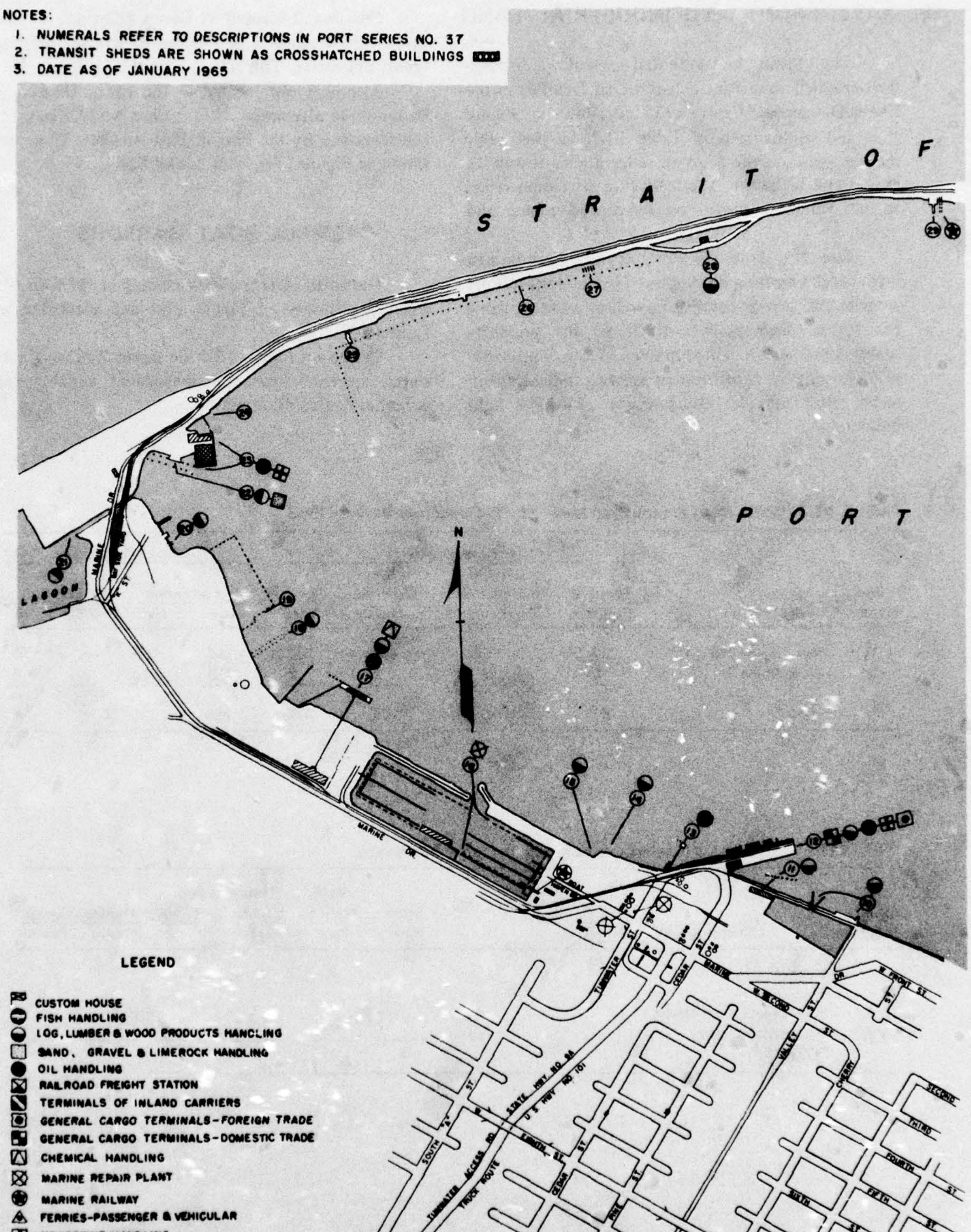
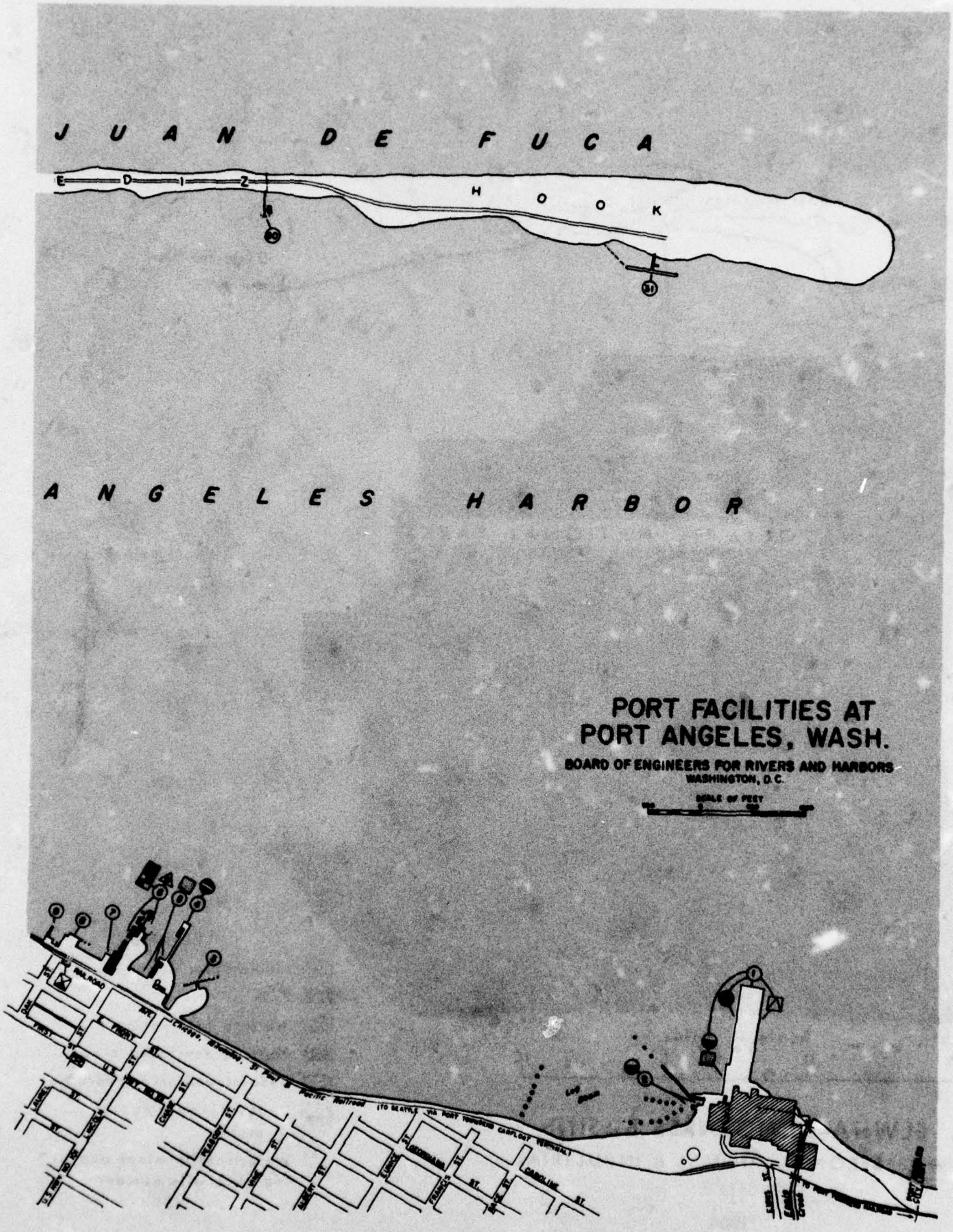
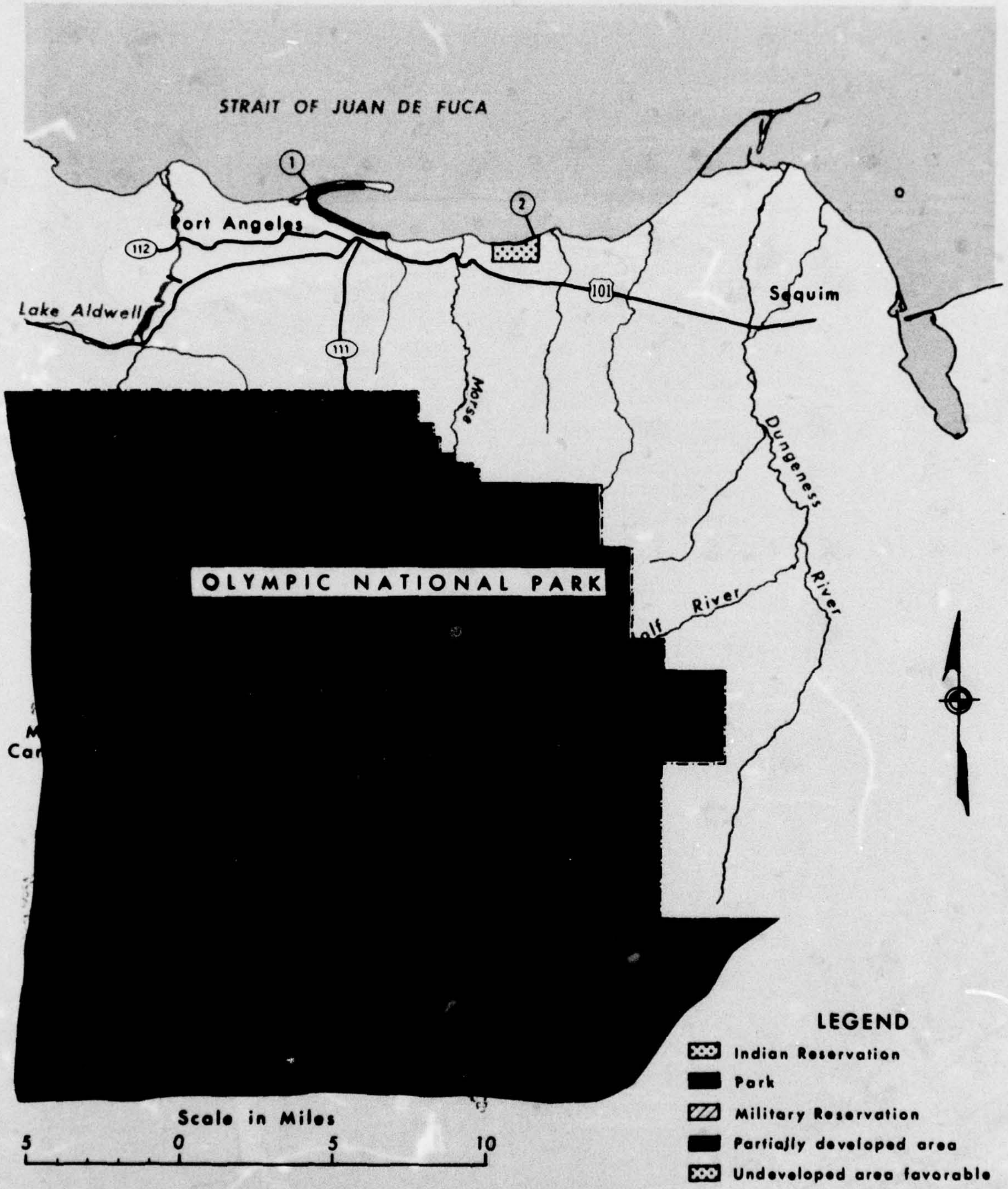

NOTES:
1. NUMERALS REFER TO DESCRIPTIONS IN PORT SERIES NO. 37
2. TRANSIT SHEDS ARE SHOWN AS CROSSHATCHED BUILDINGS
3. DATE AS OF JANUARY 1965
S T R A I T O F
P O R T
LAGOON
MARINE DR
N
LEGEND
CUSTOM HOUSE
FISH HANDLING
LOG, LUMBER & WOOD PRODUCTS HANDLING
SAND, GRAVEL & LIMEROCK HANDLING
OIL HANDLING
RAILROAD FREIGHT STATION
TERMINALS OF INLAND CARRIERS
GENERAL CARGO TERMINALS-FOREIGN TRADE
GENERAL CARGO TERMINALS-DOMESTIC TRADE
CHEMICAL HANDLING
MARINE REPAIR PLANT
MARINE RAILWAY
FERRIES-PASSENGER & VEHICULAR
NEWSPRINT HANDLING

FIGURE 12-2L



JUAN DE FUCA
EDIZ HOOK
ANGELES HARBOR
PORT FACILITIES AT
PORT ANGELES, WASH.
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C.

FIGURE 12-2R

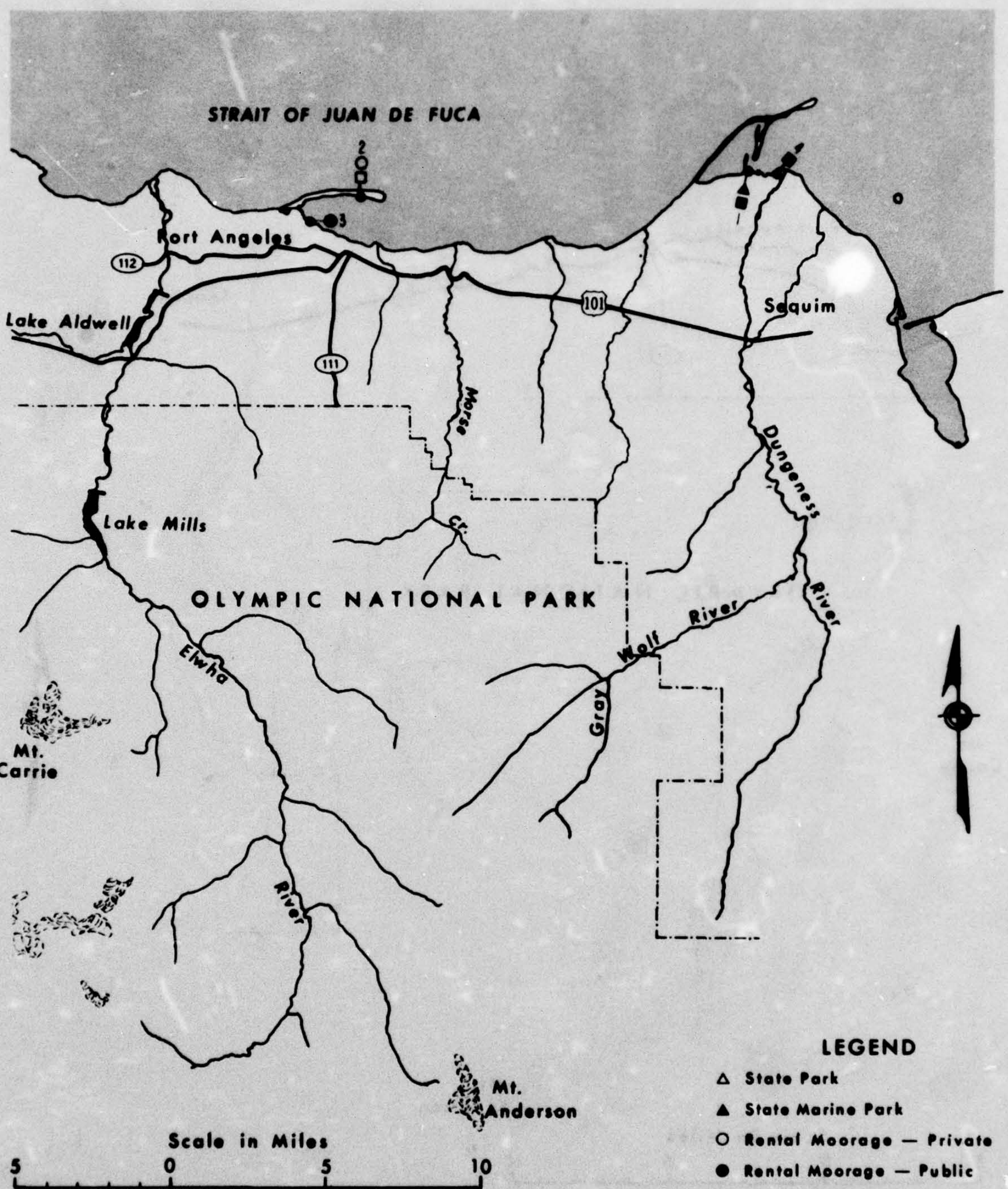


ELWHA-DUNGENESS BASINS

WATERFRONT TERMINAL & INDUSTRIAL SITES

1966

FIGURE 12-3

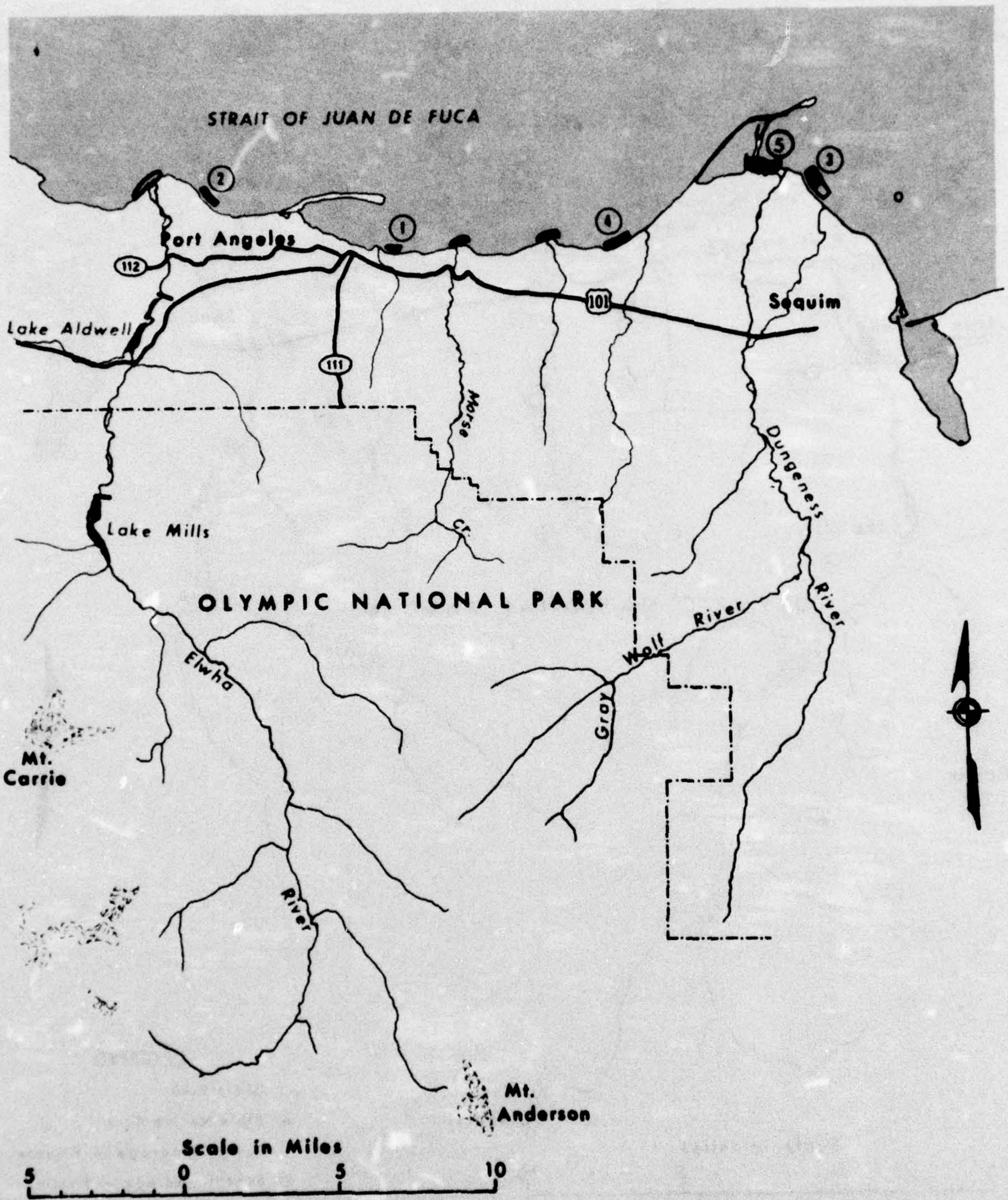


ELWHA-DUNGENESS BASINS

SMALL BOAT HARBORS

1966

FIGURE 12-4



ELWHA-DUNGENESS BASINS

SMALL BOAT HARBOR SITES

LEGEND

Favorable

Less Favorable Harbor Site

FIGURE 12-5

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 with a framework plan developed for satisfying these needs by basin. Table 12-9 summarizes the navigation needs for the Elwha-Dungeness Basins as derived in Solutions to Navigation Needs.

TABLE 12-9. Elwha-Dungeness Basins—future navigation needs

Item	Unit	Needs By 1980	Needs By 2000[1]	Needs By 2020[1]
Waterborne Commerce				
General Cargo	1,000	620		
Bulk Grain	Short Tons	0		
Forest Products		630		
Bulk Petroleum		270		
Other Dry Bulk		210		
Other Liquid Bulk		0		
Totals		1,730	2,700	4,200
Harbors & Channels Requirements				
Vessel Draft	Feet			
Freighters		35	40	40
Bulk Carriers		No vessels of this type		
Tankers		45	45	45
Land Requirements	Acres			
Terminal and water-transport-oriented industry		480	830	1,170
Small Boat Harbors	Wet Moorages[2]	1,140	1,920	2,640

[1] Only aggregate tonnage projected after 1980.

[2] Taken as summer wet moorage demand.

MEANS TO SATISFY NEEDS

Total commerce handled by the Port of Port Angeles is expected to double by the year 2020. Accordingly, expansion of port facilities will be required to accommodate the expected traffic.

TERMINAL AND INDUSTRIAL LAND REQUIREMENTS

As noted in Table 12-9, approximately 1,200 acres of terminal and industrial lands should be developed by the year 2020 to meet projected needs. This includes 207 acres already developed for this purpose. These needs can be satisfied by full development of partially developed lands in Port Angeles proper and by development of Site 2, shown in Figure 12-3.

HARBORS AND CHANNELS

Existing depths in Port Angeles Harbor are more than adequate to accommodate vessels expected to call at the harbor. Some extension of piers and wharfs may be required to reach berthing depths of some of the deeper draft vessels.

SMALL BOAT HARBORS

Listed in Table 12-10 are the sites in the Elwha-Dungeness Basins considered for development of small boat harbors. These sites are shown on Figure 12-5. Although alternative sites are also available the sites selected are the most favorable in this Basin.

A tentative schedule of development to meet 1980, 2000 and 2020 needs is contained in Table 12-9. Benefits and costs for projects recommended to meet 1980 pleasure boating demand are also shown as are the estimated costs for additional projects required by 2000 and 2020. Costs shown are for general navigation facilities and navigation aids that may require Federal assistance in financing and construction. General navigation facilities consist of breakwaters, entrance channels, and turning basins and the navigation aids are normally lighted dolphins and breakwater lights. Costs are average values and are based on actual construction or detailed study cost estimates for small boat harbor projects in the Area. Average benefit values were derived using standard methods employed by the Corps of Engineers, data from the "Pleasure Boating Study," and other studies performed for small boat harbor projects.

Factors Influencing Implementation of Plan

Erosion of Ediz Hook must be arrested in order to retain this natural breakwater protection for Port Angeles Harbor.

TABLE 12-10. Small boat harbor sites—Elwha-Dungeness Basins

Site No.	Location	Wet Moorages	Water-Land Area-Acres[4]	Tentative Schedule of Development: 1980	2000 (Wet Moorages)	2020
1	Port Angeles-Addition	150	13		150	
2	Elwha River-East	710	59	360	350	
3	Dungeness River-East	2,840	237		300	700
4	East of Green Point	1,430	119			
5	Dungeness-Sequim	350	29	350		
	Total	5,480	457	710	800	700

Summary of Benefits and Costs

1980 Construction Costs,3	1980 Average Annual Costs1&2	1980 Average Annual Benefits	2000 Construction Costs3	2020 Construction Costs3
$1,431,400	$91,700	$132,800	$1,612,800	$1,411,200

1 Annual interest and amortization charges of general navigation facility construction costs, including aids to navigation are computed for 50-year economic life at a rate of 4-5/8 percent.

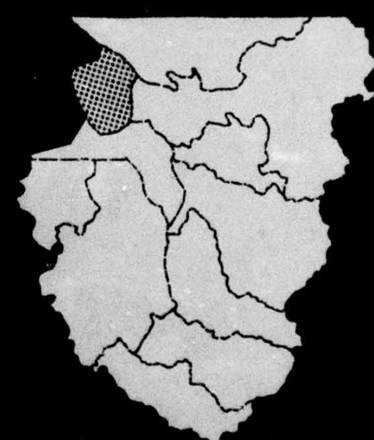
2 Includes allowance of $25 per wet moorage for annual maintenance and replacement costs.

3 Includes allowance for Engineering, Design, Supervision and Administration costs.

4 Using relationships based on Shilshole Marina wet moorage land and water area requirements are estimated at 0.056 acres of water area for moorage and maneuvering and 0.028 acres of land for parking and services per boat.

Note: Not contained in the area requirements are land needs for launching ramps which will generally be incorporated with moorage facilities. Launching facilities require about 1.5 acres of land for ramps and parking for each lane provided.

San Juan Islands



SAN JUAN ISLANDS

DESCRIPTION

These Islands to the north of Puget Sound are bounded on the south by the Strait of Juan de Fuca, to the west by Haro Strait, to the north by the Strait of Georgia and to the east by Rosario Strait. The straits and many of the channels between the islands have natural water depths of several hundred feet. They have about 376 miles of salt water shoreline. The Port of Friday Harbor is the major organized port district in this basin.

PRESENT STATUS

HARBORS AND CHANNELS

The most developed harbor in these islands is in Friday Harbor Bay on the east side of San Juan Island. Friday Harbor Bay is 87 nautical miles from the Pacific Ocean and has entrance depths of over 40 feet. The town of Friday Harbor has a ferry slip and wharves serving a fishing fleet and local freight boats. The landing wharf for the University of Washington oceanographical and marine biological research station is 0.6 miles northward of the town of Friday Harbor.

Other small harbors with wharves and piers for ferry landing and/or other local traffic in the Northeast Subregions are:

1. Deer Harbor, West Sound, Orcas and Olga on Orcas Island.
2. Roche Harbor and North Bay on San Juan Island.
3. Reid Harbor and Prevost on Stuart Island.
4. Waldron on Waldron Island.
5. Richardson and Upright Head on Lopez Island.
6. Decatur on Decatur Island.
7. Shaw Island.

WATERBORNE COMMERCE

Although not separated in published statistics of waterborne commerce indications are that there has been increased domestic internal traffic with the minor ports in the San Juan Islands. Probable decreases in forest products tonnages have been more than offset by required increases in general cargo and bulk petroleum to meet the needs of local development.

TERMINAL AND TRANSFER FACILITIES

Detailed information is not assembled for the limited port facilities at the many minor ports in these islands.

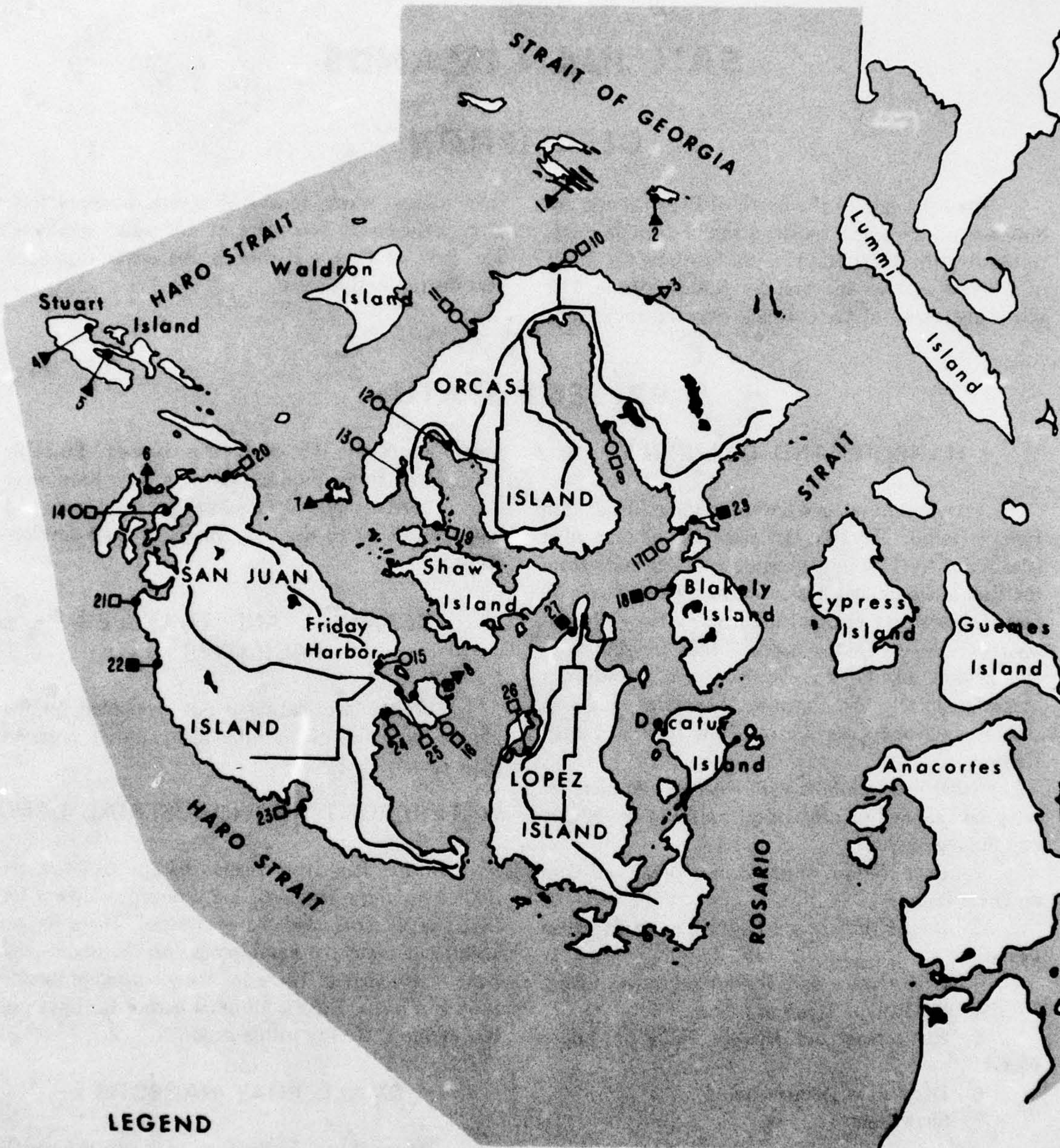
WATERFRONT AND INDUSTRIAL LAND

In the San Juan Islands harbor facilities are limited to ferry landings, log dumps, and piers for local small boat and barge traffic. There is no significant industrial development on the islands and none is anticipated. There are many natural protected bays and inlets where additional harbor facilities can be developed for any future needs.

SMALL BOAT HARBORS

The small boat facilities existing in 1966 on salt water in the San Juan Islands are shown on Figure 13-1 and identified in Table 13-1.

Shown on Figure 13-2 are about 47 miles of salt water shoreline that are considered suitable for potential marina development.



LEGEND

- △ State Park
- ▲ State Marine Park
- ○ Rental Moorage — Private
- ● Rental Moorage — Public
- ✱ Yacht Club
- □ Transient Boat Launching Ramp — Private
- ■ Transiet Boat Launching Ramp — Public

Scale in Miles

5 0 5 10

SAN JUAN ISLANDS

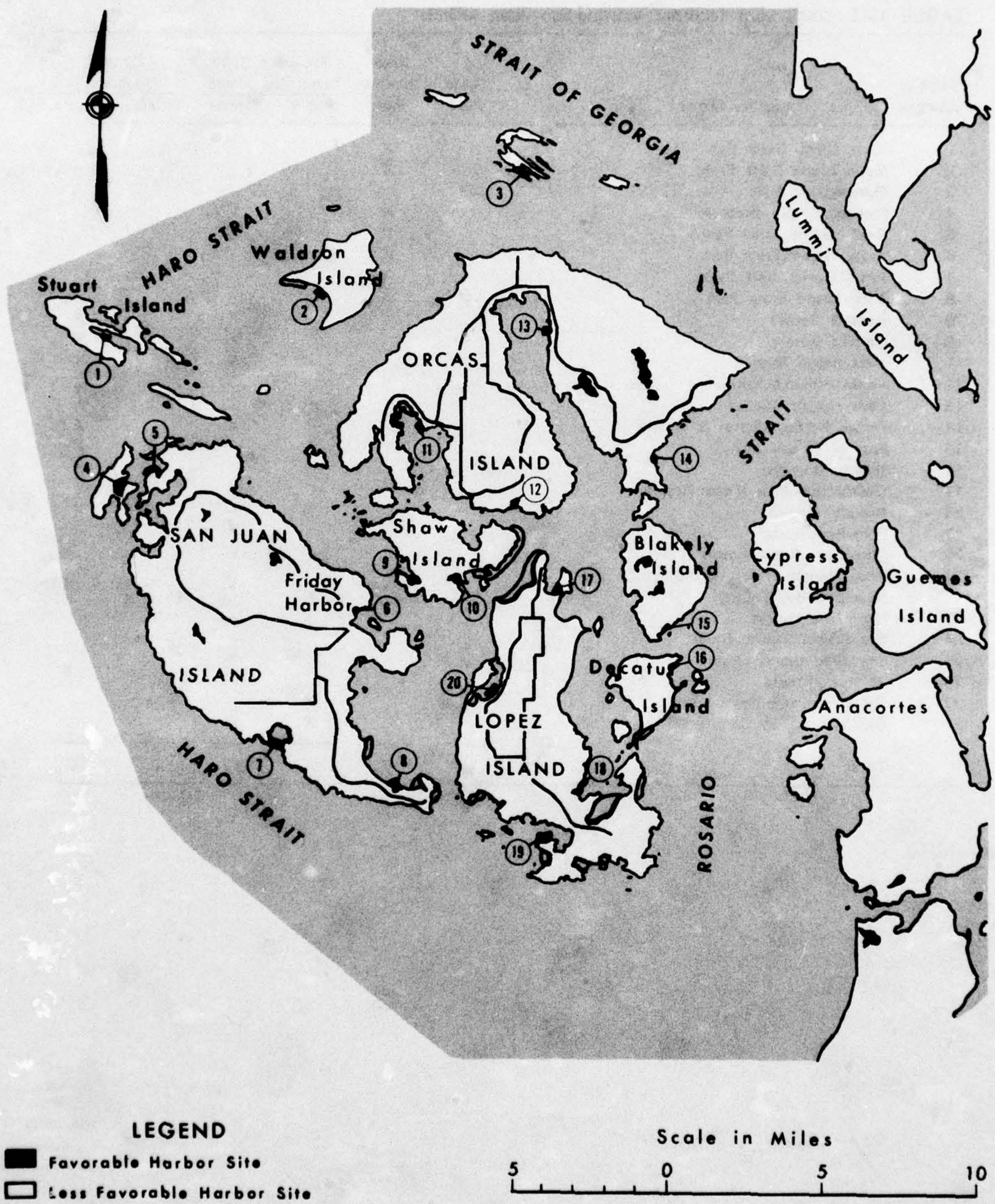
SMALL BOAT HARBORS

1966

FIGURE 13-1

TABLE 13-1. Small boat facilities existing-San Juan Islands

Facility Number	Facility Name	State Park	State Marine Park	Transient Boat Launching Ramp Public	Transient Boat Launching Ramp Private	Rental Moorage Public	Rental Moorage Private
1	Sucia Island State Park		X				
2	Matia Island State Park		X				
3	Moran State Park	X					
4	Provost Harbor State Park		X				
5	Reid Harbor State Park		X				
6	Posey Island State Park		X				
7	Jones Island State Park		X				
8	Turn Island State Park		X				
9	Rosario Resort				X		X
10	Bartel's Resort				X		X
11	West Beach Resort				X		X
12	VanMoorhem's Marina						X
13	Deer Harbor Marina						X
14	Roche Harbor Boatel & Resort				X		X
15	Port of Friday Harbor						X
16	Jensen Shipyard						X
17	Obstruction Pass Motel Resort				X		X
18	Blakely Marina			X			X
19	Pole Pass Resort				X		
20	Limestone Point Resort				X		
21	Snug Harbor Resort				X		
22	Smallpox Bay-County			X			
23	Mar Vista Resort				X		
24	Sea Breeze Trailer Coral				X		
25	San Juan Island Shipyard				X		
26	Pantleys Resort				X		
27	Odlin Park-County			X			
28	Obstruction Pass-County			X			
	Total	1	7	4	12	0	10



SAN JUAN ISLANDS
SMALL BOAT HARBOR SITES
1966

FIGURE 13-2

FUTURE NEEDS

The future navigation needs of the entire Puget Sound Area have been projected through the year 2020 with a framework plan developed for satisfying these needs by basin. Table 13-2 summarizes the navigation needs of the San Juan Islands as derived in Solutions to Navigation Needs.

