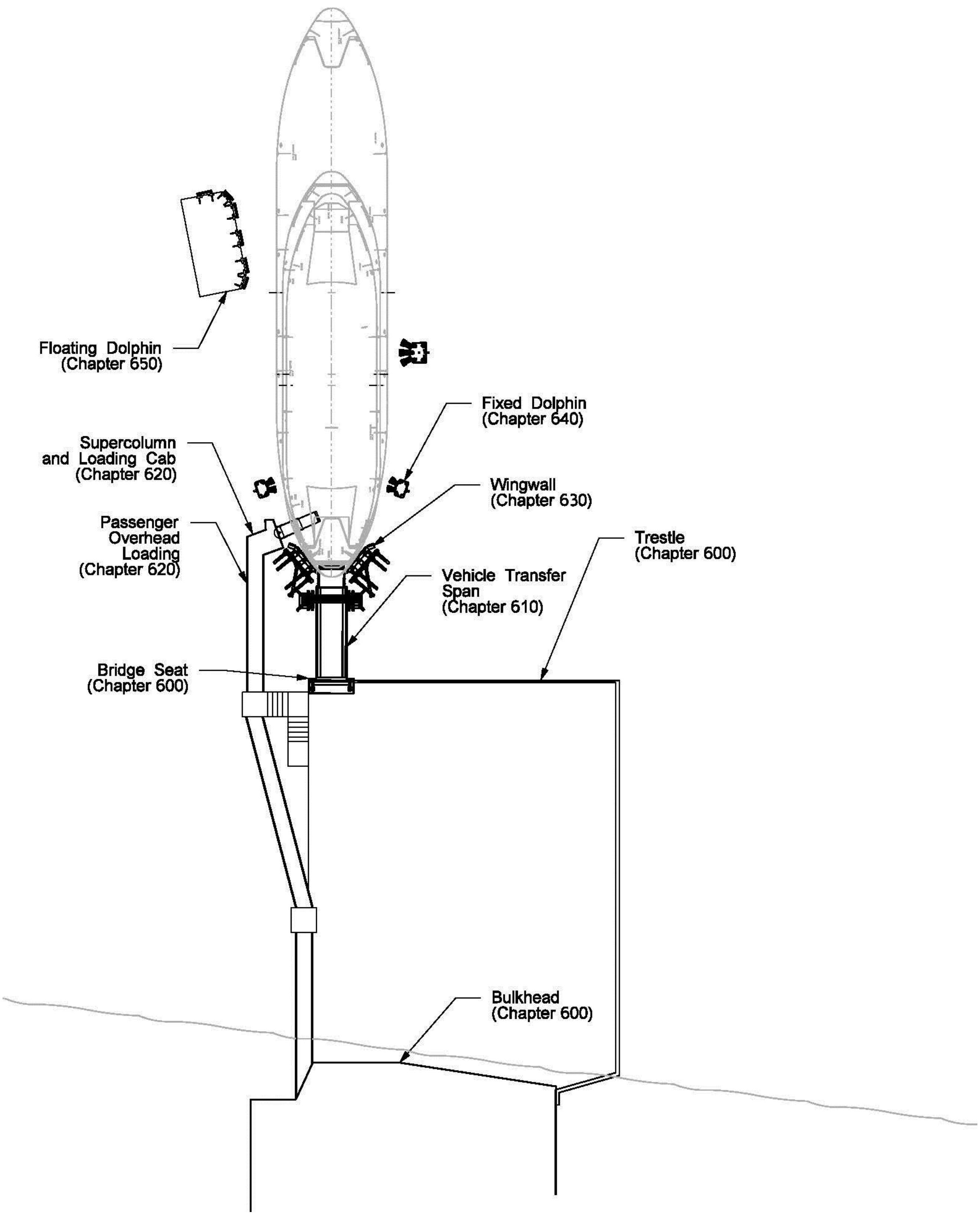
Chapter 330 Marine

330.01 General

This chapter identifies the major marine structures associated with a ferry terminal along with the specifications used for their design. Refer to Exhibit 330-2 for a sample layout of the marine structures and the chapters covering their design.

