

14th/16th Avenue South Bridge Economic Impact Analysis

Prepared for

**King County
Department of Public Works**

by

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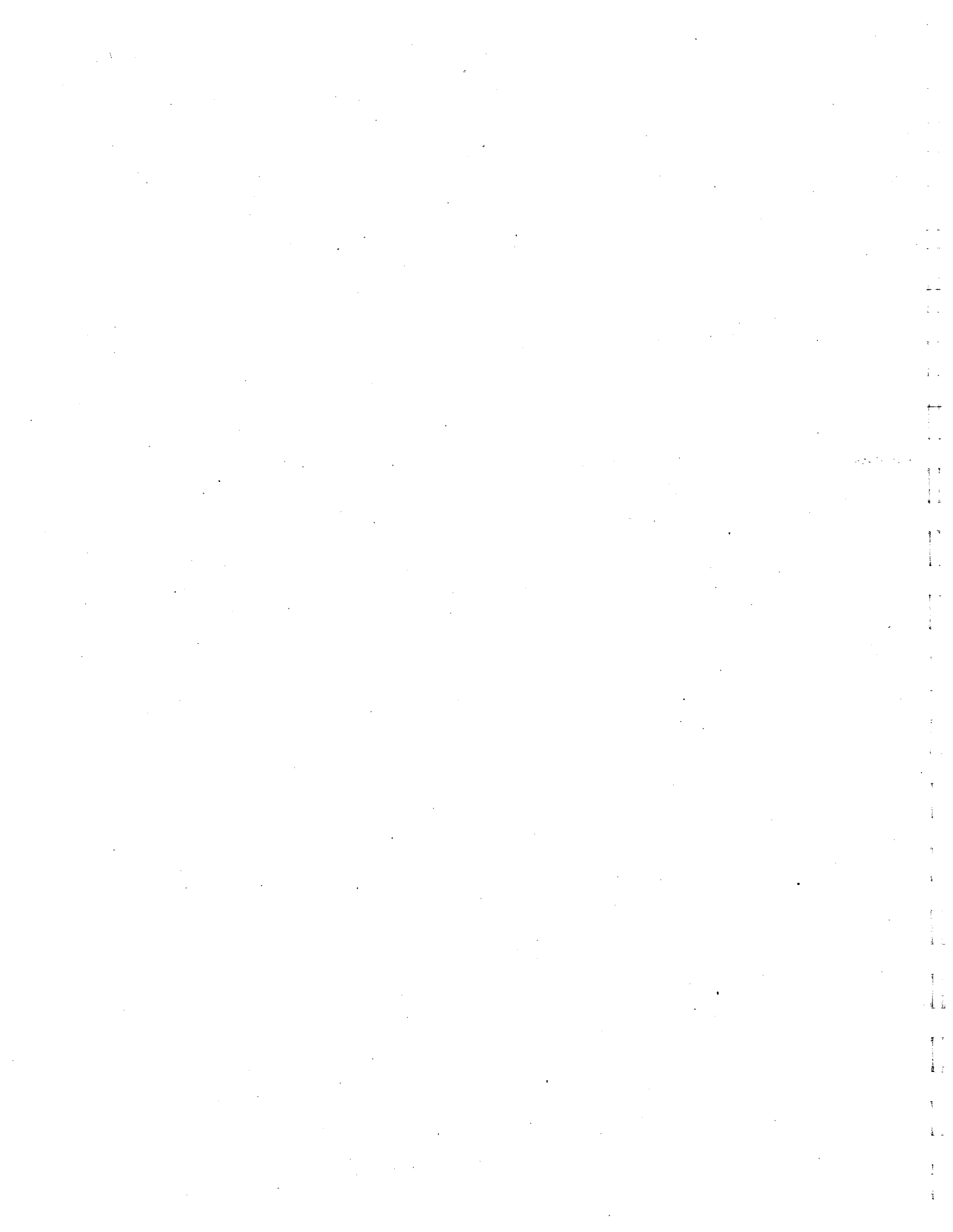
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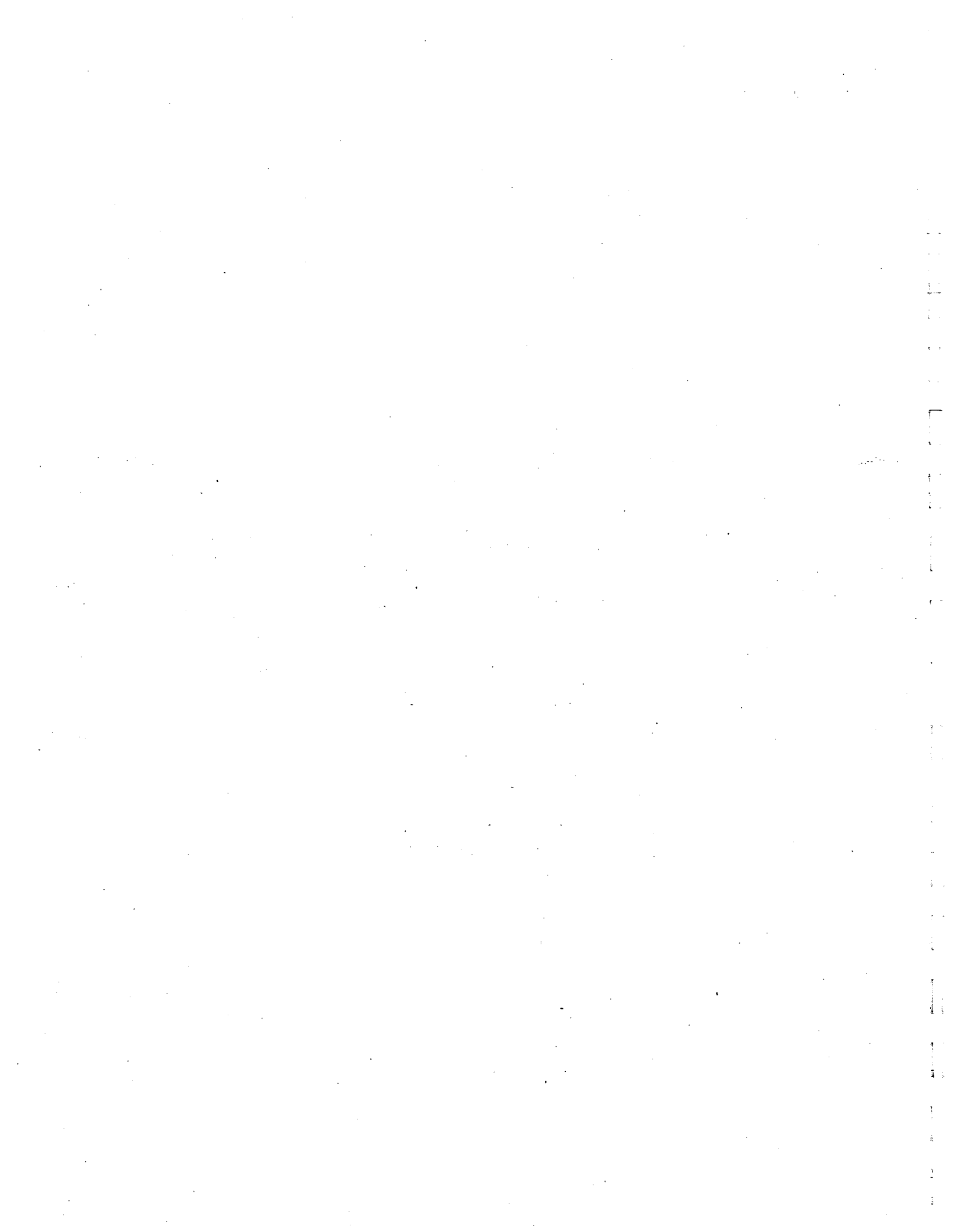
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**Chapter
One:**

Introduction



CHAPTER ONE

INTRODUCTION

The 14th/16th Avenue South Street Bridge was originally built in 1931 and over the years has sustained cracking and deterioration of the north pier. The bridge does not currently meet County standards for lateral stability in case of seismic activity. The King County Department of Public Works has conducted several studies to evaluate alternative means of improving the Bridge.

The most recent report¹ presented a summary of investigations that "compared rehabilitation of the existing 14th/16th Avenue South Bridge versus replacement with either an intermediate or high level fixed-span bridge, a moveable bridge or permanent closure of the bridge". After further analysis of traffic circulation patterns, removal of the bridge was not considered a viable option. The remaining options being considered by the County are presented below :

- Rehabilitate existing structure - \$16.5 to \$20.6 million
- Build new fixed span - 100 feet above Mean High Water (MHW) - \$31.5 to \$34.8 million
- Build new fixed span - 55-60 feet above MHW - \$19.7 to \$21.0 million
- Build new bascule bridge - \$46.2 to \$51.9 million

The lower level fixed bridge alternative (55 to 60 feet above mean high water) is the least cost replacement alternative and is approximately the same cost as rehabilitating the existing bridge (excluding ROW acquisition costs). However, there are several other factors that differentiate these alternatives in addition to cost. Specifically, the lower level fixed bridge alternative has several other advantages relative to rehabilitation of the existing bridge:

- design configuration, (the renovation of the existing bridge would require a waiver for non-compliant roadway width, reduction of the size of the sidewalks or reduction in number of lanes)
- structure life, (the replacement structures would have a longer life than rehabilitation alternatives)
- traffic disruption during construction (closure of the bridge during rehabilitation would impede traffic for approximately two years)
- traffic flow would be less effective after construction (rehabilitation of the existing bridge would most likely limit traffic flow to three

¹ **14th/16th Avenue South Bridge Rehabilitation/Replacement Design Report,**
Sverdrup March 1994

lanes as opposed to four lanes under the replacement alternatives),
and

- Traffic safety would be improved by the replacement alternatives (due to the relative number of lanes and shoulder sizes).

Sverdrup Corporation, serving as the County's Design Engineer, recommended replacement of the existing bridge using the lower fixed span option (FBR55). However, the selection of a fixed-span bridge was contingent upon permit approval of vertical restrictions by the Coast Guard.

Previous Waterway Users Study Results

As a part of earlier study efforts², the US Coast Guard posted a public notice to solicit comments on vertical clearance requirements to the proposed replacement. They received nine (9) responses to this notice from:

- U.S. Army Corps of Engineers
- Crowley Marine Services
- U.S. Department of Interior, Fish and Wildlife Service
- State of Washington Department of Community Development
- Manson Construction & Engineering Company
- U.S. Department of Commerce, National Oceanic and Atmospheric Administration
- Delta Marine Industries, Inc.
- Foss Maritime
- International Terminal Company

In addition to these nine respondents, Sverdrup staff contacted other potentially impacted waterfront businesses regarding the potential impacts. Most upriver users felt that the proposed 55 to 60 foot clearance would allow transit by tugs, barges, most recreational and commercial boats, dredging equipment and other users.

However, the identified users that would be impacted included: Manson Company, Delta Marine Industries (DMI), South Park Marina, and the Duwamish Yacht Club. The potential impacts to these facilities are described in greater detail in the following chapters.