TABLE 13-2. San Juan Islands–future navigation needs

Item	Unit	Needs By 1980	2000	2020
Waterborne Commerce				
General Cargo	1,000 Short Tons			
Bulk Grain				
Forest Products				
Bulk Petroleum		None Projected		
Other Dry Bulk				
Other Liquid Bulk				
Harbors & Channels Requirements				
Vessel Draft	Feet	None Projected		
Freighters				
Bulk Carriers				
Tankers				
Land Requirements	Acres			
Terminal and water-transport-oriented industry		None Projected		
Small Boat Harbors	Wet Moorages[1]	2,810	4,600	7,650

[1] Taken as summer wet moorage demand.

MEANS TO SATISFY NEEDS

No significant industrial development is expected in the San Juan Islands. Future expansion of terminal facilities will probably be limited to improvements of ferry terminals and small boat landings.

SMALL BOAT HARBORS

Listed in Table 13-3 are the sites in the San Juan Basin suitable for development of small boat harbors. These sites are shown on Figure 13-2. Although alternative sites are also available the sites selected are the most favorable in the Basin.

A large number of boat harbors of relatively small size was considered best to serve the needs of the many islands.

A tentative schedule of development to meet 1980, 2000 and 2020 needs is contained in Table 13-3. Benefits and costs for projects recommended to meet 1980 pleasure boating demand are also shown as are the estimated construction costs for additional projects required by 2000 and 2020. Costs shown are for general navigation facilities and navigation aids that may require Federal assistance in financing and construction. General navigation facilities consist of breakwaters, entrance channels, and turning basins and the navigation aids are normally lighted dolphins and breakwater lights. Costs are average values and are based on actual construction or detailed study cost estimates for small boat harbor projects in the Area. Average benefit values were derived using standard methods employed by the Corps of Engineers, data from the "Pleasure Boating Study," and other studies for small boat harbor projects.

TABLE 13-3. Small boat harbor sites—San Juan Islands

Site No.	Location	Wet Moorages	Water-Land Area-Acres[4]	Tentative Schedule of Development 1980	2000	2020
				Wet Moorages		
1	Stuart Island-Reid Harbor	240	20			240
2	Waldron Island-Coulitz Bay	340	28		340	
3	Sucia Island-Fossil Bay	240	20		240	
4	Henry Island-Nelson Bay	340	28			340
5	San Juan Islands-Roche Harbor	190	16		190	
6	San Juan Islands-Friday Harbor	460	38	460		
7	San Juan Islands-False Bay	1,970	164		1,030	940
8	San Juan Islands-Griffin Bay	1,180	98			1,180
9	Shaw Island-Parks Bay	340	28			
10	Shaw Island-Squaw Bay	340	28			
11	Orcas Island-Massacre Bay	340	28			
12	Orcas Island-Grindstone Harbor	340	28			
13	Orcas Island-East Sound	340	28	340		
14	Orcas Island-Deer Point	340	28			
15	Blakely Island-Armitage Island	340	28	340		
16	Decatur Island Fauntleroy Point	340	28			340
17	Lopez Island-Shoal Bay	340	28			
18	Lopez Island-Hunter's Bay	340	28			
19	Lopez Island-Machaye Harbor	340	28	340		
20	Lopez Island-Fisherman Bay	340	28			
	Total	9,040	748	1,480	1,800	3,040

Summary of Benefits and Costs

1980 Construction Costs[3]	1980 Average Annual Costs[1&2]	1980 Average Annual Benefits	2000 Construction Costs[3]	2020 Construction Costs[3]
$2,951,400	$189,000	$273,800	$3,624,800	$6,100,400

[1] Annual interest and amortization charges of general navigation facility construction costs, including aids to navigation are computed for 50-year economic life at a rate of 4-5/8 percent.

[2] Includes allowance of $25 per wet moorage for annual maintenance and replacement costs.

[3] Includes allowance for Engineering, Design, Supervision and Administration costs.

[4] Using relationships based on Shilshole Marina wet moorage land and water area requirements are estimated at 0.056 acres of water area for moorage and maneuvering and 0.028 acres of land for parking and services per boat.

Note: Not contained in the area requirements are land needs for launching ramps which will generally be incorporated with moorage facilities. Launching facilities require about 1.5 acres of land for ramps and parking for each lane provided.

5 Blaine Addition will serve commercial fishing fleet during winter months but vacant moorages will be available to public during most of summer boating season.

Factors Influencing Implementation of Plan

Considerable public investment will be required to construct the many small boat harbors planned for the San Juan Islands. However, existing authority is fragmented among several ports which do not have adequate financial capability to undertake major projects. Integrated authority with all of San Juan County constituting a port district would provide an improved base for financing needed pleasure boating facilities. Assistance in planning and financing of facilities should be sought from the State as most of the recreationists served are transient boaters.

ACKNOWLEDGMENTS

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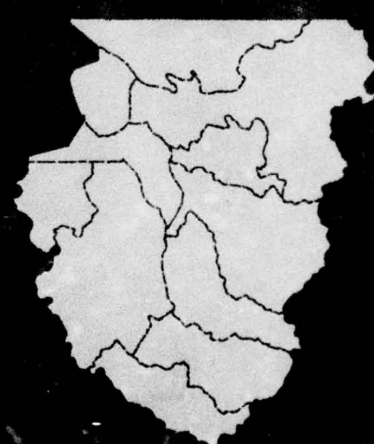
Frank J. Urabeck

Pleasure Boating Study



PLEASURE BOATING STUDY

PUGET SOUND AND ADJACENT WATERS

STATE OF WASHINGTON

NOVEMBER, 1968

PREPARED FOR:

PUGET SOUND TASK FORCE OF PACIFIC NORTHWEST RIVER BASINS COMMISSION

By:

SEATTLE DISTRICT, U. S. ARMY CORPS OF ENGINEERS & PACIFIC NORTHWEST REGION, BUREAU OF OUTDOOR RECREATION

In Cooperation with:

WASHINGTON STATE DEPARTMENT OF COMMERCE AND ECONOMIC DEVELOPMENT, WASHINGTON STATE PARKS AND RECREATION COMMISSION

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FOREWORD

This study of pleasure boating on Puget Sound and Adjacent Waters was undertaken by the U. S. Army Corps of Engineers and the Bureau of Outdoor Recreation in cooperation with the Washington State Department of Commerce and Economic Development and the Parks and Recreation Commission. Information was obtained on the number of pleasure boats in the 12-county study area and on the existing use and projections made for future demand for boating facilities. The pleasure boating needs determined by the study and defined in this report will be used in interagency water resource studies being made under the aegis of the Pacific Northwest River Basins Commission. These include the Comprehensive Water Resource Study of Puget Sound and Adjacent Waters and the Columbia-North Pacific Study.

An evaluation of available data on small boating was supplemented by field investigations including boat and air reconnaissance and a questionnaire survey made of Puget Sound area boat owners having craft registered with the United States Coast Guard. The survey measured pleasure boating demand for moorages, launching ramps, and other marine facilities in each of 19 subareas. In addition, data were obtained on boat characteristics, fuel consumption and damage to craft from debris and other causes.

Projections to 1980, 2000, and 2020 of boat ownership and marine facility demand were correlated with an economic study of Puget Sound and Adjacent Waters completed by the Consulting Services Corporation for the Puget Sound Task Force in January 1968, and with other pleasure boating studies and national boating trends.

This report can provide planners and other interested parties with a basis for determining local demand for moorages, launching ramps, marine oriented camping and picnicking facilities, harbors of refuge, and other facilities of importance to the pleasure boater.

For further information on this study address inquiries to:

Seattle District
Corps of Engineers
1519 Alaskan Way South
Seattle, Washington 98134

Pacific Northwest Region
Bureau of Outdoor Recreation
407 U. S. Court House
Seattle, Washington 98104

For copies of this report write:

Pleasure Boating Study
Washington State Parks and Recreation Commission
P. O. Box 1128
Olympia, Washington 98501

Summary of Findings and Recommendations

SUMMARY OF FINDINGS AND RECOMMENDATIONS

The pleasure boating study of Puget Sound and Adjacent Waters encompassed 12 counties bordering on 2,500 square miles of nearly land locked salt water in northwestern Washington. This water body consists of Puget Sound, Strait of Georgia, Hood Canal, and the Strait of Juan de Fuca, with approximately 2,350 miles of beaches and sheltered inlets bordering these interior waterways. Lake Washington, a 39 square mile fresh water lake connected to Puget Sound by the Lake Washington Ship Canal, was included in this study. The study area was divided into three divisions, North, Central, and West. These were further divided into 19 subareas to provide a more detailed examination of boating facility requirements.

Pleasure boat estimates for the study area were derived from the December 1966 United States Coast Guard Register and a survey conducted by the State of Washington Department of Commerce and Economic Development in 1965. An inventory of existing pleasure boat facilities was undertaken by land, water, and aerial reconnaissance. Marina operators were interviewed to obtain boater use information, and published listings of marine facilities supplemented data obtained from the field investigations. Boat characteristics and boat facility demand by season and location were derived from a questionnaire survey of registered boat owners residing in the study area.

Registered boats resident in the study area are estimated to be responsible for over 95 percent of the demand for Puget Sound pleasure boating facilities. Therefore, the United States Coast Guard register was considered to be a reasonable base from which to measure facility demand by a questionnaire survey. Approximately 1,600 questionnaires were mailed to a random sampling of boaters living within the study area. Information was obtained on the type of pleasure craft owned, seasonal use, demand for moorage and launching ramp facilities, harbors of refuge, services desired at moorage facilities, and amount of boat damage incurred during 1965 or 1966. Nearly 70 percent of the questionnaires were returned. This unusually high percentage return coupled with a telephone survey of non-respondents assures a high degree of reliability for the statistics reported herein.

An estimated 186,000 pleasure boats are owned by residents of the Puget Sound area. Of these, 62,100 are registered or documented craft. There are 94 boats per 1,000 population in the Puget Sound area as compared to 40.8 nationwide, and 53 in the Strait of Georgia area, British Columbia. Eighty-one percent of the pleasure boats are located within the Central Division, while 10 percent are in the West Division and nine percent in the North Division. The nearly two million persons in the study area own these 186,000 boats in the following categories:

Inboard	18,200
Outboard	94,400
Auxiliary Sailboats	1,400
Sailboats without power	6,300
Miscellaneous (rowboats, canoes, etc.)	65,700
Total	186,000

A total of 167 marinas supply 15,941 rental moorages, while 185 trailer boat ramps with 221 launching lanes are scattered throughout the study area. Twenty-three State parks and 14 State marine parks are located along the Puget Sound and Adjacent Waters shoreline including Lake Washington and the Lake Washington Ship Canal. An estimated nine miles of shoreline are occupied by public and private pleasure boat facility developments. An additional 200 miles of shoreline are suitable for development.

Seventy-four percent of pleasure craft owners surveyed own outboards while inboard and auxiliary powered sailboat owners account for the remaining 26 percent. The outboards average 15.8 feet in length and the inboards and auxiliary sailboats 25.3 and 29.8 feet, respectively. Approximately 69 percent of pleasure boat hulls are composed of wood, 30 percent of fiberglass, and the remaining 1 percent of steel, aluminum, and other material. All outboards and auxiliary sailboats are gasoline fueled while about 95 percent of inboards use gasoline and 5 percent use diesel.

A third of all the boat owners use their craft all year around, and nearly all use their craft from May through August. Rental moorage demand also follows seasonal patterns with more boaters requiring summer moorage than winter moorage. All auxiliary sailboat owners and 70 percent of inboard owners indicated a demand for permanent summer rental moorage facilities. Only 31 percent of the outboard owners indicated a demand for this type of facility. A need for an additional 23,400 summer rental moorages and 11,600 winter moorages is indicated for the Puget Sound area, based on the 1966 rental moorage inventory. Covered rental moorage is demanded by 62.6 percent of the boaters indicating a need for permanent summer moorage facilities and by 85.5 percent of boaters indicating a need for permanent winter moorage facilities. Permanent summer wet moorage is in demand by 74.4 percent of these boaters and permanent winter wet moorage by 56.1 percent.

The demand by trailer boat owners residing in the study area indicates a need for an additional 92 lanes of launching ramp at present. To provide for the nonresident boater trailering his craft from outside the region, this value could be increased by about 34 lanes for a total net need of about 126 launching ramp lanes.

Over 36,000 boat owners now use or would use new saltwater picnicking facilities and approximately 22,000 now use or would use new saltwater camping facilities. Harbors of refuge are needed by about 28,000 boaters. Pleasure boat damage during 1965 and 1966 averaged an estimated $850,000 annually with the majority of the damage caused by floating debris.

Total pleasure boat ownership in the study area is projected to increase dramatically from 186,000 in 1966 to 290,800 by 1980, 551,100 by 2000, and 1,037,800 by 2020. Registered and documented ownership is expected to increase proportionately. The additional pleasure craft will result in a correspondingly greater demand for boating facilities. Demand for moorages is forecast to grow at the same rate as pleasure boat ownership. From a demand for 39,300 permanent summer rental moorages in 1966, moorage demands are projected to reach 57,500 by 1980, 104,200 by 2000, and 185,300 by 2020. The demand for permanent winter rental moorages is projected to grow from 26,400 in 1966, to 40,100 by 1980, 74,300 by 2000, and 136,400 by 2020. Launching ramp demand is forecast to rise from 280 launching ramp lanes in 1966 to 410 by 1980, 750 by 2000, and 1,350 by 2020. The demands for camping and picnicking facilities, harbors of refuge, and moorage service facilities are also expected to parallel pleasure boat ownership growth.

The existing number of pleasure craft in the study area already places an unmet demand on moorage and launching ramp facilities. The current high demand for adequate facilities and the growth that is forecast for the next fifty years can only be satisfied by substantial additional capital investments. Breakwater-protected small boat harbors, due to high development costs, will require public investment at many locations. Generally, marinas located in naturally protected coves or waterways can be expanded within the capability of the private operator. However, careful consideration must be given to the type of facilities desired by the boater and the location of the demand to insure that the facilities are used once constructed.

The high demand for picnicking and camping facilities suggests that further study be given to determining the need for expanding these facilities and acquiring additional sites to serve the recreational boater. Harbors of refuge are needed throughout the Puget Sound area, as evidenced by the high boater response for this facility. Consideration should be given to allocating space within protected small boat basins for craft seeking temporary shelter. Also, studies are suggested for providing protected harbors at critical locations specifically constructed as harbors of refuge. The large amount of boat damage reported emphasizes the possible need for a expanded debris removal program. Consideration should also be given to preventing debris entry into navigable waters. Marinas should be planned and managed to minimize adverse environmental effects.

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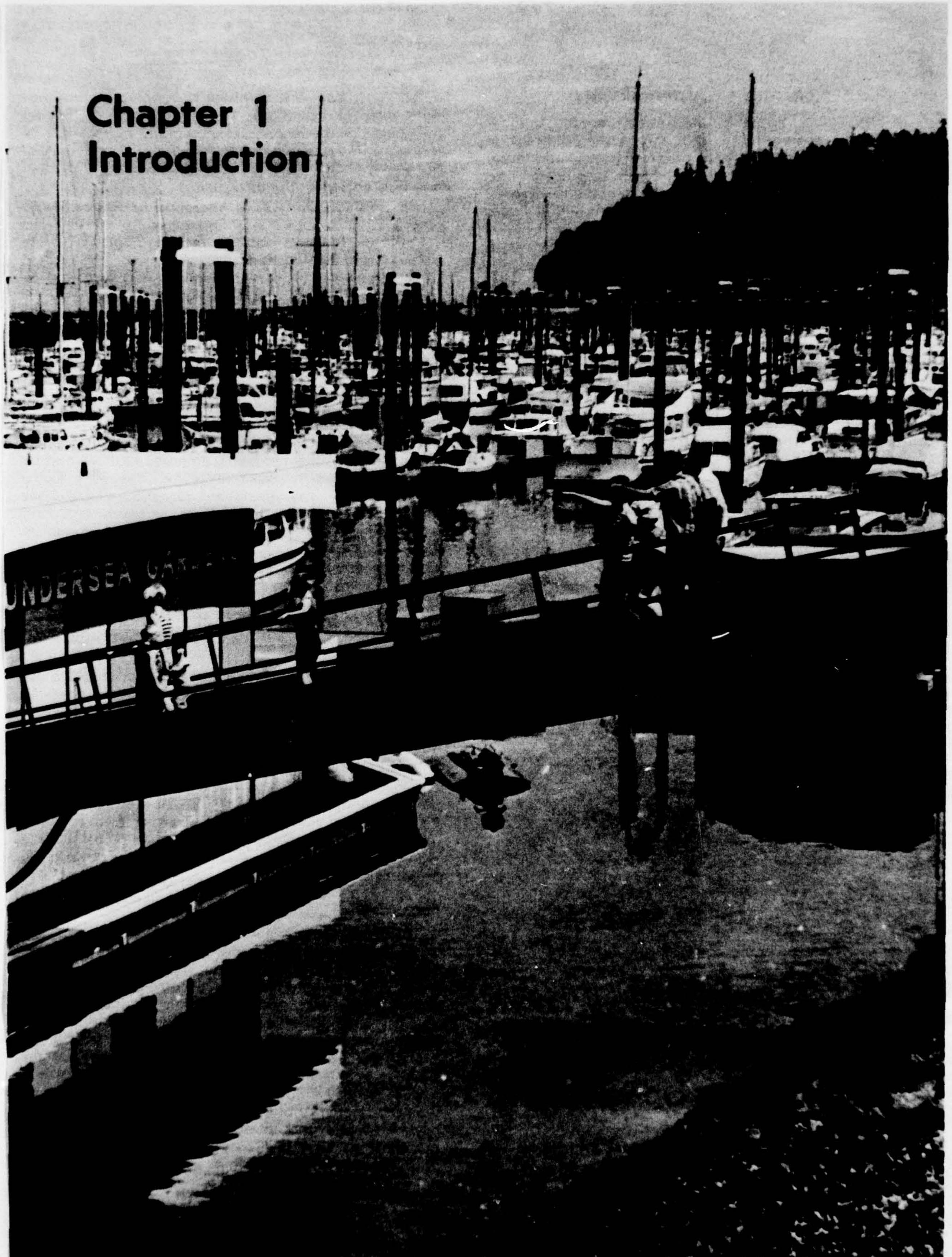
PUGET SOUND STUDY AREA

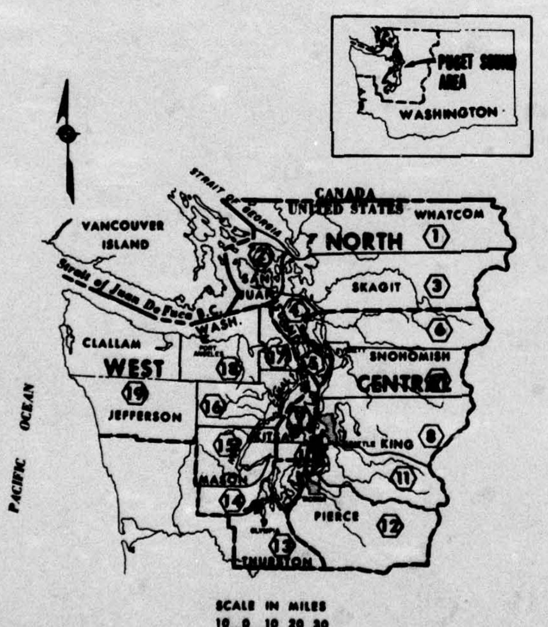
Figure 1

Chapter 1
Introduction



CHAPTER 1 — INTRODUCTION

This report provides information on the number and type of registered and non-registered pleasure boats owned by residents of the Puget Sound area. The relationship of boat ownership to population and the distribution of boats are given by three study area divisions: North, Central, and West as shown in figure 2. These divisions are further subdivided into 19 subareas for a detailed breakdown of facility demand. (See figure 2.) A comprehensive inventory of salt-water boating facilities, including marinas and launching ramps, is discussed along with figures showing the location of State shore and marine parks, public beaches, salmon fishing areas, and shoreline suitable for development of marine facilities. Facilities located on Lake Washington and the Lake Washington Ship Canal connecting the lake to Puget Sound are also noted. The current demand is presented for moorages, boating services, boat launching ramps, marine oriented parks, and harbors of refuge. Data relating to pleasure boat characteristics, seasonal use and damages caused by debris and other hazards are given. Projections of boat ownership and future demand for moorages and launching ramps are shown for 1980, 2000, and 2020.



PUGET SOUND STUDY AREA

Figure 2

Inventories

A field inventory of existing boating facilities was undertaken during the summer and fall of 1966 by automobile, boat and airplane to supplement and update data from available studies and records. During the course of the reconnaissance many marina operators were interviewed regarding the size and quality of their facilities, types of boats handled, and present and past patterns of boating use.

In addition, the entire shoreline of Puget Sound and adjacent waters was examined to locate sites suitable for marine facility development. Shoreline areas appearing feasible for development were noted after considering approach depths, dredging requirements, land access, parking area, and beach material composition.

Questionnaire Survey

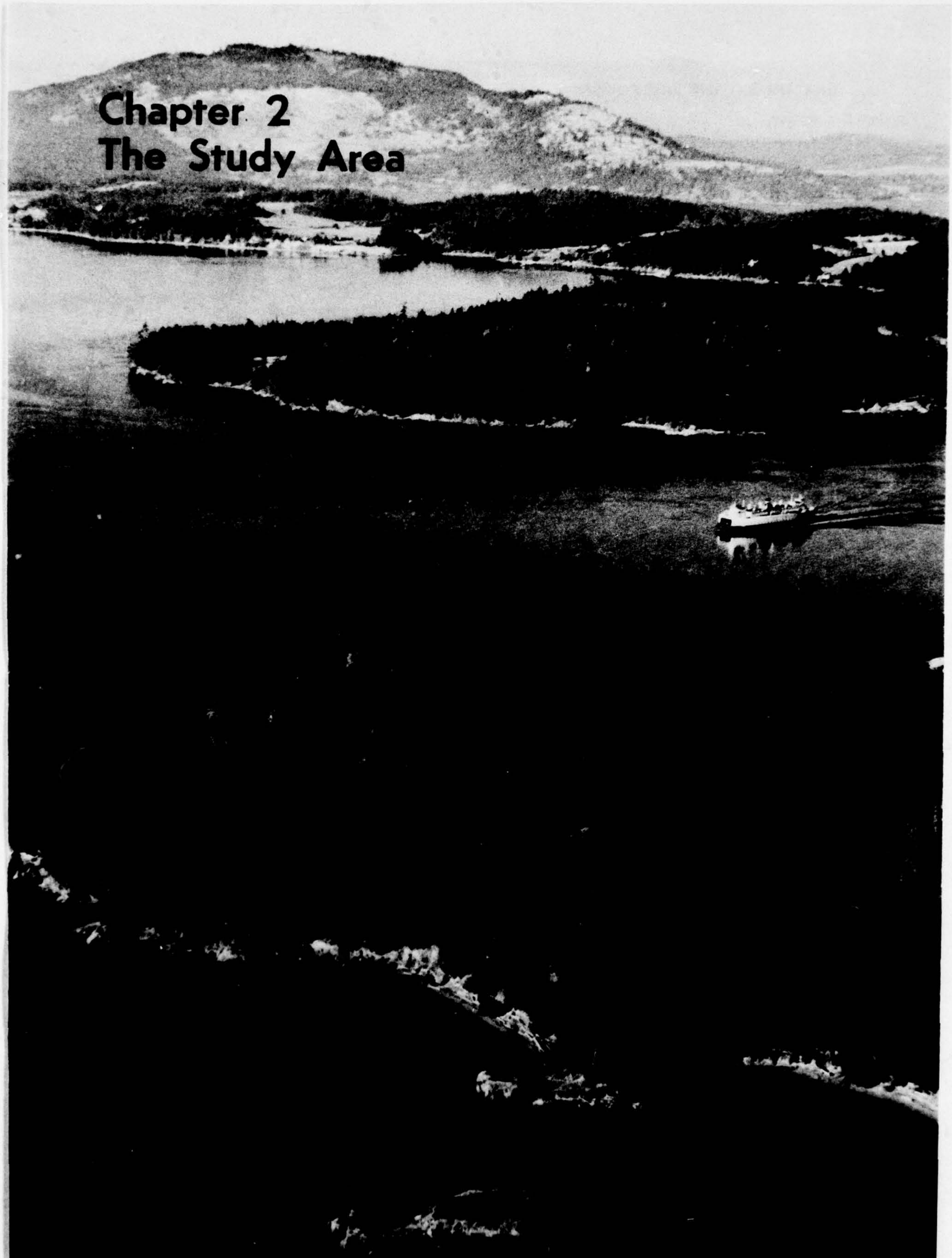
To obtain an accurate measurement of boat facility demand, a questionnaire survey was undertaken. Interviews with marina attendants and other studies indicated that approximately 95 percent of the total pleasure boat facility demand was from United States Coast Guard registered or documented craft owned by Puget Sound area residents. Therefore, the Coast Guard register was considered to be a reliable base from which to make the survey. Random sampling was undertaken, proportionate to the number of registered craft in each of the 19 subareas. The 19 subareas were selected on the basis of population concentrations, observed boating patterns, and other related factors. Sixteen hundred questionnaires were mailed, with seventy percent of the questionnaires returned. Over 700 were determined to be usable for data processing.

Data from the questionnaire were expanded to obtain facility demand figures for all registered boats. A random sample telephone interview of non-respondents indicated no distinct pattern of non response; therefore, the returned questionnaires were assumed to be representative of the total sample (See Appendix).

The results of the study were determined as 10 percent ranges within which the absolute answer is known to fall with a stated degree of certainty. The mid-point of this range has been quoted in the data which follows. The data is assumed to have a 95 percent "confidence level."

Projections

Pleasure boat ownership projections for the years 1980, 2000, and 2020 were correlated with the economic study of Puget Sound and Adjacent Waters made by Consulting Services Corporation for the Puget Sound Task Force and with other pleasure boating studies and national trends (See Appendix). The projections were related to forecasted population growth for each division of the study area. For the purpose of this study the existing percentage distribution of pleasure craft by location and type of boat was assumed to hold constant for the projection period. Moorage and launching ramp facility demand relationships were also assumed to grow concurrently with pleasure boat ownership.


Chapter 2
The Study Area

CHAPTER 2 — THE STUDY AREA

Physical Description

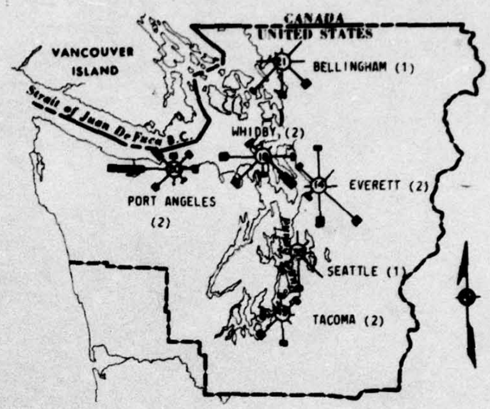
Between Vancouver Island in British Columbia and the mainland of the United States lie nearly 2,500 square miles of almost landlocked saltwater forming Puget Sound, Strait of Georgia, Hood Canal, and the Strait of Juan de Fuca. These waters lie in a setting of 13,200 square miles of forest and mountains with 10 major and 12 minor rivers flowing from the snow-capped peaks of the Cascade and Olympic Mountains, through forests and fertile farmlands to broad river deltas on saltwater. The mountains, saltwater beaches, and sheltered inlets along interior waterways, combined with a bounty of productive agricultural land and abundant year-round water supply, provide a setting which is attractive to both business and recreation. The deep water of the Strait of Juan de Fuca and the connecting deep channels of Puget Sound, Strait of Georgia, and Hood Canal are outstanding natural assets for the development of waterborne commerce. The controlling depth in the Strait of Juan de Fuca is 200 feet while Puget Sound has depths of over 900 feet.

Climate

The proximity of the Puget Sound area to the Pacific Ocean, combined with mountain barriers to the east and west, generally produces cool summers and mild, rainy winters. More than 70 percent of the annual precipitation falls within the six-month period from October through March. Mean annual precipitation at sea level varies from over 90 inches at Neah Bay, located near the entrance to the Strait of Juan de Fuca, to less than 17 inches in the Dungeness-Sequim "rain shadow," northeast of the Olympic Mountains. Along Puget Sound the mean annual precipitation ranges from 30 to 50 inches. Mean annual temperatures, adjacent to the saltwater body are around 50° F at most stations. Moderate to dense sea fog is common in the Strait of Juan de Fuca in late summer and fall.

Wind Conditions

The prevailing winds in the Puget Sound area are from the northwest during summer and southeast during winter. However, because of topography, winds within the area may vary greatly in intensity and direction. Winds are generally light to moderate during summer enabling boaters to cruise long distances over open water. During winter, due to sudden high wind potential, boaters tend to confine their saltwater boating activity to waters near their home moorage or launching site. Predominant wind speeds are from 4 to 15 m.p.h. throughout the area. In the Strait of Juan de Fuca winds tend to be higher than on the more protected inland waters with speeds of 16 to 31 m.p.h. reached over 25 percent of the time (See Figure 3).



ANNUAL SURFACE WINDROSES

Station	Total % of time wind is within MPH range		
	0-3	4-15	16-30
Bellingham	21	70	9
Whidbey	18	61	21
Everett	14	73	13
Seattle	35	61	4
Tacoma	49	40	11
Port Angeles	20	42	38

LEGEND

Number in circle indicates the percent of time wind speeds are 3 MPH or less.

Percent of time wind speeds are from 4-15 MPH.

Percent of time wind speeds are from 16-30 MPH.

Note: Percent of time measured on following scale:

SCALE (IN PERCENT OF TIME)

0 20 40 60 80

Figure 3

Tidal Conditions

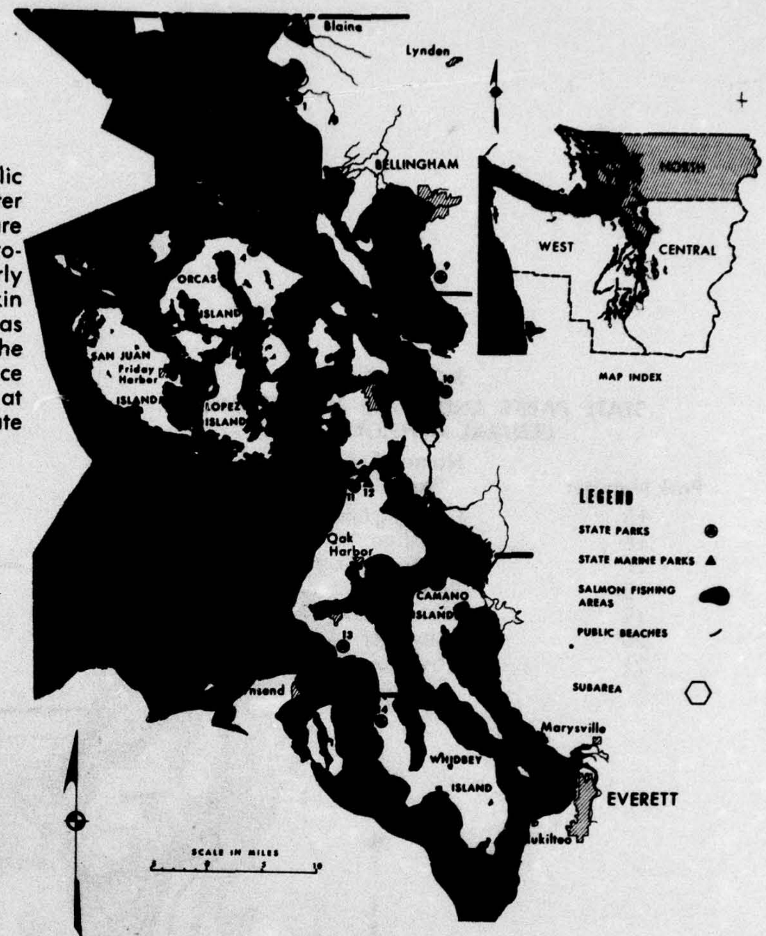
Along the Strait of Juan de Fuca estimated highest tides are in the 11 to 12 foot range and estimated lowest tides are in the minus 3½ to minus 4 foot range. In Hood Canal and at Olympia, on Puget Sound, the estimated highest tides vary between 15 and 18 feet while estimated lowest tides reach a minus 4½ feet. Elevations refer to mean lower low water.

Wave Conditions

Due to the sheltered nature of Puget Sound, waves do not generally exceed 6 feet in height. However, in the Strait of Juan de Fuca waves can exceed 15 feet during severe storms. Wave heights of these magnitudes normally occur only during winter. Summer wave heights are much less although they can occasionally become a hazard to pleasure craft in the more unprotected fetches.

ırks and Public Beaches

Many fine state shore and marine parks and public ›aches accessible to the Puget Sound pleasure boater e shown in Figures 4, 5, and 6. Marine parks are ›rmally located in areas having some degree of pro- ction from wind and waves, and are particularly ited for all forms of water activities including skin ıd scuba diving, fishing, and swimming. Comfort as ell as picnic facilities are provided at all of the ırks. Many of the parks also provide camping space r the boaters. Detailed information on facilities at ıch park can be obtained from the Washington State ırks and Recreation Commission.