This chapter also provides guidelines for designing the ferry terminal slip berthing structures (wingwalls, fixed dolphins, and floating dolphins) in addition to vessel and tidal information relevant to their design. Wingwall and dolphin design are discussed in more detail in Chapters 630, 640, and 650.

Vashon Ferry Terminal Slip 1
Exhibit 330-1



Example Marine Structures Layout
Exhibit 330-2

For additional information, see the following chapters:

Chapter	Subject
300	Accessibility
310	Security
320	Environmental Considerations
630	Wingwalls
640	Fixed Dolphins
650	Floating Dolphins

330.02 References

Unless otherwise noted, any code, standard, or other publication referenced herein refers to the latest edition of said document.

(1) Federal/State Laws and Codes

28 CFR Part 35 *Nondiscrimination on the Basis of Disability in State and Local Government Services*

33 CFR Part 66 *Private Aids to Navigation*

33 CFR Part 154 *Facilities Transferring Oil or Hazardous Material in Bulk*

33 CFR Part 165.1317 *Security and Safety Zone; Large Passenger Vessel Protection, Puget Sound and adjacent waters*

49 CFR Part 39 *Transportation for Individuals with Disabilities – Passenger Vessels*

49 CFR Part 661 *Buy America Requirements – Surface Transportation Assistance Act of 1982, as amended*

WAC 296-56 *Safety Standards – longshore, stevedore and related waterfront operations*

WAC 296-56-60115 *Other protective measures*

WAC 296-876 *Ladders, portable and fixed*

RCW 47.28.030 *Contracts — State forces — Monetary limits — Small businesses, veteran, minority, and women contractors — Rules — Work on ferry vessels and terminals, ferry vessel program*

(2) Design Codes and Specifications

AASHTO LRFD *Bridge Design Specifications* (AASHTO LRFD), American Association of State Highway and Transportation Officials, Washington, D.C.

AASHTO *Guide Specifications for LRFD Seismic Bridge Design* (AASHTO Guide), American Association of State Highway and Transportation Officials, Washington, D.C.

AASHTO *Guide Specifications for Bridges Vulnerable To Coastal Storms*, American Association of State Highway and Transportation Officials, Washington, D.C.

AASHTO LRFD *Movable Highway Bridge Design Specifications* (AASHTO Movable), American Association of State Highway and Transportation Officials, Washington, D.C.

AASHTO LRFD *Guide Specifications for the Design of Pedestrian Bridges* (AASHTO Pedestrian), American Association of State Highway and Transportation Officials, Washington, D.C.

ASCE *Minimum Design Loads for Buildings and Other Structures, ASCE/SEI 7-10*, 2010, American Society of Civil Engineers, Reston, VA.

ASCE *Seismic Design of Piers and Wharves, ASCE/COPRI 61-14*, 2014, American Society of Civil Engineers, Reston, VA.

ASCE *Flood Resistant Design and Construction, ASCE/SEI 24-14*, 2014, American Society of Civil Engineers, Reston, VA.

FEMA *Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas, FEMA P-55*, 2011, Federal Emergency Management Agency, Washington D.C.

Bridge Design Manual LRFD, M 23-50

Design: Moorings, Unified Facilities Criteria (UFC) 4-159-03, October 2005, Department of Defense, Washington D.C.

Design: Piers and Wharves, UFC 4-152-01, July 28, 2005, Department of Defense, Washington D.C.

International Building Code, International Code Council, Washington D.C.

General Special Provisions, Washington State Department of Transportation, Olympia, WA.

Design Manual M 22-01

Plans Preparation Manual M 22-31

Private Aids to Navigation, WSF Terminal Engineering Library

Region General Special Provisions, WSF

General Structural Notes, WSF

Safety Management System (SMS) Manual, United States Coast Guard (USCG)

Shoreline Master Program (SMP) Handbook, Washington State Department of Ecology

Standard Specifications for Road, Bridge, and Municipal Construction (*Standard Specifications*) M 41-10