²14th/16th Avenue South Bridge Operational Study and Life Cycle Cost Analysis
Comparing Bridge Replacement versus Rehabilitation by Sverdrup Corporation,
April 1993, Page 43

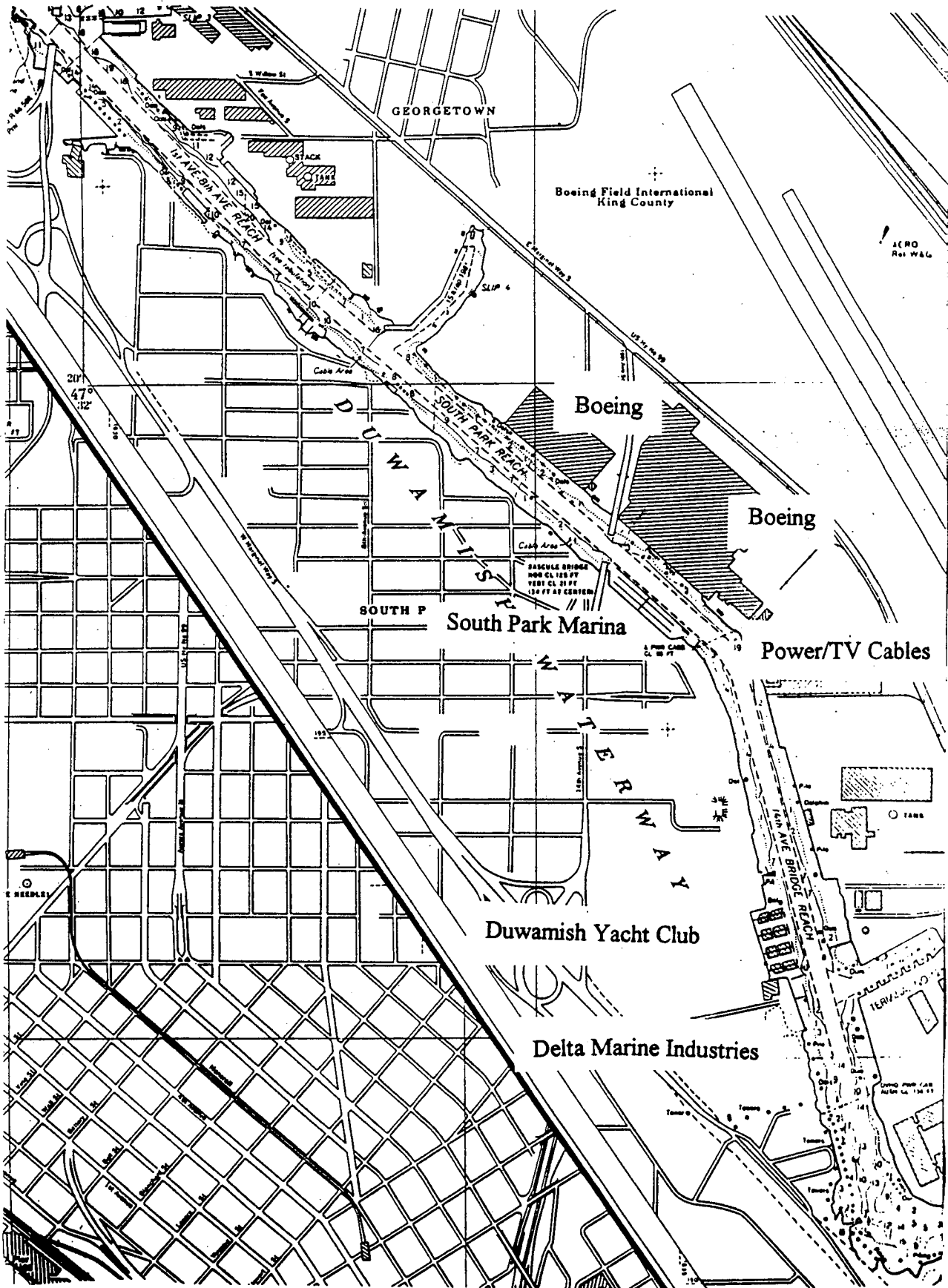
Organization and Purpose of the Report

As a result of the concerns expressed by waterway users, the Coast Guard suggested that the vertical clearance of the Bridge should be a minimum of 100 feet above MHW.

The County's desire to build a fixed span will only be accommodated by the Coast Guard and other Federal funding agencies if an economic study of existing and potential future uses is undertaken that demonstrates in a convincing manner that construction of a fixed span (55 to 60 feet above MHW) could be accomplished and still minimize (and/or compensate) the impacts to existing and potential users. This is the key objective of this study.

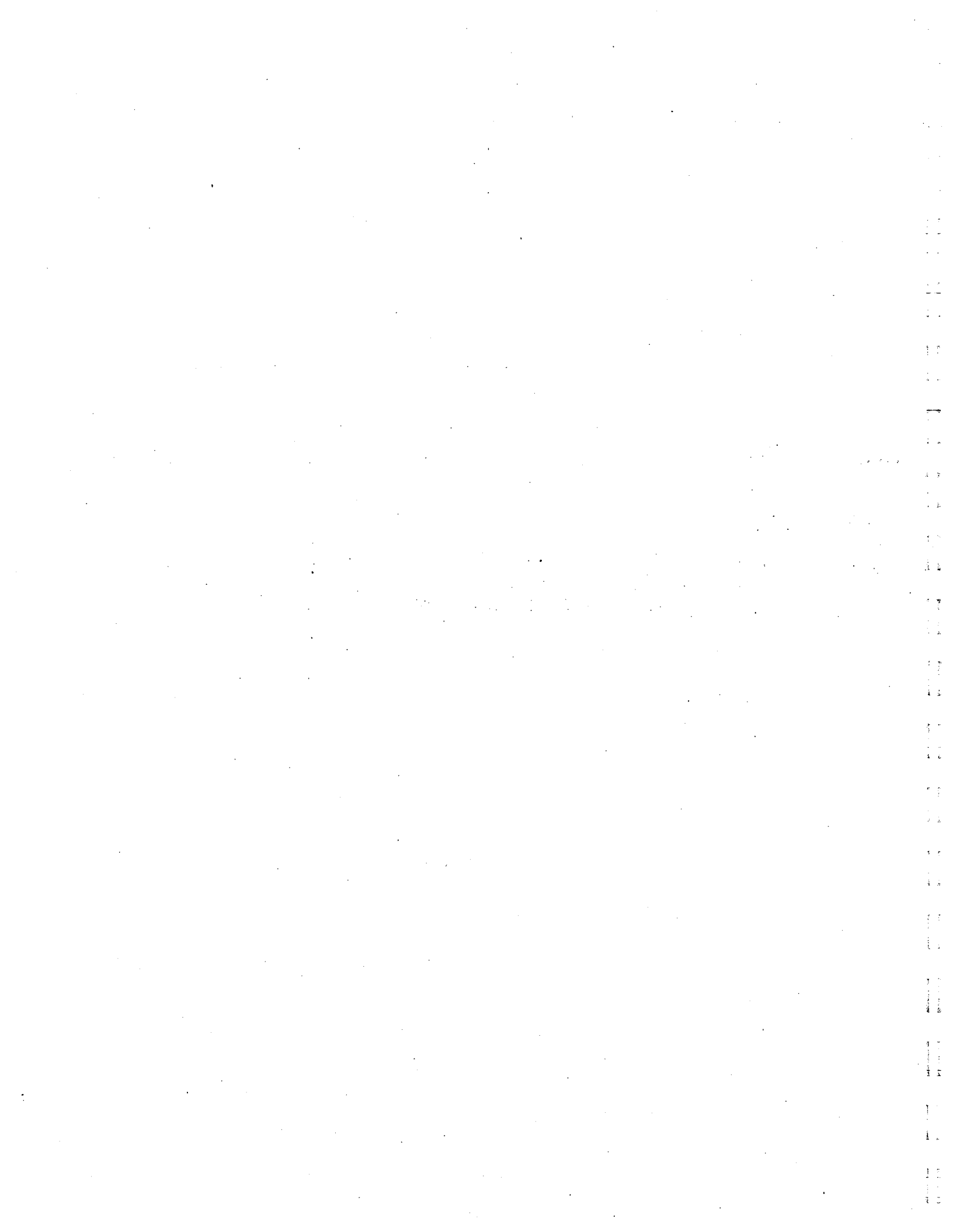
The impact analysis is organized in the following order:

- Description of Waterway and Facility Characteristics (Chapter Two)
- Description of Vessel Traffic through the Existing Bridge (Chapter Three)
- Discussion of Potential Impacts to Existing and Future Waterway Uses (Chapter Four)
- Discussion of Upland Impacts (Chapter Five)
- Conclusions and Recommendations (Chapter Six)



**Chapter
Two:**

**Waterway and
Facility
Characteristics**



CHAPTER TWO WATERWAY AND FACILITY CHARACTERISTICS

General Overview

The Duwamish River is a freshwater extension of the Seattle Harbor, extending 5.12 miles upstream from the mouth of the river at the south end of Elliott Bay. The U.S. Army Corps of Engineers (USCOE) maintains a navigational channel along the length of the waterway, which serves as the base of operations for a variety of water-dependent uses, including bulk and neo-bulk ship operations, container barge operations, dry bulk barge operations, ship building and ship repair, and recreational vessel moorage.

The 14th/16th Avenue South Bridge is near the upper end of the federally maintained channel, approximately 3.8 miles above the mouth of the river via the West Channel. Vessels sailing to the upper reaches of the channel pass through four other bridges before reaching the 14th/16th Avenue South Bridge, including three opening spans (SW Spokane Street, Burlington Northern Railroad, and 1st Avenue South) and one fixed span (West Seattle Freeway).

The following sections summarize the current configuration of the Duwamish Waterway, facilities located upriver and current uses of the channel.

Channel Characteristics

The section of the Duwamish River under study in this report is part of the Seattle Harbor navigation project, which was originally authorized by the River and Harbor Act of March 2, 1919, and modified by subsequent acts dated March 3, 1925, July 3, 1930, and August 30, 1935.

The project authorizes dredging the Duwamish Waterway 200 feet wide and 30 feet deep between the West Waterway (Spokane Street) and 1st Avenue South; 150 feet by 20 feet between 1st and 8th Avenues South; and 150 feet by 15 feet to a point approximately 1.4 miles above the 14th/16th Avenue South Bridge.

The authorization also provides for a turning basin 500 feet by 250 feet and 15 feet deep, and a settling basin with a capacity of about 100,000 cubic yards at the upper end of the waterway.

The project was completed in 1931, except for the settling basin and the turning basin south of the 1st Avenue Bridge, which were deauthorized in 1986.

While the following table shows the channel having a depth of less than 15 feet in the 14th Ave Bridge Reach at the time of the survey, the channel is maintained regularly by the Corps of Engineers at the project depth of 15 feet.

Table 1

<i>Seattle Harbor Project Dimensions and Controlling Depths - Duwamish Waterway</i>						
Name of Channel	Left Outside Quarter	Middle Half of Channel	Right Outside Quarter	Width (feet)	Length (naut miles)	Depth (feet)
Harbor Island Reach	26.7	29.1	18.3	200	0.5	30
Georgetown Reach	27.3	27.5	25.7	200	1.7	30
1st Ave/8th Ave Reach	18.1	18.2	13.3	150	0.7	20
South Park Reach	11.0	16.3	9.6	150	0.5	15
14th Ave Bridge Reach	12.0	12.3	10.7	150	0.85	15

Controlling depths from seaward in feet at Mean Lower Low Water
Source: USCOE Port Series No. 36

Currently one of the vertical height restrictions on the river is imposed by the West Seattle Freeway bridge, which has a vertical clearance of 140 feet at Mean High Water (MHW). However, TV and electrical power cables just upstream of the 14th/16th Avenue South Bridge also constrain vertical heights passing through this reach of the River. This is described in greater detail in the following sections.

Description of Vertical Constraints Impacting the Waterway

Bridges

As listed in the following table five bridges cross the navigation channel of the Duwamish Waterway, between Elliott Bay and the upper end of the navigable waterway. The table lists clearances for all five bridges, including channel width, bridge type, and clearance height at high water. Clearances are listed at mean high water (MHW) because the waterway is subject to tidal fluctuations.