RECREATIONAL ENVIRONMENT
NORTH DIVISION

FIGURE 4
STATE PARKS AND STATE MARINE PARKS
NORTH DIVISION—1966

rk Number	Name of Park
1	Birch Bay
2	Sucia Island
3	Matia Island
4	Moran
5	Prevost Harbor
6	Posey Island
7	Jones Island
8	Turn Island
9	Larrabee
10	Bay View
11	Deception Pass
12	Deception Pass
13	Fort Casey
14	South Whidbey

Figure 4

FIGURE 5
STATE PARKS AND STATE MARINE PARKS
CENTRAL DIVISION—1966

Park Number	Name of Park
15	Camano Island
16	Mukilteo
17	Fay Bainbridge
18	Illahee
19	Blake Island
20	Saltwater
21	Dash Point

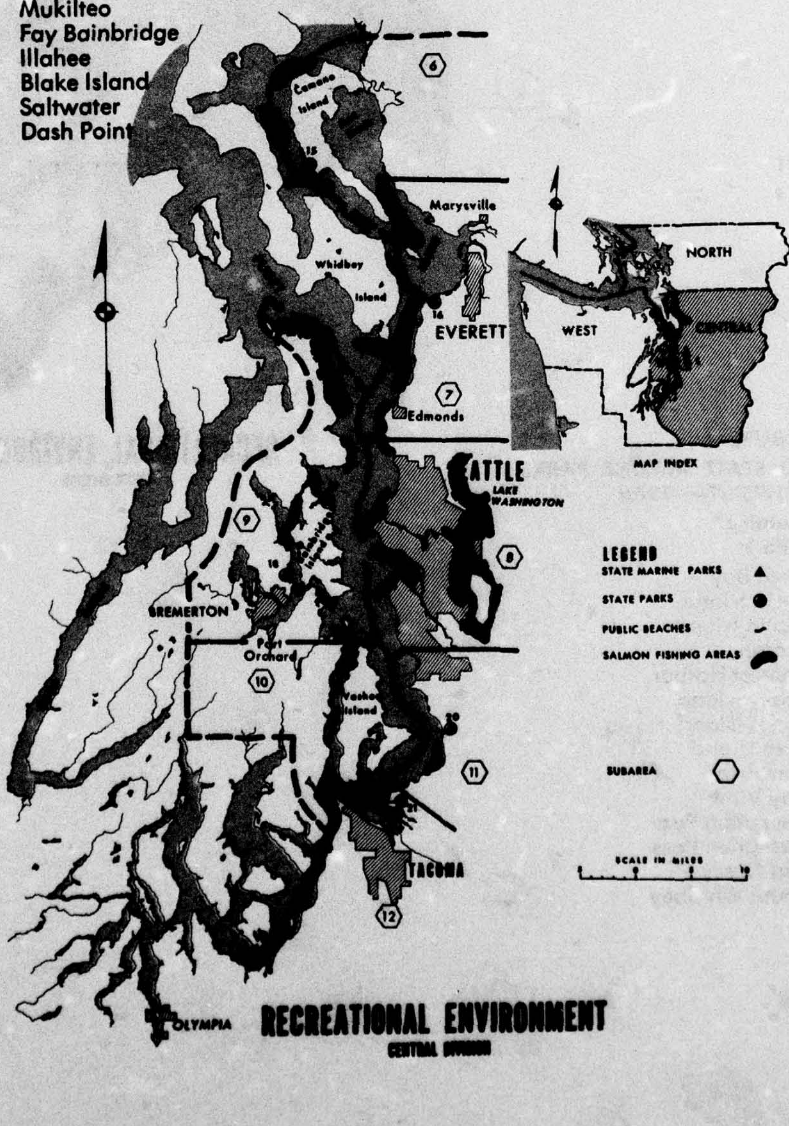


Figure 5

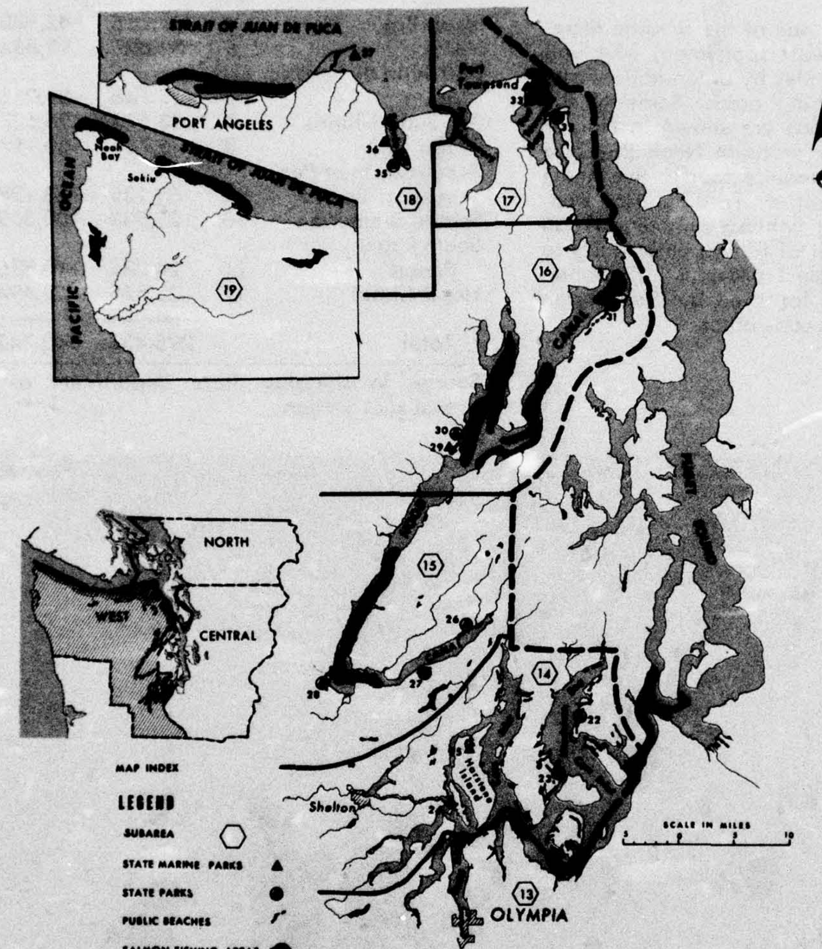


FIGURE 6
STATE PARKS AND STATE MARINE PARKS
WEST DIVISION—1966

Park Number	Name of Park
22	Kopachuck
23	Penrose Pt.
24	Squaxin Island
25	Jarrall Cove
26	Belfair
27	Twanoh
28	Potlatch
29	Pleasant Harbor
30	Dosewallips River
31	Kitsap Memorial
32	Fort Flagler
33	Old Ft. Townsend
34	Old Ft. Townsend
35	Sequim Bay
36	Sequim Bay
37	Dungeness Spit

RECREATIONAL ENVIRONMENT
WEST DIVISION

Sport Fishing Areas

Saltwater sport fishing is one of the favorite recreational pastimes of Northwest sportsmen, who will cruise by boat, travel many miles by automobile, or fly to their favorite salmon fishing areas. Some of the popular saltwater fishing areas are shown in Figures 4, 5, and 6. Highly popular areas at Neah Bay and Sekiu, in the West Division, require four to five hours of travel from Seattle, Everett, or Tacoma. However, the possibility of catching a fighting chinook salmon entices an increasing number of fishing enthusiasts to these waters each year. Table 1 provides information on saltwater salmon fishing for 1966 by Washington State Department of Fisheries code areas.

TABLE 1
WASHINGTON SALMON CATCH
PUGET SOUND AREA—1966

	Sub-Area Code	Total Salmon Catch	Total Angler Trips	Salmon Per Trip
Neah Bay	4	78,016	62,980	1.24
Sekiu	5	33,887	92,884	.36
East Juan de Fuca Strait	6	23,748	84,258	.28
San Juan Islands	7	23,575	96,607	.24
Skagit Bay	8	5,729	60,157	.10
Admiralty Inlet-Possession Sound	9	60,135	163,128	.37
Seattle-Bremerton	10	22,533	100,359	.22
South Puget Sound	11	24,235	110,875	.22
Hood Canal	12	23,575	69,494	.34
Total		295,433	840,742	

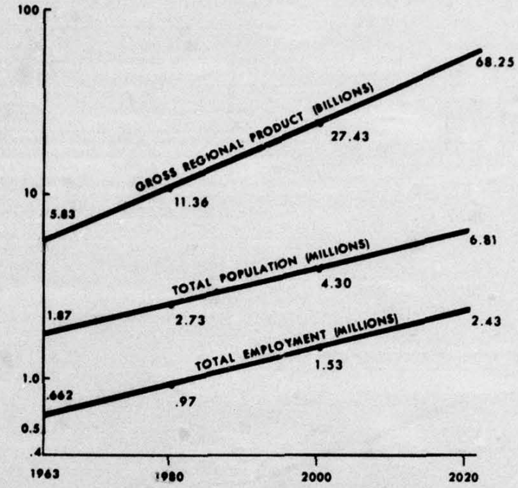
Source: Washington State Department of Fisheries, Statistics Section

Economic Base

The 12-county study area of western Washington has evolved from a sparsely populated region primarily oriented to forestry and agriculture to a moderately dense populated region noted for the production of transportation equipment and forest products. The major industry is the manufacture of aerospace equipment, ships, and trucks. The forest products industry is second, which ranges from the harvesting of saw logs to the manufacture of finished wood and pulp products. Of the approximately two million people in the 12-county area, the majority are concentrated in a dense urban band along the eastern shores of Puget Sound known as the Seattle-Tacoma-Everett metropolitan complex. Other population centers in the Puget Sound area are located in the communities of Bellingham, Bremerton, Olympia, and Port Angeles. The study area contains about 60 percent of the population of the State of Washington.

Employment in the manufacturing of transportation equipment and the forest products industry greatly exceeds employment in all other manufacturing industries combined. In addition, other major sectors of employment are services, wholesale, and rental trade, and government. The large number of people employed in the service industry is due to the concentration of population, as well as the recreational and tourist atmosphere of the area. The convenience and abundance of both water and land recreation opportunities is unique. Future growth in the recreation industry will have a significant effect on services and trade employment. Gross regional product or the total goods and services produced in an area is an important indicator of economic well-being because it is closely related to personal income.

These two indicators usually follow almost identical growth patterns. In 1963, the Puget Sound areas gross regional product was $5.8 million. In terms of 1963 dollars, the gross regional product is expected to increase by 1980 to $11.4 million and by 2020 to $68.2 million. As personal income increases, the amount of expenditures for recreational items will rise at a greater percentage increase. The projected population within the 12-county study area is 2.7 million by 1980, 4.3 million by 2000, and over 6.8 million by 2020. Population projects by divisions within the study area are shown in Table 2. Employment is projected to rise to one million by 1980 and over two million by 2020. The following table compares anticipated average annual growth rate per population employment and gross regional product of the Puget Sound area and the United States. Figure 7 presents the projected growth of gross regional product, population, and employment in the study area.



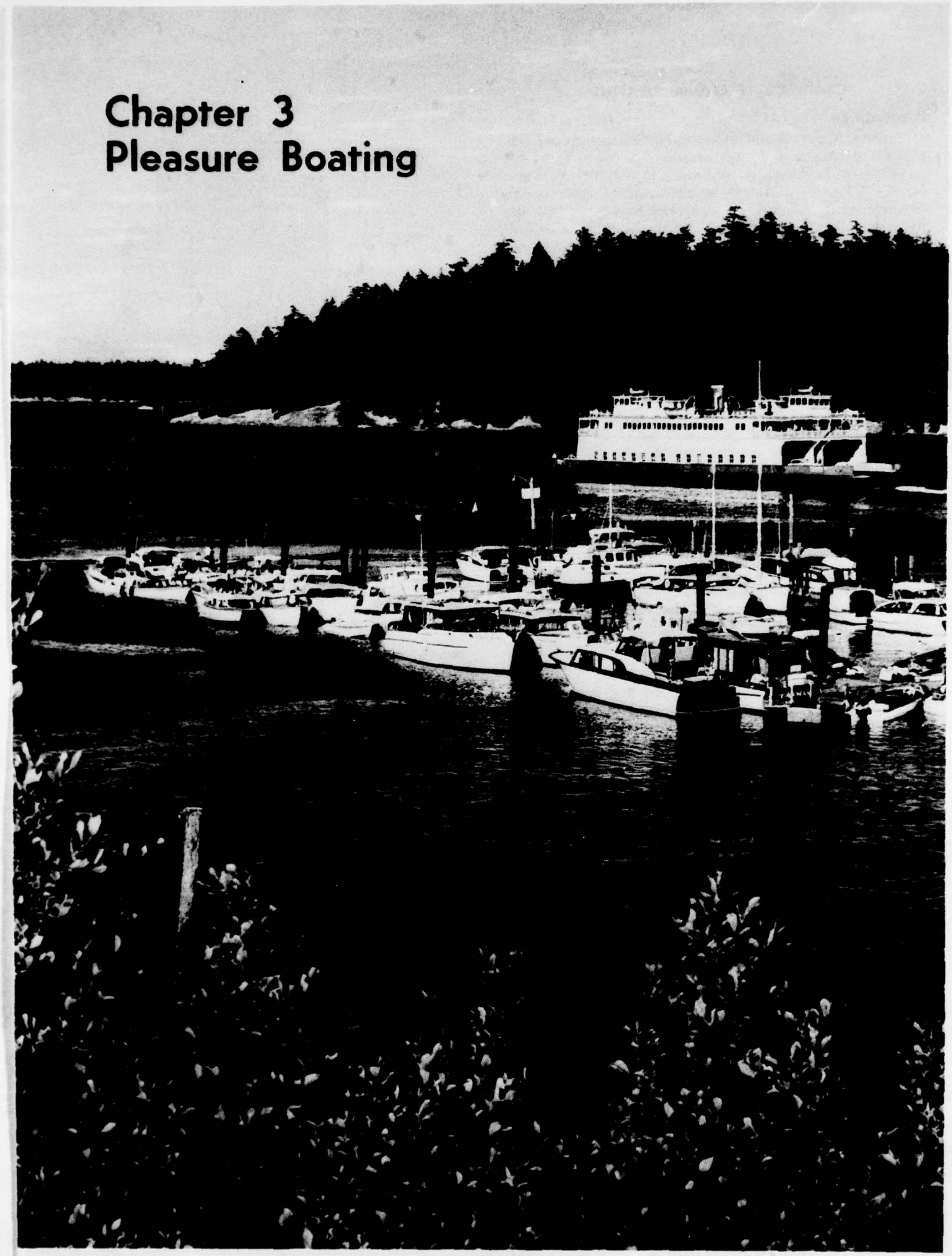
COMPARISON OF GROSS REGIONAL PRODUCT WITH PROJECTED POPULATION & EMPLOYMENT

Figure 7

TABLE 2
PROJECTED AVERAGE ANNUAL GROWTH RATES OF ECONOMIC INDICATORS

Area	Central Division	Twelve Counties Puget Sound and Adjacent Waters	United States
Population	%	%	%
1963-1980	2.4	2.3	1.3
1980-2000	2.4	2.3	1.3
2000-2020	2.4	2.3	1.3
Employment			
1963-1980	2.4	2.3	1.8
1980-2000	2.4	2.3	1.4
2000-2020	2.4	2.3	1.3
Gross Regional Product			
1963-1980	4.0	4.0	4.4
1980-2000	4.6	4.5	3.9
2000-2020	4.7	4.7	3.9

Chapter 3
Pleasure Boating



CHAPTER 3—PLEASURE BOATING

Participation

In the Puget Sound study area, an estimated 34 percent of the population engage in some form of recreational boating, as compared to a national average of 20 percent (1)*. A study by the Puget Sound Governmental Conference revealed that residents of the area place a great emphasis on boating with 8.3 activity days per person expended annually, as compared to a national average of 2.6. (2). The questionnaire survey indicated that an average of 168 hours a year are spent by registered boat owners on Puget Sound and adjacent waters with 75 percent of these hours devoted to cruises of one day or less.

Non-Resident Boat Use

A telephone survey of eight marinas in the study area revealed that from 2 to 5 percent of their moorages were rented by persons living outside the study area. Assuming this percentage range is representative of all marinas, there are between 300 to 800 pleasure boats from outside the study area presently using moorage facilities within the region. Preliminary data from a trailer boat survey undertaken by the Bureau of Outdoor Recreation during 1967 indicates that as many as 7,500 Washington boaters, non-resident to the study area, would presently trailer their craft to Puget Sound and adjacent waters provided facilities were available. A review of the Lea report (3) indicates that perhaps 300-400 Canadian pleasure craft annually navigate the waters of the North Division particularly around the San Juan Islands.

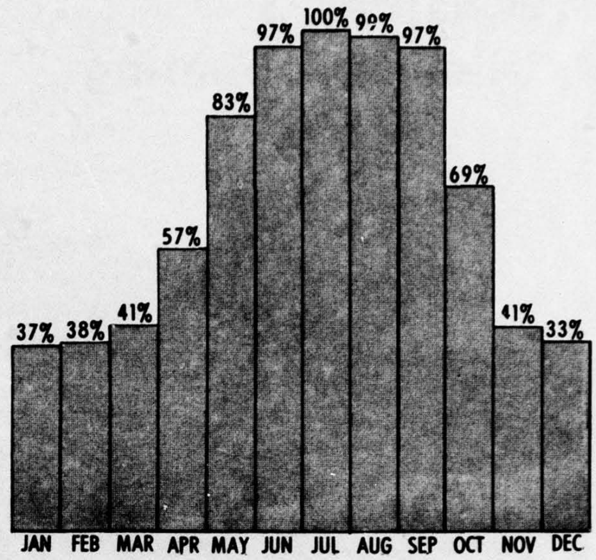
Season

Figure 8 shows boating activity for each of the twelve months. The questionnaire survey revealed that one third of the boaters use their craft throughout the year testifying to the unique boating environment of the area. Over 83 percent of the boat owners use their craft from May through September. This generally coincides with the major boating season in the Strait of Georgia area of British Columbia, as reported by Lea (3).

Expenditures

No direct sources of information are available from which study area pleasure boating expenditures can be extrapolated. However, assuming that local outboard motor sales bear the same relationship to local expenditures as they do nationally, it can be estimated that approximately $51,300,000 was spent in the study area in 1966. These estimates were derived from statistics published by the National Association of Engine and Boat Manufacturers and the Outboard Industry Association.

*Number indicates references listed in the selected bibliography.



BOATING ACTIVITY BY PERCENT OF TOTAL BOATERS IN 1966

Figure 8

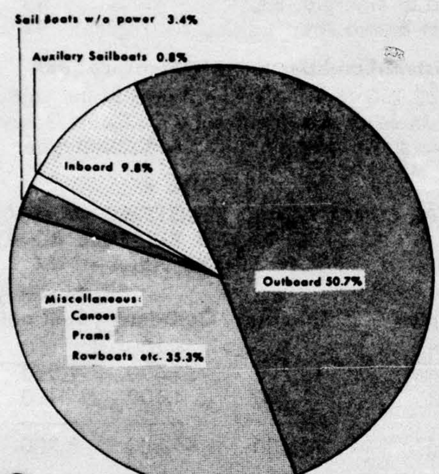
Number of Pleasure Boats

The number of pleasure boats in the study area was estimated using statistics gathered as a part of a Washington State Department of Commerce and Economic Development personal interview survey in 1965 (8). Examination of these statistics for the twelve counties composing the Puget Sound Study Area revealed that 33% of all pleasure boats, 86% of inboards and 48% of outboards are registered. From these percentages and craft registered in the study area in 1966 estimates were developed for the total number of boats, inboards, outboards, and auxiliary powered sailboats. Auxiliary powered sailboats were included with inboards in the survey and, therefore, the percent registered for inboards was also used for these craft. Sailboats without power and miscellaneous craft were estimated by subtracting from the total of the inboards, outboards, and auxiliary sailboats and proportioning the remainder on the basis of the state estimates for these craft. State estimates indicated a total boat population of 223,000 in 1965 as compared to the 186,000 pleasure craft estimated in the Puget Sound Study Area in 1966. Table 3 shows a breakdown of pleasure craft in the study area by division and by boat type.

TABLE 3
TOTAL PRIVATELY OWNED PLEASURE BOATS
PUGET SOUND AREA—1966

Division	Inboard	Outboard	Auxiliary Sailboat	Sailboat w/o Power	Miscellaneous①	Total
North	1,800	8,600	100	600	5,900	17,000
Central	14,700	76,200	1,200	5,100	53,200	150,400
West	1,700	9,600	100	600	6,600	18,600
Total	18,200	94,400	1,400	6,300	65,700	186,000

①Miscellaneous includes rowboats, canoes, rubber rafts, pram skiffs, etc. Figure 9 indicates the number of each type of craft by percent.

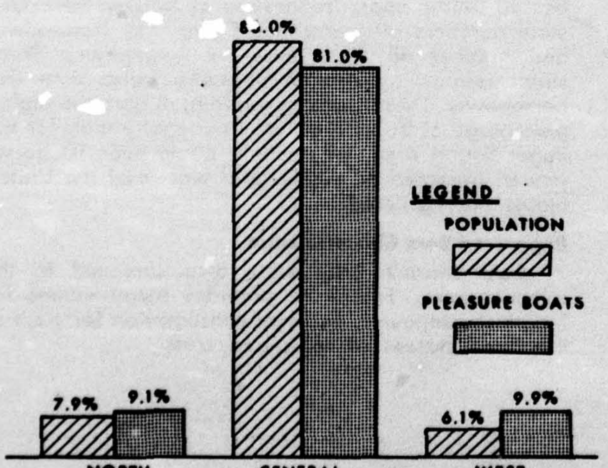


TOTAL PRIVATE OWNED PLEASURE BOATS DISTRIBUTION BY TYPE IN 1966

Figure 9

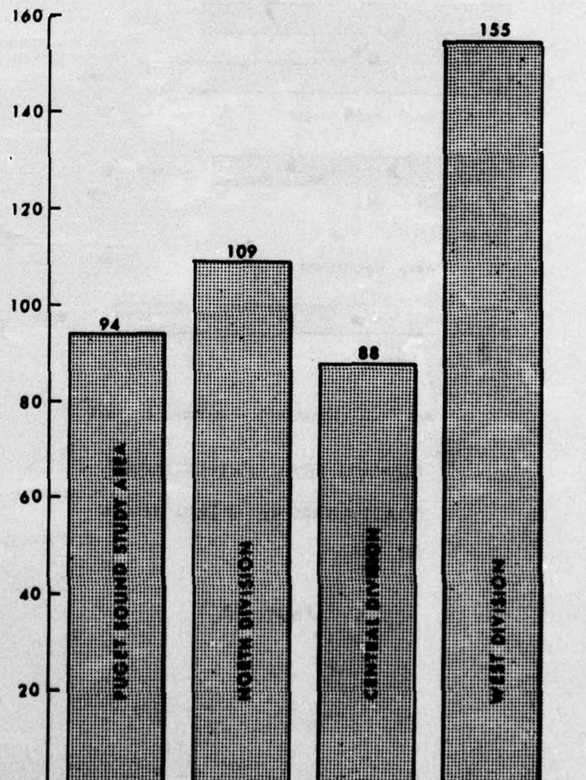
In figure 10 the percentage of the total study area population within the various divisions are shown together with the percentage of the total study area pleasure boats within each division.

A comparison of boat types in the Puget Sound area with those over the entire nation and Strait of Georgia area, B.C., is shown in Table 4.



PERCENT DISTRIBUTON OF POPULATION AND PLEASURE BOATS IN 1966

Figure 10



NUMBER BOATS PER 1000 POPULATION IN 1966

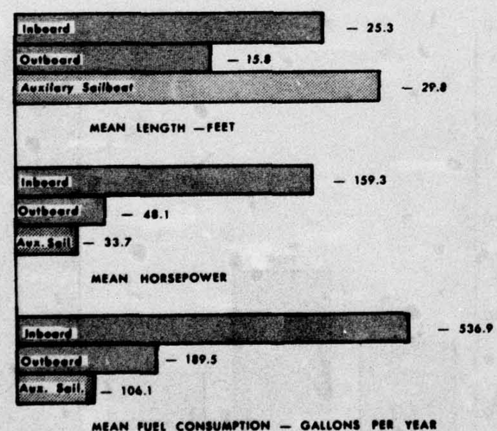
Figure 11

TABLE 4
BOAT TYPES
(Distribution by Percent)

Boat Types	Puget Sound Area	United States	Strait of Georgia
Inboard	9.8	7.2	11.2
Outboard	50.7	58.2	50.3
Auxiliary Sailboat	0.8	①	3.8
Sailboat w/o Power	3.4	6.8	2.7
Miscellaneous Craft	35.3	27.8	32.0

①Included with inboards.

Figure 11 provides a more direct relationship between population and number of boats in each Division. Shown are the total number of pleasure craft per 1,000 population for 1966. The West has a very high 155 boats per 1,000 population which is 65 percent higher than for the overall study area and 76 percent higher than for the Central Division.



PLEASURE BOAT CHARACTERISTICS
COAST GUARD REGISTERED BOATS
IN 1966

Figure 12

Table 5 compares pleasure craft ownership per 1,000 population for the Puget Sound area with national and Strait of Georgia, B.C. ownership figures. The high ownership in the study area can be attributed to the plentiful supply of both fresh and salt water suitable for boating and to the temperate climate of the region.

TABLE 5

Location	Boats per 1000 Population
United States	40.8
Strait of Georgia, B.C.	53
Puget Sound Area	94

Registered and Documented Pleasure Boats

62,100 of the pleasure boats in the study area are registered or documented by the Coast Guard. Table 6 shows these craft by division and boat type.

TABLE 6
TOTAL COAST GUARD REGISTERED OR DOCUMENTED PRIVATE OWNED PLEASURE BOATS
PUGET SOUND AREA—1966

Division	Inboard	Outboard	Auxiliary Sailboat	Total
North	1,500	4,100	100	5,700
Central	12,700	36,600	1,000	50,300
West	1,400	4,600	100	6,100
Total	15,600	45,300	1,200	62,100

Pleasure Craft Registration and Control

Nationally, 51 percent of the total number of recreational boats on all waters of the United States are State or Coast Guard registered (1). Forty-seven of the fifty states administer and regulate boating activity. The State of Washington is one of the few states leaving this function to the Coast Guard. Twenty-one of the 47 states which regulate boating activity number all motor boats (regardless of horsepower). One state numbers all motor boats over 7½ horsepower and another all those over six horsepower. Three states require registration of motor boats over five horsepower. These statistics explain, in part, the higher percentage of boats registered nationally than for the Puget Sound area, where only boats over 10 horsepower, operated on the Federal waters of the United States, are registered.

Registered Boat Characteristics

Boat characteristics were also surveyed in the questionnaire. Figure 12 provides mean values for length, horsepower, and fuel consumption for each of the three classes of registered craft.

The mean fuel consumption shown in figure 12 includes gasoline and diesel fuel for inboards. The returned questionnaires revealed that all outboards and auxiliary sailboats surveyed were gasoline powered. About 95 percent of the inboards are gas powered with the remaining 5 percent diesel powered.

The percent breakdown by hull material types is shown in Table 7.

TABLE 7
BOAT HULL MATERIAL
COAST GUARD REGISTERED BOATS
PUGET SOUND AREA—1966

Material	Percentage of Boats
Wood	68.6
Steel	0.1
Aluminum	0.7
Fiberglass	30.0
Other	0.6
	100.0

Pleasure Boat Projection

Studies by the Puget Sound Governmental Conference (2) and N. D. Lea and Associates (3) served as useful guidelines in developing projections for the study area. Both of these studies related boat purchases to personal income projections. The Lea study also considered population growth as a parameter for boat ownership projections. Both studies report that pleasure boat growth rates are expected to be in excess of population growth. The Puget Sound Governmental study projected a total pleasure boat average annual growth rate of 3 percent between 1965 and 1985 (2). This represented about a 7/8 percent annual growth above the population projections. The Lea study projected pleasure boat growth in the Strait of Georgia area, B.C., at an average annual rate of 4 percent between 1966 and 1976 and 3 percent between 1976 and 1986. In the first period 1.3 percent average annual growth was considered due to factors other than population increase and in the second period 1.0 percent. From NAEBM figures the average annual growth rate of pleasure craft ownership in the United States between 1964 and 1966 was approximately 2.4 percent, as compared to an average annual population growth rate of 1.2 percent for this same two year growth period. The difference of 1.2 percent can be attributed to such factors as increased disposable income and greater interest in boating, although increased disposable income is thought to be the biggest single element.

In light of the Puget Sound Governmental Conference, Lea studies, and national trends, an average annual pleasure boat growth rate of 1.0 percent was deemed reasonable to add to the average annual population growth rates derived from projected figures by Consulting Service Corporation.

Shown in Table 8 are pleasure boat ownership growth rates for each Division.

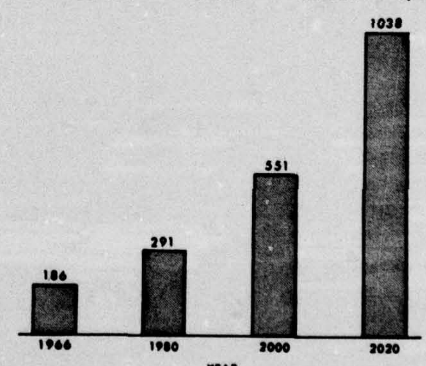
TABLE 8
PLEASURE BOAT OWNERSHIP GROWTH RATES
PUGET SOUND AREA—1966

	Average Annual Growth Rate—Percent		
Period	**North**	**Central**	**West**
1966-1980	2-1/4	3-9/16	1-7/48
1980-2000	2-1/2	3-3/8	2-19/32
2000-2020	2-9/16	3-3/8	1-5/8

Table 9 provides projected total pleasure boats by division for the years 1980, 2000, and 2020; and figure 13 summarizes the projections for the entire study area. Pleasure craft in the area is expected to increase by 56 percent from 186,000 in 1966 to 291,000 in 1980 and reach 551,000 by 2000. This is comparable to the expected growth in California where registered pleasure craft, 10 feet in length and longer, were projected to increase from 283,000 in 1962 to 1,100,000 by 2000 (4).

TABLE 9
PROJECTED PLEASURE BOATS (THOUSANDS)
PUGET SOUND AREA—1966

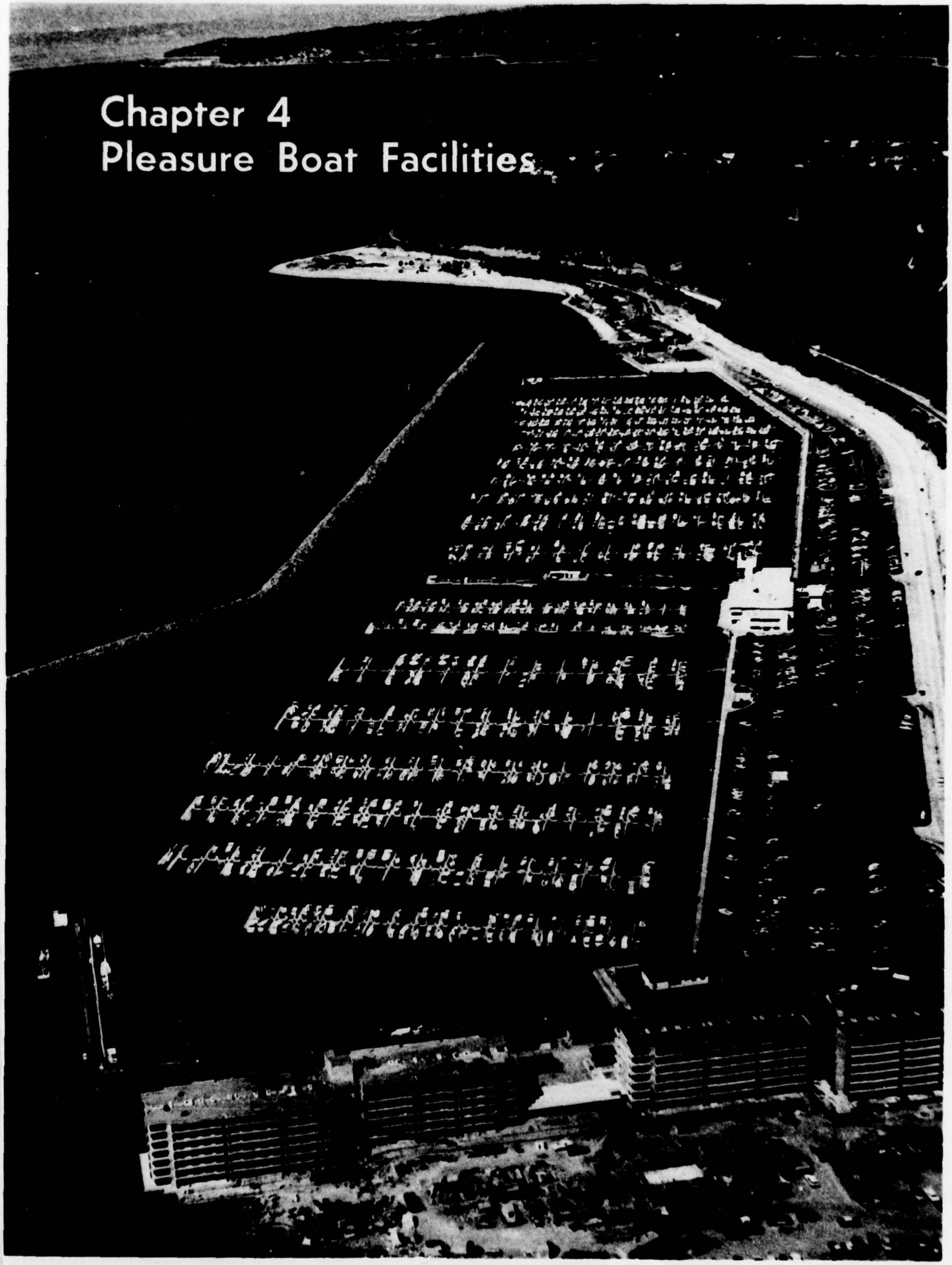
Division	1966	1980	2000	2020
North	17.0	23.8	39.0	64.7
Central	150.4	245.2	475.7	922.9
West	18.6	21.8	36.4	50.2
Total	186.0	290.8	551.1	1,037.8



PROJECTED PLEASURE BOATS (THOUSANDS)

Figure 13

Chapter 4
Pleasure Boat Facilities



CHAPTER 4 — PLEASURE BOAT FACILITIES

Inventory

Boating facilities now in use were inventoried. Moorage and launching ramp data were collected from boating facilities publications (5) and from field reconnaissance by automobile, boat and airplane. Facilities used exclusively by rental boats were excluded from the inventory as the purpose of this study was to determine facility needs of the boat-owning public. Marina attendants were interviewed regarding type of moorages provided, transient boater origin and destination, services available, fees charged, items for sale and plans for expansion.

As launching facilities other than launching ramps are usually privately owned, this study has defined launching facility demand and need in terms of equivalent launching ramp lanes. Other types of launching facilities, such as hoists or marine railways, which might satisfy some of the demand for launching ramps were inventoried.

Marinas

There are 167 marinas in the Puget Sound area supplying rental moorage facilities (figures 14, 15, 16, and 17). This number includes marinas supplying only summer moorage. Marinas operated by Port Districts and private enterprises vary considerably in quality. Many facilities are outdated and in poor condition with moorage floats and docks in need of repair. Access roads are unpaved, parking areas are of inadequate size, and often comfort facilities are lacking or poorly maintained. Other marinas are outstanding examples of modern complexes providing complete facilities for the boating public, including fine restaurants and shops.