(3) Supporting Information

Life Cycle Cost Model (LCCM), WSF

330.03 Design Specifications Matrix

Terminal Structure	AASHTO LRFD Specifications[1]	AASHTO LRFD Movable Bridge Design Specs	International Building Code	WSF *Terminal Design Manual* [2]	Washington Administrative Code 296-56
Bulkhead	X				
Trestle	X			X	
Transfer Span & Apron	X	X		X	
Gangway/Gangplank	X	X		X	
Fixed Pedestrian OHL	X			X	
Movable Pedestrian OHL	X	X	X	X	
Terminal Buildings & Toll Booths			X	X	
Ladders/Stairs - Employee			X		X
Stairs - Public			X		
Guardrail/Railing – Employee	X		X		X
Guardrail/Railing – Public	X		X		
Wingwalls				X	
Dolphins				X	

[1] AASHTO LRFD Specifications include the following:
Guide Specifications for LRFD Seismic Bridge Design, *LRFD Bridge Design Specifications*, and *LRFD Guide Specifications for the Design of Pedestrian Bridges*

[2] WSF *Terminal Design Manual* guidelines are intended to supplement design codes where applicable.

Structural Design Specifications Matrix
Exhibit 330-3

330.04 Design Considerations

(1) Accessibility

Wherever pedestrian facilities are intended to be a part of a transportation facility, 28 CFR Part 35 requires that those pedestrian facilities meet ADA guidelines. Federal regulations require that all new construction, reconstruction, or alteration of existing transportation facilities be designed and constructed to be accessible and useable by those with disabilities and that existing facilities be retrofitted to be accessible.

Additionally, 49 CFR Part 39 prohibits owners and operators of passenger vessels from discriminating against passengers on the basis of disability, requires vessels and related facilities to be accessible, and requires owners and operators of vessels to take steps to accommodate passengers with disabilities.

Design pedestrian facilities to accommodate all types of pedestrians, including children, adults, the elderly, and persons with mobility, sensory, or cognitive disabilities. Refer to Chapter 300 for accessibility requirements.

(2) Security

Chapter 310 includes a general discussion of the United States Coast Guard (USCG) three-tiered system of Maritime Security (MARSEC) levels, vessel security requirements, and additional information pertaining to marine design. Below are links to relevant sections by topic. Coordinate with the WSF Company Security Officer (CSO) regarding design issues pertaining to security. In addition, coordinate with the USCG and Maritime Security for all terminals, the United States Customs and Border Protection (USCBP) for international terminals, and the Transportation Security Administration (TSA) for Transportation Worker Identification Certification (TWIC) and Sensitive Security Information (SSI).

- MARSEC Levels: 310.04
- Vessel Security: 310.05
- Waterside Structures: 310.09
- Access Control/Restricted Areas/TWIC: 310.10
- Signage: 310.13

(3) Environmental Considerations

Refer to Chapter 320 for general environmental requirements and design guidance. Refer to the project NEPA/SEPA documentation for project-specific environmental impacts and mitigation.

(4) Operations and Maintenance

Consult with WSF Operations and Terminal Engineering Maintenance for consideration of the following operations and maintenance issues:

- Minimize repair and maintenance required during the design life.
- Specify paint colors on the darker side to help reduce oxidation process.
- Provide bird deterrence as necessary
- Accommodate navigational aids as required
- Consider construction methods and phasing impacts to vessel and terminal operations.
- Provide corrosion protection of steel piles as required to achieve the design life specified in the *Life Cycle Cost Model* (LCCM).
- Accommodate accessibility for repair crews
- Accommodate inspection access for federal regulations

Note that bird deterrence can include bird wire and bird point systems, but structures can also be designed so as to not provide nesting opportunities for birds.

Additionally, design structures and facilities so that maintenance activities can be completed in compliance with OSHA/WISHA requirements.

(5) Vessel Restraint

WSF has been investigating the development of a vessel restraint system as one means of reducing fuel consumption while the vessel is docked and unloading and loading passengers and vehicles. Currently, vessel captains apply significant engine thrust pushing the vessel against the wingwalls and dolphins to ensure the vessel does not drift away from these structures. By developing a mechanical means to hold the vessel in position, this thrust can be reduced and significant fuel and cost savings can be achieved. One system currently under study is a vacuum-based automated mooring technology.

Where vessel restraint has been identified to be a feasible and cost-effective component of a slip's infrastructure, incorporate the appropriate system into the berthing aid arrangement.