In addition to these existing bridges, construction is scheduled to begin shortly on a second bascule bridge adjacent to and aligned with the existing 1st Avenue South Bridge. The design of this new span is such that the dimensions of the Duwamish River Navigation Channel will not be affected.

<i>Seattle Harbor Project Dimensions</i>					
<i>List of Bridges</i>					
<i>Duwamish Waterway</i>					
Miles above mouth	Location and Name	Type	Horizontal Clearance (feet)	Vertical Clearance (feet HW)	Remarks
0.2	West Seattle Freeway	Fixed	150	140	
0.3	SW Spokane Street (West Seattle low level)	Swing	240	55	
0.4	Burlington Northern Railroad	Bascule	150	7	
2.5	1st Avenue, South	Bascule	150	24	120 feet between open leaves
3.8	14th Avenue, South	Bascule	125	21	41 feet at center of span
Controlling depths from seaward in feet at mean lower low water					
Source: USCOE Port Series No. 36					

Cables

In addition to the bridges listed above, there is also a powerline crossing the Duwamish just south of the 14th/16th Avenue South Bridge at 17th Avenue South and South Dallas Street. According to NOAA charts, this line has an authorized clearance of 90 feet high at MHW.

According to the Seattle City Light personnel (Mr. Tom Teevin) the midconductor of the powerline crossing the Duwamish River at 17th S and S Dallas is a main distribution line for The Boeing Company and has an authorized clearance of 90 feet above MHW. With the above clearance requirement, vessel height is restricted to 90 feet above MHW. This is the controlling height restriction which impacts all users upriver of the 14th/16th Avenue South Bridge, south of South Park Marina. This limitation impacts Delta Marine Industries, Inc and the Duwamish Yacht Club and other waterway users at the upper end of the waterway.

A 20-foot safety allowance is mandated by the Code of Federal Regulations (CFR Chapter 11 (7-1-93 Edition, page 430):

"The following minimum clearances are required for aerial power transmission lines crossing navigable waters of the United States. These clearances are related to the clearances over the navigable channel provided by existing fixed bridges, or the clearances which would be required by the U.S. Coast Guard for new bridges, in the vicinity of the proposed power line crossing. The clearances are based on the low point of the line under conditions which produce the greatest sag taking into consideration temperature, load, wind, length or span and type of supports as outlined in the National Electrical Safety Code (see Table 3)."

Table 3

<i>Clearance Requirements for Transmission Lines across Navigable Waterways</i>	
Nominal system Voltage (kV)	Minimum additional clearance (in feet) above clearance required for bridges
115 and below	20
138	22
161	24
230	26
350	30
500	35
700	42
750-765	45

Source: United States Code of Federal Regulations

There is also a TV cable located at this crossing. The 90 foot vertical height constraint (above MHW) is the controlling factor limiting navigation upriver of this point.

This crossing is located at the approximate midpoint of Boeing Field and as a result, is governed by the height restriction zone of Boeing Field. A formal request to ascertain height restriction impacts has been submitted by Sverdrup personnel.

Modifying the height of the crossing to allow transit by larger vessels is problematic for a number of reasons. First, the Boeing Company needs an uninterrupted supply of power which eliminates the option of temporarily removing the line. Second, City Light has an easement for this crossing and efforts to relocate the crossing would be extremely expensive. Third, the proximity of the crossing to Boeing Field places a restriction on the height of the towers. In short, allowing temporary or permanent access to vessels with a height above 90 feet will be very expensive if not impossible.

Tidal Influence

The proximity of the lower Duwamish River to an arm of the Pacific Ocean (Elliott Bay) causes the river level to vary with the tide more than eight feet at the upper end of the channel. The following table documents the range of tides both in Elliott Bay (at the foot of Madison Street) and in the Duwamish River at 8th Avenue South, approximately 0.5 miles downstream from the 14th/16th Avenue South Bridge (the nearest measurement point to the bridge).

As shown in the table above, the level of the river in the Duwamish Waterway varies 7.5 feet between Mean Low Water (MLW) and Mean

High Water (MHW) 11.1 feet between MHW and MLLW and as much as 15.9 feet between Mean Higher High Water (MHHW) and Extreme Low Water. At MLW, the vertical bridge clearances increase by 7.5 feet giving the fixed West Seattle Freeway span a clearance of 147.5 feet and the 14th/16th Avenue South Bridge a clearance of 48.5 feet at the center of the span.

Table 4

<i>Tides in Elliott Bay and the Duwamish River (sounding in feet at Mean Lower Low Water)</i>				
Location	MHHW	MHW	MLW	Extreme Low
Elliott Bay	11.4	10.5	2.8	-4.5
Duwamish Waterway	11.1	10.3	2.8	-
Source: NOAA Chart 18450				

With an air draft clearance allowance of 2.5 feet, the existing 14th/16th Avenue South Bridge has a usable clearance of 46 feet in the closed position.

ADD 5'
for low tide
clearance

Replacement of the bridge by a fixed-span bridge 55 to 60 feet above MHW would yield a usable vertical clearance of approximately 60 to 65 feet at MLW.

Using the tides to maximize passage is suitable for virtually all current users of the waterway. This procedure is used at numerous other fixed bridge spans throughout the United States. Discussions with U.S. Army Corps of Engineers (headquarters division in Washington) and State Transportation officials in the southeast United States illustrates that several movable-span bridges are being replaced with fixed span bridges. These fixed-span bridges are sized to allow transit by vessels with a height up to 65 feet. This trend is discussed in greater detail in the following chapter.

Facilities Located Above the 14th/16th Avenue South Bridge

The following section briefly describes the waterfront facilities that are located upriver of the 14th/16th Street bridge. Chapter 4 provides greater details on potential facility impacts due to height restrictions from the fixed spans.

Figure 1

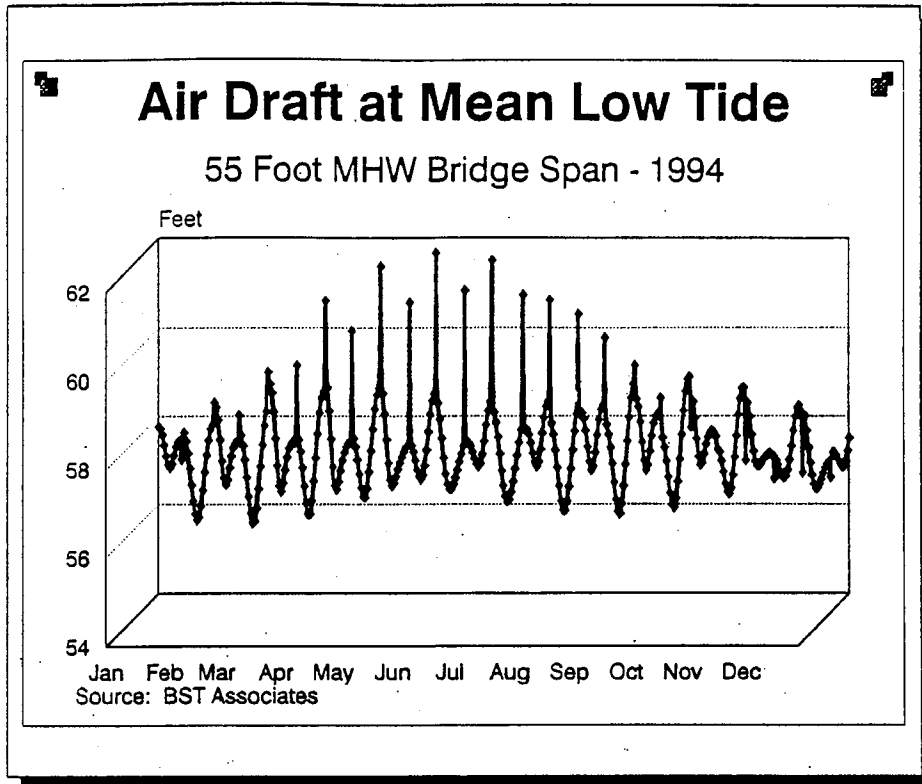
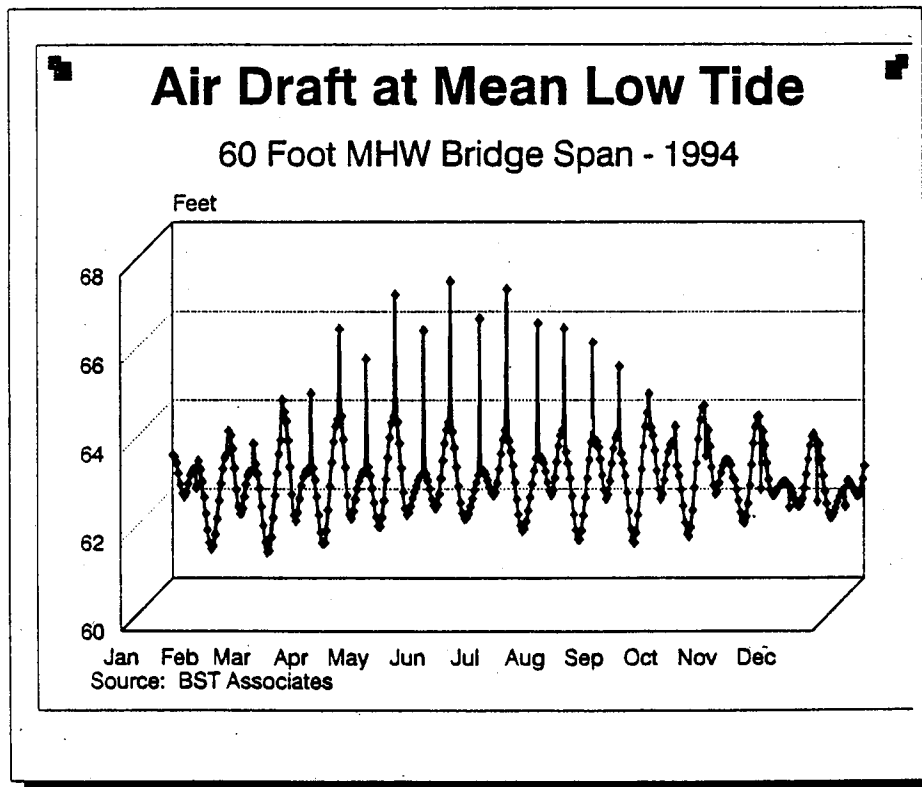


Figure 2



The Corps of Engineers Port Series No. 36 lists two dock facilities upriver from the 14th/16th Avenue South Bridge: the Boeing Company Wharf, and Delta Marine Industries Wharf. (See map on page 4).

The Boeing Company Wharf

The Boeing Company owns or controls most of the land on the east side of the Duwamish River between the 14th/16th Avenue South Bridge and the end of the navigation channel (with the exception of the idled Monsanto Chemical facility and a Kenworth truck facility). The Boeing Company Wharf consists of a series of six concrete-decked loading platforms, 30 feet by 30 feet each and 16 feet high, with a depth alongside of 18 feet. The Boeing Defense and Space Group controls the wharf, but the facility is currently not in use and is fenced off. Prior to purchase of this facility by Boeing in 1985 this property was used by SeaFreeze, a cold storage firm which received fish from fishing vessels.

Boeing has used heavy-lift marine equipment in the distant past to assist with placement of air conditioning equipment and other equipment on company buildings. However, a Boeing spokesman indicated that the change from a manufacturing to a mockup/testing plant would minimize the need for heavy lift operations.