Marinas are located on a wide range of sites with some sheltered in coves and river estuaries or inland waterways, while others are operated as summer resorts with limited protection. Those located on exposed shorelines and operated all year around require breakwater protection. In the North Division, the greatest concentration of marinas occurs near Anacortes (figure 14). In the Central Division, the major share of the marinas are located along the Lake Washington Ship Canal, connecting Lake Washington with Puget Sound, and along waterways of Commencement Bay in Tacoma (figures 15 and 16). Very few marinas are located along Puget Sound frontage due to the lack of sheltered locations for such facilities. The public facilities that have been constructed on this frontage are provided with breakwater protection. These include the small boat harbors at Edmonds and Shilshole Bay in Seattle. In the West Division, rental moorages are clustered in southern Puget Sound near Olympia (figure 17).

To be financially successful marinas requiring extensive breakwater protection generally need space for a minimum of 200 pleasure craft as well as provisions for land-based, revenue-producing services. The quality of services provided by marina operators and attendants is also an important factor of success, as with any business. If a marina site is exposed and requires extensive breakwater construction and dredging, then only in special circumstances can the project be financed without public aid. The associated costs are usually prohibitive to the private developer. Small boat harbors constructed, with assistance provided by the Federal Government, through the Corps of Er ,-neers, are shown in Table 10.

TABLE 10
SMALL BOAT HARBORS
CONSTRUCTED WITH FEDERAL ASSISTANCE
PUGET SOUND AREA—1966

Harbor	No. shown on maps Fig. 14, 15, 16 & 17	Fig. 19
Edmonds①	37	
Shilshole Bay Marina	50	
Blaine	1	
Bellingham	4	
Kingston	38	
Port Townsend	155	
Anacortes	21	
Port Angeles	158	
Lake Crockett		42

①Maintenance dredging only.

Existing Moorages

Approximately 16,000 public and private rental moorage spaces are available to pleasure craft owners in the Puget Sound area (Table 11). Seventy-eight percent of these moorages are located in the Central Division, followed by 11 percent in the North Division, and 11 percent in the West Division. The majority of rental moorages are private, water-based, all-year facilities.

TABLE 11
RENTAL PLEASURE BOAT MOORAGES IN
PUGET SOUND AREA—1966

LOCATION	PUBLIC SUMMER ONLY Wet	PUBLIC SUMMER ONLY Dry	PUBLIC ALL YEAR Wet	PUBLIC ALL YEAR Dry	PRIVATE SUMMER ONLY Wet	PRIVATE SUMMER ONLY Dry	PRIVATE ALL YEAR Wet	PRIVATE ALL YEAR Dry	TOTAL
NORTH DIVISION									
SUB AREA: 1			102		22	10	90	60	284
2					193	2	227	6	428
3			375				186	400	961
4			8				78		86
5					1	4	15	11	31
TOTAL			485		216	16	596	477	1,790
CENTRAL DIVISION									
SUB AREA: 6									0
7			772	150	90		2	154	1,168
8			1,688	118			3,959	822	6,587
9	117		130	2			613		862
10					20		508	40	568
11					14	204			218
12			73	475			1,330	1,104	2,982
TOTAL	117		2,663	745	124	204	6,412	2,120	12,385
WEST DIVISION									
SUB AREA: 13							511	54	565
14			55				111		166
15					65	60			125
16			61		64		14		139
17			236	20					256
18			265	21			10		296
19					219				219
TOTAL			617	41	348	60	646	54	1,766
PUGET SOUND AREA	117		3,765	786	688	280	7,654	2,651	15,941

Rental Moorage Demand

Table 12 indicates boater preference for permanent moorage by type of craft, as determined by the questionnaire survey.

TABLE 12
BOATER PERMANENT MOORAGE PREFERENCE BY PERCENT OF EACH TYPE OF CRAFT
PUGET SOUND AREA—1966

Type of Craft	Type of Moorage Desired: Permanent Summer	Permanent Winter
Inboard	70%	72%
Outboard	31%	25%
Auxiliary Sailboat	100%	89%

The estimated number of pleasure boats demanding permanent and temporary moorage by summer and winter season is given in table 13 for each subarea.

TABLE 13
PLEASURE BOAT RENTAL MOORAGE DEMAND BY NUMBER OF BOAT OWNERS①
PUGET SOUND AREA—1966

Location Of Demand		Permanent Summer	Temporary Summer	Permanent Winter	Temporary Winter
North Division					
Subarea:	1	561	3,121	386	435
	2	1,223	12,484	403	2,486
	3	1,376	7,350	966	1,616
	4	458	6,091	372	870
	5	1,325	5,789	546	1,243
Central Division					
Subarea:	6	357	2,366	321	248
	7	3,159	5,084	3,533	1,864
	8	6,371	5,336	6,105	1,927
	9	2,191	8,055	1,766	4,599
	10	560	4,380	409	1,927
	11	815	1,913	869	621
	12	2,956	2,869	2,915	994
West Division					
Subarea:	13	866	3,625	507	1,056
	14	1,427	6,696	1,181	2,362
	15	713	3,725	548	684
	16	866	7,500	613	1,243
	17	458	5,135	372	1,243
	18	866	3,373	866	684
	19	1,580	5,991	249	1,056

①Owners may have indicated the desire for moorage in more than one subarea.

Rental Moorage Need

The needs for both summer and winter moorage facilities were taken as the sum of permanent moorage demand and a percentage of temporary moorage demand with an allowance for sailboats without power. Temporary moorage demand for summer and winter facilities was converted to equivalent permanent demand by allowing one permanent moorage facility for 10 temporary rental moorage users. This ratio, used in the California study (4), was considered appropriate to the Puget Sound area. Conceivably, a greater number of moorages could economically be provided to meet peak weekend demand by transient boaters, if a separate and higher rate were charged during the weekend, rather than the current practice of using a uniform rate throughout the week. The moorage facility demands are shown in Table 14, with the needs also indicated, based on the number of moorages existing in 1966.

TABL' 14
PLEASURE BOAT RENTAL MOORAGE NEED
PUGET SOUND AREA—1966

		FACILITIES					
		SUMMER			WINTER		
Location Of Need		Demand	Equivalent Summer Moorage Existing	Net Need	Demand	Equivalent Winter Existing Moorage	Net Need
North Division							
Subarea:	1	886	284	602	436	252	184
	2	2,508	428	2,080	660	233	427
	3	2,143	961	1,182	1,143	961	182
	4	1,083	86	997	465	86	379
	5	1,933	31	1,902	679	26	653
Total		8,553	1,790	6,763	3,383	1,558	1,825
Central Division							
Subarea:	6	612	0	612	355	0	355
	7	3,777	1,168	2,609	3,819	1,078	2,741
	8	7,352	6,587	765	6,688	6,587	101
	9	3,087	862	2,225	2,286	745	1,541
	10	1,028	568	460	618	548	70
	11	1,036	218	818	956	0	956
	12	3,340	2,982	358	3,095	2,982	113
Total		20,232	12,385	7,847	17,817	11,940	5,877
West Division							
Subarea:	13	1,247	565	682	621	565	56
	14	2,128	166	1,962	1,435	166	1,269
	15	1,102	125	977	624	0	624
	16	1,640	139	1,501	747	75	672
	17	987	256	731	502	256	246
	18	1,221	296	925	946	296	650
	19	2,212	219	1,993	360	0	360
Total		10,537	1,766	8,771	5,235	1,358	3,877
Puget Sound Area		39.322	15.941	23.381	26,435	14,856	11,579

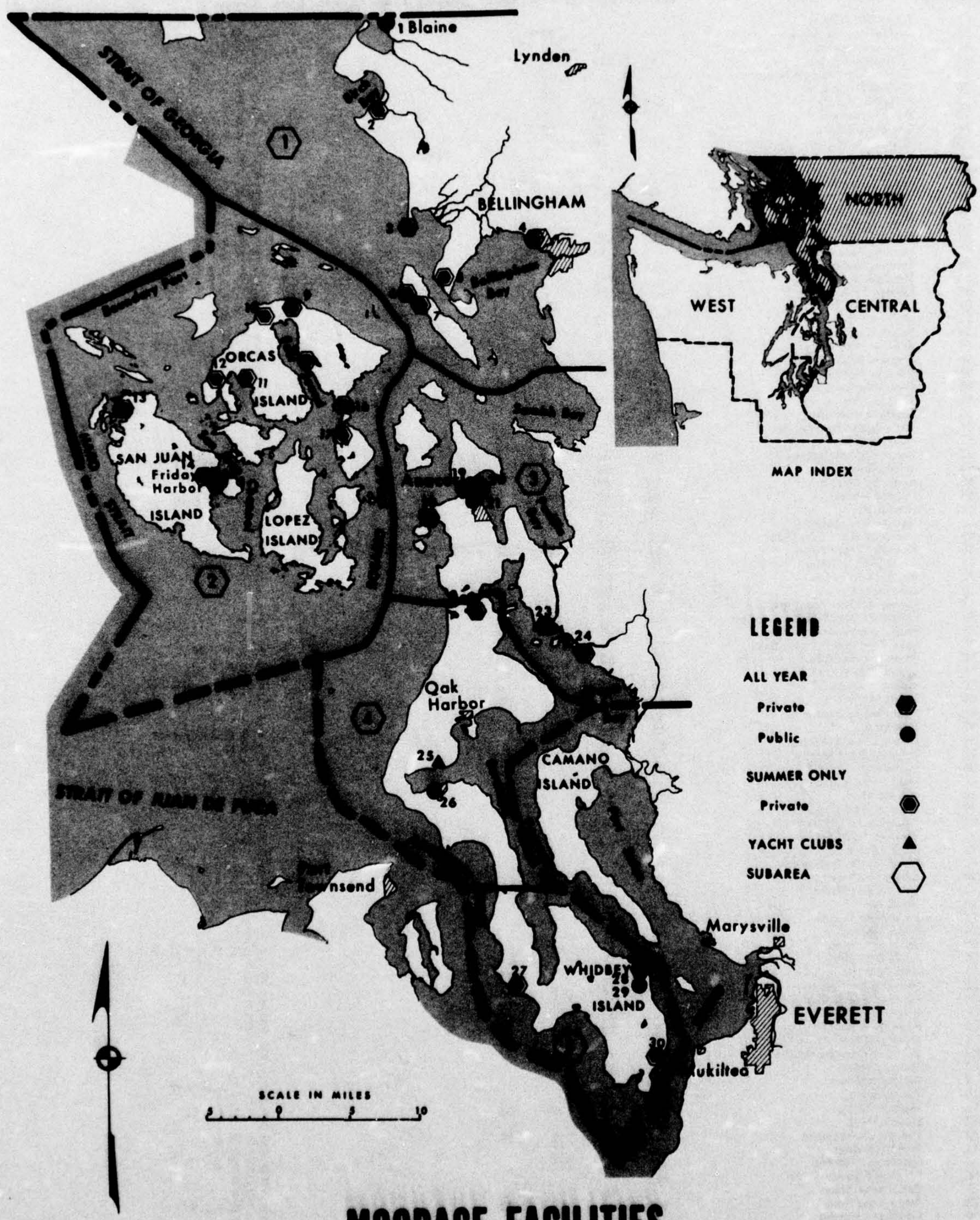
FIGURE 14

MOORAGE FACILITIES—NORTH DIVISION

Facility Number	Name of Facility	All Yr. Facilities Wet Covered	All Yr. Facilities Wet Open	All Yr. Facilities Dry Covered	All Yr. Facilities Dry Open	Summer Only Facilities Wet Covered	Summer Only Facilities Wet Open	Summer Only Facilities Dry Covered	Summer Only Facilities Dry Open	Services①
1	Blaine Marina		102							A, C
2	Birch Bay Marina						8			A, B, C, D, E, F, J, M
3	Sandy Point Marina						10			D, E, F, G
4	Port of Bellingham		90	60						A, B, C, D, J, M
5	Fisherman's Cove							1		A, B, C, D, E, F, M
6	Gramac Marina						4			B, C, D, E, M
7	Hawleys Marina Resort							8	1	A, B, C, D, E, F, G, K, L, M
8	Rosario Resort						36			A, C, D, E, F, G, J, K, L
9	Bartel's Resort		16							A, C, D, E, F, G, J, K, L, M
10	West Beach Resort						12			A, C, D, E, G, H, J, K
11	Van Moorhem's Marina						43	2		C, D, G
12	Deer Harbor Marina						22			C, D, E, F, G, J, K
13	Roche Harbor Boatel & Resort		154	6						A, C, D, E, F, G, J, K, M
14	Port of Friday Harbor		40							C, D, F, G, J, K
15	Jensen Shipyard	17								A, B, C
16	Obstruction Pass Motel Resort						8			A, B, C, D, G, K
17	Blakely Marina					4	68			A, C, D, E, F, G, K, L
18	Skyline Marine Corp.		165	250						B, C, D, K
19	Gateway Marina Inc.		5	45						B, D, L, M
20	Bryants Marina				80					B, C, D, J, M
21	Port of Anacortes	50	325							B, C, D, E, J, K
22	Cornet Bay Marina	12	60							A, B, C, D, E, F, G, L
23	Otis Marina		10		25					B, C, D, G
24	Phil's Boat House		6							A, C, D, H
25	Whidbey Deception Pass Boat Club		6							A
26	City of Coupeville		8							A, C, D, F, G
27	Shore Meadows Resort		3	5						B, D, E, K, M
28	Sunrise Beach Resort		12							B, D, E, G, J, K, M
29	Langley Marina				6					B, C, D, G, L, M
30	Lee Ora Del Mar, Inc.						1	4		A, B, D, E, M

①Services Code

A Ramp
B Hoist
C Moorage
D Gas & Oil
E Boat Rentals
F Eating Facilities
G Groceries
H Camping Space
J Showers
K Overnight Accom.
L Charters
M Dry Storage



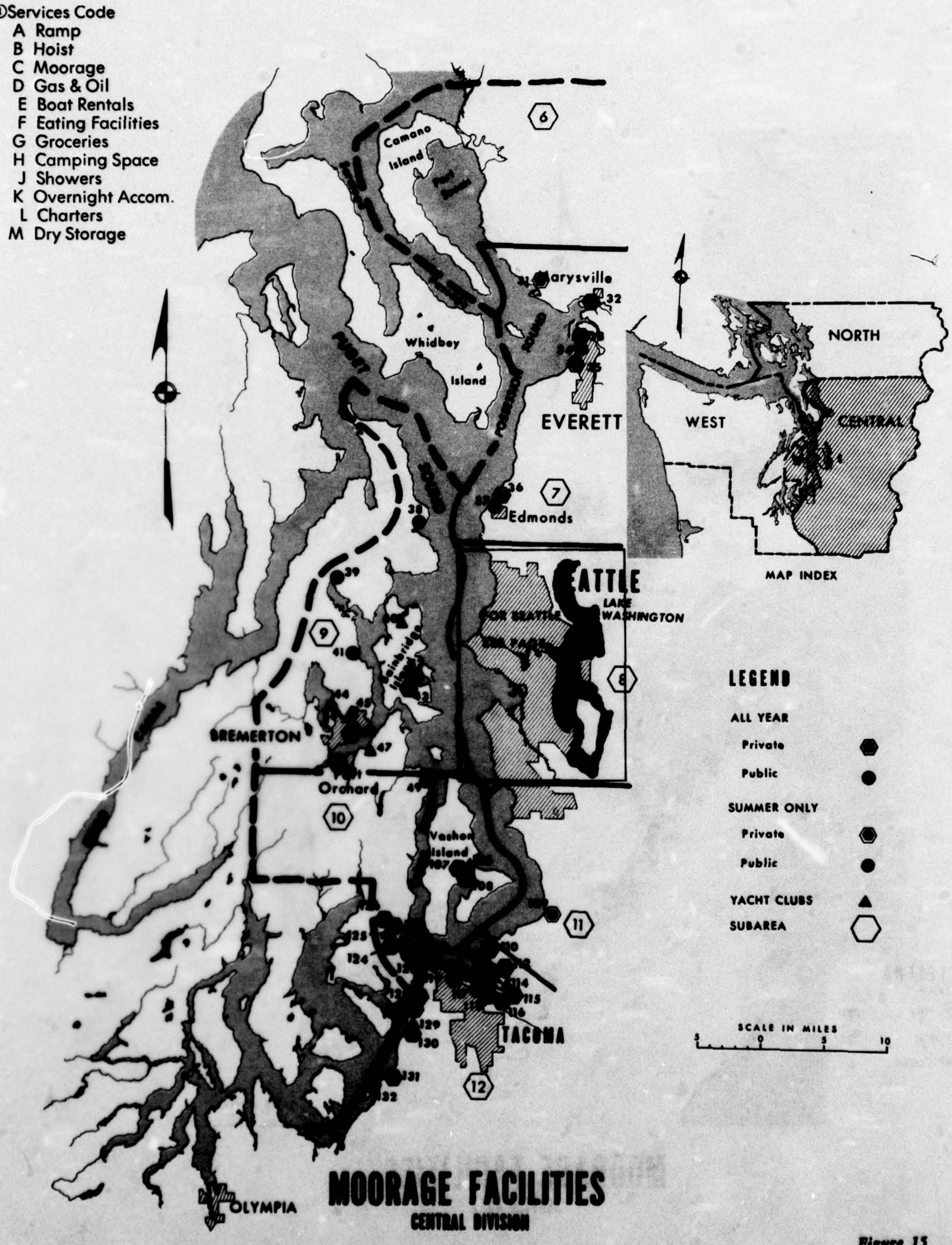
MOORAGE FACILITIES

NORTH DIVISION

Figure 14

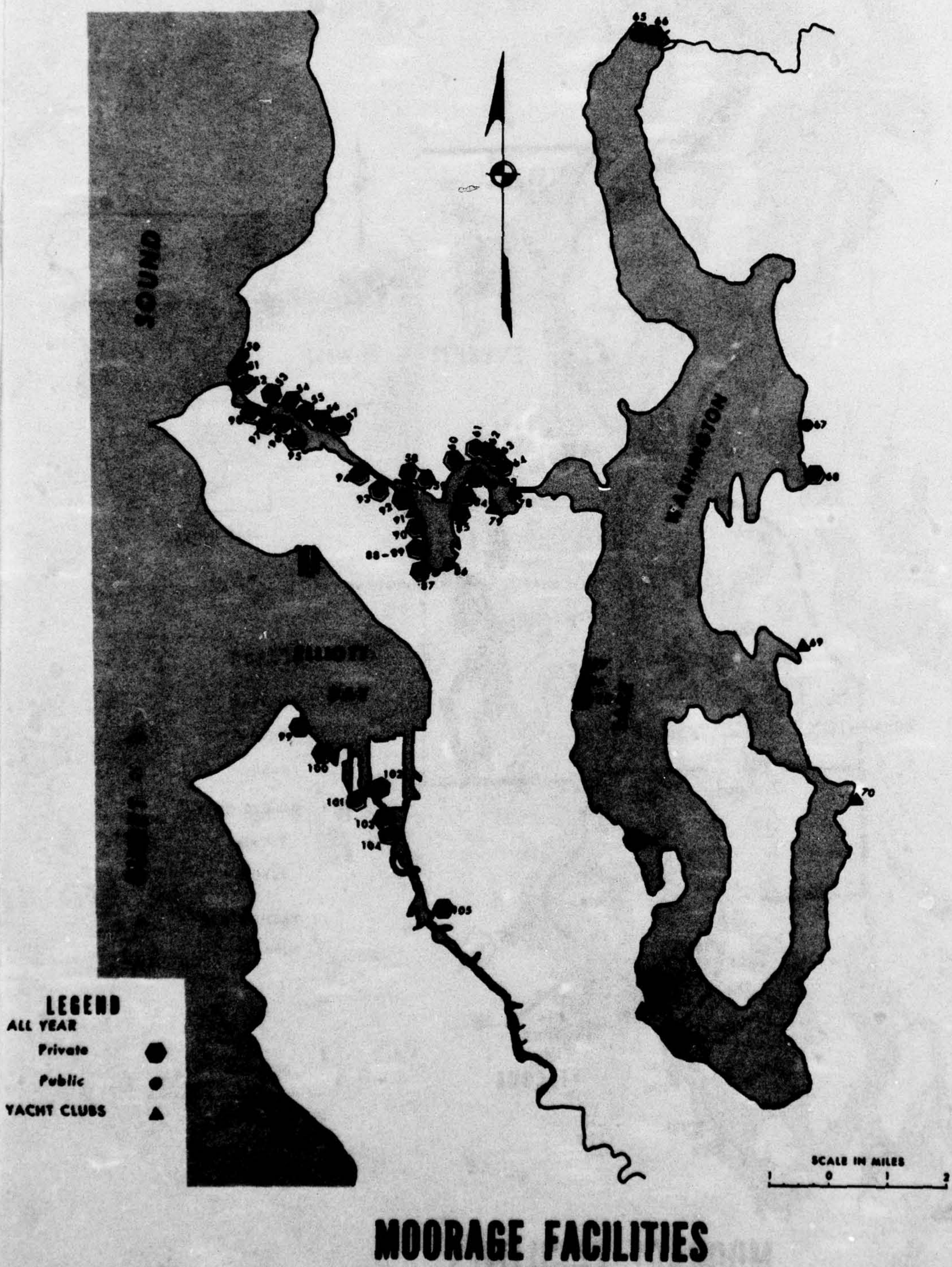
FIGURES 15 AND 16
MOORAGE FACILITIES—CENTRAL DIVISION

		All Yr. Facilities				Summer Only Facilities				
		Wet		Dry		Wet		Dry		
Facility Number	Name of Facility	Covered	Open	Covered	Open	Covered	Open	Covered	Open	Services①
31	Totem Beach Resort						90			B, C, D, E, F, G, K
32	Geddes Marine Service			68						A, B, C, D, L, M
33	Robinson Marina		2	3						B, C, D, M
34	14th Street Marina	48	335							B, C, D, F, M
35	Everett Boat House & Marina			3						B, C, D, E, M
36	Bartons Marina, Inc.			80						A, B, D, E, M
37	Port of Edmonds	210	179	150						B, C, D, G, J, M
38	Port of Kingston		316							C, D, F, G
39	City of Poulsbo		130	2						A, C, F, G, J, K, M
40	Seattle Yacht Club		19							C
41	Port of Brownsville					99	18			A, C, D, E, G
42	Bainbridge Marine Service		25							C, D
43	Snug Harbor Marina	6	20							C, D
44	Bremerton Yacht Club	99	11							C, D, M
45	Mannette Yacht Club		6							C
46	Olympic Marina		9							C, D
47	Port Orchard Yacht Club	40	32							C, D, M
48	Suldans Boat Works		30				20			C, D, M
49	Sebring Marina									B, C, D, E, G
50	Shilshole Bay Marina		1441		50					A, B, C, D, F, M
51	Golden Tides Marina		75							B, D, F
52	Shilshole Marina, Inc.			20	39					A, B, C
53	McGinnis Marina	14	42							C
54	Sagstad Marina	50	4							B, C, D
55	Stimson Marina	195								C
56	Fremont Boat Co.	13	100							C
57	Vesojas Marina	38	5							A, B, C, L
58	West Lake Marina	41								A, C
59	Tillicum Marina	25	13							A, C, D
60	Seattle Marina, Inc.	135								C
61	Washington Boat Center	35								B, C
62	Boat Street Marina	25								B, C, J
63	University Boat Sales	20	140							A, B, C, D, F, M
64	Wies Marina		15	20						A, B, D, M
65	Kenmore Marina	30	67							A, C, D, J
66	Uplake Marina	43	65	20						A, B, C, D, E, M
67	Houghton	46								A, C
68	Yarrow Bay Marina		15	6						B, C, D, M
69	Meydenbauer Yacht Club	123	10							C, M
70	Newport Yacht Basin	56	170	35	50					A, B, C, D, M
71	Aqua Marine Service	10	8	6						A, C, D, E, M
72	Rainier Yacht Club		79							C
73	Lakeshore Marina	27	36							C
74	Lakewood Boat Moorage		118							A, C
75	Seaborn Leschi Park Boat House	6	23	37	40					B, C
76	Municipal Yacht Moorage		201		68					
77	Lake Washington Yacht Basin	20	20	150	150					A, B, C, D, M
78	Seattle Yacht Club	134	53		20					
79	Queen City Yacht	35	93							
80	Blanchard Boat Co.	10	38	9	4					B, C, M
81	Houtz Marina		10		15					C
82	Thunderbird Marina	30	35							C
83	Bryants, Inc.	15	20	25						A, B, C, D, E, F, L, M
84	Denny's Toxas Marina	62	14							A, C, D
85	Fairview Boat Service	3	8							C
86	Webster Yacht Club	30	27							
87	West Shore Marina	41								C, M
88	Marina Mart	138	33							C
89	Leger Marine Charters	39								C, D, J, L
90	Puget Sound Marina	93	9							C
91	Western Yacht Basin	6								C, M
92	Gove's Cove	2	14							C
93	Tom Wheeler Boat Sales	35	25							C
94	Ewing St. Moorings	6	40		5					B
95	Salmon Bay Marina	109	12							C, D
96	Lloyd Jett		50	1						B, C
97	Lockhaven Marina	85	25	5						C, E
98	Bergs Marina	58	10							A, C
99	Seacrest Marina		104	86	7					A, B, C, D, E, F, G, M
100	Triple & Everett		10		4					
101	Anchor Marina	32	180		15					C, D
102	Nelsen & Hansen		4	4	3					A, C
103	Pioneer Marina Ford	7	76	1	10					B, C
104	Riverside Marina	4	105		25					B, C
105	South Park Boat Haven	2	72		10					B, D
106	Quarter Master Yacht Club		1							C
107	Burk Worthington Marina	8	40							C
108	Larson Marina	6	46							B, C, D
109	Redondo Marina						14	204		B, C, D, E, F, G, M
110	Tyee Marina	55	25							A, C, D, J
111	Harbor Marina	60	16	115	35					B, C, D, E, F, M
112	Lloyd's Float	72	43							C
113	Hylebo's Boat House		80	20	50					B, C, D, M
114	Port Yacht Basin	31	35	10						B, C, D, E, F, L, M
115	Sportsman Marina	28	33	152						B, C, D, M
116	Fairliner Pleasure Craft	78	3							B, C, D
117	Canal Boat House		55							C, D, E
118	Totem Boat Haven	80		120	20					B, C, D, E, L, N
119	Caddigan Marina		14	22						B, C, M
120	Tacoma Yacht Club	130	85	145						A, B, C, D, F, M
121	City of Tacoma	161	57							A, C, D, E, F, M
122	Point Defiance Boat House			475						
123	Gig Harbor	44	1							C, D, F, G
124	Long Branch Marina		34							D
125	Peninsula Yacht Basin	50	150							B, C, D, J, K
126	Triple TTT Marina	8	120	40						B, C, D, M
127	Narrows Marina	63	37	100						A, B, C, D, E, M
128	Sixth Avenue Boathouse		33	66						C, D, E, M
129	Day Island Yacht Club		150	110						A, C
130	Day Island Marina	90	20	75						B, C, D, M
131	Steilacoom Outboard			58	12					B, C, F
132	Ketron Island Marina	2	12							A, C, D, G, J



MOORAGE FACILITIES
CENTRAL DIVISION

Figure 15



MOORAGE FACILITIES
SEATTLE AREA

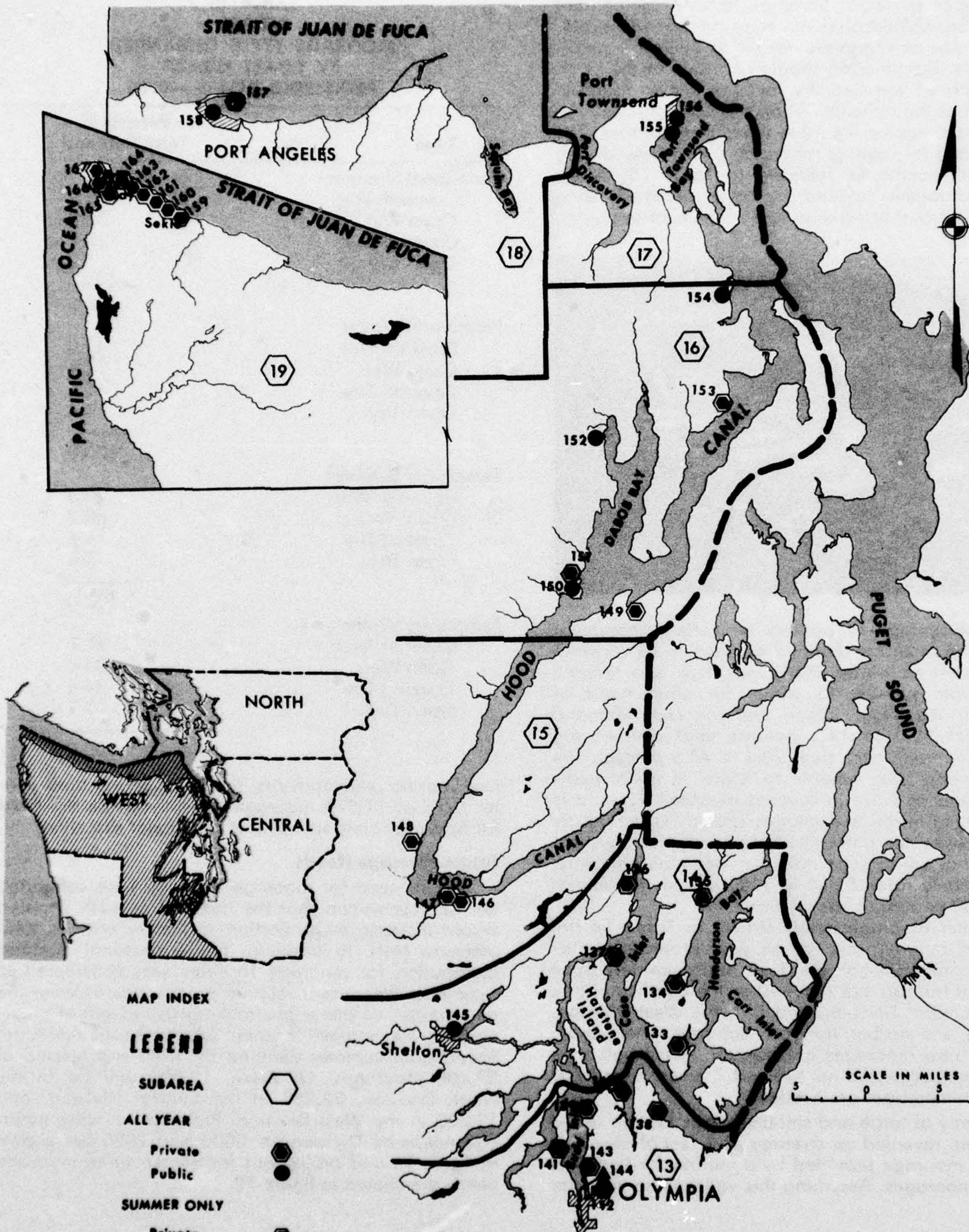
Figure 16


WELCOME to
Alderbrook Inn

FIGURE 17
MOORAGE FACILITIES—WEST DIVISION

Facility Number	Name of Facility	All Yr. Facilities Wet Covered	Wet Open	Dry Covered	Dry Open	Summer Only Facilities Wet Covered	Wet Open	Dry Covered	Dry Open	Services①
133	Long Branch Marina		40							A
134	Lake Bay Marina	2	22							A
135	Glen Cove Boat House	10	20							A, C, D
136	Fair Harbor Marina		15							C, D, F
137	Jarrells Cove		2							C, D, G
138	Puget Marina	1	6							A, B, D, E, M
139	Boston Harbor Marina		22	9						A, C, D, E, M
140	Bayside Beach									A, B, C, D
141	West Bay Marina	60	70							A, B, C, D
142	Sea Mart Marina	7	24							A, C, D
143	Olympia Marina	26	70	30						A, B, C, D, F, M
144	Olympia Yacht Club	89	136	15						A, C, D, M
145	Shelton Port Commission	31	24							A, C, D
146	Hood Canal Marina						10	60		A, C, D, E, F, G, M
147	Alderbrook Inn						30			C, D, E, F, G, L
148	Hoodsport Marina						25			B, C, D, E, F, K
149	Seabeck Outboard Service						63			B, C, D, E, F, G
150	Pleasant Harbor		10							C, D, G
151	Trader Mac's Marina		14							A, C, D, F, G
152	Quilcene Boat Haven		39							A, C, D
153	South Point Marina						1			C
154	Mats Mats Bay Marina		12							A, C, D
155	Port Townsend Boat Haven	18	134							C, D, F, G, K, L
156	Point Hudson Marina	12	72	20						A, B, C, D, E, G, J, K, M
157	Thunderbird Marina		10							A, B, C, D, E, F, L
158	Port Angeles Boat Haven		265	21						B, C, D, F, G, K
159	Thunderbird Resort						37			A, C, D
160	White's Cove						30			A, C, D, E, F, G, H, J, K, L
161	Olson's Resort						35			A, C, D, E, H, J, K, L
162	Snowcreek Resort						10			A, B, C, D, H, K, M
163	Peter's Neah Bay Resort						10			A, B, C, D, E, F, G, H, J, K,
164	Cape Flattery Resort & Lodge						20			A, C, D
165	O'Hearn's Four Star Resort						30			A, C, D, E, K, L
166	Bob's Sport Fishing Resort						15			A, C, D, E, H, J, K, L
167	Mortons Salmon Fishing Resort						32			A, C, E, F, G, H, K, L

①Services Code
- A Ramp
- B Hoist
- C Moorage
- D Gas & Oil
- E Boat Rentals
- F Eating Facilities
- G Groceries
- H Camping Space
- J Showers
- K Overnight Accom.
- L Charters
- M Dry Storage



MOORAGE FACILITIES
WEST DIVISION

Figure 17

The types of rental moorage facilities demanded by the public should be given close attention in evaluating the type of moorages needed to overcome moorage deficits. Examination should be made of the existing numbers of wet and dry facilities shown in Table 11 in light of the indicated public demand through the questionnaire survey for these types of moorages. The high demand for covered moorage, particularly during the winter months, is reflected in Table 15, which shows permanent covered moorage demand rising from 62.6 percent in summer to 85.5 percent in winter.

The percentage of boaters indicating permanent covered wet moorage demand appears to be constant from summer to winter. However, there is a marked change from summer to winter for other types of permanent moorages. Open wet moorage demand drops from 32.2 to 14.1 percent, and covered dry moorage demand rises from 20.4 to 43.5 percent. The seasonal drop from summer to winter in open moorage demand and rise in covered moorage demand is also reflected in the percentages shown for temporary moorage use. This partially explains why at Shilshole Bay Marina, which supplies open wet moorage only, the occupancy rate of nearly 100 percent in summer drops to 80 percent or less in winter.

If winter moorage needs shown in Table 14 are viewed as requirements for all year protected moorages or small boat harbors, then approximately three small boat harbors are required in the North Division, 5 in the Central Division, and 5 in the West Division, providing one harbor for each subarea where more than 200 new moorages are needed. Two small boat harbors are suggested for subarea 7 where over 2700 additional moorages are needed.