(6) Proprietary Items

WSF uses competitively acquired products to fulfill the requirements of a contract wherever feasible to help achieve the lowest price, the best quality, and the most efficient use of resources. There are instances in which competitive bidding may not or cannot be provided and a specific proprietary product is allowed. Refer to Section 220.07(2) for limitations on the use of proprietary items.

(7) Long Lead Time Items

Consider potential long lead time items for the contractor to procure in both the design and the construction schedules. Many long lead time items will be shop-fabricated and assembled off-site prior to delivery for installation. Include a thorough shop drawing preparation submittal and review process for these items. Also the requirement of Federal Funding Partners to buy American-produced steel to meet the Buy America requirements per 49 CFR Part 661 for steel products may require additional time due to the mill rolling schedules of the various domestic steel manufacturers. This procurement process could take anywhere from six to nine months. Other strategies to accommodate long lead times include advanced purchase, using WSF stock, and delay of the contract to allow for procurement.

Typical long lead time items include:

- Steel pipe piles
- Precast prestressed concrete piles
- Precast prestressed concrete deck members
- Marine fenders
- UHMW polyethylene rubbing faces
- Wingwall timbers
- Hydraulic lift cylinders, pumps and valves for the VTS and OHL systems
- Sheaves and blocks
- Hoist motors
- Steel chains for floating dolphins

(8) Design Life

Design life is based on the current *Life Cycle Cost Model* (LCCM) as required by the Washington State Office of Financial Management (OFM). Refer to Table 1 for the design life of new structures (as of 2007) and Table 2 for design life of structures prior to 2007, in the 2010 *Life Cycle Cost Model* Update (2010 LCCM) for information on when existing marine structures and their systems are due for replacement. Confirm design lives given below are consistent with the current LCCM. Replacement life may be reduced due to functional obsolescence. Replacement life of berthing structures also may be reduced due to damage from vessel impact.

(9) Corrosion Mitigation

Corrosion is the primary factor in the life span reduction of a structure in the marine environment. For those structural components that rely on steel to provide strength, develop a corrosion protection program (including coatings and/or reserve material) to meet their design lives as set forth in the LCCM. Provide a plan for preserving the corrosion protection system for the design life of the structure. Base design on the following estimated corrosion loss rates for bare steel:

- Atmospheric zone: 0.004 inch per year
- Splash zone: 0.006 inch per year
- Tidal zone: 0.004 inch per year
- Submerged zone: 0.003 inch per year
- Other zones: 0.001 inch per year

Consider the site- and structure-specific corrosion protection methods below for use in the design, based on life cycle costs.

(a) Reinforced Concrete Shafts and Cast-in-place Concrete Piles

- Use a minimum 3-inch concrete cover for reinforcing steel.
- Use standard WSDOT Class 4000P concrete mix.
- Use epoxy-coated steel reinforcement.

(b) Steel Pipe Piles

- Coat all piles in accordance with the pile coating system specified in the current WSF Region General Special Provisions covering painting of steel piling. The bottom 20 feet of pile may be uncoated
- The minimum required design thickness of the piles shall be shown in the Contract Plans for the various corrosion zones listed above.
- Coatings will be maintained based on the results of required inspections performed every two years.

(c) Steel Framing

- Coat all steel accordance with the coating system specified in the current WSDOT *Standard Specifications* as supplemented by the WSF Region General Special Provision covering painting of steel.

(d) Cast-in-place and Precast Concrete

- All cast-in-place superstructure members (including pilecaps) that are not prestressed shall meet the serviceability requirements of Paragraph 5.7.3.4 of AASHTO LRFD *Bridge Design Specifications*. Use an exposure factor γ_e of 0.60.
- Precast prestressed structures shall be designed for zero net tension for service load combinations which include dead load and live load.
- In non-prestressed concrete, the concrete cover shall be 3 inches for all reinforcing steel. For prestressing steel in its effective zone, 2 inches of concrete cover is allowed. Prestressing is not fully effective at the end of a beam and therefore the cover should be 3 inches at the end of the beam or panel.
- Use standard WSDOT concrete mixes.
- Use epoxy-coated steel reinforcement.