Further discussions with Boeing officials indicated that the proposed bridge height would not constrain any existing or potential company plans for use of the waterway. Previous use of Manson heavy lift equipment to place HVAC equipment on Boeing buildings occurred long ago and is unlikely to occur again.³

Monsanto Wharf

In February of 1991, Rhone Poulenc purchased the Monsanto Wharf which is also located in Slip 6. When active, this facility received lignin and caustic soda by barge from pulp/paper and chemical plants respectively. Barge activity averaged 2 barges per week during this period, according to a company spokesman.⁴

Since its acquisition by Rhone Poulenc the facility has been idle because the company shifted the manufacture of vanillin to the S.E. United States. Rhone Poulenc no longer needs the wharf and has attempted to lease or sell the facility. Efforts to date to lease or sell the wharf have been unsuccessful because of the facility's distance upriver and concerns about the environmental status of sediments adjacent to the wharf.⁵

³Telephone Conversations with Jeff Zahir, Manager, Corporate Planning, The Boeing Company, date : July 19, 1994

⁴Telephone conversation with Buzz Rahier, Rhone Poulenc, date July 19, 1994

⁵Telephone conversation with Rick Osterhout, CB-Commercial, date July 19, 1994

The Delta Marine Industries Wharf

The Delta Marine Industries Wharf is located on the west side of the Duwamish River across from the Boeing Company Wharf. The facility consists of a row of permanently-moored 8-foot wide floats used for outfitting and repairing vessels. A shop at the back of the property is used for manufacturing fiberglass fishing and recreational boats. The wharf includes a 125-ton electric-hydraulic stiff-leg derrick with a 105-foot boom mounted on a bull-wheel. This derrick can lift Purse Seiners and other craft that weigh approximately 100 tons or less.

DMI builds and repairs motor yachts and fishing vessels. Vertical clearance allowing transit by vessels built and/or repaired at DMI could be impacted using a lower level span (i.e., 55 feet to 60 feet) according to DMI's response to the Coast Guard public notice. This potential impact is reviewed in greater detail in the next chapter.

In addition, DMI launches and retrieves larger vessels using floating derricks. Manson provides this service with company owned floating derricks (i.e., such as the Haakan, Manson 24 and other derricks) which can require up to 100 feet of clearance. These potential impacts are also discussed in greater detail below.

South Park Marina and Duwamish Yacht Club

In addition to these facilities, there are two recreational marinas (South Park Marina and Duwamish Yacht Club) and a barge mooring area.

The Waterways User Study undertaken by Sverdrup Corporation indicated that South Park Marina and the Duwamish Yacht Club could be impacted by height restrictions depending on the height of the fixed span. According to this study, "the maximum boat height (in the South Park Marina) is approximately 60 feet and only two or three boats are greater than 50 feet in height. The tenants displaced by a height restriction could be replaced without hardship. Therefore the impacts to the South Park Marina would be negligible although the proposed 55 feet height would limit the time when taller boats could pass beneath the bridge to lower tides" (Page 44).

Duwamish Yacht Club was reported in the same study to have 42 uncovered slips whose owners' vessels would all be impacted at 55 feet and 13 of which would be impacted at 60 feet. This potential impact associated with height restrictions to sailboats appears to be overstated based upon a more detailed review of vessel characteristics and discussions with the sailboat representative of the Yacht Club.

South Park Marina

The South Park Marina is located immediately upstream of the 14th/16th Avenue South Bridge on the west bank and has moorage space for 150

boats. The fixed spans would have minimal impact on the marina according to the owner.⁶

Moorage charges are \$5.25 per foot per month at this marina. The marina is full and has a waiting list. The tenants tend to be people who work in the area (e.g. especially at Boeing) rather than local residents, so one advantage of the location is its proximity to places of employment. Another advantage of mooring upriver is the freshwater environment, which is much less corrosive on boats than saltwater. Also, despite the fact that the marina is approximately five miles from open water the trip only takes 45 minutes at the posted speed limit of 7 knots. This compares very favorably with moorage in Lake Union, which is also freshwater but is more expensive, and requires a trip through the government locks to reach saltwater.

Duwamish Yacht Club

The Duwamish Yacht Club is located farther upstream adjacent to Delta Marine Industries.

The Yacht Club has 106 slips of which 64 are covered and 42 uncovered. According to a tenant of the facility (who represents the sailboat owners in the facility), there are currently 9 sailboats in the yacht club, with an average mast height of 57 feet from the water line. According to the sailboat representative of the Yacht Club, there would be minimal impact if the span was 60 feet above MHW.⁷

Impacts to recreational vessels are discussed in greater detail below.

Kenco Marine facility

In addition to the above mentioned facilities, barges and vessels are also moored to pilings at the Kenco Marine facility which is on the western bank of the turning basin, at the upper end of the navigation project. This area is upstream from all other water-oriented activities on the Duwamish Waterway. A company owner indicated that the proposed fixed spans would have limited impact on company operations.⁸

Beyond this point upstream the river is blocked to navigation by a number of low-level fixed bridges which precludes passage by all but the smallest vessels.

⁶Interview with Guy Crow, owner and operator of South Park Marina.

⁷Telephone conversation with Brian Guptil, date July 19, 1994.

⁸Telephone conversation with Tom Kent, July 18, 1994

Summary Conclusions

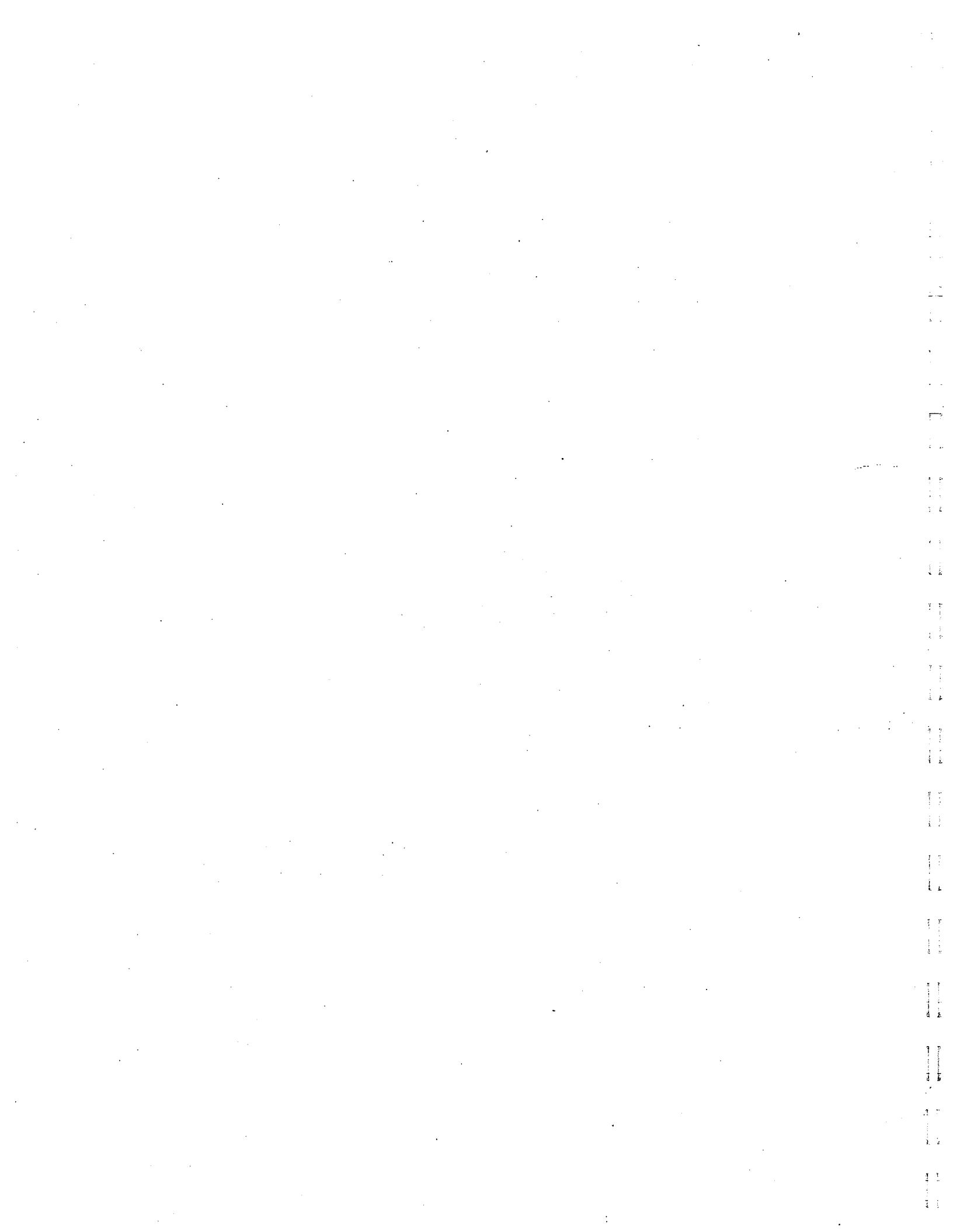
A 55-foot-high or 60-foot-high fixed-span bridge (above MHW) would limit navigation for vessels to a height of 60 to 65 feet above the water line with the use of tides. This restriction would impact the Manson derricks which currently provide lifting service to Delta Marine Industries (DMI). The 55 foot high fixed span would also impact a few resident sailboats but the 60 foot high span would eliminate the impact to sailboats.

Further discussion with Delta Marine Industries indicated that a bridge 62 to 63 feet above mean high water would be acceptable to DMI.

Vertical height restrictions of 90 feet (above MHW) are imposed by the distribution power lines serving Boeing which are located one block south of the 14th/16th Avenue Bridge. This height restriction essentially eliminates the potential for very large power sailers (i.e., with masts greater than 90 feet) to use the waterway upriver of the bridge.

**Chapter
Three:**

**Vessel Traffic
Trends**



CHAPTER THREE

VESSEL TRAFFIC TRENDS

Overview of Vessel Traffic

Vessel traffic passing through the 14th/16th Avenue Bridge Reach of the Duwamish Waterway falls primarily into the following categories:

- tugs moving alone or with barges/derricks,
- barges/derricks
- fishing vessels
- recreational vessels with moorage at South Park Marina or the Duwamish Yacht Club, and
- motor yachts moving to and from Delta Marine Industries,

No ocean freighters use this stretch of the waterway due to the limited dimensions of the channel. In addition, there are no existing active cargo facilities located in this reach of the Duwamish River.

As can be seen in Table 5 and Figures 2 and 3, vessel traffic requiring an opening of the 14th/16th Avenue South Street bridge has declined markedly from 1989 and 1990 to the present. In 1989 and 1990, there were 1,726 and 1,704 openings, respectively. In 1991 and 1992, openings decreased to 1,228 and 1,228. In 1993, openings fell further to 877 occurrences.

All vessel traffic categories experienced a decrease in activity but the greatest decline was in tugs (and their tows). This category fell from a high of 805 transits in 1990 to just 114 in 1993 due to two primary factors. First, the closing of the Monsanto plant in 1991 reduced the number of tug/barges in the area by approximately 200 operations per year. Second, the Duwamish was dredged in 1990 requiring several hundred tug and barge operations.

In addition to the decline in tug/barge traffic, sailboats declined from a high of 802 operations in 1989 to 567 in 1993 (primarily due to the poor weather in 1993) and fishing vessels declined from a high of 195 operations in 1991 to 114 in 1993 (the reason for this decrease is unknown).

The following section of this report discusses each of these types of vessels that currently use or could use the stretch of the Duwamish Waterway above the 14th/16th Avenue South Bridge in detail.