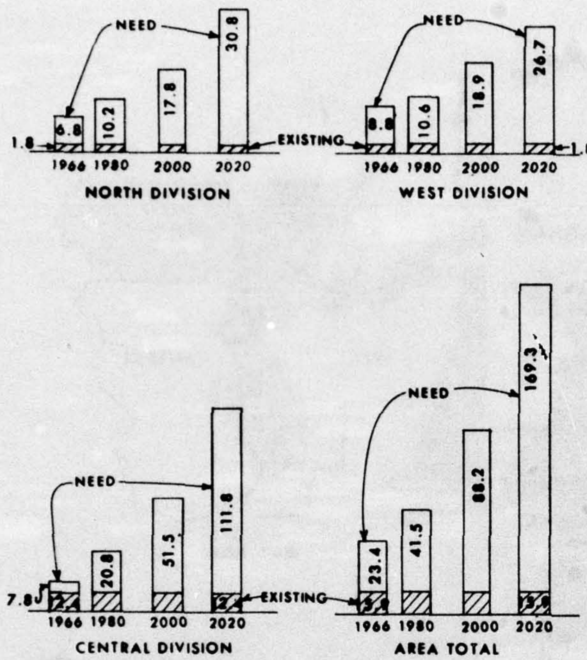
A survey of large and small marinas located in the study area, revealed an average of 3 feet of shoreline for every moorage provided by a marina for both wet and dry moorages. Assuming this value to be valid for new marina developments, the Puget Sound area winter need of 11,579 moorages would dictate the need for approximately six miles of additional shoreline.

TABLE 15
RENTAL
MOORAGE TYPES DEMANDED
BY COAST GUARD
REGISTERED BOATS—1966

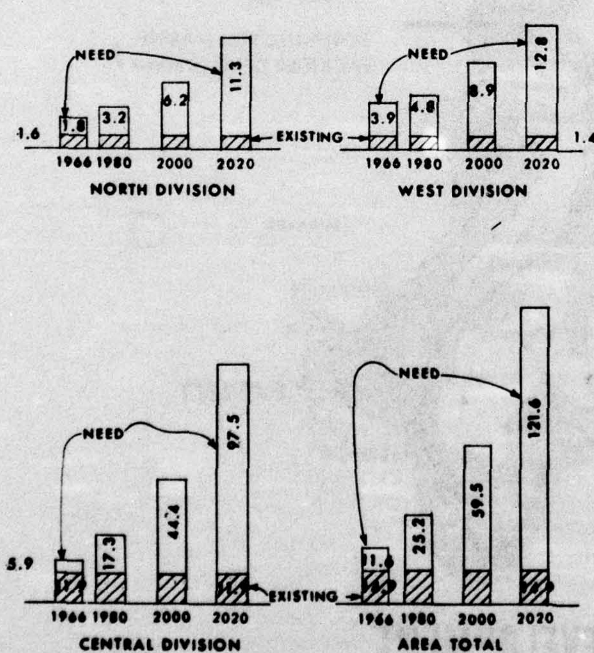
Type	Percent of Total Demand
Permanent Summer	
Covered Wet	42.2
Open Wet	32.2
Covered Dry	20.4
Open Dry	5.2
	100.0
Permanent Winter	
Covered Wet	42.0
Open Wet	14.1
Covered Dry	43.5
Open Dry	0.4
	100.0
Temporary Summer	
Covered Wet	22.6
Open Wet	60.2
Covered Dry	11.6
Open Dry	5.6
	100.0
Temporary Winter	
Covered Wet	27.7
Open Wet	34.6
Covered Dry	34.6
Open Dry	3.1
	100.0

Future Moorage Needs

Future need for moorage facilities were computed on the assumption that the demand in each Division would increase in proportion to the increase in total pleasure craft. In addition, future seasonal demand distribution for moorage facilities was considered to remain at the current relative proportions as were the percentages of the public making use of rental moorage facilities in each location. On this basis, the Puget Sound area summer demand by 1980 is projected at 57,400 moorages. Of these, 12,000 will be in the North Division, 33,200 in the Central Division, and 12,300 in the West Division. Projected summer moorage needs by Division for 2000 and 2020 are shown in figure 18 and projections for winter rental moorage needs are shown in figure 19.



SUMMER MOORAGE – EXISTING – PRESENT AND FUTURE NEEDS (MOORAGES IN 1000'S) *Figure 18*



WINTER MOORAGE – EXISTING – PRESENT AND FUTURE NEEDS (MOORAGES IN 1000'S) *Figure 19*

Moorage Development Potential

Many of the existing marinas can increase their moorage capacities to meet the needs of the boating public. Summer moorage needs can easily be met in a number of locations where only additional floats are required to provide wet moorage. However, supplying the winter moorage needs involves greater capital investment since the majority of boaters demand covered facilities for their craft. New small boat harbors along the shoreline of Puget Sound will require expensive breakwater protection and the acquisition of high value waterfront property to provide the necessary parking and backup areas. During the course of the small boat study the entire 2350 mile shoreline of the Puget Sound area was examined to locate sites where new marine facilities could be constructed. Shoreline areas appearing feasible for development were noted after considering approach depths, dredging requirements, land access, parking area, and beach material composition. Office studies were made of the wind and wave conditions at sites found from field reconnaissance to merit consideration for marina or launching site development. Approximately 200 miles of shoreline were found to be potentially suitable for development. Sites considered suitable for development, subject to detailed studies, are shown in figures 20, 21, and 22.

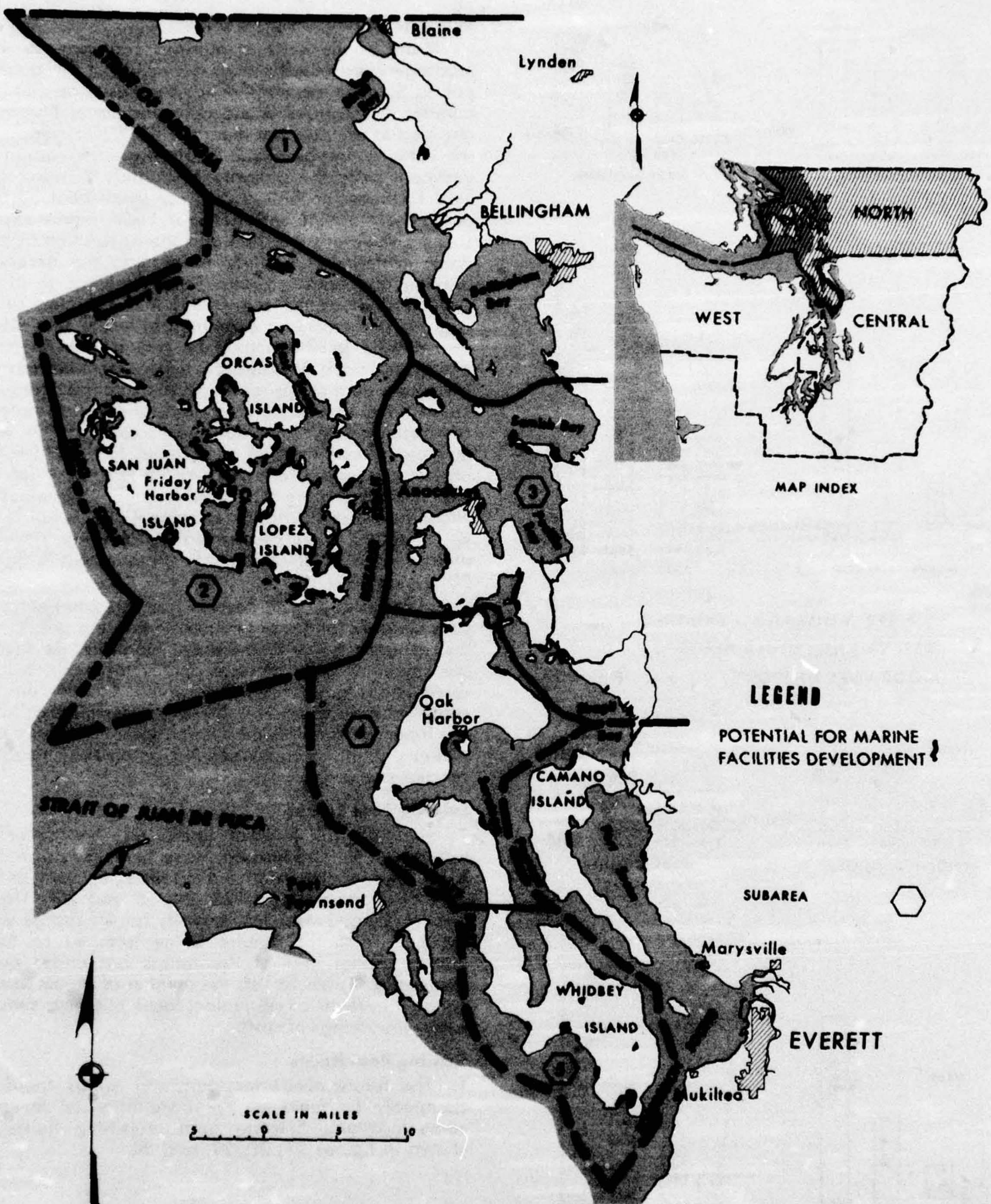
In the future, with several interests competing for sites suitable for development, the boating public may find marinas going to more dry moorage. As favorable shoreline becomes scarce, developments will be constructed to accommodate more boaters on less shoreline than at present. It seems possible that future dry moorage facilities may be patterned after the multilevel parking garages serving automobile needs in congested cities.

Existing Boat Ramps

The 185 trailer boat launching ramps, located throughout the study area, have been constructed by state, county, city, and port agencies as well as private developers (figures 23, 24, 25 and 26). Use of publicly owned ramps is normally free of charge while the private ramps require a fee from $1 to $2 to launch. About half of the ramps are under public ownership. Table 16 lists the number of ramps in each subarea in terms of equivalent lanes allowing simultaneous launchings of craft.

Existing Boat Hoists

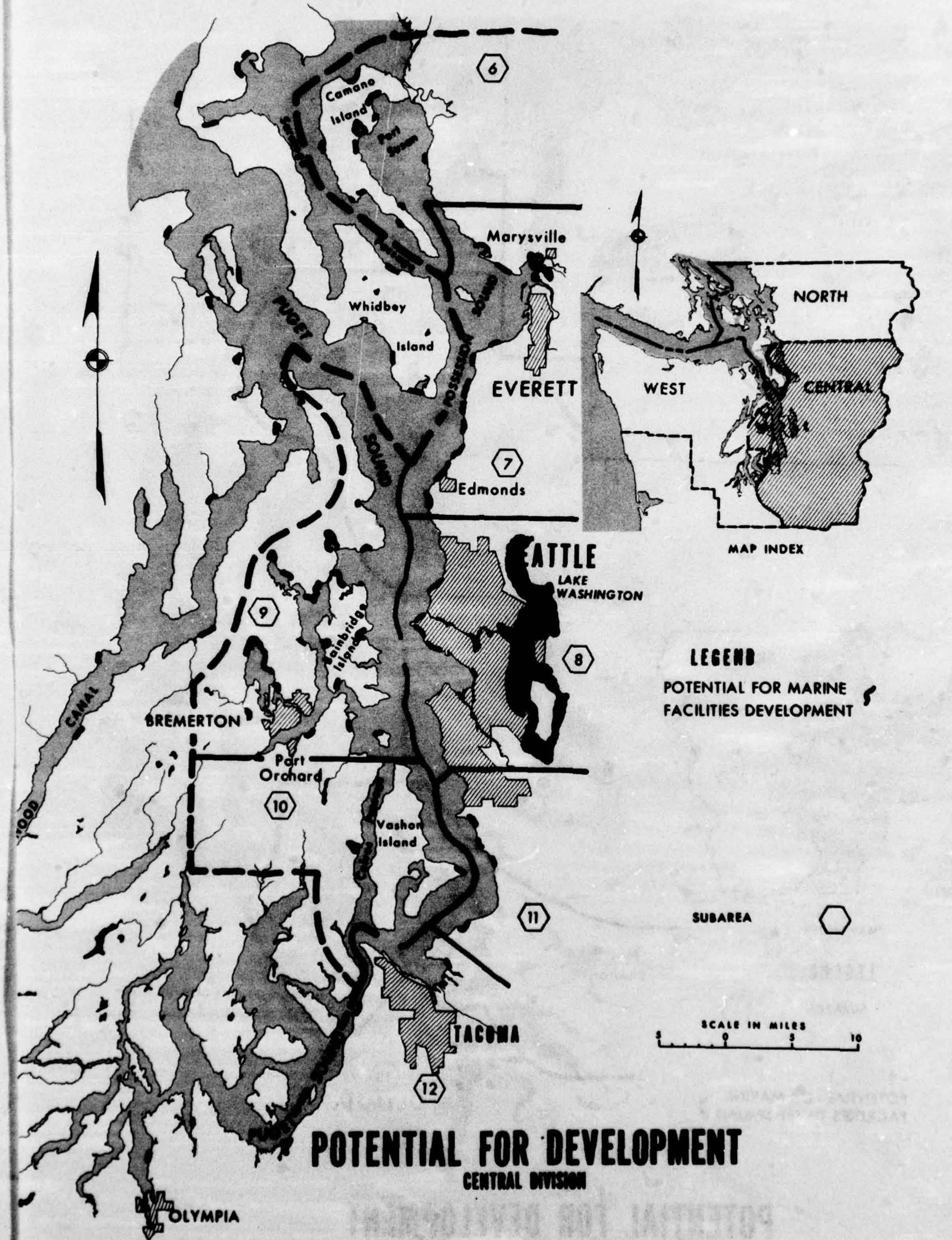
The future needs for launching ramps could undoubtedly be filled by the installation of hoists at some locations. Existing boat launching hoists are shown in figures 27, 28, 29, and 30.



POTENTIAL FOR DEVELOPMENT

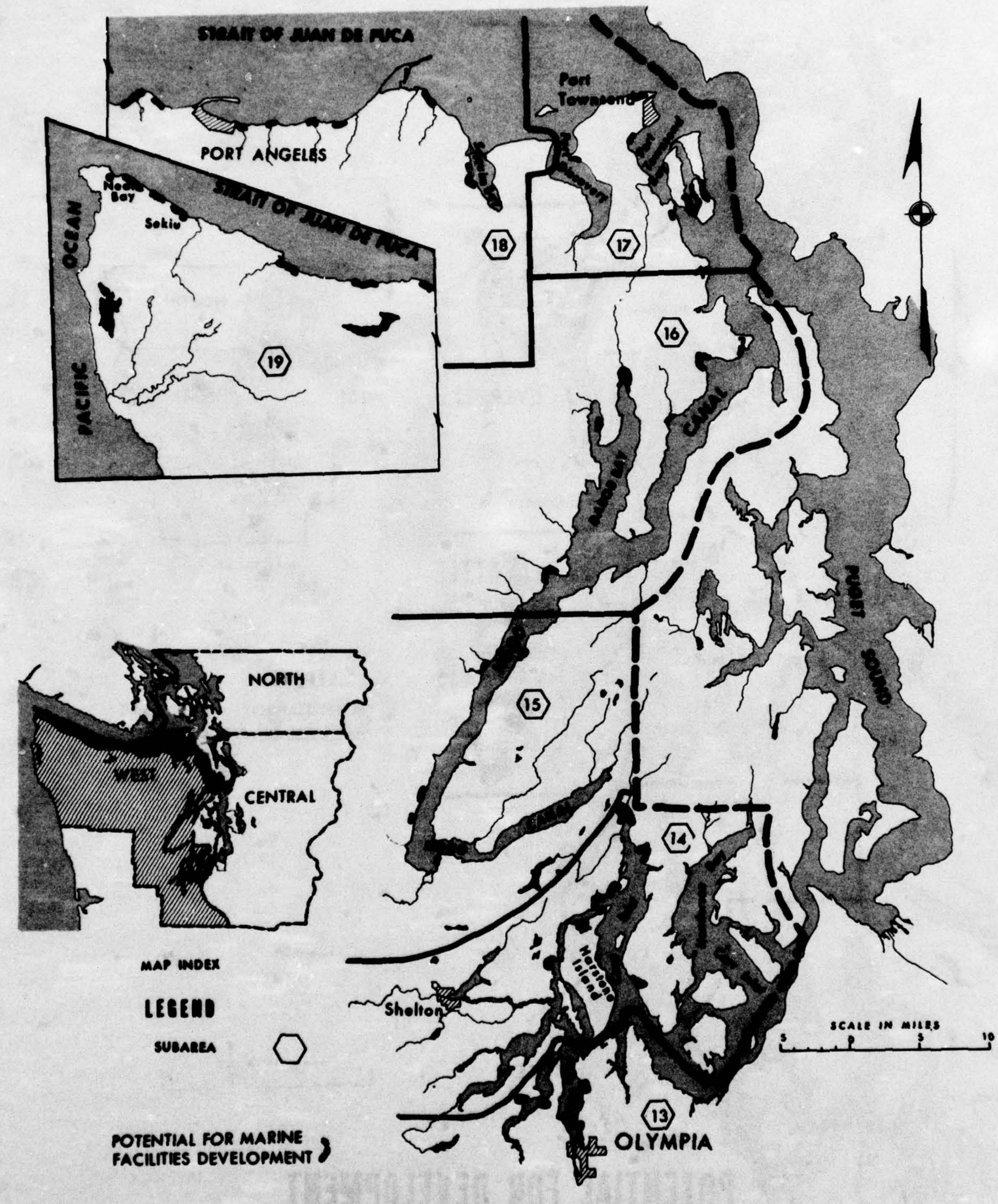
NORTH DIVISION

Figure 20



POTENTIAL FOR DEVELOPMENT
CENTRAL DIVISION

Figure 21



POTENTIAL FOR DEVELOPMENT

WEST DIVISION

Figure 22

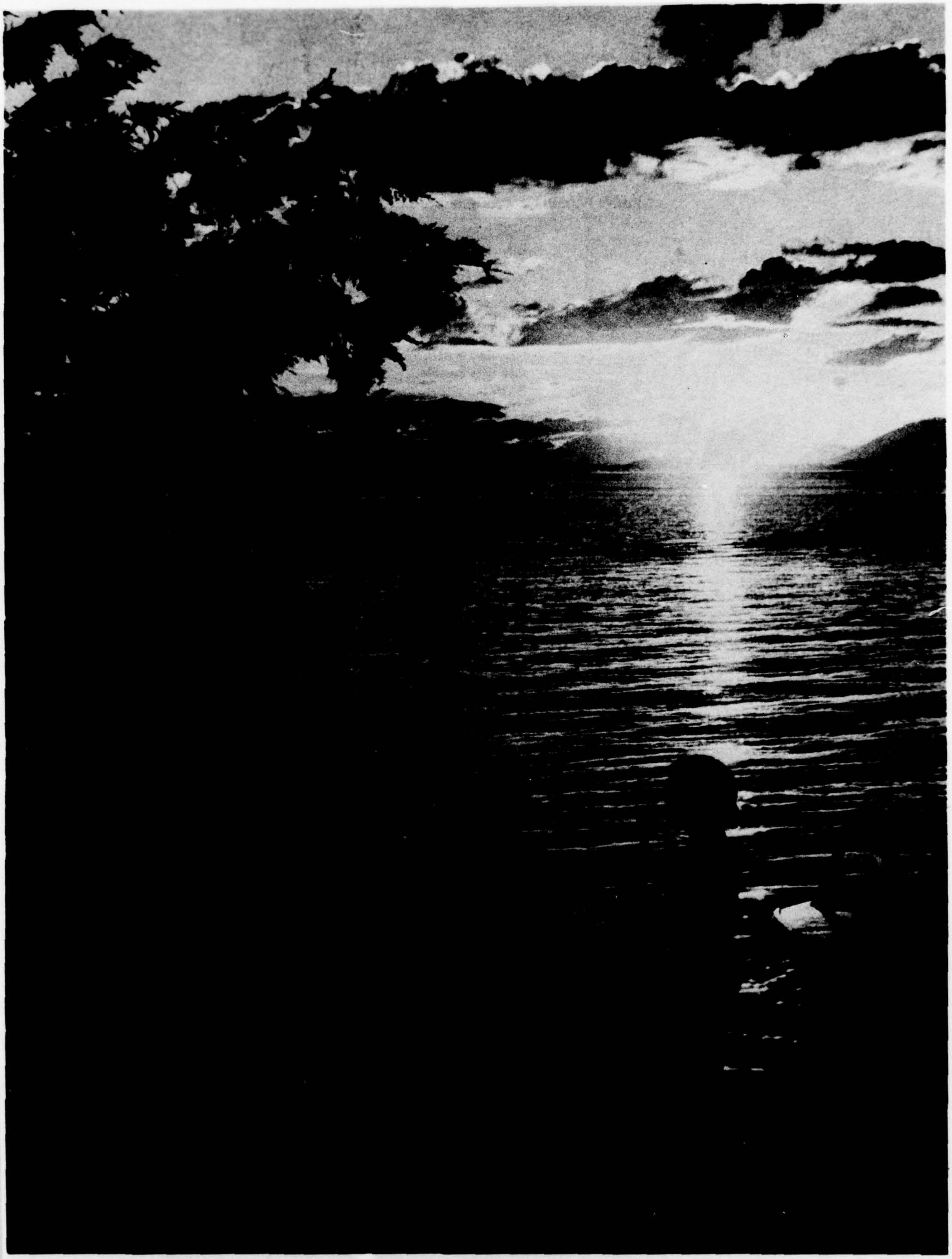
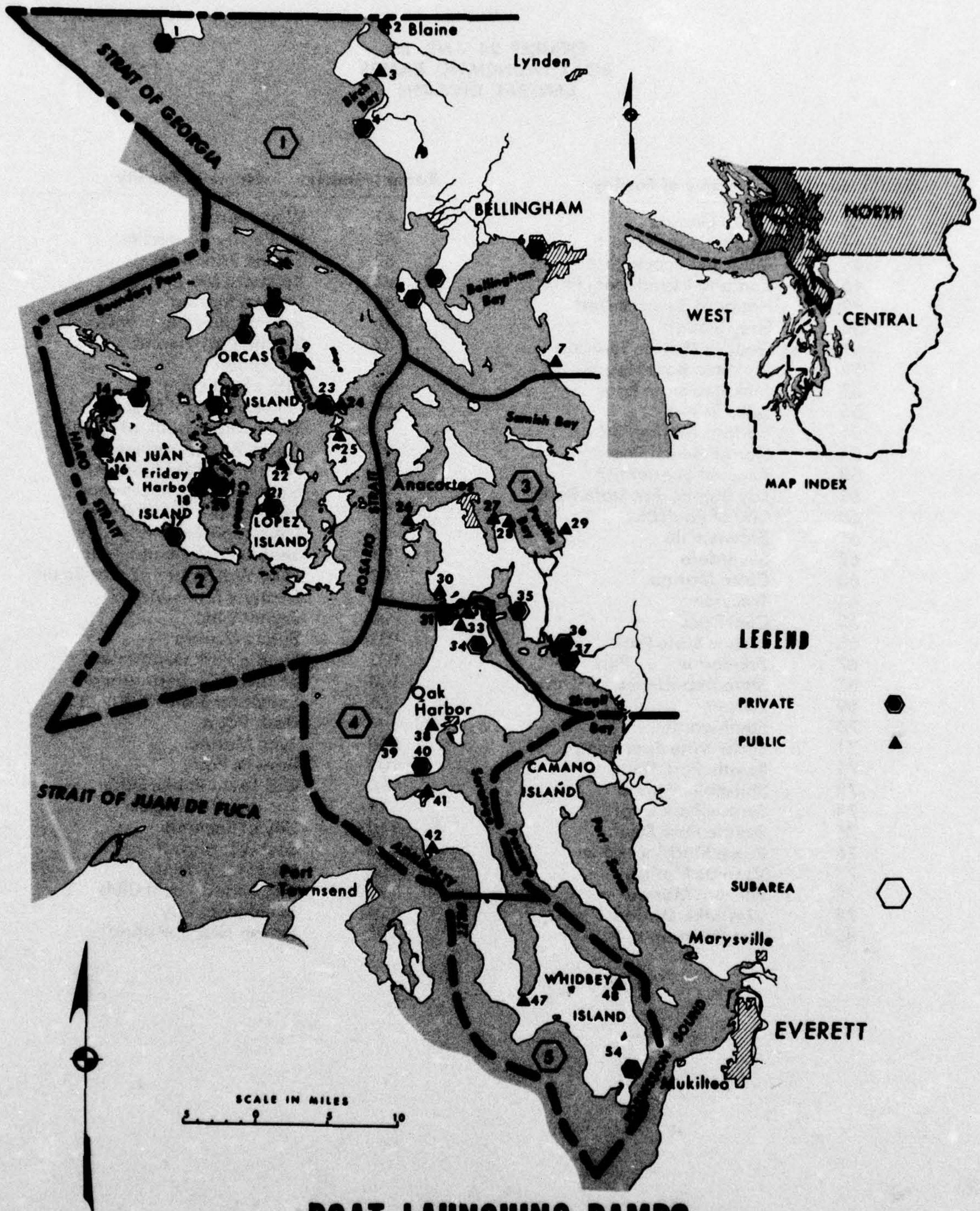


FIGURE 23
BOAT LAUNCHING RAMPS
NORTH DIVISION

Ramp Number	Name of Facility
1	Point Roberts
2	Blaine Marina
3	Birch Bay
4	Birch Bay Marina
5	Fisherman's Cove
6	Weldcraft Steel and Marine Co.
7	Larrabee State Park
8	Hawley's Marine Resort
9	Rosario Beach
10	Bartels Resort
11	West Beach Resort
12	Pole Pass Resort
13	Limestone Point Resort
14	Roche Harbor Boatel & Resort
15	Snug Harbor Resort
16	Smallpox Bay
17	Mar Vista Resort
18	Sea Breeze Trailer Coral
19	San Juan Island Shipyard
20	Jensen Shipyard
21	Pantleys Resort
22	Odlin Park
23	Obstruction Pass Motel Resort
24	Obstruction Pass County
25	Blakley Marina
26	City of Anacortes
27	March Point State
28	March Point Public
29	Bay View State Park
30	Deception Pass State Park
31	Cornet Bay Marina
32	Deception Pass State Park
33	Cornet Bay State Marine Park
34	Dugalla Bay
35	Hope Island Fishing Resort
36	Al's Landing
37	Phil's Boat House
38	Oak Harbor City Beach
39	West Beach Road
40	Whidbey Deception Pass Boat Club
41	City of Coupeville
42	Island County Keystone Park
47	Holmes Harbor
48	Langley City Dock



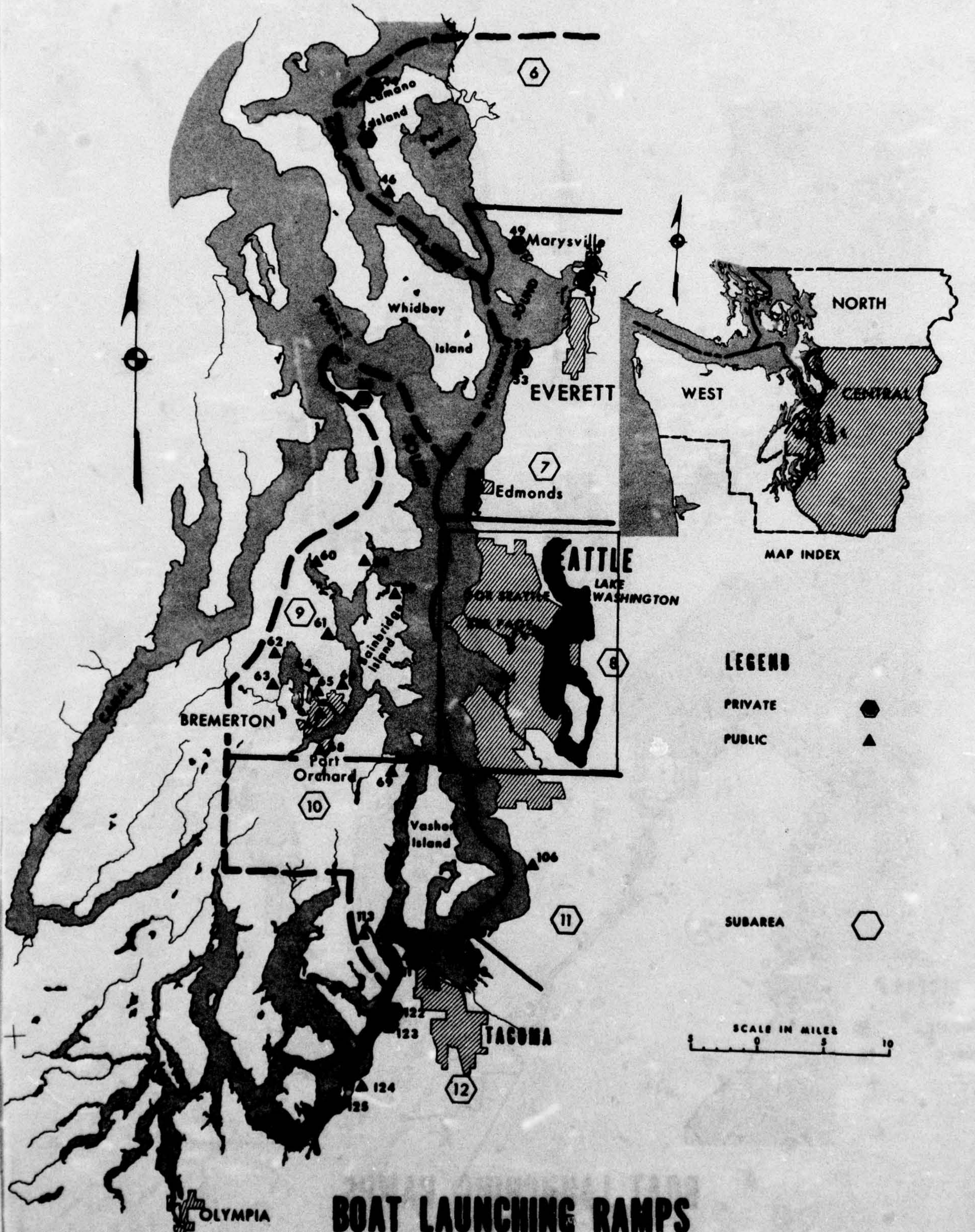
BOAT LAUNCHING RAMPS

NORTH DIVISION

Figure 23

FIGURES 24 AND 25
BOAT LAUNCHING RAMPS
CENTRAL DIVISION

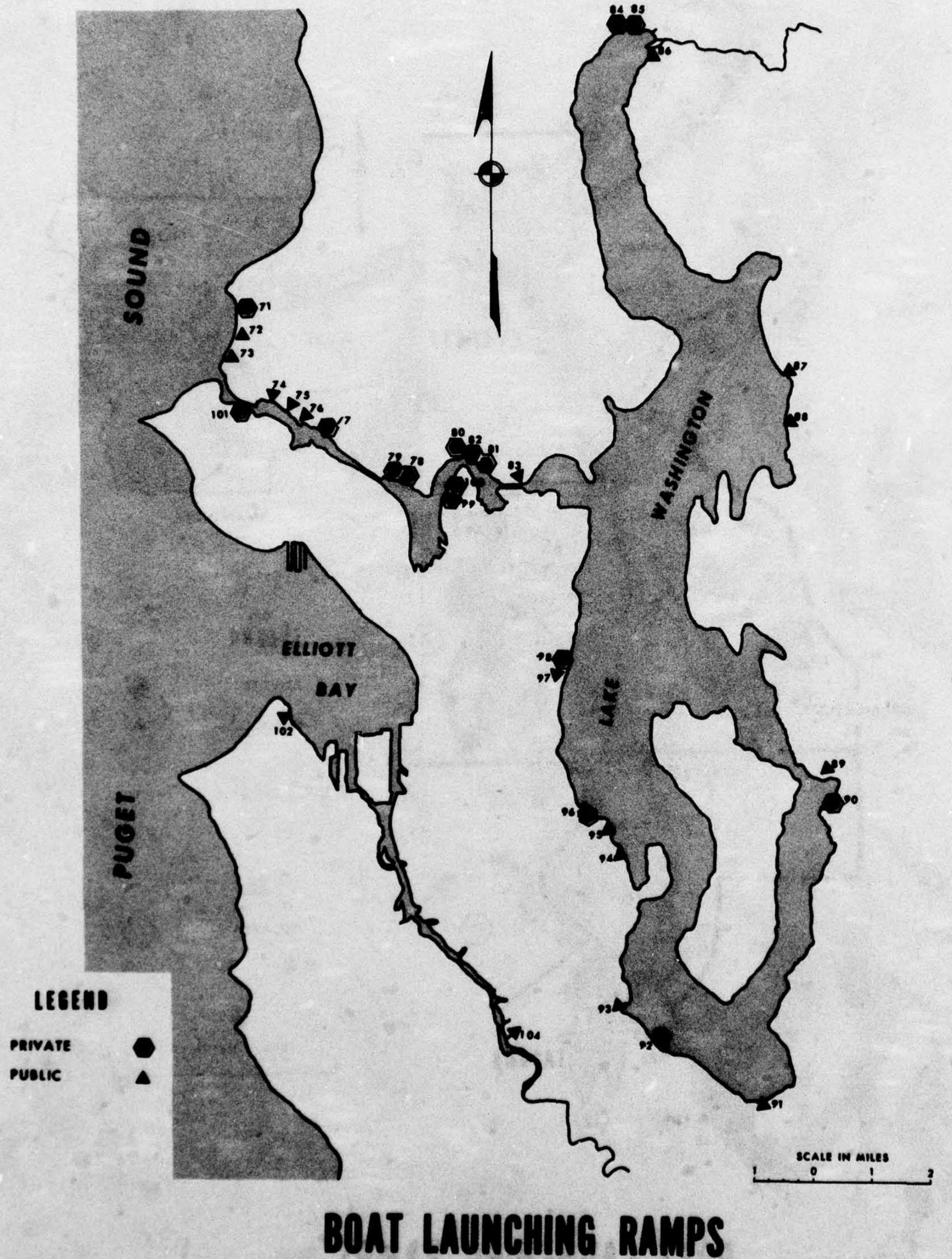
Ramp Number	Name of Facility	Ramp Number	Name of Facility
43	Camp Grande	81	Wies Marina
44	Maple Grove Resort	82	University Boat Sales
45	Madrona Beach Resort	83	Seattle Park Dept.
46	Camano Island State Park	84	Kenmore Marina
49	Hermosa Beach Resort	85	Uplake Marina
50	Ebey Slough	86	Washington Dept. of Game
51	Geddes Marine Service	87	Seattle Park Department
52	Mukilteo Boat House	88	Houghton
53	Mukilteo State Park	89	City of Bellevue
55	Lyles Resort	90	Newport Yacht Basin
56	Bartons Marine, Inc.	91	Wash. State Dept. of Game
57	Norma Beach Resort	92	Aqua Marina Service
58	Town of Suquamish	93	Seattle Park Department
59	Fay Bainbridge State Park	94	Seattle Park Department
60	City of Poulsbo	95	Seattle Park Department
61	Brownsville	96	Lakewood Boat Moorage
62	Silverdale	97	Seattle Park Department
63	Chico Marina	98	Lake Washington Yacht Basin
64	Tracyton	99	Denny's Texas Marina
65	Coal Dock	100	Bryant's Inc.
66	Illahee State Park	101	Berg's Marina
67	Bremerton City Park	102	Seattle Park Department
68	State Department of Game	104	Seattle Park Department
69	Harper	106	Saltwater State Park
70	Southworth	107	Dash Point
71	Eddie Vine Boat Ramp	108	Tyee Marina
72	Seattle Park Dept.	109	Browns Point
73	Shilshole Marina	110	Old Town Public Dock
74	Seattle Park Dept.	111	Tacoma Yacht Club
75	Seattle Park Dept.	112	City of Tacoma
76	Rowe Machine works	113	East Gig Harbor
77	Vesojas Marina	122	Narrows Marina
78	Tillicum Marina	123	Day Island Yacht Club
79	Westlake Marina	124	Steilacoom City
80	Doc Freeman's	125	Ketron Island Marina