(10) Scour and Mudline Elevations

Determine mudline elevations for structural and geotechnical design from line soundings and predicted scour over the life of the structure. Consider the effects of pile removal activities (including clam shelling of timber piles and pile stubs) and scour coincident with or adjacent to the piles or shafts in establishing the design mudline elevations for the structures at the start and end of their design life. Consider the effects of changing design mudline elevations on the performance of the structures (in terms of strength and displacement) over their design life. In general, when clam shelling occurs at the location of new piles, discount the top five feet of soil based on the assumption it is disturbed. Scour is caused by ferry vessel propeller wash and tidal currents. The estimated scour depths are a function of soil properties and past scour at the locations of the structures. The pile removal activities and scour effects are not additive (i.e., when clam shelling and scour both occur, use the maximum discounted soil depth). If a more accurate analysis of scour is warranted the WSF Maintenance group has annual records at all slips available for review.

Consult the WSDOT Geotechnical Branch to review these guidelines and to determine whether less or more soil should be discounted based on the soils at the location of the structure under consideration.

(11) Geotechnical Requirements

Design geotechnical elements in accordance with the Geotechnical Recommendations provided by the WSDOT Geotechnical Branch. The Geotechnical Recommendations will typically include:

- Site-specific seismic design
- Liquefaction and lateral spreading
  - Slope stability
  - Downdrag forces
  - Axial capacity of foundation elements
  - Input data for L-Pile lateral analysis
  - Group reduction factors due to pile spacing
  - Lateral forces for bulkhead design
  - Constructability recommendations including type and capacity of pile driving equipment and use of cutting shoes.

(12) Materials Specification

Utilize materials that are in accordance with the requirements of the WSDOT *Standard Specifications* and WSF *General Structural Notes* and *Region General Special Provisions*.

Make use of WSF stockpiles of materials where possible; however Buy America and Buy American requirements need to be addressed before approval to use stockpiled materials is allowed. Early consultation with HQ Design ASDE is recommended. State force labor limits also apply (refer to RCW 47.28.030 for more information).

For material requirements of federally funded projects including the requirement for American-made steel refer to 49 CFR Part 661. See Section 220.07(3) Buy America and Buy American, for additional information.

(13) Miscellaneous Considerations

Use standard WSF structures where appropriate.

(14) Right of Way and Sundry Site Plans

Right of Way Plans are the official state documents used as the basis to acquire real estate and other property rights for roadways. It is the responsibility of the region to prepare plans for the acquisition of rights of way (R/W), including easements, permits, and any substantiating documentation necessary for completion of the plans. Verification of ownership of existing R/W is also required.

A Sundry Site Plan is used to map property that cannot be shown on a Right of Way Plan such as ferry terminals, wetlands mitigation sites, park and ride lots, stockpile sites, and stormwater retention or other reclamation sites.

Both Right of Way Plans and Sundry Site Plans convey legal information regarding property boundaries. Right of Way Plans are typically based on roadway alignments whereas Sundry Site Plans are not based on roadway alignments. When the boundaries of an existing ferry terminal are modified, the corresponding Right of Way Plans and Sundry Site Plans must also be modified. The Sundry Site Plan contains all terminal property information with the exception of property on highway right of way. Refer to the WSDOT *Plans Preparation Manual* for additional information regarding Right of Way and Sundry Site Plans. To obtain title reports or determine if any acquisition, easements, leases or right of entry agreements may be needed for the project, contact the WSDOT regional or headquarters Real Estate group.

WSDOT has decision authority on state right of way in unincorporated areas and within cities below a specified population as set forth in the WSDOT *Design Manual*. WSDOT also maintains decision authority in limited access areas. Obtain approval through the local WSDOT region and the HQ Right of Way Office for modifications to state right of way in unincorporated areas. Coordinate with both WSDOT and the local jurisdiction for improvements and any associated permit requirements within incorporated areas.

(15) DNR Leased Property

WSF leases offshore state-owned land through the Washington State Department of Natural Resources (DNR) at several existing terminals. A DNR authorization to use state-owned aquatic lands is required if projects will occur on or over state-owned aquatic lands. The use of this land is through a DNR authorization that serves as a legal contract that outlines the terms and conditions of use and conveys certain property rights to the user (WSF) in exchange for rent. WSF/WSDOT is responsible for contacting the DNR early in the design process to determine any requirements for attaining or altering existing leases. Coordinate with the WSDOT Right of Way Branch on issues regarding DNR leased property.