Figure 3

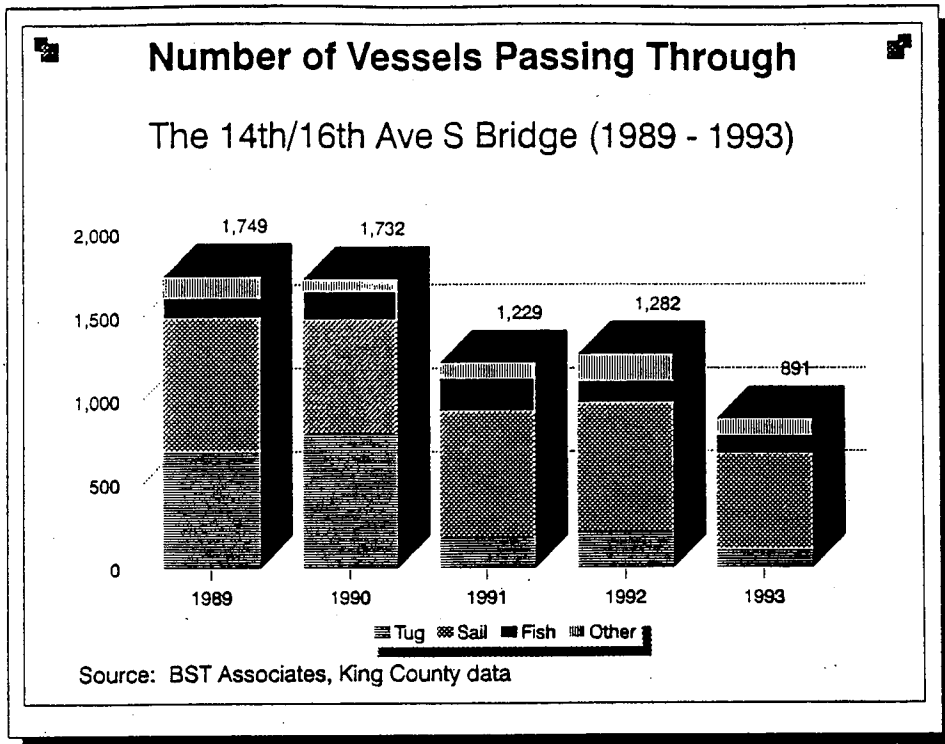


Figure 4

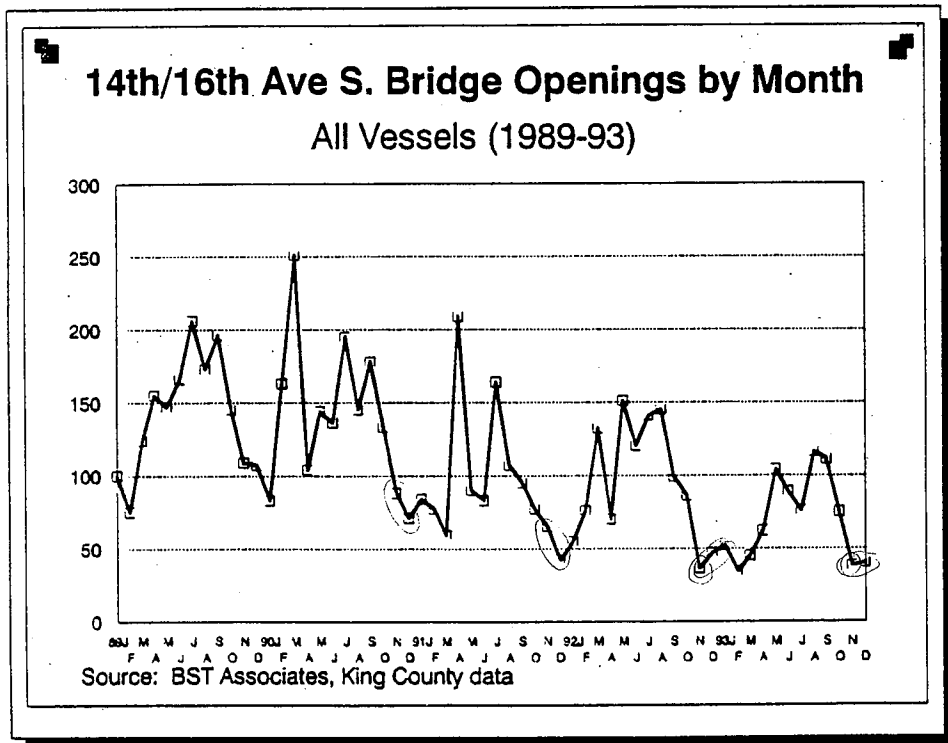


Table 5

<i>Vessels requiring a Bridge Opening by Type and Year</i>					
TYPE	1989	1990	1991	1992	1993
TUG	704	805	183	214	114
SAIL	802	687	759	777	567
FISH	120	168	195	131	114
OTHER					
M/V	70	25	12	33	46
PASSENGER	0	0	0	1	0
PILOT	0	1	0	0	0
FIRE	4	2	2	2	0
SUB-TOTAL	74	28	14	36	46
NOT SPECIFIED	10	13	13	9	16
SUB-TOTAL	10	13	13	9	16
BRIDGE TEST	16	3	64	61	20
SUB-TOTAL	16	3	64	61	20
TOTAL	1,726	1,704	1,228	1,228	877
Percent by Vessel Type	1989	1990	1991	1992	1993
TUG	40.8%	47.2%	14.9%	17.4%	13.0%
SAIL	46.5%	40.3%	61.8%	63.3%	64.7%
FISH	7.0%	9.9%	15.9%	10.7%	13.0%
OTHER	0.0%	0.0%	0.0%	0.0%	0.0%
M/V	4.1%	1.5%	1.0%	2.7%	5.2%
PASSENGER	0.0%	0.0%	0.0%	0.1%	0.0%
PILOT	0.0%	0.1%	0.0%	0.0%	0.0%
FIRE	0.2%	0.1%	0.2%	0.2%	0.0%
SUB-TOTAL	4.3%	1.6%	1.1%	2.9%	5.2%
NOT SPECIFIED	0.6%	0.8%	1.1%	0.7%	1.8%
BRIDGE TEST	0.9%	0.2%	5.2%	5.0%	2.3%
Source: BST Associates using King County Bridge Tender logs					

Tugs

Because there are no existing cargo facilities on the upper stretch of the Duwamish channel tugboats pass through the 14th/16th Avenue South bridge for a limited number of reasons:

- moving dredging equipment,
- delivering lifting equipment to DMI, and
- taking barges upriver for storage.

Figure 5

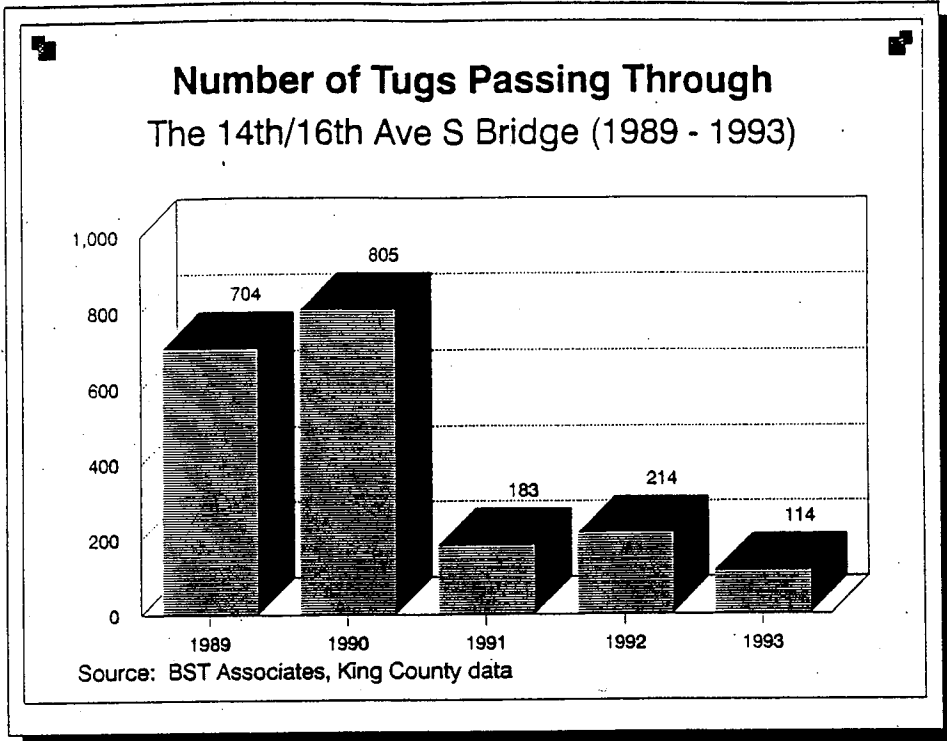
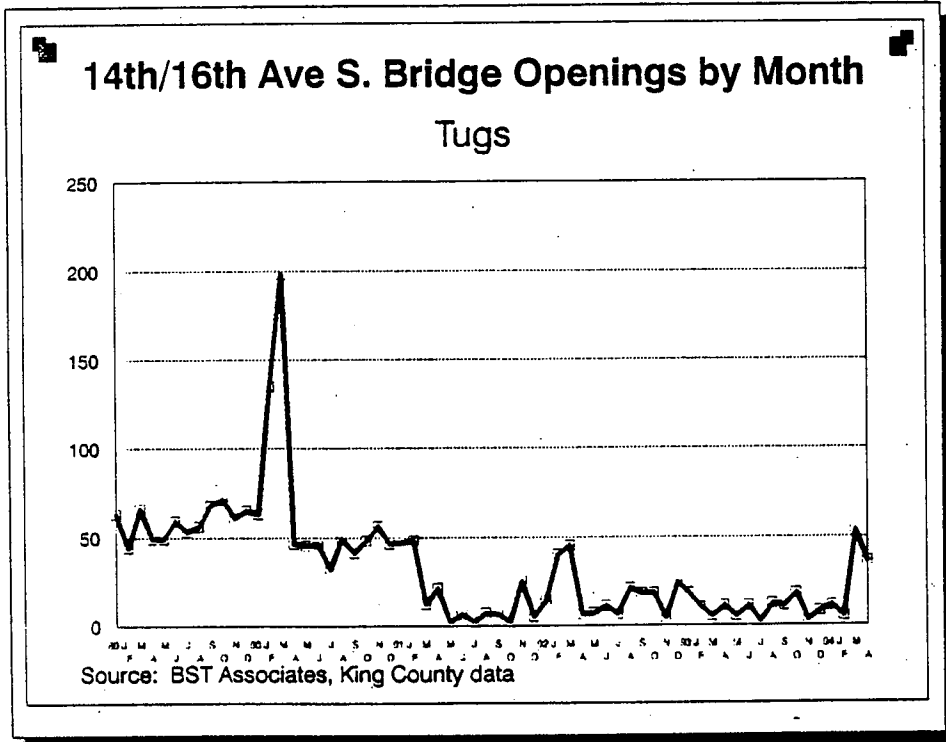


Figure 6



With very few exceptions, tugboats would not encounter a problem with vertical clearance with a 55-foot or 60-foot high bridge span (above MHW). Few of the tugboats that operate in the region have a highest fixed point of more than 55 feet, and many of the taller tugs tend to have collapsible masts which allow a reduced highest point (up to 20 feet reduction in height). In addition, this stretch of the River is difficult to serve with larger tugs and thus is generally served by smaller harbor tugs.

Table 7, which is located at the end of the chapter, presents the dimensions and operator of all of the tugboats for which the 14th/16th Avenue South bridge opened between January of 1989 and May of 1994. A total of 64 different tugboats have required the bridge to open over the last 5 + years. Of these 64 tugs, 59 have highest fixed points of less than 55 feet, while only four have highest fixed points higher than 55 feet. The Iver Foss, which accounted for 96 of the 134 transits by higher profile tugs, has a collapsible mast, providing a vertical profile approximately 45 feet in height.

The remaining 38 trips by height constrained tugs accounted for 1.9% of the tug calls in this section of the River. Discussions with tug operators revealed that these impacted transits are not the norm and that any activity in this reach of the River can be completed using other equipment.