BOAT LAUNCHING RAMPS

CENTRAL DIVISION

Figure 24



BOAT LAUNCHING RAMPS
SEATTLE AREA

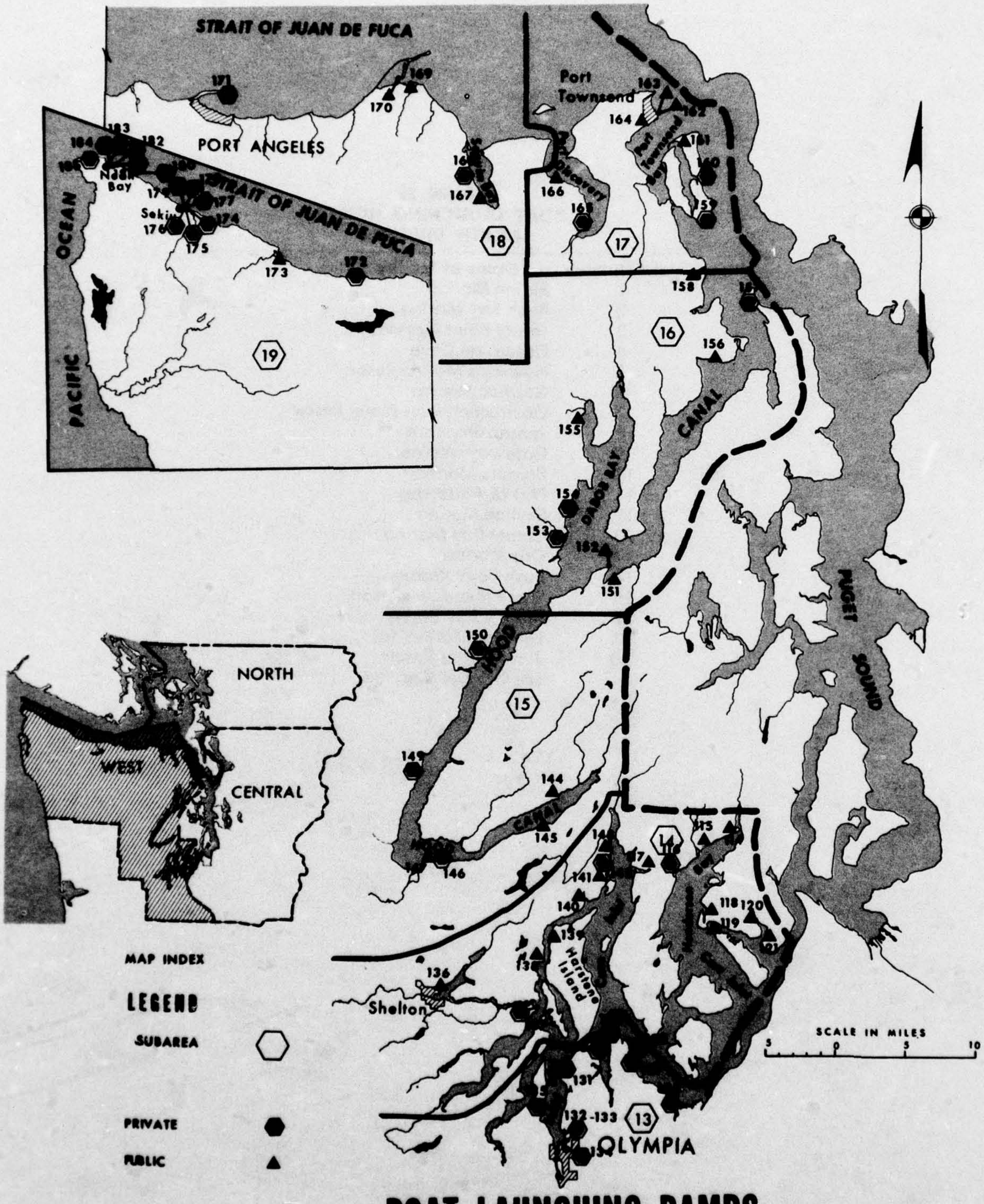
Figure 25

TABLE 16
TRANSIENT PLEASURE BOAT LAUNCHING RAMPS IN PUGET SOUND AREA—1966

Location		Public Lanes	Private Lanes
North Division			
Subarea:	1	3	6
	2	4	14
	3	6	3
	4	7	4
	5	2	1
TOTAL		22	28
Central Division			
Subarea:	6	2	2
	7	1	6
	8	25	26
	9	15	2
	10	2	..
	11	1	..
	12	8	8
TOTAL		54	44
West Division			
Subarea:	13	..	11
	14	11	5
	15	5	3
	16	5	5
	17	7	3
	18	3	2
	19	1	12
TOTAL		32	41
Puget Sound Area		108	113

FIGURE 26
BOAT LAUNCHING RAMPS
WEST DIVISION

Ramp Number	Name of Facility
114	Wauna
115	Minter Creek
116	Glen Cove Boat House
117	Fox Island
118	Horsehead Bay
119	Fox Island (County)
120	Wollochet Bay
121	Wollochet (County)
126	Luhr Beach Resort
127	Puget Marina
128	Johnson Point Marina
129	Henrys Resort
130	Bayside Beach
131	Boston Harbor Marina
132	Olympia Marina
133	Olympic Yacht Club
134	Sea Mart Marina
135	West Bay Marina
136	Shelton Port Commission
137	Arcadia Point
138	Graham
139	Harstine Island
140	McLane Cove
141	Grapeview
142	Reach Island Boat Haven
143	Allyn
144	Belfair
145	Twanoh State Park
146	Hood Canal Marina
147	Union
149	Restwhile Park, Inc.
150	Mike's Beach Resort
151	Miami Beach County
152	State Department of Game
153	Trader Mac's Marina
154	Rainbow Lodge
155	Quilcene Boat House
156	Shine
157	Twin Spits Resort
158	Mats Mats Bay Marina
159	Marrowstone Resort
160	Mystery Bay
161	Fort Flagler State Park
162	Port Townsend City Ramp
163	Port Townsend County Ramp
164	Point Hudson Marina
165	Rhoda-Drona Resort
166	Gardiner
167	Sequim State Park
168	Haques Point Mobile Park
169	Dungeness (County)
170	Dungeness Ramp (State)
171	Thunderbird Marina
172	Agate and Crescent Beach Park
173	Pillar Point
174	Thunderbird Resort
175	White's Cove
176	Olson's Resort
177	Snow Creek Resort, Inc.
178	Peter's Neah Bay Resort
179	Coho Resort Motel & Trailer Park
180	Ackerman's Motel & Boat Service
181	Bar West Marina
182	Morton's Salmon Fishing Resort
183	Cape Flattery Resort and Lodge
184	O'Hearn's Four-Star Resort
185	Bob's Sport Fishing Resort

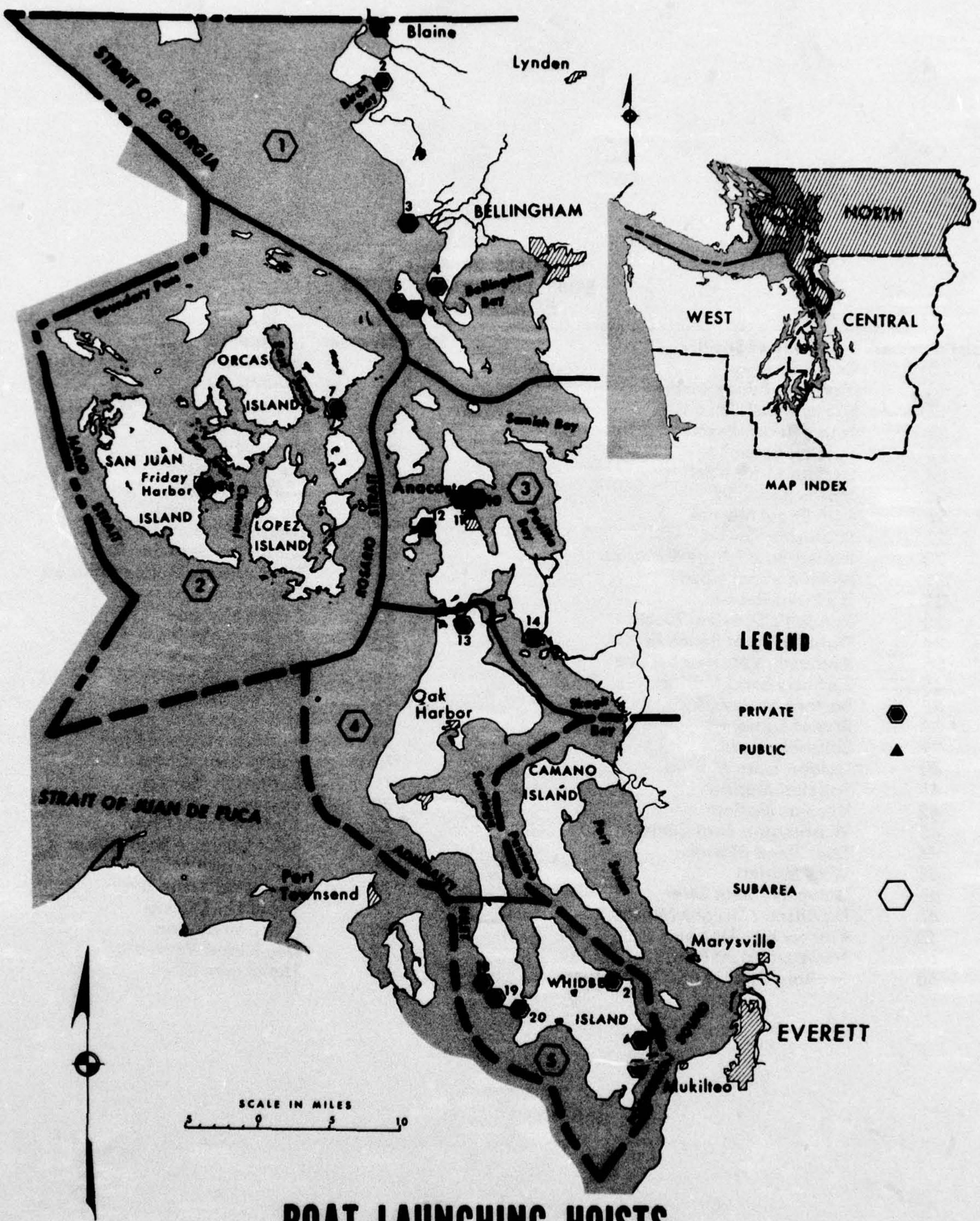


BOAT LAUNCHING RAMPS
WEST DIVISION

Figure 26

FIGURE 27
BOAT LAUNCHING HOISTS
NORTH DIVISION

Hoist Number	Name of Facility
1	Blaine Marina
2	Birch Bay Marina
3	Sandy Point Marina
4	Fisherman Cove
5	Hawley's Marine Resort
6	Gramac Marina
7	Obstruction Pass Motel Resort
8	Jensen Shipyard
9	Gateway Marina
10	Bryants Marina
11	Port of Anacortes
12	Skyline Marina
13	Cornet Bay Marina
14	Otis Marina
18	Bush Point Resort
19	Shore Meadows Resort
20	Mutiny Bay Resort
21	Langley Marina, Inc.
30	Jim & Johns Resort
31	Lee Ora Del Mar, Inc.



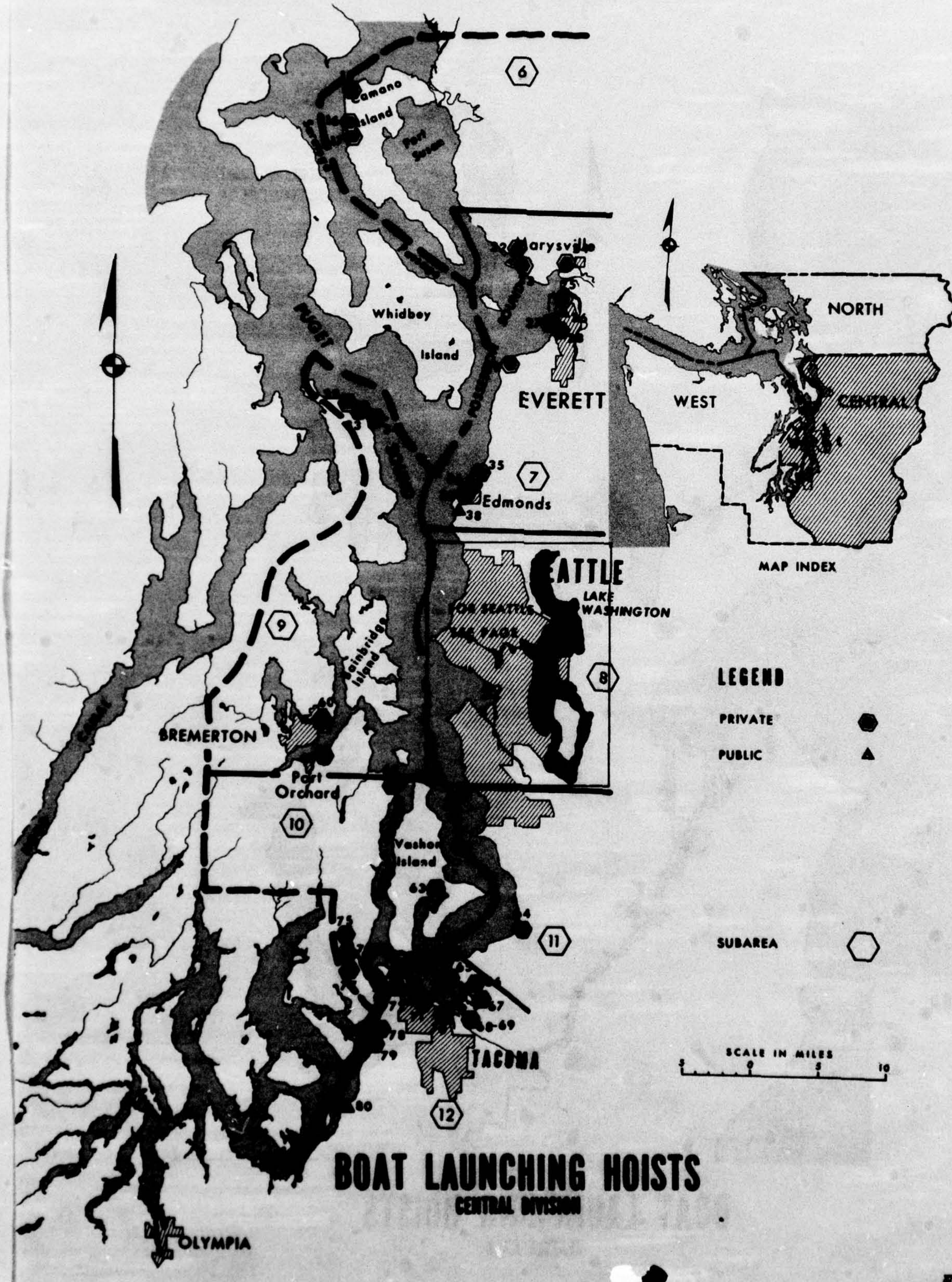
BOAT LAUNCHING HOISTS

NORTH DIVISION

Figure 27

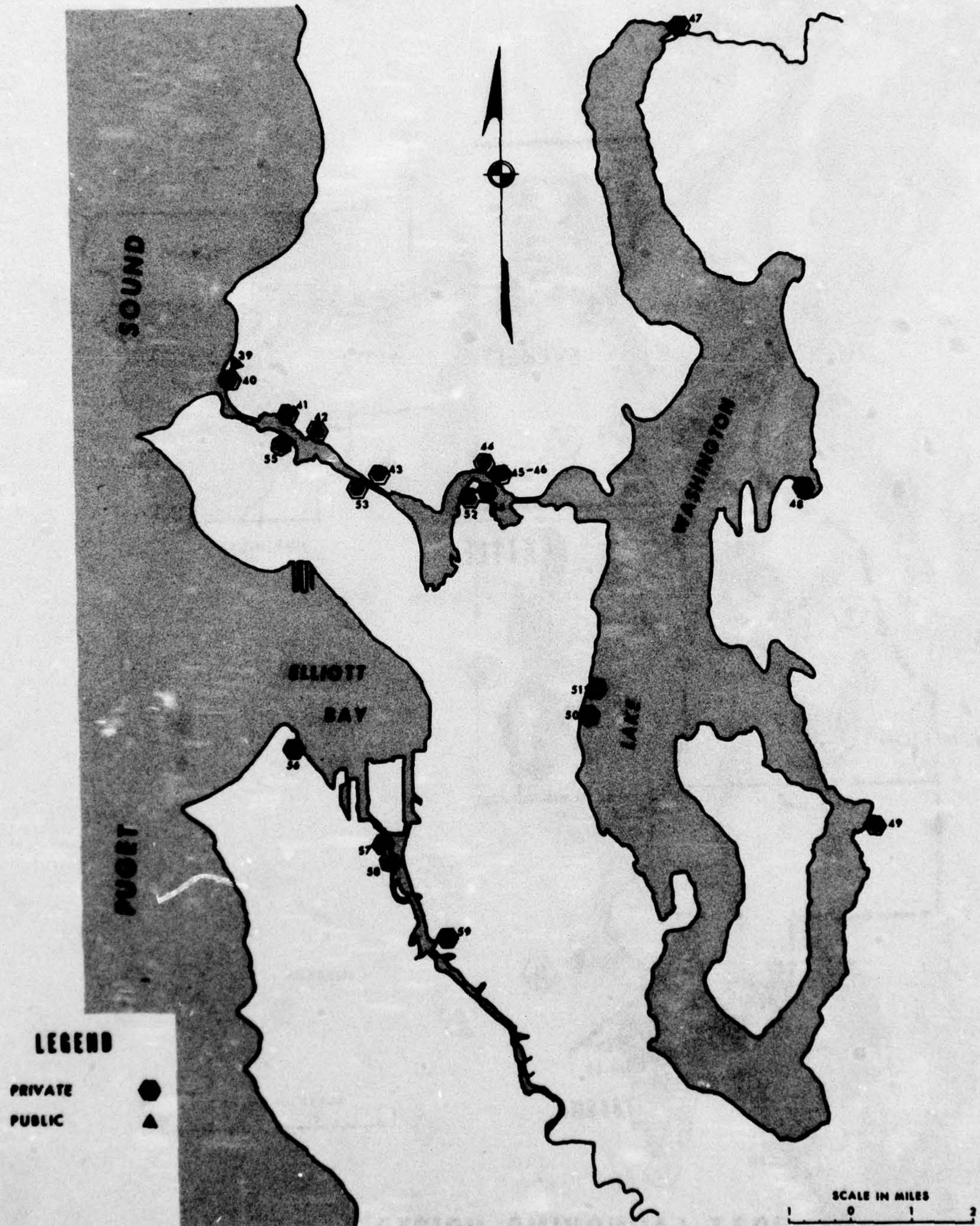
FIGURES 28 AND 29
BOAT LAUNCHING HOISTS
CENTRAL DIVISION

Hoist Number	Name of Facility	Hoist Number	Name of Facility
15	Camp Grande	51	Lake Washington Yacht Basin
16	Madrona Beach Resort	52	Bryants, Inc.
17	Sunset Beach Resort	53	Erwing Street Moorings
22	Totem Beach Resort	54	Blanchard Boat Co.
23	Mission Beach	55	Lloyd Jett
24	Geddes Marine Service	56	Seacrest Marina
25	Morris Boats, Inc.	57	Pioneer Marina Ford
26	14th Street Marina	58	Riverside Marina
27	Robinson Marina	59	South Park Boat Haven
28	Everett Boat House & Marina	60	Bremerton Boat Service
29	Mukilteo Boat House	61	Port Orchard Marine Railroad
32	Ericksons Resort	62	Sebring Marina
33	Randall's Seaview Resort	63	Larsen Marina
34	Point No Point Beach Resort	64	Redondo Marina
35	Anderson's Marina Service	65	Harbor Marina
36	*Surf and Sand Marina*	66	*Hylebo's Boat Haven*
37	Bartons Marina, Inc.	67	Port Yacht Basin
38	Port of Edmonds	68	Sportsman Marina
39	Shilshole Marina	69	Fairliner Pleasure Craft
40	Golden Tides Marina	70	Totem Boat Haven
41	Sagstad Marina	71	Caddigan Marina
42	Vesojas Marina	72	Bayshore Boat Locker
43	Washington Boat Center	73	Tacoma Yacht Club
44	Boat Street Marina	74	Point Defiance Boat House
45	Wies Marina	75	Longbranch Marina
46	University Boat Sale	76	Peninsula Yacht Basin
47	Davidson's Uplake Marina	77	Triple TTT Marina
48	Yarrow Bay Marina	78	Narrows Marina
49	Newport Yacht Basin	79	Day Island Marina
50	Seaborn Leschi Park Boat House	80	Steilacoom City



BOAT LAUNCHING HOISTS
CENTRAL DIVISION

Figure 28



BOAT LAUNCHING HOISTS
SEATTLE AREA

Figure 29

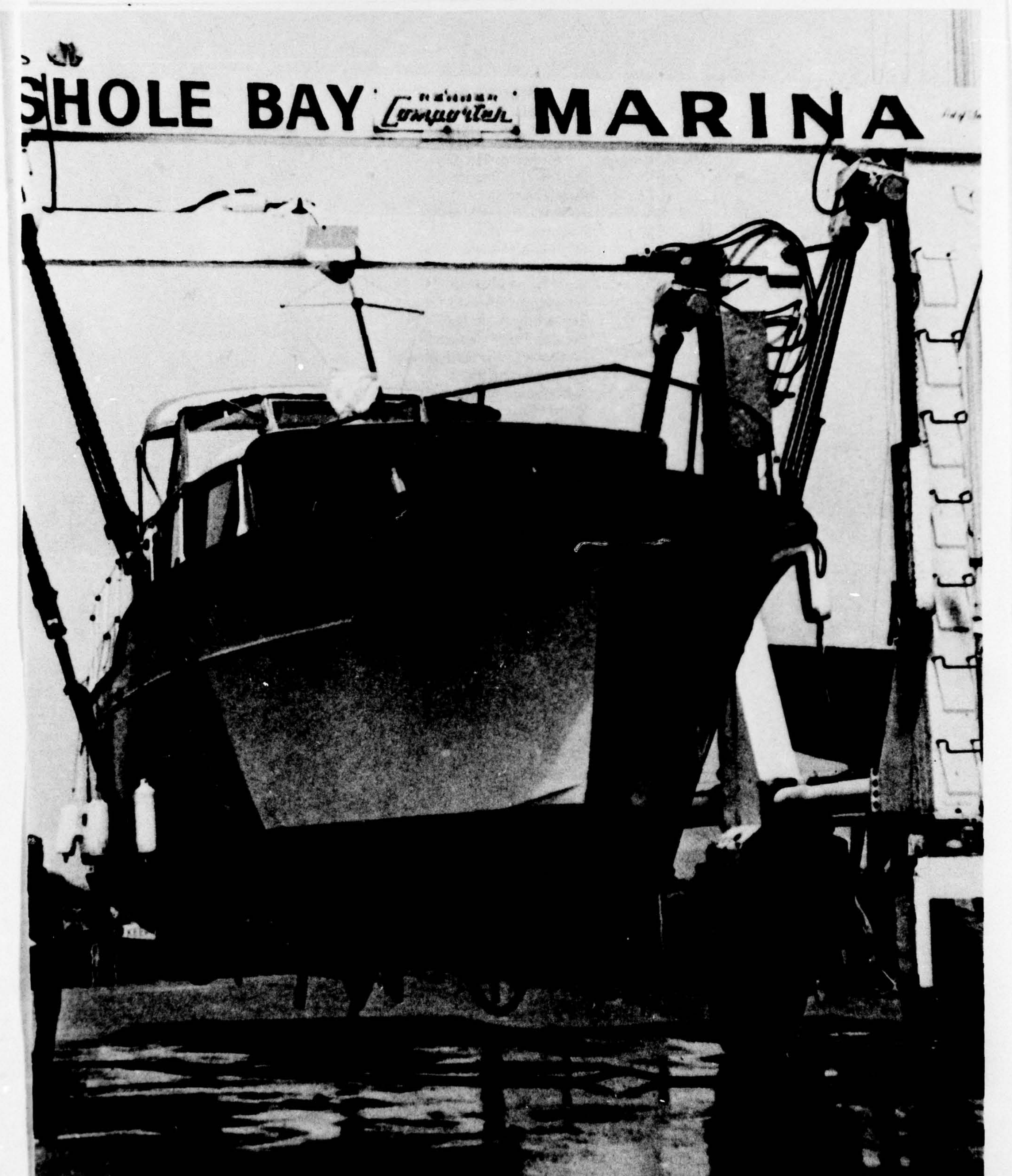
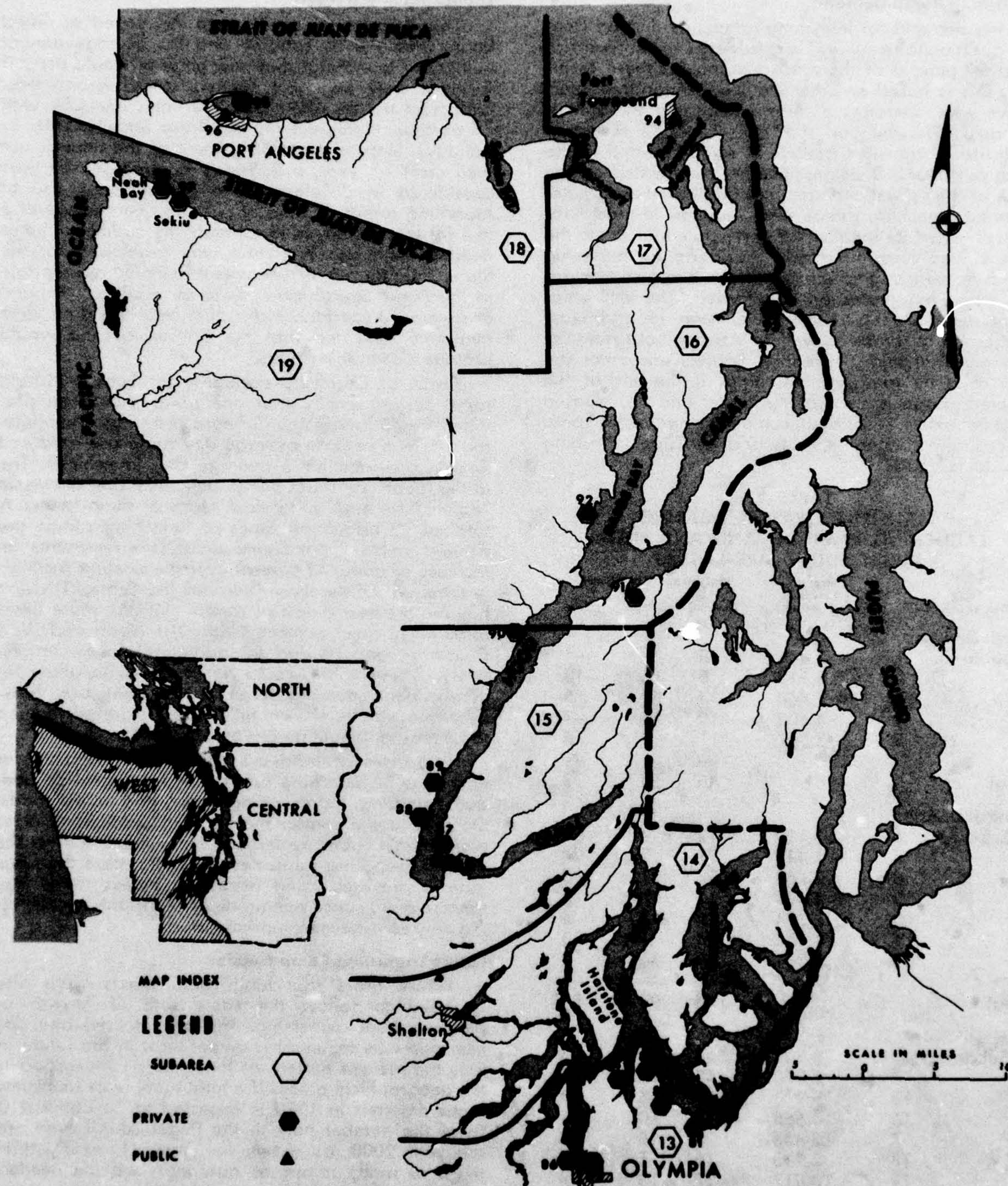

SHOLE BAY
MARINA

FIGURE 30
BOAT LAUNCHING HOISTS
WEST DIVISION

Hoist Number	Name of Facility
81	Luhr Beach Resort
82	Puget Marina
83	Johnson Point Marina
84	Bayside Beach
85	Olympia Marina
86	West Bay Marina
87	Bald Point Marina
88	Hoodsport Marina
89	Restwhile Park, Inc.
90	Beacon Point Resort
91	Seabeck Outboard Service
92	Rainbow Lodge
93	Twin Spits Resort
94	Point Hudson Marina
95	Thunderbird Marina
96	Port Angeles Boat Haven
97	Snowcreek Resort, Inc.
98	Peter's Neah Bay Resort



BOAT LAUNCHING HOISTS

WEST DIVISION

Launching Ramp Demand

The demand for launching ramps, as derived from the questionnaire survey, is considered to represent at least 90 percent of the total demand for these facilities. This is based on other studies and random interviews with operators of marinas located throughout the area. The demand shown in Table 17 reflects a high use by transient boaters of ramps located in the West and North Divisions. Boaters commented on the back of their questionnaires that additional and better planned launching ramps were required in most subareas. A need for breakwater protection adjacent to the ramps was also indicated. Launching or retrieving pleasure craft during windy periods becomes hazardous where no protection is afforded. The difficulties encountered during rough water tend to aggravate congestion at ramps as well as increase boat damage and personal injury potential. Boaters encounter delays at some ramps at low tides if the end of the concrete apron is short of the water and an exposed mud flat exists. A sandy beach off the end of the ramp will usually support vehicles and low tide launching can still be made.

TABLE 17
TRANSIENT PLEASURE BOATING
LAUNCHING RAMP DEMAND AND NEEDS
PUGET SOUND AREA—1966

Location of Demand		Demand by① Number of Boaters	Equivalent Lanes Needed Demand	Existing	Need
North Division					
Subarea:	1	2,446	8	9	–1
	2	3,913	5	18	–13
	3	7,460	14	9	5
	4	4,403	10	11	–1
	5	3,547	11	3	8
Total			48	50	13
Central Division					
Subarea:	6	3,119	12	4	8
	7	9,478	31	7	24
	8	12,168	51	51	0
	9	4,403	12	17	–5
	10	2,324	6	2	4
	11	4,158	14	1	13
	12	5,381	18	16	2
Total			144	98	51
West Division					
Subarea:	13	3,302	8	11	–3
	14	5,320	17	16	1
	15	5,993	11	8	3
	16	6,665	15	10	5
	17	2,446	4	10	–6
	18	3,913	10	5	5
	19	10,517	27	13	14
Total			92	73	28
Puget Sound Area			284	221	92

①Owners may have indicated the desire for launching ramps in more than one subarea.

Launching Ramp Need

Launching ramp needs were developed to reflect boater demand by subarea and the average annual number of launchings that now occur or would occur if facilities were available. Boaters would launch their craft from trailers about 833,500 times annually with 75 percent of this activity occurring on weekends or holidays. Since at least 33 percent of the boaters use their craft all year, a 365 day boating season was considered in developing the average day use of launching ramps. A ratio of peak to average use of 5 to 1 (4) was employed to estimate the number of lanes needed. Although this ratio was developed for the State of California, its use was considered appropriate to the Puget Sound area. A check made of demand at several ramps for which trailer boat use data were available indicated that the California ratio would provide reasonable results.

Corps of Engineers standards for boat launching ramp design specify that one ramp should be provided for 40 launchings during a peak day. Therefore, for a 5 to 1 peak to average day ramp use ratio one lane is provided for 8 average day launchings. The trailer boat launching ramp demands are shown in Table 17 for each subarea in terms of ramp lanes. A total of 92 additional lanes of launching ramps are needed in the Puget Sound area. This represents an increase of about 42 percent over the existing facilities in the area. Of the three Divisions the Central Division has the greatest deficit of ramps, with 51 more lanes required to meet present needs. The North and West Divisions need 13 and 28 additional lanes, respectively. These values could be increased to allow for non-resident, non-registered trailer boat use, however, the values shown in Table 17 are considered to be reasonable reflections of total needs.

Two acres of land are considered necessary for each lane of launching ramp in order to provide adequate parking, maneuvering space, and access roads. On this basis approximately 184 additional acres along Puget Sound waterfront are needed to meet the present launching ramp needs. Where more than one lane is provided, land needs for access roads and maneuvering space remain nearly constant, necessitating only an increase in parking area.

Future Launching Ramp Needs

Future gross launching ramp needs were also assumed to follow the same rate of growth as pleasure boat ownership. The peak to average day use ratio was assumed to be constant in the future as was the present pattern of launchings with respect to the geographical areas. The total number of launching lanes required in 1980 is expected to be about 410, twice the number now in the Puget Sound area. By the year 2000, as shown in figure 31, nearly three times as many ramps as now exist will be needed.

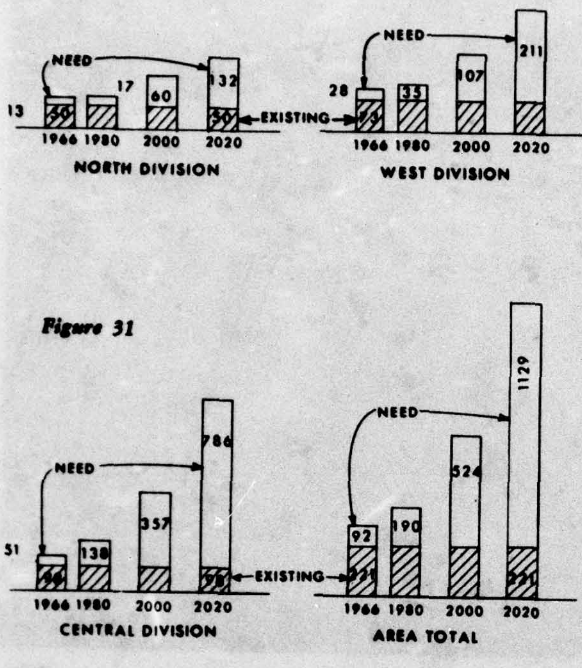


Figure 31

LAUNCHING RAMP LANES — EXISTING — PRESENT AND FUTURE NEEDS

Other Boating Facility Demand

Although the small boat study was primarily concerned with defining the needs for moorages and launching ramps, other data derived from the questionnaire survey is of interest and importance to the planner and marina operator. Demand was also measured for shopping or service moorage, service facilities at marinas, harbors of refuge, saltwater camping, and saltwater picnicking. Table 18 relates the location of the demand for boating facilities to the residence area originating the demand. For example, 39 percent of the total demand for permanent summer moorage in the North Division is by persons living in the North Division with 60 percent and 1 percent by residents of the Central and West Divisions respectively.