330.05 Vessels

(1) Design Vessels

Exhibit 330-4 provides a summary of the design vessels for each of the WSF ferry terminals. Design vessels are broken out into two categories.

- Use Category I includes vessels that will typically use the terminal. These vessels will be used during all operating conditions and will be moored overnight at terminals that have mooring facilities.
- Use Category II includes vessels that will be <u>utilized</u> as substitutes for Category I vessels <u>during planned maintenance activities</u>. Vessels will be infrequently moored overnight at terminals that have mooring facilities.

Terminal	Jumbo Mark II	Jumbo	Super	Olympic	Issaquah 100/ Issaquah 124	Evergreen State	Hiyu	Kwa-di Tabil
Anacortes			I	I	I	II		II
Bainbridge Island	I	II						
Bremerton		I	I	I	I			
Clinton				I	I			
Coupeville								I
Edmonds	I	I	II	II	II			
Fauntleroy					I	I		II
Friday Harbor			I	I	I	I	II	II
Kingston	I	I	II	II	II			
Lopez			I	I	I	I	II	II
Mukilteo			<u>II</u>	I	I	<u>II</u>		<u>II</u>
Orcas			I	I	I	I	II	II
Point Defiance						II	II	I
Port Townsend								I
Seattle	I	I	I	I	I			
Shaw			I	I	I	I	II	II
Southworth					I	I		II
Tahlequah						II	II	I
Vashon					I	I		II