Foss dispatchers indicated that the Barbara and Phillip Foss, which do not have collapsible masts, would not normally transit this reach of the River. Transits by these larger tugs only represented 2.7% of Foss's total bridge passages during the study period. Tug service could be provided to this reach of the River by other tugs that would not have a height constraint if a new bridge were constructed.⁹

The Crowley dispatch office, contacted as a part of the study, said that they do not now serve this reach of the River but would not anticipate any difficulties with the fixed bridge spans if service were initiated.

Barges are discussed in the following section.

Cargo Barges

The bridge tender's logs do not generally report the name of the barge (or derrick) being towed by the tugboat. In order to evaluate the potential impact on barges, BST Associates undertook a detailed assessment of U.S.-flag barge equipment operating in the States of Washington and Alaska.

⁹ Telephone conversation with Foss Dispatch office, date July 17, 1994

In Washington and Alaska, there are a total of 509 U.S.-owned barges, including 382 dry cargo barges and 127 liquid cargo barges. All of these vessels have a light (unloaded) draft of less than 15 feet, and would therefore not be limited by water depth from using the upper reach of the Duwamish when empty.

Of the entire inventory of dry cargo barges, 361 barges have a height less than 55 feet (94.5%), 3 have a height between 55 and 59 feet, 7 have a height between 60 and 64 feet and only 2 have heights above 65 feet. The height of 11 of the remaining barges is unknown but is assumed to be in the above ranges.

Of the entire inventory of liquid cargo barges, 124 barges have a height less than 55 feet (97.6%), 1 has a height between 60 and 64 feet and none have heights above 65 feet.

As discussed above, with a fixed span at 55 feet above MHW, the controlling height is approximately 60 feet at MLW. Extreme tides could be used but this practice would be limited by the draft (loaded) of the barge. The 55-foot-high bridge could accommodate 95.3% of the dry cargo and 97.6% of the liquid barge inventory. With a fixed span of 60 feet MHW, the controlling height is 65 feet which would accommodate 97.1% of dry cargo and 100% of the liquid cargo barge inventory.

Further evaluation of the higher barges reveals that it would be extremely unlikely that they would transit this reach of the River due to their draft and beam restrictions. As a result, none of the US-flag cargo barges operating in the PNW that could conceivably utilize the River would be impacted by a fixed span of 55 to 60 feet above MHW. Therefore, even though there are no existing cargo operations in this reach of the River, cargo operations would be possible using most of the barges in the US-flag fleet that operate in the PNW.

However, this evaluation of barges is based upon the highest structural profile, which does not include a crane on board. An evaluation of cargo barges is presented below.

Table 6

<i>Number of U.S.-Owned Barges Active in the PNW by Type and Clearance</i>			
Type	Clearance	Number of Barges	Percent
Dry Cargo	Air Draft < 55'	361	94.5%
	Air Draft 55' to 59'	3	0.8%
	Air Draft 60' to 64'	7	1.8%
	Air Draft 65' +	2	0.5%
	Not Specified	9	2.4%
	Total	382	
Liquid Cargo	Air Draft < 55'	124	97.6%
	Air Draft 55' to 59'	0	0.0%
	Air Draft 60' to 64'	1	0.8%
	Air Draft 65' +	0	0.0%
	Not Specified	2	1.6%
	Total	127	

Source: BST Associates, USCOE data

Container Freight Barge Operations

The Duwamish Waterway has always been a major site for small freighter and barge operations. However, all of this activity is focussed downstream of the 14th/16th Avenue South Bridge. As discussed above, smaller freighters generally would not be able to access the upper reaches of the Duwamish due to beam and water depth restrictions. However, if the above mentioned constraints did not prohibit them, vertical height restrictions imposed by the fixed spans under consideration would not preclude their access. Most smaller freighters have a height profile of less than 60 feet.

Most of the barge traffic in the Duwamish serves the Southeast (SE) or Western Alaskan markets. The barge industry serving Alaska can be differentiated into two segments for the purposes of this report - those that carry cranes on board and those that do not carry cranes on board.

First, there are high volume scheduled barge operators such as Alaska Marine Lines (AML) which dominates the SE Alaska market. AML serves major ports such as Juneau, Ketchikan, Sitka, Skagway, among others, which are large enough to support acquisition of a crane. As a consequence, AML does not need to carry a crane on board their barges. These barges are typically loaded four or five containers high and could pass under either fixed span bridge under consideration. [In addition, there is no need for a crane in the Hawaii and Canadian coastal barge markets.]

Second, there are barges that serve the more remote cities and towns of Western Alaska or that provide service as charter operators. These barge firms which include Northland and Samson (among others) frequently carry a crane on board because they must load and unload containers in smaller

communities where this equipment is not available. The profile of the crane can be in excess of 100 feet above the water line. These barge operators would be precluded from operating under either fixed span alternative unless they set the crane after passing the bridge.

With this perspective in mind, there are three key market related factors which are impacting the Alaskan market. First, there is significant competition for the Western and SE Alaskan cargo markets from other locations including numerous services with terminals on the Lake Washington Ship Canal and Lake Union. These firms include Alaska Coastal Transport, Western Pioneer, Sunmar, and Alaska Outport Transport. All of these firms serve the smaller Alaskan communities and none of them would be precluded from entering the Upper Duwamish by the fixed spans under consideration if they chose to relocate, which is considered highly unlikely. Second, these markets have become extremely competitive because of the great increase in bottomfish activity in the Bering Sea and to a lesser extent the Gulf of Alaska. As these markets began to increase, Sealand began to call directly at Kodiak and Dutch Harbor and APL continued service through its terminal in Dutch Harbor. This forced a reduction in cargo moving by barge and small coastal freighter from Puget Sound and an increase of feeder service from these smaller communities to Kodiak and Dutch Harbor. However, the bottomfish industry has recently experienced a decline in productivity due to overfishing and the pollock harvest seasons have been sharply curtailed. As a consequence the cargo throughput to these communities has declined precipitously. There is little long-term potential for the fisheries sector to return to its recent historic size. Oil revenues which account for approximately 87% of Alaskan state revenues (and which fund a large percentage of state and local capital improvement projects) are projected by the State of Alaska to be flat or decline slightly through the year 2010. In addition, some communities such as Sitka and Wrangell are facing significant economic downturns as forest products manufacturers shut down operations.

The bottom line of these market factors is that there will be little or no growth in the barge industry serving Alaska and therefore no need for new terminals even if land became available in the upper reach of the Duwamish. It should also be recognized that there are substantial waterfront industrial lands in Bellingham, Anacortes, Everett, Tacoma, Olympia, Port Angeles and Grays Harbor that are actively being marketed to the shipping community. The potential for barge service requiring a crane on board in the Upper Duwamish area is considered extremely remote.

The following section evaluates the marine construction industry.

Construction Barges

The same database used for cargo barges also reveals the characteristics of some (but not all) of the tug and barge equipment used by the construction companies (see the following table). None of listed equipment would have a constraint transiting either of the fixed spans. However, some of the lifting equipment is not available from this database.

Many of the largest lifting derricks of the Manson Company have a reported maximum height of 90 to 95 feet. This height includes the spuds on the barge in a vertical position.

Manson is one of a handful of company's on the West Coast of the U.S. that provide large general purpose equipment serving pile driving, heavy lift, dredging, and other waterfront construction services. The other PNW company in this segment of the market is General Construction. Manson's equipment is sized to meet the typical needs of all harbors that it serves. The spuds (that are the highest controlling point of the equipment) are sized to serve a port facility with water depth of 55 feet plus 15 foot tidal variation plus 15 feet of access above the water line to the top of the barge and 5 feet of penetration into the sediment. This requires spuds being approximately 90 to 95 feet in height which is the stated height of the company's largest equipment. According to Manson officials, spuds are usually 6 to 8 feet into the water during transit so adjusted height requirement with spuds is 82 to 87 feet (not including a clearance allowance factor).

When taken out, the fixed height of the A-frame (which is not adjustable) is approximately 70 to 80 feet, which would not be capable of transiting either of the fixed spans under consideration. Manson derricks generally draw 8 to 10 feet of water so it would be possible to take advantage of lower tides which would reduce the profile to 65 to 70 feet.

A height restriction of 55 to 60 feet above MHW would preclude use of the waterway by Manson's larger equipment. Manson's usage characteristics can be documented by studying the movement of the 4 company tugs (i.e. Gladys M, Jeffery M, Harry M and Kimberly). From 1989 through May of 1994, Manson barges/derricks passed through the 14th/16th Avenue South Bridge approximately 22 round trips or approximately 4 times per year. Frequently, two tugs pass through the bridge with a barge or derrick, leave the derrick upriver, pass through the bridge without a tow and then return to pickup the barge. In total Manson tugs passed through the Bridge 85 times during this time frame. Manson's use of this reach of the River includes dredging and occasional picks for DMI and less frequent picks for other waterfront users.

Manson firmly believes that in order to maintain the industrial character of the River, access by all vessels up to 100 feet in height is required. This

would accommodate all Manson equipment with the spuds up. Manson officials also believe that future waterfront development will necessitate additional heavy picks which will require their type of equipment.

These issues and potential solutions to provide access for dredging equipment and for heavy lift equipment is discussed in greater detail in the final chapter.

Table 7

<i>Vertical Height Characteristics of Selected Manson Heavy Lift Derricks</i>		
<i>Name</i>	<i>Operator</i>	<i>Reported Highest Fixed Point</i>
Haakon	Manson	90'
Manson 24	Manson	95'
Derrick 6	Manson	90'
Derrick 8	Manson	90'
Valkyrie	Manson	95'
Scandia	Manson	95'
Viking	Manson	90'
Norseman	Manson	90'
Vasa	Manson	93'
Hagar	Manson	90'
Derrick 3	Manson	90'

Source: BST Associates, Manson Company brochures

Fishing Vessels

Fishing vessels vary in size, length and height depending on the type of gear installed and the type of vessels. However, few large vessels (over 60 feet in length) have transited the upper reaches of the Duwamish for ten years or more. In the early 1980s, when SeaFreeze operated a cold storage facility in Slip 6, larger vessels did transit this reach of the River. As indicated above, after Boeing acquired SeaFreeze, the cold storage facility was closed and there is now no reason for large fishing vessels to come upriver past the 14th/16th Avenue South Bridge.

The fishing vessel traffic that remains on this reach of the River consists almost exclusively of purse seiners which were constructed at DMI returning for maintenance. DMI has constructed several hundred fiberglass purse seiners which have remained in the area, being primarily engaged in the Alaska salmon industry.

These vessels are currently limited to 58 feet in length. According to Marco Shipyards, the average height of these vessels is approximately 59 feet (including antenna) which could pass at MLW under either fixed span alternative using the tides. As discussed above, the 55-foot high (MHW) span allows transit by vessels up to 60 feet in height at MLW including allowance for 2.5 feet air draft clearance. In addition, the highest parts of the vessel are usually antennas and other peripheral gear, and on some vessels, the top ten feet consists of a flexible whip antenna. Since these vessels return infrequently (i.e., approximately once per year), working the tides would not present a problem.