TABLE 18
PERCENT DISTRIBUTION OF PLEASURE BOAT FACILITY DEMAND BY DIVISION
PUGET SOUND AREA—1966

LOCATION OF DEMAND	FACILITY DEMANDED	RESIDENCE DIVISION NORTH	CENTRAL	WEST	
NORTH DIVISION	Permanent Summer Moorage	39	60	1	100%
	Permanent Winter Moorage	50	50	0	
	Temporary Summer Moorage	9	88	3	
	Temporary Winter Moorage	29	71	0	
	Harbor of Refuge	16	83	1	
	Saltwater Camping	15	82	3	
	Saltwater Picnicking	18	81	1	
	Boat Launching Ramp	22	76	2	
CENTRAL DIVISION	Permanent Summer Moorage	0.4	99.2	0.4	100%
	Permanent Winter Moorage	0.4	99.6	0	
	Temporary Summer Moorage	1	97	2	
	Temporary Winter Moorage	0	99	1	
	Harbor of Refuge	2	97	1	
	Saltwater Camping	0	96	4	
	Saltwater Picnicking	1	97	2	
	Boat Launching Ramp	0.8	98.8	0.4	
WEST DIVISION	Permanent Summer Moorage	4	54	42	100%
	Permanent Winter Moorage	6	49	45	
	Temporary Summer Moorage	1	91	8	
	Temporary Winter Moorage	2	85	13	
	Harbor of Refuge	3	83	14	
	Saltwater Camping	3	83	14	
	Saltwater Picnicking	2	81	17	
	Boat Launching Ramp	2	77	21	

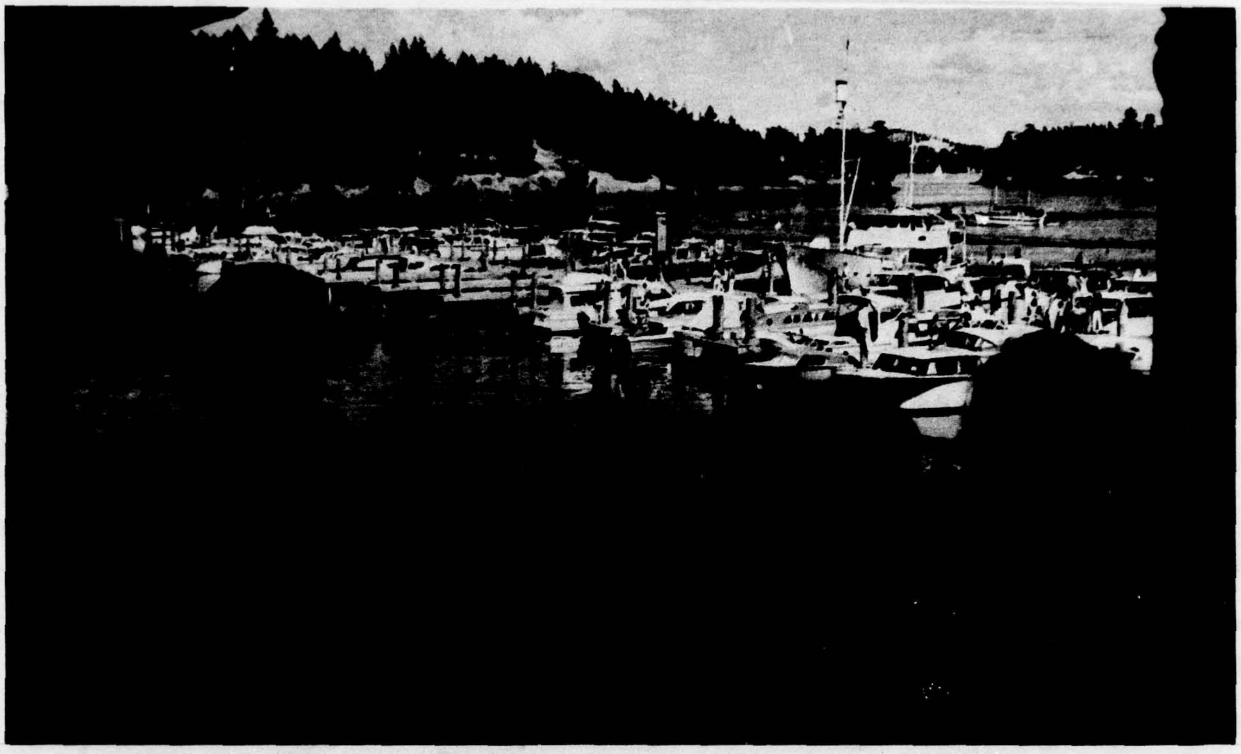


TABLE 19
SHOPPING OR SERVICE MOORAGE DEMAND①
PUGET SOUND AREA—1966

Location of Demand		Summer: Number of Boaters	Summer: Total Number of Stops	Winter: Number of Boaters	Winter: Total Number of Stops
North Division					
Subarea:	1	2,921	10,808	435	696
	2	10,752	65,585	2,051	8,409
	3	6,463	31,671	1,243	4,848
	4	5,531	23,784	684	1,709
	5	4,910	21,603	994	3,580
Central Division					
Subarea:	6	1,740	14,269	186	373
	7	4,266	35,922	1,492	8,054
	8	5,221	42,285	2,175	9,353
	9	6,712	36,917	3,356	10,404
	10	3,791	13,269	1,616	5,009
	11	1,927	15,413	808	3,716
	12	2,797	24,890	1,057	7,184
West Division					
Subarea:	13	3,418	14,356	994	6,762
	14	5,283	28,526	2,175	13,704
	15	2,735	9,571	808	6,302
	16	5,283	27,469	870	2,523
	17	4,040	10,099	808	3,312
	18	2,672	9,888	559	1,231
	19	3,418	22,560	559	2,965

①Boaters may have indicated the desire for shopping or service moorage in more than one subarea.

Shopping or Service Demand

Puget Sound boating activity by season and location is mirrored in the demand for shopping and service moorages shown in Table 19. Boaters appear to enjoy navigating their craft in each of the three divisions during the summer season with the North Division receiving the greatest use. The popularity of the San Juan Islands in summer is indicated by the high boater demand for temporary moorage in subarea 2. During winter, with boating primarily confined to local waters, the more populated Central Division has the largest boater demand for service facilities. Services desired at temporary and permanent moorages are reflected in Table 20. As would be expected, fuel and oil supplies are demanded by the highest percentage of boaters.

TABLE 20
SERVICE FACILITIES DEMAND
PUGET SOUND AREA—1966

Facilities	Demand at: Temporary Moorage	Demand at: Permanent Moorage
1. Walk-in Lockers	2.8%	6.4%
2. Small Lockers	5.5	10.8
3. Marine Supply	30.4	25.8
4. Fresh Water	46.1	35.4
5. Ice Supply	42.1	30.0
6. Fishing Supplies	40.4	27.9
7. Restaurant	44.4	23.5
8. Electrical Power	21.1	26.2
9. Boat Repair	15.6	16.4
10. Engine Repair	23.8	20.8
11. Launching Hoist	24.1	23.7
12. Fuel and Oil Supply	57.6	42.2
13. Showers	27.4	13.9
14. Laundry Facilities	18.3	8.2

Debris Control

Floating debris or hidden underwater obstacles are the principal hazards to boat hulls and propellers in Puget Sound. The Corps carries on a minor debris removal program in Puget Sound waters through use of its unique stern-wheeler snagboat "Preston." The importance and need for this debris control program is reflected in the results of the questionnaire survey shown in Table 21. An average of about $161 damage per boat was incurred by an estimated 10,823 registered boats during 1965 and 1966 for a total average annual damage of $850,000.

Many survey respondents provided written comments with their returned questionnaires expressing dissatisfaction with the excessive debris in the study area waters. Night cruising was considered particularly hazardous under current conditions. Greater debris removal and litter control is desired.

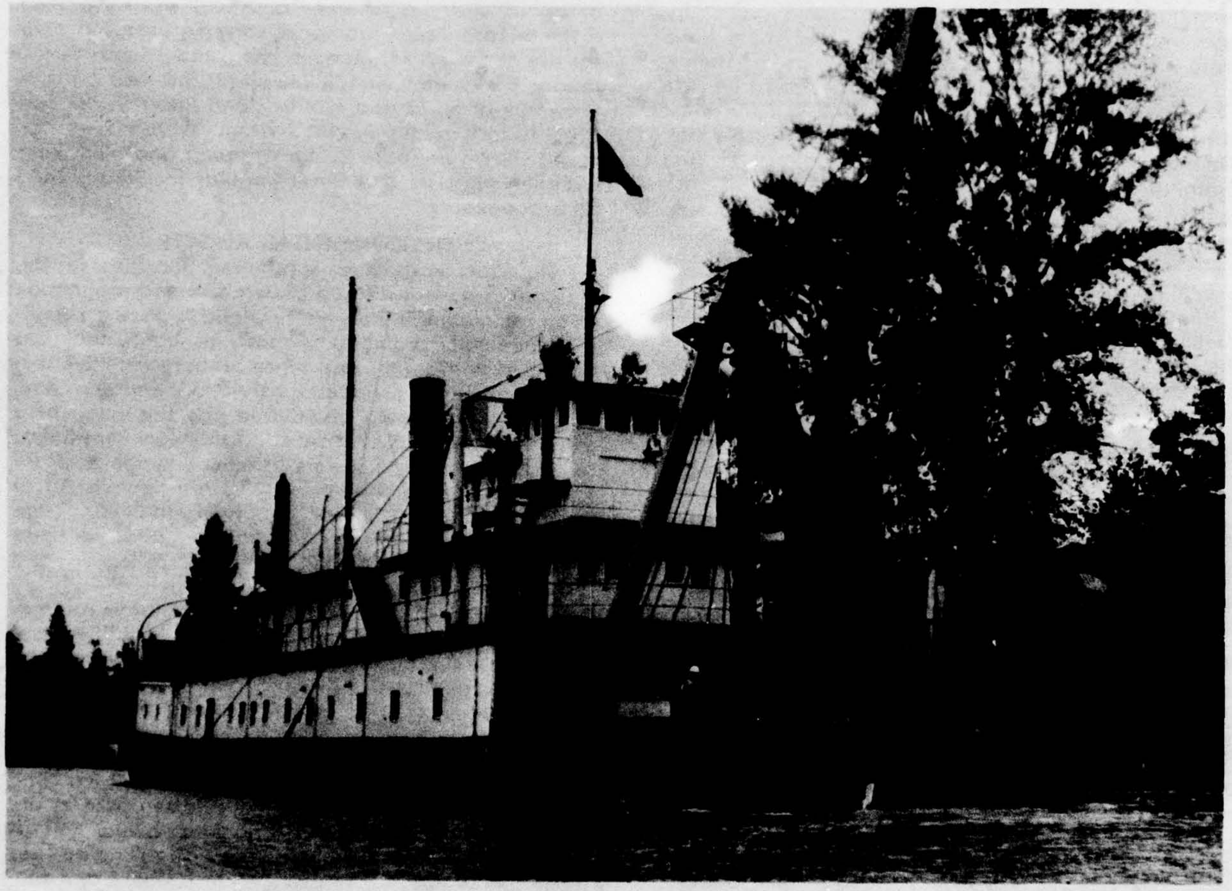


TABLE 21
BOAT DAMAGE
COAST GUARD REGISTERED BOATS
PUGET SOUND AREA—1965-1966

NUMBER OF BOATS DAMAGED

BY HAZARD		BY LOCATION	
Waves	710	North	2660
Debris	9110	Central	7460
Underwater Obstacle	2030	West	3440
Other	1510		
Total	13,360①	Total	13,560①

①Totals differ since the same boat may have incurred damage in more than one location during the boating year or by a combination of hazards.

Harbors of Refuge

Boaters were asked by the questionnaire survey to indicate where they need a harbor to flee heavy weather. The very high response, as reflected in Table 22, demonstrates a definite need for harbors of refuge where protective breakwaters are provided. A harbor of refuge is defined as a temporary haven for small craft in distress or seeking shelter from approaching storms; a safe place of rest and replenishment for transient boats. A harbor of refuge must offer anchorage or moorage protected from waves of hazardous magnitude from any quarter, must have access by land, must have a public landing, and must have some means of obtaining aid, supplies or assistance. Entrances to small craft harbors of refuge must be safe for navigation by small craft under all but the most extreme sea and weather conditions found at the site. The entrance channel must be of adequate depth and width to allow for maneuvering by the small craft using the harbor. A harbor of refuge in a given area must be large enough to accommodate the estimated number of small craft that might require refuge at any one time (4).

No harbor located on Puget Sound and Adjacent Waters is designated as a harbor of refuge. Several of the larger public boat basins are able to afford some protection to transient small craft; however, moorages

TABLE 22
PLEASURE BOAT FACILITY DEMAND①
PUGET SOUND AREA—1966

Location of Demand		Harbors of Refuge	Saltwater Camping	Saltwater Picnicking
		GROSS DEMAND — NUMBER OF BOATERS		
North Division				
Subarea:	1	2,735	373	2,486
	2	10,379	9,509	10,814
	3	5,034	2,983	5,158
	4	8,204	2,747	5,966
	5	8,825	2,735	6,339
Central Division				
Subarea:	6	2,175	1,057	2,797
	7	6,526	1,616	6,091
	8	4,599	1,057	7,831
	9	6,463	4,413	9,944
	10	2,797	1,864	5,655
	11	2,175	621	2,548
	12	2,548	808	3,667
West Division				
Subarea:	13	1,243	1,057	3,605
	14	3,542	5,220	8,452
	15	2,362	3,418	5,469
	16	5,034	5,220	7,893
	17	4,226	1,616	2,735
	18	4,226	2,362	2,797
	19	6,277	5,718	4,288

①Boaters may have indicated the desire for facilities in more than one subarea.

have not been set aside for this purpose. The growth of pleasure boat activity increases the peril as more boaters are subjected to adverse wave actions during periods of sudden high winds. Uncertainty of weather conditions and the many miles of shoreline without protected harbors tend to reduce the cruising radius of many boaters.

Saltwater Camping and Picnicking Facilities

During the field surveys many inboard and outboard pleasure craft were viewed anchored off Marine parks. The bulk of these craft were not equipped with on-board sleeping facilities and had cruised a long distance from home moorages carrying camping gear for use at the parks. Many of the campgrounds at the marine parks were completely filled. This was particularly true of Sucia and Matia Island Parks in the San Juan Islands of the North Division. A very high demand shown in Table 22 for camping and picnicking facilities suggests that these popular facilities should be expanded.

ENVIRONMENTAL ASPECTS

Pleasure boats and supporting facilities in the study area have increased in numbers and magnitude to the point where their waste products pose a significant pollution problem. Almost all boats that are equipped with toilets and other sanitary facilities discharge untreated sewage directly into the water. Raw sewage is also being discharged into the water at a substantial number of shoreside facilities where toilets are not connected to sewers or other sewage disposal installations. Public toilet facilities are nonexistent at many marinas and docks. Thoughtless individuals are more apt to dump refuse into the water where there are no provisions for the adequate collection and disposal of solid wastes.

Boats and marinas do not contribute large volumes of sewage when compared with municipalities and industries; nevertheless, the pollution problem may be significant due to the high concentration of floating population and other public activity at recreation areas, especially during certain peak weekends. The problem is particularly acute where facilities and moorage sites are located near shellfish beds and outdoor recreational areas where adjacent waters are used for swimming, skiing, and other water contact sports. Boats pose a rather unique problem as they move freely into and rendezvous in isolated and previously unspoiled recreational waters.

Waste discharges from boats and marinas not only make the water unsightly and lower its use for other purposes, but may introduce disease-producing organisms into the water. Fresh body wastes may contain pathogenic bacteria and virus that cause illnesses including dysentery, shigellosis, typhoid fever, and infectious hepatitis. A serious hazard exists when shellfish are harvested and consumed from contaminated water in that shellfish can concentrate and retain disease microorganisms within their digestive tract.

Legislation recently adopted at both the Federal and State levels, requires the implementation of effective programs to preserve and enhance the quality of water for recreation and other purposes. In accordance with this legislation, efforts are underway to develop appropriate standards and control mechanisms to eliminate the discharge of untreated wastes from boats. Presently, there are several methods available for holding or treating sewage on boats; however, none has been found completely satisfactory. It is anticipated that additional study will lead to the development of effective devices, regulations, and standards to resolve the problem.

The proper location, construction and operation of supporting shore facilities is also an essential element in the preservation of water quality and protection of the public's health and estuarine resources. Sites of proposed marinas should be carefully selected so that they do not adversely affect other existing or potential uses, including shellfish culturing, harvesting, and water-oriented recreational activities. Physical and hydrographic characteristics of the site should be evaluated to determine if surrounding waters can safely assimilate any pollution that may occur despite precautions that have been followed.

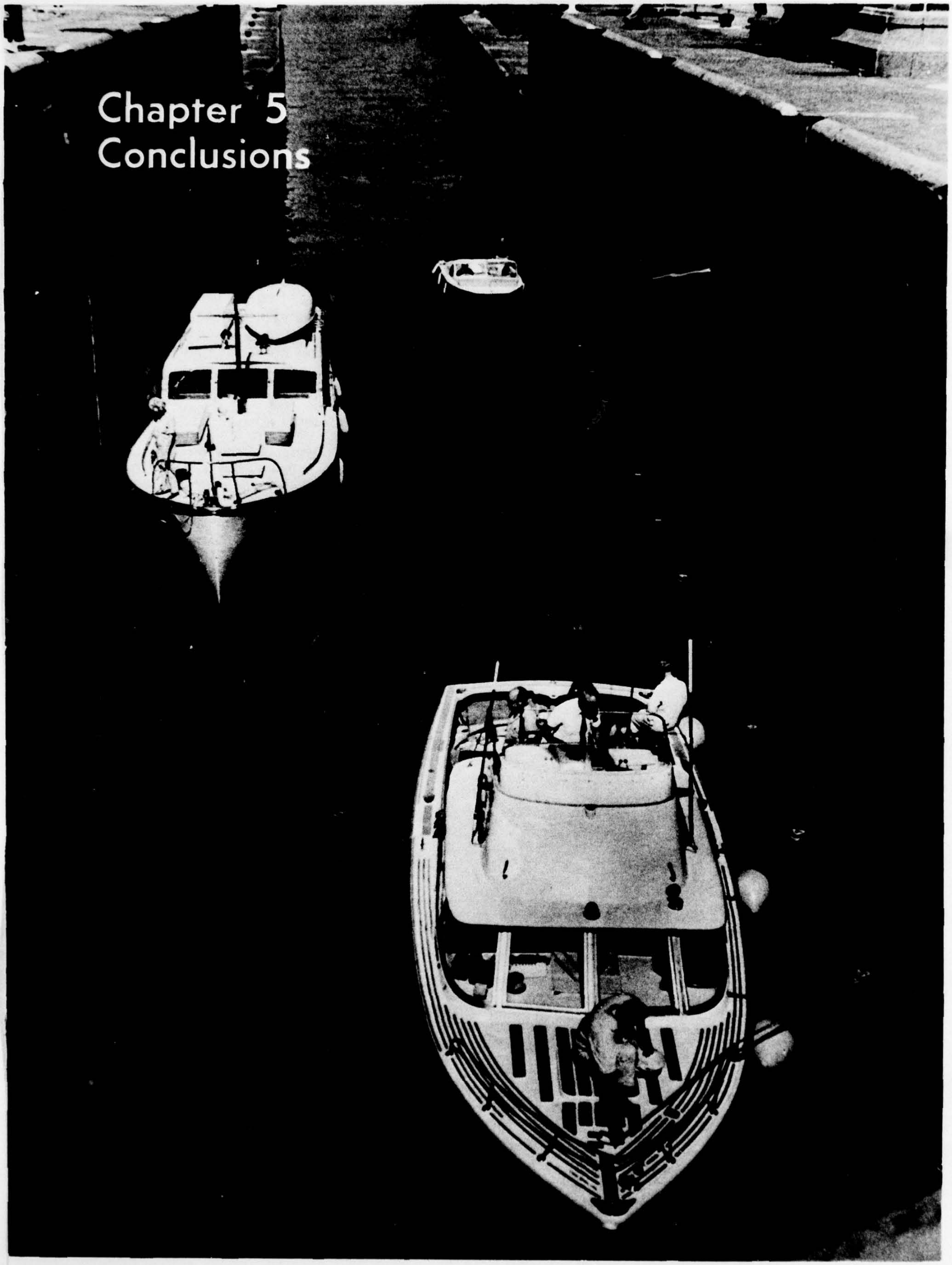
Shellfish culture within the state is carried on at present in and below the intertidal zone. Commercial oyster culture is carried on in many of the protected and semi-protected bays and inlets. Intertidal clams have provided a readily available food supply, and recent investigations have shown exploitable subtidal clam populations. These sedentary forms are especially vulnerable to permanent damage from severe environmental changes. Ambulatory species are also adversely affected by such changes. However, they do possess greater facility for recovery.

Three aspects of marinas which can adversely affect the fishery resources are location, method of construction, and subsequent operation. Proper location of marinas is a key factor in reducing their impact on the fishery resources. Marinas should not be located in or adjacent to areas of shellfish culture. Locating a marina directly in a shellfish area will result in a direct loss of shellfish production through the physical construction of the marina.

In addition to site selection, attention must also be focused on construction and operational considerations. Basic sanitary facilities, including shoreside toilets and refuse containers, must be provided at all marinas. Sanitary facilities must be connected to public sewers or an individual sewage disposal system approved by the local health department. Marinas must make provisions for the collection and disposal of wastes, including sewage, refuse, oil, fuel and paint, from boats.

Marina operators have a responsibility to provide adequate maintenance and supervision of all facilities provided for the public. Management should also establish and enforce rules restricting anyone from living aboard boats or flushing toilet facilities not equipped with approved treatment or retention devices while boats are docked at a marina.

When planning the development of a proposed marina the developer should contact the Washington State Department of Fisheries and the Washington State Department of Health. The State or local health department can provide guidance in the selection of a site and recommendations relating to the provision of an adequate water supply, sewage disposal installation, toilet and refuse facilities. The health department can also advise management concerning housekeeping functions and other operational problems relating to protection of the marine environment.


Chapter 5
Conclusions

CHAPTER 5 — CONCLUSIONS

The study of small boating on Puget Sound and adjacent waters has found that pleasure boat ownership in the area is currently very high and expected to increase 56 percent by 1980 and triple by 2000. The interest in boating is reflected in per capita ownership estimates which show that the study area has over twice as many boats per person as the nation. The area is very attractive to boaters with its 2500 square miles of water, 2350 miles of shoreline, scenic mountain backdrop and pleasant, marine tempered environment.

The study shows that pleasure craft owners residing in the area demand transient and permanent moorages, launching ramps, harbors of refuge, and camping and picnicking areas in excess of the capacity of existing facilities to meet these needs. Also, they are concerned with the lack of protection from wave action at launching ramps and damage to craft from debris and other hazards. Many facilities now serving the boating public are of inadequate quality and insufficient size. Other marinas of good quality are not providing the type of facility demanded by boaters to meet their seasonal needs. In all divisions additional facilities are required.

The study indicated that over 11,000 additional winter rental moorages are currently needed with a large portion of these required in subarea 7, i.e. in the Everett area. Winter rental moorages needs are projected to rise from over 11,000 in 1966 to 25,000 by 1980. The majority of boaters using permanent rental moorages are demanding covered facilities during both summer and winter. Over ninety additional boat launching ramp lanes are currently needed in the area. At two acres per lane this amounts to nearly 200 acres of required land acquisition. Harbors of refuge are also urgently needed as reflected in the high boater response for this facility.

To meet the needs of recreational boating, both public and private investments will be required. Summer moorages can be constructed within the financial capabilities of the private developer, as little breakwater protection is normally required. Additional floats at established marinas will, in most instances, be sufficient to supply the needs of the transient boater. However, expensive breakwater protection is required for wet moorage marinas operated all year around and located along exposed shorelines. The large amount of capital required to construct a suitable protected marina usually limits small boat harbor development to public agencies.

GLOSSARY

AUXILIARY SAILBOATS — Sailboat powered by auxiliary motors greater than 10 horsepower.

BOAT HARBOR — An area of water protected to a degree sufficient to provide safe moorage for small craft, including both recreational and commercial vessels. A small boat harbor may contain a number of marinas or constitute a single moorage basin in itself.

COVERED DRY MOORAGE — Land or pier deck based moorage with overhead cover.

COVERED WET MOORAGE — Water moorage with overhead cover.

DEMAND — A term expressing marine facility use by pleasure boat owners or indicated use if facilities were available.

DIVISIONS — The study area was subdivided to coincide essentially with the three divisions examined in the economic study of Puget Sound and Adjacent Waters by Consultant Services Corporation. The North Division consists of the counties of Whatcom, San Juan, Skagit, and Island. The Central Division consists of Snohomish and King Counties and portions of Kitsap and Pierce Counties. The West Division consists of Thurston, Mason, Jefferson, and Clallam Counties and portions of Kitsap and Pierce Counties.

DOCUMENTED BOAT — A boat of over five net tons capacity formerly documented through the Bureau of Customs, now documented through the Coast Guard.

HARBORS OR REFUGE — A temporary haven for small craft in distress or seeking shelter from approaching storms; also a safe place of rest and replenishment for transient boats.

INBOARDS — Inboard powered vessels including those craft classed as inboard-outboard.

LAUNCHING RAMP —An inclined surface leading into the water from which trailered boats may be launched. A launching ramp may consist of one or more lanes of approximate 12-foot width. The capacity of a launching ramp is measured in terms of its lanes and equals the number of boats that can be launched simultaneously from the facility.

MARINA —A marine development having moorages. Other facilities may be available, including repair facilities, bait, tackle and general supply services. Restaurants and hotels or motels are often part of a modern marina complex.

MEAN — The arithmetic average.

MISCELLANEOUS BOATS — Canoes, prams, rowboats, rubber rafts, etc.

MOORAGE FACILITY — One or more piers, wharfs, floats, or permanently anchored buoys to which boats can be secured and left in the water for storage purposes; or land or deck storage areas used with hoists or inclined railways.

NEED — A term used to indicate additional marine facilities required to satisfy a given level of pleasure boat owner demand.

OPEN DRY MOORAGE — Land or pierdeck-based moorage exposed to the weather.

OPEN WET MOORAGE — Water moorage exposed to the weather.

OTHER SAILBOATS —Sailboats not mechanically powered or having power of 10 horsepower or less.

OUTBOARDS — All outboard powered pleasure craft.

PERMANENT MOORAGE —A place where a boat is kept more than one month.

PUBLIC AND PRIVATE MARINE FACILITIES — Public facilities refer to marine facilities operated by public agencies such as State, counties, cities, and ports for use by the general public. Private facilities refer to marine facilities operated for profit by private ownership. They are available for general public use.

PUGET SOUND STUDY AREA — The 12 counties in northwestern Washington bordering Puget Sound and Adjacent Waters. These consist of Whatcom, San Juan Island, Skagit, Snohomish, King, Pierce, Kitsap, Thurston, Mason, Jefferson, and Clallam Counties. Only Puget Sound and adjacent saltwaters were examined with reference to marine facilities and boating demand. Lake Washington was included as an extension of Puget Sound.

REGISTERED BOAT—An undocumented craft propelled by an engine of more than 10 horsepower, used on navigable waters of the United States and registered by the United States Coast Guard, as required by the Federal Boating Act of 1958.

SUBAREAS — Each of the Divisions was subdivided for questionnaire distribution purposes with the North Division containing five subareas, the Central Division containing seven subareas, and the West Division containing the remaining seven subareas.

SUMMER MOORAGE — A moorage used from mid-April to mid-September. This type may or may not require breakwater protection from wind generated wave action.

TEMPORARY MOORAGE — A place where a boat is kept less than one month.

WINTER MOORAGE — A moorage used from mid-September to mid-April which usually requires breakwater or sheltered inlet protection from winter storm generated wave action.

YACHT CLUBS — Privately owned marine facilities used by a select segment of the public.

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APPENDIX

Columbia Basin Inter-Agency Committee

TASK FORCE FOR COMPREHENSIVE STUDY
PUGET SOUND AND ADJACENT WATERS

Task Force Members
State of Washington
Dept. of Agriculture
Dept. of Army
Dept. of Interior
Dept. of Labor
Federal Power Commission
Dept. of Commerce
Dept. of Health, Education & Welfare

Address Replies to either Co-Chairman

Alfred T. Neale, Asst. Director
Washington State Pollution Control Commission
P. O. Box 829
Olympia, Washington 98501
Phone: 753-6895

Robert H. Gedney
Chief, Basin Plng.Br.
U.S. Army Engr.Dist., Seattle
1519 Alaskan Way South
Seattle, Washington 98134
Phone MU 2-2700 Ext. 382

Dear Boater:

Have you ever wished that you had been asked before pleasure boating facilities were constructed? Here's your chance. The Task Force for Comprehensive Study of Puget Sound and Adjacent Waters is examining the water resources of the Puget Sound area, and preparing plans for management and development of these water and related land resources. In conjunction with this the Bureau of Outdoor Recreation and the U. S. Army Corps of Engineers, as members of the Task Force, are conducting a survey to determine the nature and location of Puget Sound area boating facilities, and they need your opinion. We would like you to complete the attached questionnaire and return it in the inclosed self-addressed envelope.

There are not enough funds to contact all boaters in the state, so this is going to a small number who have been selected at random. From these few, inferences can be made about the desires of all boaters using facilities in the area. However, in order to accomplish the purposes of this study, every single person taking part in the survey must complete and return the questionnaire. Therefore, it is vitally important that yours is received.

We wish we could say this is a short questionnaire. Unfortunately, we can't; it will probably take you 20 to 30 minutes. However, we can say that it is an important opportunity to make a valuable contribution to boating. Whether we like it or not, there can be no doubt that the years ahead will bring a steady, if not explosive, increase in boating. This growth and the problems it entails will only be manageable, and we will only be able to preserve the fun in boating, if we do an intelligent job of planning facilities. This survey will play a central role in that planning. We heartily indorse it and urge you to fill it out completely.

We know that some questions will be difficult to answer. We ask that you think carefully about each one and answer as best you can. This is going to a variety of boaters and not all questions will apply to you. If a question does not apply, circle "None" so we will know you didn't overlook it. Please complete this questionnaire tonight and mail it tomorrow, or in any event, before the end of the week. Whatever you say will be held in strict confidence and your answers will only be used to combine with others in this study.

Thank you for your help and happy boating.

Sincerely yours,

Alfred T. Neale

Alfred T. Neale, Asst. Director
Pollution Control Commission
State of Washington

Robert H Gedney

Robert H. Gedney, Chief, Planning Branch
U. S. Army Engineer District, Seattle
Corps of Engineers

Exhibit 1

Columbia Basin Inter-Agency Committee

TASK FORCE FOR COMPREHENSIVE STUDY PUGET SOUND AND ADJACENT WATERS

Task Force Members
State of Washington
Dept. of Agriculture
Dept. of Army
Dept. of Interior
Dept. of Labor
Federal Power Commission
Dept. of Commerce
Dept. of Health, Education & Welfare

Address Replies to
either Co-Chairman

Alfred T. Neale, Asst. Director
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Control Commission
P. O. Box 829
Olympia, Washington 98501
Phone: 753-6896

Robert H. Gedney
Chief, Basin Plng. Br.
U.S. Army Engr. Dist., Seattle
1519 Alaskan Way South
Seattle, Washington 98134
Phone MU 2-2700 Ext. 382

Dear Boater:

About 10 days ago, we sent you a questionnaire just like this, but have received no reply. We know you're busy, but this study is vitally important to a very large number of people and it won't mean much unless the people we chose at random complete the questionnaire. We especially need responses from owners of boats such as yours. Won't you please help out by completing this and returning it to us right away?

Thank you,

Alfred T. Neale

Robert H. Gedney

ALFRED T. NEALE, Asst. Director
Pollution Control Commission
State of Washington

ROBERT H. GEDNEY, Chief, Planning Branch
U. S. Army Engineer District, Seattle
Corps of Engineers

Exhibit II

PUGET SOUND AND ADJACENT WATERWAYS
RECREATIONAL BOAT USE QUESTIONNAIRE

/ / No longer own a boat.

SECTION A

To begin, we'd like to find out some things about your boat.

I. Please circle the length and class into which your boat would fall.

1 - 20 ft. or under	4 - over 28 ft. to 32 ft.	7 - over 40 ft. to 46 ft.
2 - over 20 ft. to 24 ft.	5 - over 32 ft. to 36 ft.	8 - over 46 ft. to 50 ft.
3 - over 24 ft. to 28 ft.	6 - over 36 ft. to 40 ft.	9 - over 50 ft.

II. Do you have a trailer for your boat? (Please circle) 1-yes 2-no.

III. Please circle the description below which most nearly fits your boat. (Consider "Inboard-Outboards" as "Inboards")

1. Inboard Cabin Cruiser	3. Outboard with remote controls and windshield	5. Auxiliary Sailboat
2. Outboard Cabin Cruiser	4. Other Outboard	6. Other ______ (Please specify)

IV. What is the total horsepower of your boat? (Include all engines if you have more than one) ___________ HP.

V. Please circle your boat hull material. 1. Wood 2. Steel 3. Aluminum 4. Fiberglass 5. Other

VI. Approximately how many hours did you use your boat in 1966? _________ hrs. (Please exclude hours spent aboard at home moorage).

VII. Approximately what percent of those hours were devoted to one-day (or less) cruises in and out of your home moorage? __________ %

VIII. Approximately how many gallons of fuel did your boat consume in 1966? _________ Gals.

IX. What type of fuel does it use? (Please circle) 1-gas 2-diesel oil 3-other

X. Do you use your boat year around? (Please circle) 1-Yes 2-No (If yes, skip next question)

XI. If you don't use your boat year around, please indicate your boating season below:

Circle number indicating first month of season on top row.

Circle number indicating last month of season on bottom row.

From:	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec
To:	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec

SECTION B

The purpose of this study is to find out where the boating facilities on Puget Sound ought to be. Maybe some facilities should be reduced in size or abandoned; maybe some facilities should be expanded; or maybe new facilities should be built where none exist.

To help us do this, please indicate below what facilities are needed to satisfy you. It may be that facilities are already ideal for you, or it may be that you would like some new ones. We want your answers in either case. We just need to know where you want the facilities to be, whether they are already there or not.