Figure 7

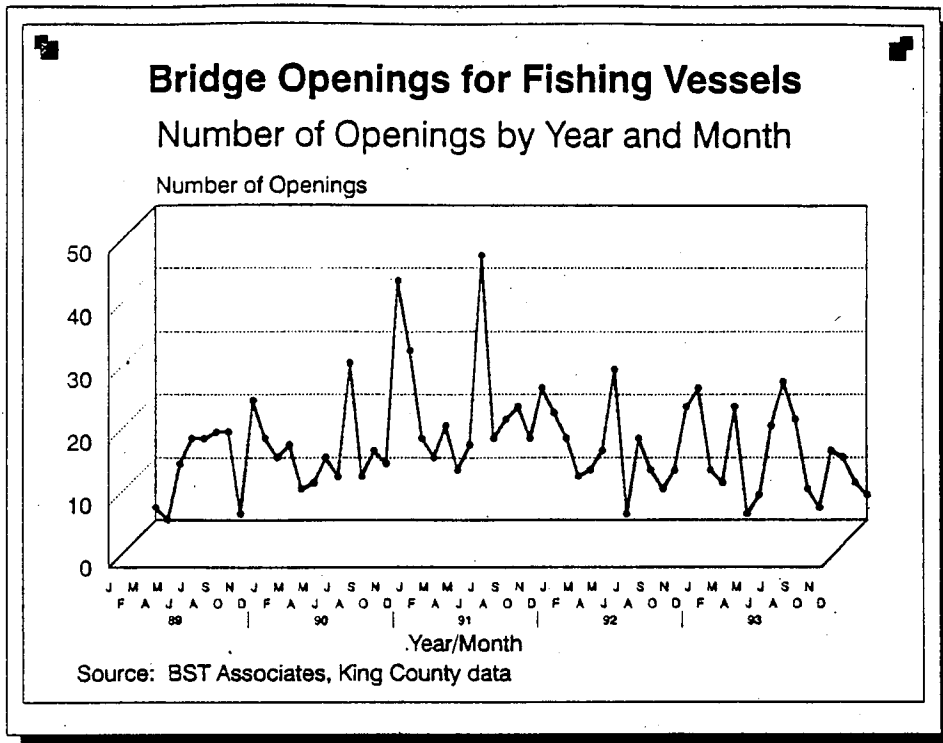
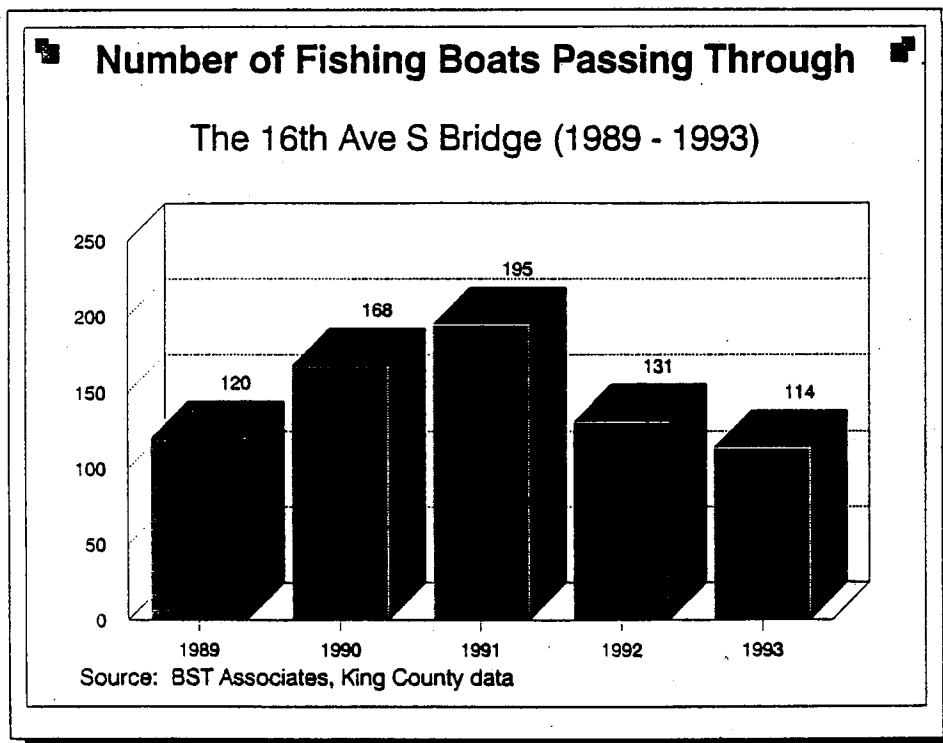


Figure 8



Recreational Vessels - Resident Sailboats

Sailboat Vessel Characteristics

In order to understand the use of this reach of the River by sailboats, it is instructive to evaluate the characteristics of the entire King County sailboat population. There are 3,312 sailboats in King County, according to registered and documented vessel reports. Only 206 vessels (6.2% of the total) are longer than 45 feet. These vessels could have a height restriction if a fixed span were constructed. This impact is discussed below.

Table 8 also shows that there are nearly 25,000 power boats in King County, none of which would experience a difficulty crossing the proposed fixed spans. There are 1,085 power boats greater than 45 feet in length or more than 5 power boats for each sailboat in this length range.

During the past five years there have been 3,591 bridge openings at 14th/16th Avenue South Bridge for sailboats. Bridgetenders recorded the name of the sailboat in 2,667 of the openings. These openings were associated with 267 vessels. However, 218 of these vessels had 10 or fewer openings over the five year span.

There are 49 remaining vessels that had more than 10 openings in the five year period. Only 9 boats had 50 or more openings during the five year period, which is 5 or more trips per year on average (assuming 2 openings per trip).

These vessels range in length from 27 feet to 41 feet in length. Sailboats longer than approximately 35 feet could encounter problems with a 55-foot fixed-span bridge at 14th/16th Avenue South. The following table lists the dimensions (e.g. length, beam, and draft) of one of the most popular boats of one manufacturer (Hunter Marine). As shown, the longest vessel with a mast height less than 55 feet is the 33.3 foot model, while the 36.0 foot model would be six feet too tall to pass under the span at MHW. Draft limitations in the channel do not present a problem for any of the sailboats listed in this table.

For a sailboat to have draft problems with the 15-foot channel in the upper Duwamish it would most likely be an ocean racing vessel, which is much longer than those listed here and which are rare in this region.

Mast height data presented below is measured to the top of a clean mast and does not take into account any gear installed at the top of the mast. Typically a VHF antenna and windex are mounted to the top of a sailboats mast, increasing the height by a foot or more. The VHF antenna is the larger of the two items, and is somewhat flexible. The windex is four to six inches high, and is not flexible.

Table 8

**Typical Heights Above Water Line For Sailboats
(all figures in feet)**

Length	Beam	Draft	Mast Height ¹	Height to Length
29.5	10.5	4.0	45.8	1.55
32.0	11.3	4.3	53.0	1.66
33.3	10.9	4.5	53.4	1.60
36.0	12.8	4.8	61.6	1.71
37.5	12.8	4.9	59.0	1.57
40.2	13.4	4.8	62.8	1.56
42.5	14.0	4.9	60.3	1.42

¹ Distance above waterline
Source: BST Associates, Hunter Marine

Figure 9

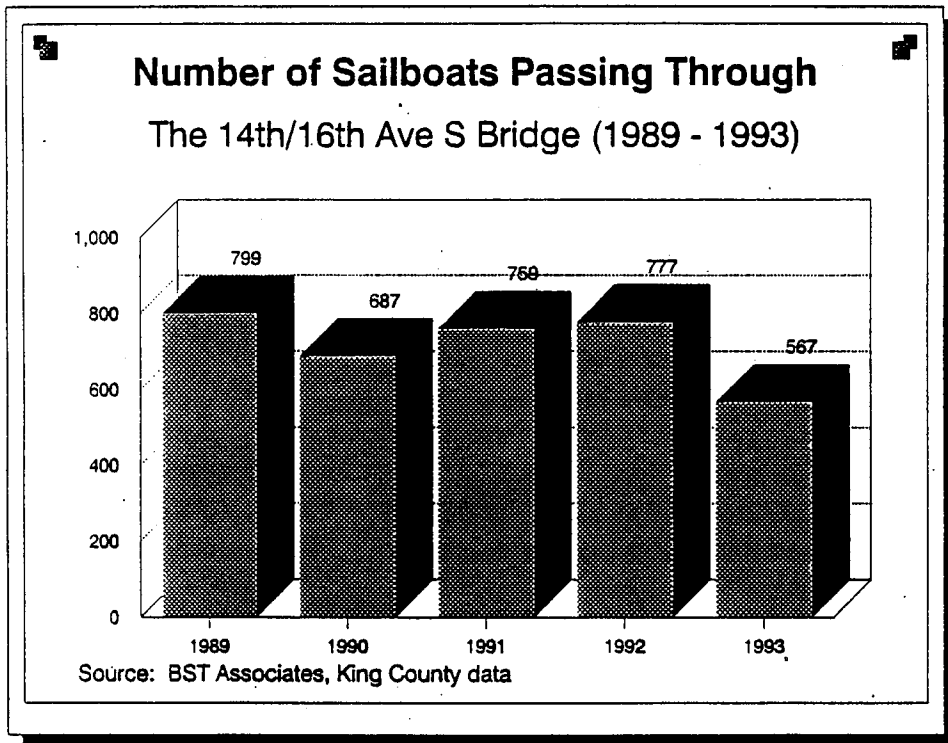


Figure 10

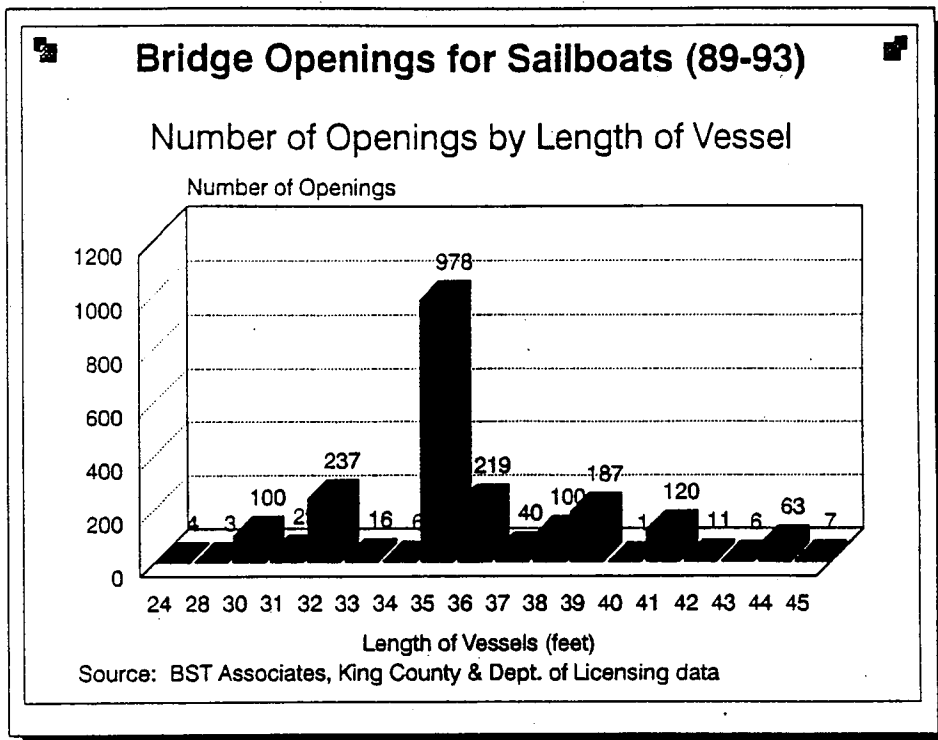
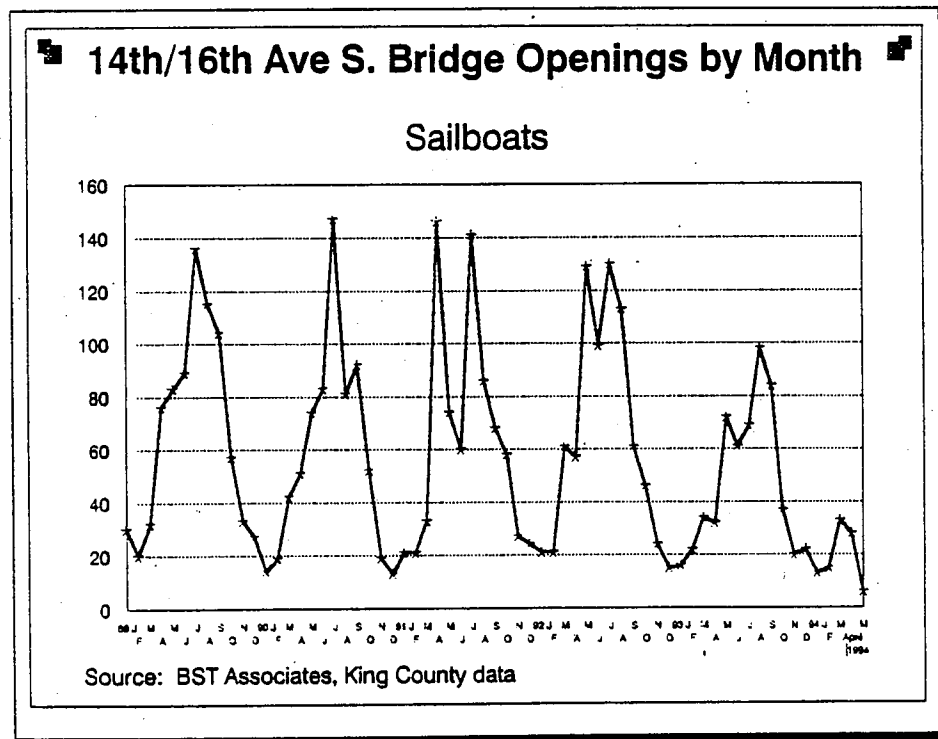


Figure 11



Marinas in Upper Duwamish

As mentioned above, there are two pleasure craft marinas located on the Duwamish River above the 14th/16th Avenue Bridge: South Park Marina and Duwamish Yacht Club.

South Park Marina

At South Park Marina, one of two marinas on the upper Duwamish, the largest vessel is a 58-foot sailboat with 63-foot mast. The remainder of the approximately 150 boats are well under 50 feet in length and would not be constrained by a fixed bridge of 55 or 50 feet, according to the Marina owner.

As discussed above, the owner of South Park Marina (Mr. Guy Crow) has stated that the fixed-span limits under consideration would not impact the marina. The largest sailboat could transit the 60-foot-high bridge at MLW and the loss of a sailboat tenant could be replaced easily with a power boat user.

Duwamish Yacht Club

The Duwamish Yacht Club is predominantly used by power boats. Of the 107 tenants, there are currently only 11 sailboats and 96 power boats. Of the sailboats, 7 would experience a height impact at 55 feet and none would have an impact at 60 feet. However, the nature of the height restriction also depends upon vessel usage characteristics.

Users range from frequent (weekly sailors) to infrequent sailors (few times a year). Using the tides would be acceptable for infrequent sailors but onerous for more frequent sailors at the lower 55-foot height limit. This is due to the limited distribution of tides on a daily (and annual) basis in combination with the present limitations on all bridge openings, which are limited during the peak vehicular times (i.e., 6:30 to 8:00 a.m. in the morning and 3:30 to 5:00 p.m. in the evening). This combination constrains the use of tides for frequent users.

However, discussions with the sailboat representative of Duwamish Yacht Club indicated that a fixed span at 60 feet above MHW would accommodate all existing users.¹⁰

¹⁰ Brian Guptil, tenant and representative of sailboat users

Recreational Vessels - Motor Yachts

As discussed above, Delta Marine Industries historically has been a builder of fishing vessels (e.g. limit seiners), and still engages in the repair of such vessels. However, the fisheries sectors in Alaska and Washington have been seriously and negatively impacted by environmental constraints (i.e., loss of habitat and environmental constraints) and by changes in the marketplace with new international competition from other wild harvested salmon and the dramatic growth of raised salmon. As a result, the construction of fishing vessels has declined precipitously. According to some experts in the business, there are no fishing boats being built anywhere in the region currently, due to the combined forces of fishing restrictions and low prices. For the foreseeable future DMI will not likely construct new fishing boats, although this could change in the longer term future due to international marketing opportunities.

FRP (fiberglass reinforced plastic) is the leading construction material for vessels in the PNW, and is the type of construction used by Delta Marine. FRP accounts for 718 of the 1,141 vessels built in Seattle since 1970. The peak year for vessel construction in Seattle was 1979, the year in which a total of 121 documented vessels were built, including 79 fiberglass vessels. After that year, however, the market dropped precipitously, to a low in 1985 of 18 vessels, then back up to 46 vessels in 1990. The market dropped again in 1992, though, to a new historic low of 14 vessels, seven of which were fiberglass boats.

PNW builders (including DMI) have begun to diversify into the mega-yacht industry. A recent industry listing of mega-yacht builders by Showboats International (September 1994 Issue - see Appendix for a copy) lists 66 manufacturers. Of this total, 12 (18%) are from this region, including the area from the Columbia River to Lower Mainland British Columbia. The list includes :

- Admiral Marine Works (Port Townsend) builds custom composite yachts from 60 to 200 feet in length. Admiral recently built the M/V Evviva, which is 162 feet in length which is presently the largest of any PNW yachts.
- Christen Shipyards (Vancouver, WA) builds fiberglass ocean-going motoryachts from 110 feet to 150 feet long.
- Cooper & Queenship (Albion, BC) builds custom yachts from 70 to 125 feet in length.
- Crescent Beach Boatbuilders (Hamilton, BC) builds fiberglass vessels from 100 to 115 feet in length.
- Delta Marine (Seattle, WA) builds fiberglass motoryachts from 50 feet to 150 feet in length.
- Heisley Marine (Portland, OR) builds fiberglass yachts from 50 to 90 feet in length.

- Nordlund Boat Company (Tacoma, WA) builds high-tech custom motoryachts 60 to 110 feet in length.
- North Coast Yachts (Tacoma, WA) recently completed 111-foot and 131-foot long yachts.
- Puglia Shipbuilding Inc (Tacoma, WA) builds steel hull/aluminum superstructure megayachts, its largest vessel to date is the 150 foot long Samantha Lin.
- Sovereign Yacht (Seattle, WA at 8th Avenue South on the Duwamish - just downstream of the 14th/16th Avenue South Bridge) builds motor and sailing yachts up to 110 feet in length.
- West Bay SonShip (Delta, BC) builds yachts from 52 to 120 feet in length with capacity to build to 160 feet in length.
- Westport Shipyard (Westport, WA) builds fiberglass yachts from 70 to 130 feet in length.

In 1991, there were 206 megayachts on order (defined as vessels in excess of 90 feet in length.) The market fell precipitously in 1992 to 149 orders due to a worldwide recession. In 1993, orders rebounded slightly to 156 orders according the Showboat International Magazine. However, the overall market still lags behind 1991.

The megayacht business includes two distinct segments: motoryachts and power sailors. Power sailors have declined consistently as a percentage of the entire market and now represent less than 25% of the entire market. Motor yachts represent the remaining 77% of the market.

The largest segment of the sailboat market is the range from 100 to 149 feet in length. Only 4 of the vessels on order are greater than 150 feet in length (only 2.4% of the total market). Likewise, motor yachts are also most attractive in the 100- to 149-foot range, with 24 greater than 150 feet in length (15.4% of the total market).

Table 9

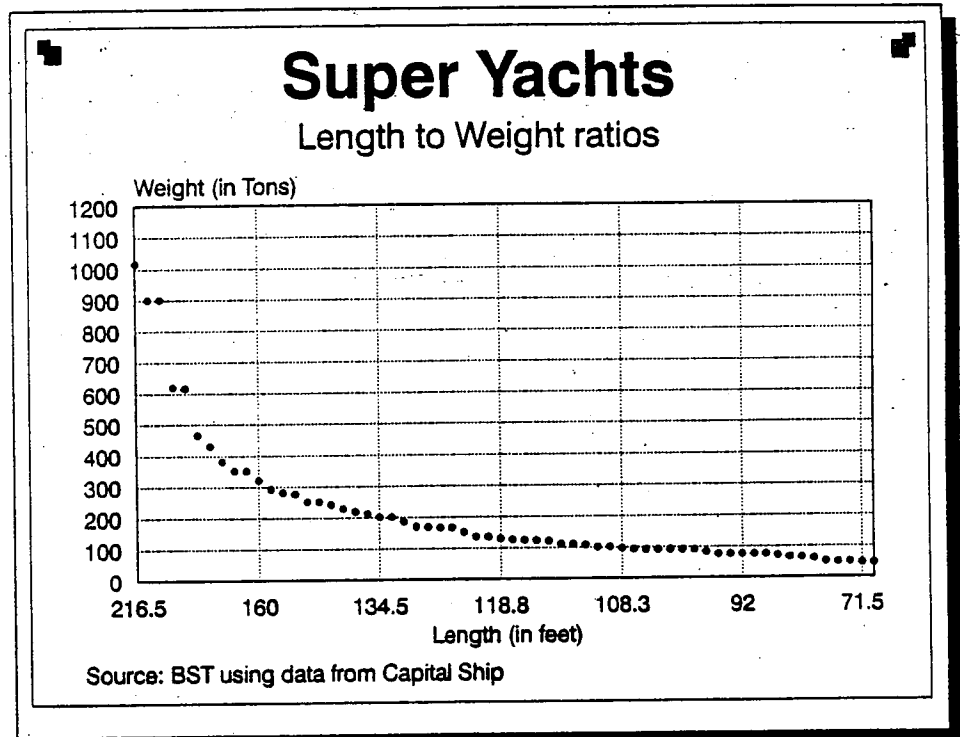
<i>Megayachts Market on Order - 1993</i>			
Category	Number	% Group	% Total
Sail			
90-99 ft	7	22.2%	5.1%
100-119 ft	14	38.9%	9.0%
120-149 ft	10	27.8%	6.4%
150 ft +	4	11.1%	2.6%
Total	36	23.1%	23.1%
Power			
90-99 ft	20	16.7%	12.8%
100-119 ft	42	35.0%	26.9%
120-149 ft	33	28.3%	21.8%
150 ft +	24	20.0%	15.4%
Total	120	76.9%	76.9%
Total	156		

Source: Showboats International, January 1994, Pages 109 to 112

A recent review of megayachts by the magazine Capital Ship provides a relationship between vessel length and weight. As seen in Figure 12, all of the vessels less than 134.5 feet in length weigh less than 200 tons. Up to 160 feet in length, vessels are less than 300 tons. Beyond 160 feet, vessels weigh up to 1,000 tons or more. All of these larger vessels are constructed of steel or steel/aluminum hulls. No fiberglass vessels are listed at more than 110 tons (with the largest being the 131 footer under construction by DMI). However, DMI is currently building vessels weighing between 350 and 450 tons which were not included in the magazine article.

DMI has indicated that future vessels could weigh more than 400 tons and that DMI vessel lifting capacity should be equipped with an extra margin in order to meet insurance requirements. (Weight requirement based on discussions with DMI).

Figure 12



As discussed above, motoryachts are large powered boats typically ranging from 100 to 161 feet (or more) in length. Most of these boats come in double-or triple-deck form. Double deckers are typically 30 to 40 feet in height and triple-deckers may reach 50 to 55 feet in height. Vessel draft typically does not exceed 12 feet. As a result, there would little interference from height restrictions posed by the fixed-span bridge alternatives under consideration. In the unlikely event that a higher fixed point is established, it would be possible to use the extreme low tides in the upper reaches of the Duwamish, although passage may be constrained by actual water depth between dredging periods.