A map on which Puget Sound is divided into numbered areas is attached. Please refer to it for the area numbers required in the questions below. We realize that you may use your boat in many areas. However, on this questionnaire we are interested in the areas enclosed by the heavy lines on the map. We are finding out about the others on another survey. Please answer only with regard to the numbered areas on this map.

XII. Please circle every number that represents a map area (see map for area numbers) in which you now use permanent moorage or would use new permanent moorage in the summer (from mid-April to mid-September). We call "permanent moorage" a place where you keep your boat more than 1 month.

None 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

XIII. At prevailing prices, what type of permanent moorage would you like to rent in the summer? (Please circle)

1-wet covered 2-wet open 3-dry covered 4-dry open 5-none

XIV. Please circle every number that represents a map area (see map for area numbers) in which you now use permanent moorage or would use new permanent moorage in the winter (from mid-September to mid-April).

None 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

XV. At prevailing prices, what type of permanent moorage would you like to rent in the winter? (Please circle).

1-wet covered 2-wet open 3-dry covered 4-dry open 5-none

XIV. Please circle every number that represents a map area (see map for area numbers) in which you now use temporary moorage or would use new temporary moorage in the summer (mid-April to mid-September). (We call "temporary moorage" any place where you keep your boat 1 month or less.) Please indicate the number of nights you would use temporary moorage in that area each summer. Then, indicate how many of these nights would be "in" on Saturday night and "out" on Sunday morning. Finally, please indicate the number of occasions when you would not use the moorage overnight but would use it for a short shopping, visiting, or service stop.

Area	Total number of nights would use	Number of in Saturday nights out Sundays	Shopping or Service Stops
None(0)			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			

XVII. At prevailing prices, what type of temporary moorage would you like to rent in summer? (Please circle)

1-wet covered 2-wet open 3-dry covered 4-dry open 5-none

XVIII. Please circle every number that represents a map area (see map) in which you now use temporary moorage or would use new temporary moorage in the winter. (mid-September to mid-April). Please indicate the number of nights you would use moorage in that area each winter. Then, indicate how many of those would be "in" on Saturday night and "out" Sunday morning, and on how many occasions you would make shopping or service stops.

Area	Total number of nights would use	Number of Saturday Nights	Shopping or Service Stops
None(0)	______	______	______
1	______	______	______
2	______	______	______
3	______	______	______
4	______	______	______
5	______	______	______
6	______	______	______
7	______	______	______
8	______	______	______
9	______	______	______
10	______	______	______
11	______	______	______
12	______	______	______
13	______	______	______
14	______	______	______
15	______	______	______
16	______	______	______
17	______	______	______
18	______	______	______
19	______	______	______

XIX. At prevailing prices, what type of temporary moorage would you like to rent in winter? (Please circle).

1-wet covered 2-wet open 3-dry covered 4-dry open 5-none

XX. Is the lack of adequate moorage facilities keeping you from buying a different type boat? (Please circle) 1-Yes 2-No

XXI. Please circle every number that represents a map area in which you now use trailer boat launching ramps or would use new launching ramps. Also, please indicate the number of times you would use them in each area, (call "in and out" one time) and the number of these times which would fall on a weekend or holiday.

Area	Total times per year would use	Number of these that would fall on weekend or holiday	Area	Total times per year would use	Number of these that would fall on weekend or holiday
None(0)	______	______			
1	______	______	11	______	______
2	______	______	12	______	______
3	______	______	13	______	______
4	______	______	14	______	______
5	______	______	15	______	______
6	______	______	16	______	______
7	______	______	17	______	______
8	______	______	18	______	______
9	______	______	19	______	______
10	______	______			

Exhibit III

XXII. Please circle every number that represents a map area in which you now use daytime beach and picnic facilities or would use new facilities. Also please indicate the number of days on which you would use them and the number of those days that would be on a weekend or holiday.

Area	Total times per year would use	Number of these days that would be on a weekend or holiday	Area	Total times per year would use	Number of these days that would be on a weekend or holiday
None(0)	______	______			
1	______	______	11	______	______
2	______	______	12	______	______
3	______	______	13	______	______
4	______	______	14	______	______
5	______	______	15	______	______
6	______	______	16	______	______
7	______	______	17	______	______
8	______	______	18	______	______
9	______	______	19	______	______
10	______	______			

XXIII. Please circle every number that represents a map area in which you now use overnight camping facilities designed for boaters or would use new facilities. Also, please indicate the number of nights you would use them per year and how many of those nights would be Saturday or the night before a holiday.

Area	Total nights would use	Number of these nights that would be a Saturday or night before a holiday	Area	Total nights would use	Number of these nights that would be a Saturday or night before a holiday
None(0)	______	______			
1	______	______	11	______	______
2	______	______	12	______	______
3	______	______	13	______	______
4	______	______	14	______	______
5	______	______	15	______	______
6	______	______	16	______	______
7	______	______	17	______	______
8	______	______	18	______	______
9	______	______	19	______	______
10	______	______			

XXIV. In which of the areas do you ever use or need a harbor to get out of heavy weather? (Please circle)

None 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Section C

We think that if facilities were ideal, use patterns might be different than they are now. Therefore, for comparison purposes, we would like to ask two questions you answered earlier. This time, we want to know what you would do if facilities were ideal for your purposes, if they already are, then your answers will be the same as before. If not, then your answers may either be the same as before or different.

XXV. If facilities were ideal for you, approximately how many hours per year would you use your boat? ________hrs/year

XXVI. If facilities were ideal for you, approximately what percent of those hours would be devoted to one day cruises in and out of your home moorage? __________%

SECTION D

Now, we would like to get some information on what moorages should be like.

XXVII. Please answer this question only if you do use or would use some permanent moorage facility. Please circle each of the following facilities you use or would use at your permanent moorage, if available.

1-walk-in lockers	5-ice supply	9-boat repair	13-showers
2-small lockers	6-fishing supplies	10-engine repair	14-laundry facilities
3-marine supply	7-restaurant	11-launching hoist	
4-fresh water	8-electric power	12-fuel and oil supply	

XXVIII. Please circle each of the following facilities you use or would use at a temporary moorage, if available.

1-walk-in lockers	5-ice supply	9-boat repair	13-showers
2-small lockers	6-fishing supplies	10-engine repair	14-laundry facilities
3-marine supply	7-restaurant	11-launching hoist	
4-fresh water	8-electric power	12-fuel and oil supply	

SECTION E

An important matter of concern is debris control and obstacle marking.

XXIX. Did your boat incur any underway damage during 1965 or 1966? (Please circle) 1-Yes 2-No (If no, skip to end)

XXX. Cause of damage? (Circle all that apply)

1-waves 2-floating debris 3-stationary underwater obstacle 4-other ____________ (Please specify)

XXXI. Amount of damage in dollars $____________

XXXII. Area in which damage occurred?

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

We would be interested in any comment you would care to make about boating facilities on Puget Sound. Please use the back of the preceding page.

Thank you for your help, we'll try to use your answers to make boating in Puget Sound more fun.

Please mail this to us in the return envelope today.

School of Business Administration
University of Washington
Seattle, Washington 98105
June 26, 1967

Ref.: NPSEN—PL—R

The District Engineer
U. S. Army Engineer District, Seattle
1519 Alaskan Way South
Seattle, Washington 98134

This letter is a report of work performed under contract #NPSSU—67-401. I have completed the specified scope of work under that contract as follows:

(a) I have designed three questionnaires to obtain data needed for economic analysis. One of these is for the Intra-Coastal Waterway Study, another for the Puget Sound and Adjacent Waters Study, and the third is a modification of the second pertaining only to trailer boats. The first two questionnaires have been mailed out and tabulated, and the third has been mailed but is awaiting tabulation by your offices.

(b) I have specified the number of questionnaires needed in each case to obtain valid results.

(c) This letter is the required written report.

(d) I have met with Corps of Engineers Personnel on several occasions for review, discussion, and instruction in the meaning and interpretation of the questionnaire results.

The preparation of the questionnaires specified in the contract proceeded in a very careful and systematic way. Several conferences defined the problems which the surveys were intended to investigate and resulted in an initial draft for each questionnaire. The initial draft was circulated to interested parties, and, on the basis of their comments and of additional conferences with Corps of Engineers personnel and others, there was some redefinition of the problems and revision of the questionnaires.

Each questionnaire was then field tested. The test was conducted by Corps personnel and consisted of observed completion of the questionnaire by approximately twenty arbitrarily selected members of the boating population. A final revision of the questionnaire was made as a result of the test.

Whenever we make inferences about a population by investigating a portion of that population rather than the entire population, we run the risk that those inferences will be in error. But, whenever we select our sample randomly, we are helped by the fact that it is then subject to the laws of probability, and we can make some statement about the probability of our error. That statement depends upon the variability of the answers which we receive to the questions we ask, and upon the size of our sample. If all respondents give the same or very similar answers, then our error will be smaller. If all respondents give widely differing answers, then our error will be larger. If the sample is a very large one, then our error will be smaller. If the sample is a very small one, then our error will be larger.

Since we do not know before we draw our sample how variable the answers to our questions will be, we estimate or assume the extent of that variability and then design our sample size to give us some probability of error and some limit of error that we are willing to accept. Thus, in these surveys, the estimates of variability of response and of the numbers of people who would respond to the questionnaire, coupled with the acceptable limits and size of error, led to the decision to draw a sample of 1600 for each survey.

Therefore, for each questionnaire, Corps personnel drew a random sample of 1600 boat owners from the United States Coast Guard list of registered boats in the geographic area under consideration.

The questionnaires were then mailed to this sample with an explanatory letter and a request to respond, and after ten days, the members of the sample who had not responded were sent another copy of the questionnaire with an additional request to respond.

After adjustment for minor errors in the Coast Guard list, which were discovered during the mailing, approximately 70 per cent of each sample responded. This is an unusually high response rate for mail samples of this sort and is a result of which the Corps can be justly proud.

Each questionnaire was then edited for errors and consistency by Corps personnel and coded for computer tabulation. In addition, Corps personnel wrote the computer program to my specifications, and I personally reviewed the results of the test runs of that program.

After the completion of computer tabulation, I held a conference with Corps personnel regarding the interpretation of the results. In addition, I stand ready to review their final report should they wish to have me do so.

Strictly speaking statistical reliability for surveys such as these cannot be computed for the entire population of boat owners, because 30% of the sample did not respond. However, for that sub-population represented by the 70% who did respond, we can make very precise estimates of our error. These are still estimates, however, because in order to know the true amount of error, we would have to know the exact values of the population parameters and these, of course, we could never know unless we had investigated the entire population, rather than just a sample.

According to a well known statistical theorem, the Central Limit theorem, if we were to draw another sample from this same population, and then another and then another until we had drawn a very large number of such samples, and if, from each of those samples, we computed an average value in which we were interested, those average values would distribute themselves around the true average value of the population in a normal, bell-shaped distribution. The measure of the variability of that distribution is called Standard Error and is computed for two different cases by the formulas below. For the first case, which we call an attribute, the formula is:

$$P = \frac{pq}{n}$$

where:

P = Standard Error of the Percentage
p = the probability that the population has the attribute in question
q = 1-p
n = sample size

Since we do not know p or q for the population, we compute them for the sample and use those values in our computations. The result, therefore, is an estimate but a very accurate one.

For the second case, which we call a variable, the formula is:

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$$

where:

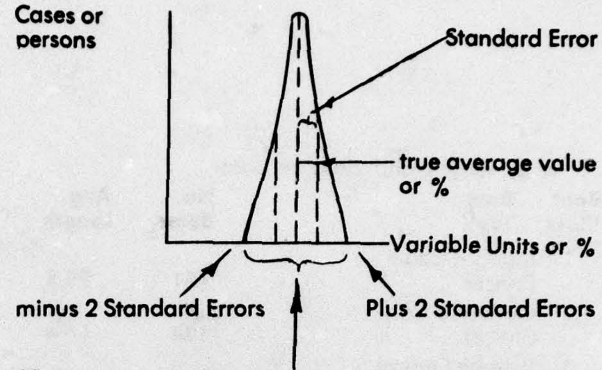
$\sigma_{\bar{x}}$ = Standard Error of the Mean
σ = Standard Deviation of the Population

Since we do not know , we compute it for the sample and use that value in our computations. The result, again, is an estimate.

Because not every respondent will provide a usable response to every question for one reason or another, the value of n will usually be different for each question, leading to a different standard error for each question. Where appropriate, the computer tabulations contain the standard error, which will permit the Corps to make a statement such as the following:

"95 times out of 100 the true population statistic for this item will be the stated value plus or minus **(two times the stated standard error)**."
5%

Such a statement is possible, because according to the laws of probability, the true value plus or minus the Standard Error will contain the value computed from a given sample, 2 times out of 3, and plus or minus two times the Standard Error will contain the value computed from a given sample 95 times out of 100. The figure below illustrates the point:



95 times out of 100 this area will contain the average value for the percent computed from a given sample.

The key to knowing whether or not these reliability statements can also reasonably be expected to pertain to the entire population of boat owners lies in knowing something about the 30% non-respondents. At my suggestion, Corps personnel drew a random sample of one-hundred from the non-respondents to each questionnaire and made several attempts to contact each by telephone. The exact results of these efforts are in your hands. Generally speaking, according to the initial analysis, there seems to be no consistent bias among the non-respondents, and if the inferences are drawn according to the instructions which I set forth in my last meeting with the persons in charge of the surveys, the Corps can be quite confident that they will provide a valid basis for making economic analyses of boating for the intended purposes.

Obviously, these inferences must be tempered with judgment, because the surveys have discovered what the boating population **says it will do,** not what it **actually does,** and we know from experience that what people **say they will do** is oftentimes different from what they **actually do.** However, given the kinds of questions which people were asked in these surveys, the subject matter of the surveys, and the care with which the surveys were constructed, considerable reliance on the results seems justified.

All-in-all these surveys provide, in my judgment, a sound basis for making decisions with regard to boating in Puget Sound. The very high response rate makes them useful as base-line studies for comparison purposes in future years. They are well-defined, carefully performed, and should prove to be of great benefit to the Corps.

Sincerely,
F. L. DENMAN (signed)
F. L. Denman, Ph.D.

FLD:alh

SUMMARY OF REPLIES TO PUGET SOUND AND ADJACENT WATERWAYS RECREATIONAL BOAT USE QUESTIONNAIRE

1. & 3. Length and class of boat:

Boat Class	Boat Type	No. Boats	Avg. Length
1	Inboard Cabin Cruiser	151	25.3
2	Outboard Cabin Cruiser	124	16.4
3	Remote Control Outboard	345	15.6
4	Other Outboard	50	15.5
5	Aux. Sail	9	29.8
6	Other	23	18.3

2. Do you have a trailer for your boat?
477 Yes
224 No

4. Horsepower of boat:

Class	Average Horsepower
1	159.3
2	61.9
3	44.9
4	36.1
5	33.7
6	121.1

5. Hull material

Material	No. of boats
1. Wood	481
2. Steel	1
3. Aluminum	5
4. Fiberglass	210
5. Other	4

6. & 7. Hours of boat use in 1966 and % of hours devoted to one day or less cruises in and out of home moorages:
167.6 Hours used
74.4 % one day cruises

8. Gallons of fuel consumed in 1966:

Boat Class	Avg. Gal.
1	536.9
2	269.5
3	174.0
4	97.6
5	106.1
6	650.2

9. Type of fuel:

Gas	Diesel Oil	Other
691	10	1

10. Use boat year around:
Yes 251
No 448

11. Boating Season (those who don't use their boat year around)

Month	Boater Use
Jan	4
Feb	12
Mar	31
Apr	148
May	335
June	440
July	458
Aug	456
Sept	437
Oct	234
Nov	34
Dec	9

12. Areas were permanent moorage is or would be used in summer:
Total response—705

Area	Response	%	Area	Response	%
1	8	1.1	10	8	1.1
2	17	2.4	11	11	1.6
3	19	2.7	12	41	5.8
4	6	0.9	13	12	1.7
5	18	2.6	14	20	2.8
6	5	0.7	15	10	1.4
7	44	6.2	16	12	1.7
8	88	12.5	17	6	0.9
9	30	4.3	18	12	1.7
			19	22	3.1

13. Type of permanent moorage would like to rent at prevailing prices in summer:
Total response—697

Type	Resp.	%
1. Wet covered	118	16.9
2. Wet open	90	12.9
3. Dry covered	57	8.2
4. Dry open	14	2.0
5. None	419	60.1

14. Areas where permanent moorage is or would be used in winter:
Total response—705

Area	Response	%	Area	Response	%
None	435	61.7			
1	5	0.7	10	5	0.7
2	5	0.7	11	10	1.4
3	11	1.6	12	33	4.7
4	4	0.6	13	8	1.1
5	7	1.0	14	15	2.1
6	4	0.6	15	6	0.9
7	40	5.7	16	7	1.0
8	78	11.1	17	4	0.6
9	23	3.3	18	10	1.4
			19	3	0.4

15. Type of permanent moorage would like to rent at prevailing prices in winter:
Total response—699

Type	Response	%
1. Wet covered	107	15.3
2. Wet open	36	5.2
3. Dry covered	111	15.9
4. Dry open	1	0.1
5. None	445	63.7

Exhibit V

16. Areas where temporary moorage is used or would be used in summer:
Total response—705

Area	Response	%	Area	Response	%
None	376	53.3			
1	44	6.2	11	27	3.8
2	175	24.8	12	40	5.7
3	103	14.6	13	51	7.2
4	85	12.1	14	94	13.3
5	81	11.5	15	52	7.4
6	33	4.7	16	105	14.9
7	71	10.1	17	72	10.2
8	75	10.6	18	47	6.7
9	113	16.0	19	84	11.9
10	61	8.7			

17. Type of temporary moorage would like to rent in summer:
Total response—688

Type	Response	%
1. Wet covered	60	8.7
2. Wet open	160	23.3
3. Dry covered	31	4.5
4. Dry open	15	2.2
5. None	422	61.3

18. Areas where temporary moorage is used or would be used in winter:
Total response—705

Area	Response	%	Area	Response	%
None	540	76.6			
1	5	0.7	10	27	3.8
2	28	4.0	11	11	1.6
3	19	2.7	12	18	2.6
4	11	1.6	13	15	2.1
5	17	2.4	14	33	4.7
6	4	0.6	15	9	1.3
7	29	4.1	16	16	2.3
8	36	5.1	17	14	2.0
9	62	8.8	18	8	1.1
			19	12	1.7

19. Type of temporary moorage would like to rent in winter:
Total response—704

Type	Response	%
1. Wet covered	53	7.5
2. Wet open	66	9.4
3. Dry covered	66	9.4
4. Dry open	6	0.9
5. None	513	72.9

20. Is lack of adequate moorage facilities keeping you from buying a different type boat?

Yes 59

No 637

21. Areas where trailer boat launching ramps are or would be used, number of times used, number of times on weekend or holiday.
Total response—705

Area	Response	%	Mean Days Per Year Would Use	Mean Days Per Yr. would use on Weekend or Holiday
0(None)	298	42.3	0	0
1	28	4.0	9.1	5.9
2	45	6.4	4.0	3.2
3	86	12.2	5.4	4.4
4	51	7.2	6.9	4.8
5	41	5.8	9.0	6.7
6	36	5.1	11.1	7.8
7	109	15.5	9.6	6.6
8	140	19.9	12.3	7.9
9	51	7.2	8.1	6.4
10	27	3.8	7.1	5.7
11	48	6.8	10.1	6.8
12	62	8.8	9.8	7.0
13	38	5.4	7.3	8.5
14	61	8.7	9.5	7.2
15	69	9.8	5.4	4.7
16	77	10.9	6.4	5.1
17	28	4.0	5.0	4.3
18	45	6.4	7.4	6.7
19	121	17.2	7.6	4.8

22. Areas where daytime beach and picnic facilities are used or would be use:
Total response—707

Area	Response	%	Mean Days Per Year Would Use	Mean Days Per Yr. would use on Weekend or Holiday
0(None)	292	41.3	0	0
1	28	4.0	5.4	4.2
2	123	17.4	6.3	4.2
3	59	8.3	4.1	3.8
4	68	9.6	4.6	3.9
5	72	10.2	5.2	4.2
6	32	4.5	7.5	7.6
7	69	9.8	7.3	6.2
8	89	12.6	8.5	6.0
9	113	16.0	5.0	4.5
10	64	9.1	5.3	4.2
11	29	4.1	7.8	5.3
12	42	5.9	8.5	7.7
13	41	5.8	5.1	4.7
14	96	13.6	7.6	6.0
15	62	8.8	5.5	3.7
16	90	12.7	4.6	3.7
17	31	4.4	5.3	5.8
18	32	4.5	6.5	4.9
19	49	6.9	5.7	4.0

23. Areas where overnight camping facilities are used or would be used, number of nights used, and number of weekends or holidays used:
Total response—705

Area	Response	%	Mean Nights Per Year Would Use	Mean Nights Per Yr. would use on Weekend or Holiday
0(None)	454	64.4		
1	4	0.6	5.5	5.0
2	108	15.3	5.4	3.3
3	34	4.8	3.7	2.6
4	32	4.5	2.9	2.3
5	31	4.4	3.8	3.7
6	12	1.7	6.1	6.1
7	18	2.6	5.8	4.8
8	12	1.7	5.9	5.3
9	20	7.1	4.4	3.7
10	21	3.0	7.5	5.2
11	7	1.0	3.3	3.3
12	9	1.3	3.6	4.0
13	12	1.7	4.5	3.5
14	59	8.4	4.9	4.5
15	39	5.5	3.8	3.0
16	59	8.4	4.1	2.9
17	18	2.6	5.0	5.3
18	27	3.8	5.7	4.4
19	65	9.2	8.8	6.4

24. Areas where harbors of refuge are used or needed:
Total response—705

Area	Response	%
None	375	53.2
1	31	4.4
2	118	16.7
3	57	8.1
4	93	13.2
5	100	14.2
6	25	3.5
7	74	10.5
8	52	7.4
9	73	10.4
10	32	4.5
11	25	3.5
12	29	4.1
13	14	2.0
14	40	5.7
15	27	3.8
16	57	8.1
17	48	6.8
18	48	6.8
19	71	10.1

25. **Hours boat would be used per year if facilities were ideal:**

646 responses with an average value of 217.1 hours. This value is 29.5% higher than the present average yearly use of 167.6 hours.

26. If facilities were ideal, % of hours that would be one day cruises in and out of home moorage:
602 responses with an average % of 68.1.

27. Facilities used or which would be used at permanent moorage:
Total response—706

Facility	No. Use	%
1. Walk-in lockers	45	6.4
2. Small lockers	76	10.8
3. Marine supply	182	25.8
4. Fresh water	250	35.4
5. Ice supply	212	30.0
6. Fishing supplies	197	27.9
7. Restaurant	166	23.5
8. Electric power	185	26.2
9. Boat repair	116	16.4
10. Engine repair	147	20.8
11. Launching hoist	167	23.7
12. Fuel and oil supply	298	42.2
13. Showers	98	13.9
14. Laundry facilities	58	8.2

28. Facilities used or would be used at temporary moorage:
Total response—705

Facility	No.	%
1. Walk-in lockers	20	2.8
2. Small lockers	39	5.5
3. Marine supply	214	30.4
4. Fresh water	325	46.1
5. Ice supply	297	42.1
6. Fishing supplies	285	40.4
7. Restaurant	313	44.4
8. Electric power	149	21.1
9. Boat repair	110	15.6
10. Engine repair	168	23.8
11. Launching hoist	170	24.1
12. Fuel and oil supply	406	57.6
13. Showers	193	27.4
14. Laundry facilities	129	18.3

29. Did your boat incur damage during 1966:
Yes 132
No 560

30. & 31. Cause of damage and amount of damage in dollars:

		%
1. Waves	8	6.1
2. Floating debris	103	78.0
3. Stationary underwater obstacle	23	17.4
4. Other	17	12.9
5. Amount (Average)	$161.20	

Total response: Damage 132
Amount 125

32. Area in which damage occurred:
Total response—122

Area	Response	%
1	1	0.8
2	11	9.0
3	2	1.6
4	4	3.3
5	10	8.2
6	3	2.5
7	7	5.7
8	35	28.7
9	20	16.4
10	5	4.1
11	2	1.6
12	6	4.9
13	4	3.3
14	9	7.4
15	2	1.6
16	6	4.9
17	4	3.3
18	6	4.9
19	5	4.1

VERIFICATION OF QUESTIONNAIRE SURVEY

Introduction

The **Pleasure Boating Study,** a comprehensive report on recreational salt water boating in Puget Sound and the Strait of Juan de Fuca, provides information on present and future boating patterns in the study area. Basic information on present boating patterns was developed from a questionnaire survey made from a sample of Coast Guard Registered boat owners. The survey, sent to a randomly selected group of 1600 boat owners in the Puget Sound Region, was designed so that its results would be applicable to all boat owners in the Puget Sound Study area. The worth of the questionnaire may be measured, in part, by comparing some of its findings with known information. For this reason several questions were included in the questionnaire to which the answers were already known. The results of these questions and the comparisons with known data are contained in the following text.

Verification

1. **Boating Season**—The boating season by percentage of boat owners using their craft for recreational purposes during different months of the year has been defined in previous Corps of Engineer survey reports for individual small boat projects. The following table gives the results of the present questionnaire survey and other surveys.

These data indicate that respondents to the questionnaire use their boats during a particular season in a manner similar to that used by respondents to other surveys. Although some percentages are higher than and some are lower than the questionnaire data, the general month to month trend is the same for all studies. The pleasure boat questionnaire is a composite of several areas such as those mentioned above, and due to its composite nature would not be expected to be identical to any of the other studies.

2. **Classification of pleasure boats**—Types of pleasure boats in various classifications have been defined in other regional studies as well as nationally. Tabulated below are the questionnaire findings for the Puget Sound study area in comparison with national figures from "Boating 1966, A Statistical Report on America's Top Family Sport" by the National Association of Engine and Boat Manufacturers (NAEBM) and The Marketing Department of the Boating Industry Association. Also presented are regional figures from the **Recreational Boating Study, Strait of Georgia Area** by N. D. Lea and Associates.

Type of Boat	Questionnaire Percentage	United States Percentage	Strait of Georgia Percentage
Inboard	9.8	7.2	11.2
Outboard	50.7	58.2	50.3
Auxiliary Sail	0.8	(with inboards)	3.8
Sail without Power	3.4	6.8	2.7
Miscellaneous	35.3	27.8	32.0
Total	100.0	100.0	100.0

Study or Questionnaire	Percent of Boaters Participating in a Month											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pleasure Boat Quest.	37	38	41	57	83	97	100	99	97	69	41	33
Mats Mats Quest.	37	41	53	79	94	100	100	100	98	83	51	38
Quilcene Quest.	20	22	26	55	86	98	100	100	99	79	41	23
Tulalip Quest.	9	10	17	45	80	98	100	100	94	56	19	10
Sekiu Quest.	11	13	23	55	83	98	100	100	94	60	21	12

3. **Hull Material**—The questionnaire derived information on the type of boat hull material used for construction of registered pleasure boats in the study area. This information is compared with boat hull material for numbered boats in the nation as developed in "Coast Guard Boating Statistics 1966."

Hull Material	Percent of Boats Questionnaire	Coast Guard Statistics
Wood	68.6	62.0
Steel	0.1	0.8
Aluminum	0.7	4.2
Fiberglass	30.0	33.0
Other	0.6	0.0

4. **Service Facilities**—Another question in the questionnaire asked respondents to indicate service facilities they would like to have at permanent or temporary moorages. A January 1964 publication by NAEBM entitled "Some Boat Owner Impressions of Marina Services" developed a similar list of desired service facilities. The NAEBM data is presented for the nation and for the West Coast. The questionnaire data presented is the demand for service facilities at temporary moorages, since boaters at a temporary moorage would be more inclined to use a variety of services. Only those services appearing on both the questionnaire and the NAEBM survey are ranked. The numbers in the list indicate relative ranking of the services.

Item	Rank: Questionnaire	National	West Coast
Fuel	1	1	1
Fresh Water	2	2	2
Restaurant	3	8	10
Ice	4	3	3
Fishing Supplies	5	9	4*
Marine Supplies	6	6	7*
Showers	7	7	7*
Repair Facilities	8	4	7*
Electricity	9	5	4*
Laundry	10	10	6
Lockers	11	11	11

*Indicates a tie.

Although this question was not included on the questionnaire solely for verification purposes, the results of the comparison indicates a correlation between services considered most important and those considered least important.

Conclusion

These comparisons substantiate data derived from the questionnaire. Application of responses from the random sample to the entire recreational boating fleet in the Puget Sound Study area yields an accurate reflection of the boating public's demands.

METHODOLOGY OF PROJECTIONS

General

The **Pleasure Boating Study** developed a variety of data on recreational boat numbers, on existing facilities, and on projection of future boat numbers and future facility demands. Existing numbers of boats and existing facilities were obtained, respectively, from a questionnaire survey and from field inventories. Projections of boater facility demands were based primarily on a report, "Projections: 1980, 2000, 2020; an Economic Study of Puget Sound and Adjacent Waters Area" by Consulting Service Corporation. This study developed projections of population, employment, and gross regional product for the twelve-county area comprising the study area. Other regional studies on recreational boating provided supplemental information.

Assumptions

The following assumptions were made in the study of pleasure boating:

1. The total growth in number of boats is directly related to population growth rates and the increased per capita income in the study area.

2. The demand for moorage and demand for boat launching ramps would grow at the same rate as pleasure boat ownership in the study area.

The derivation of boat number projections then proceeded in the following manner.

Population Growth

Population growth for the study area from the Consulting Services Corporation economic study is tabulated below.

Year	Population	Growth Factor	Annual % Growth
NORTH DIVISION			
1963	151,000		
1966	156,000①		
1980	185,500	1.19	1-1/4
2000	249,900	1.35	1-1/2
2020	341,500	1.37	1-9/16
CENTRAL DIVISION			
1963	1,603,000		
1966	1,700,000①		
1980	2,418,900	1.42	2-9/16
2000	3,882,100	1.60	2-3/8
2020	6,235,500	1.61	2-3/8
WEST DIVISION			
1963	116,000		
1966	120,000①		
1980	122,500	1.02	7/48
2000	168,500	1.38	1-19/32
2020	232,400	1.38	1-5/8

①Derived from State of Washington Census Board figures.

Per Capita Income Growth—Again, from the economic report, the following data on per capita incomes were developed.

$$\text{PER CAPITA INCOME} = \frac{\text{GROSS REGIONAL PRODUCT}}{\text{POPULATION}}$$

YEAR	NORTH DIVISION		CENTRAL DIVISION		WEST DIVISION	
1963	$ 390,000,000 / 151,000	= $ 2,583	$ 5,153,000,000 / 1,603,000	= $3,215	$ 287,000,000 / 116,000	= $2,474
1980	848,400,000 / 185,500	= $ 4,574	10,021,800,000 / 2,418,000	= $4,145	497,800,000 / 122,500	= $4,064
2000	1,798,700,000 / 249,900	= $ 7,198	24,569,300,000 / 3,882,100	= $6,329	1,066,100,000 / 168,500	= $6,327
2020	3,977,400,000 / 341,500	= $11,647	62,061,100,000 / 6,235,000	= $9,953	1,329,200,000 / 232,400	= $5,719

PER CAPITA GROWTH

	NORTH DIVISION			CENTRAL DIVISION			WEST DIVISION		
Year	**Per Capita**	**Growth Factor**	**Annual %**	**Per Capita**	**Growth Factor**	**Annual %**	**Per Capita**	**Growth Factor**	**Annual %**
1963	$ 2583			$3215			$2474		
1980	$ 4574	1.77	3-3/8	$4145	1.29	1-9/32	$4064	1.64	2-1/2
2000	$ 7198	1.57	2-5/16	$6329	1.53	2-1/8	$6327	1.56	2-1/4
2020	$11647	1.62	2-7/16	$9953	1.57	2-5/16	$5719		

Projection of Number of Boats—The data for population growth were assumed to be directly related to *boat number growth.* Growth in income, however, was taken into account for only a portion of boat number growth. This method was derived from study of a report by N. D. Lea and Associates on recreational boating in the Strait of Georgia, B.C., and a study of a report by the Puget Sound Governmental Conference on recreational boating on Puget Sound. These reports considered higher expenditures on each boat to temper the total boat number increase caused by growth in per capita income. The increasing per capita income was found to augment growth in number of boats by 1% to 1.3% in the Lea report and by 7/8% in the Puget Sound study. The projections for this study were based on a 1% increase in number of boats due to income growth as shown below.

	% Population Growth	*% Study Growth Rate*	*Compound Growth Factor*
NORTH DIVISION:			
1966-1980	1-1/4	2-1/4	1.40
1980-2000	1-1/2	2-1/2	1.64
2000-2020	1-9/16	2-9/16	1.66
CENTRAL DIVISION:			
1966-1980	2-9/16	3-9/16	1.63
1980-2000	2-3/8	3-3/8	1.94
2000-2020	2-3/8	3-3/8	1.94
WEST DIVISION:			
1966-1980	7/48	1-7/48	1.17
1980-2000	1-14/32	2-19/32	1.67
2000-2020	1-5/8	1-5/8	1.38

Application of the above data to present number of boats developed by the questionnaire study yielded the following projections:

DIVISION	1966 NO. OF BOATS	GROWTH FACTOR	1980 NO. OF BOATS	GROWTH FACTOR	2000 NO. OF BOATS	GROWTH FACTOR	2020 NO. OF BOATS
NORTH	17,000	1.40	23,800	1.64	39,000	1.66	64,700
CENTRAL	150,400	1.63	245,200	1.94	475,700	1.94	922,900
WEST	18,600	1.17	21,800	1.67	36,400	1.38	50,200
TOTAL	186,000		290,800		551,100		1,037,800

The Coast Guard registered pleasure boat growth in Washington State between 1965 and 1966 was 3.76%. Washington State Census Board data for this period indicated a population increase at 1.75%. The difference between these figures, 2.01%, was considered indicative of pleasure boat growth for reasons other than population growth. Therefore, the projections in this study are verified as conservative.

MOORAGE DEMAND

DIVISION	1966 DEMAND	GROWTH FACTORS 1980	2000	2020	FUTURE DEMAND 1980	2000	2020
North (Summer)	8,553	1.40	2.29	3.81	11,974	19,586	32,587
(Winter)	3,383	1.40	2.29	3.81	4,736	7,747	12,889
Central (Summer)	20,232	1.64	2.29	6.14	33,180	63,933	124,224
(Winter)	17,817	1.64	2.29	6.14	29,220	56,301	109,396
West (Summer)	10,537	1.17	1.96	2.70	12,328	20,653	28,450
(Winter)	5,235	1.17	1.96	2.70	6,124	10,260	14,135
Total (Summer)	39,322	....	....	....	57,482	104,172	185,261
(Winter)	26,435	....	....	....	40,080	74,308	136,420

LAUNCHING RAMP DEMAND

DIVISION	1966 DEMAND	1980	2000	2020	1980	2000	2020
North	48	1.40	2.29	3.81	67	110	182
Central	144	1.64	2.29	6.14	236	455	884
West	92	1.17	1.96	2.70	108	180	284
Total	284	....	....	....	411	745	1,350