Design Vessels
Exhibit 330-4

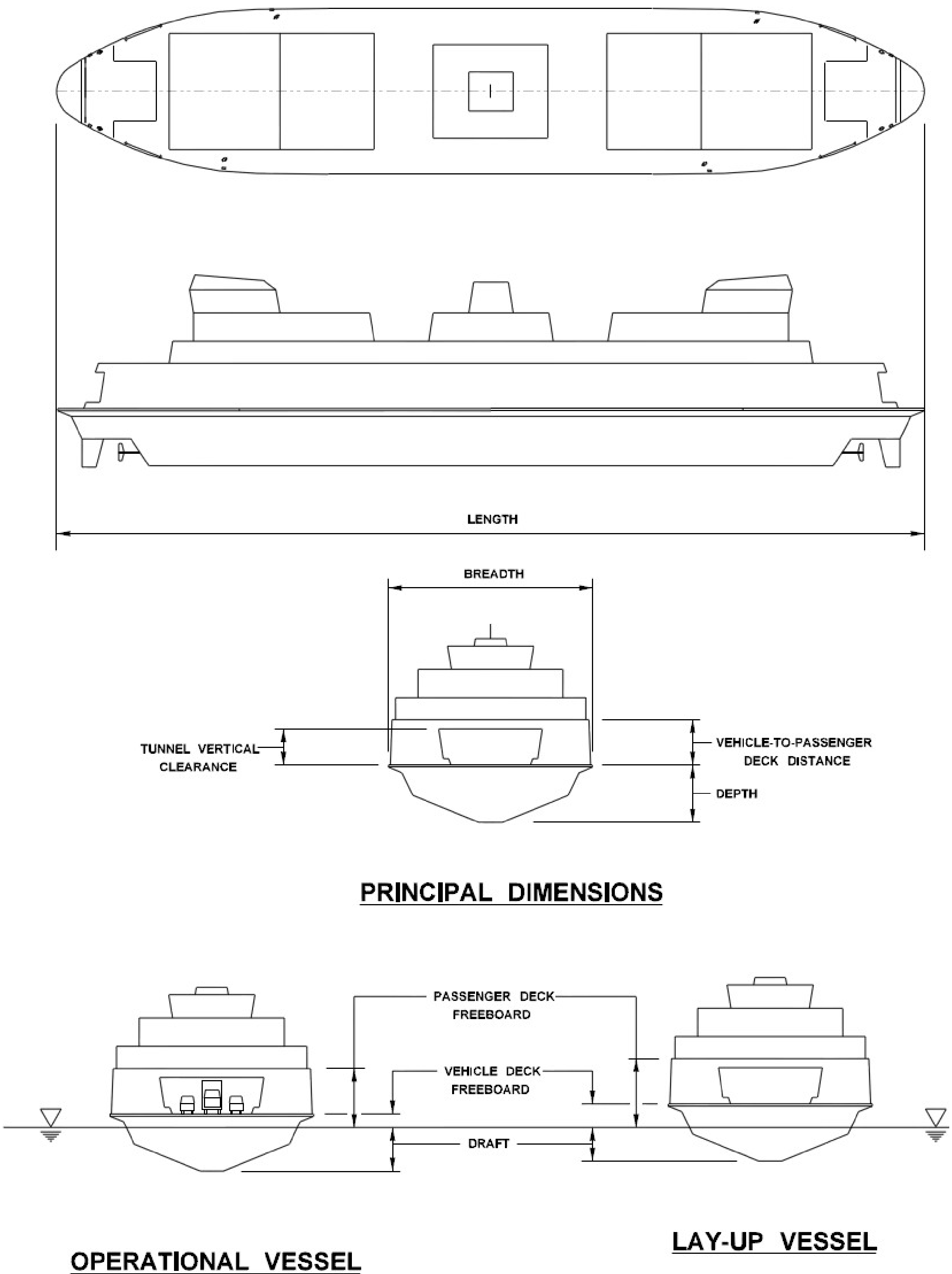
(2) Vessel Particulars

Refer to Appendix O and Exhibit 330-6 for design vessel particulars. Design particulars are the dimensional, capacity and other properties of the design vessel, especially those that are required for the design of the facilities and structures the vessel uses. These include the vessel's displacement, length, beam, draft, freeboard, passenger capacity and vehicle capacity. The displacement is a function of the vessel's weight, the capacities of its fuel and water tanks as well as its passenger and vehicle capacities. While the vessel's length and beam are independent of the displacement, the draft is directly proportional and the freeboard is inversely proportional to the displacement. The vessel's draft is critical to the design of a slip to ensure adequate clearance between the vessel's keel and engines and the slip's mudline. The freeboard is a primary factor in the design of tide-dependent structures such as the vehicle transfer span, overhead loading, and tie-up slip gangplank systems as well as the wingwall and dolphin rubfaces.

Some particulars will vary as a result of the different levels of loading a vessel is subject to. The most common condition used for design is termed the Operational Vessel (or Heavy Vessel) which is defined as tanks at full capacity and the full capacity of vehicles and passengers for which the vessel is designed and licensed. However, a vessel will frequently be empty of vehicles and passengers and have either full or partially full tanks. This condition is termed the Lay-up Vessel and results in the highest freeboard which, when coupled with the highest design tide, gives the maximum vessel deck elevation. The following table Exhibit 330-5 illustrates the two loading conditions and their uses in the design of terminal facilities. Operations staff will provide guidance as to which loading condition(s) are to be used for the design of particular facilities.

Loading Condition	Definition	Design Elements
Operational Vessel	Full Tanks Full Passenger Load Full Vehicle Load	Operating Slip Landing Aid Design Energy Low Tide Operational Range Operating Slip Mudline Elevation
Lay-up Vessel	Half-full or Full Tanks No Passengers No Vehicles	Tie-up Slip Landing Aid Design Energy High Tide Operational Range Tie-up Slip Mudline Elevation Night Tie-up Mooring Range

Vessel Conditions
Exhibit 330-5



Vessel Diagrams
Exhibit 330-6

(3) Vessel Utilities

Exhibit 330-7 identifies the type of vessel utilities provided at each WSF terminal. Refer to utility criteria below for utilities to be provided. See Chapter 560 Site Utilities for additional information.

Terminal	Potable Water	Sewer Pump-out	Solid Waste	Shore Power	Vessel Backfeed	Fueling Method
Anacortes	X	X	X	X	X	Truck
Bainbridge Island	X			X	X	Pier 15
Bremerton	X			X	X	Truck
Clinton	X			X	X	Truck
Coupeville				X	X	Truck
Edmonds	X	X	X	X	X	Pier 15
Fauntleroy	X	X	X	X	X	Truck
Friday Harbor	X	X	X	X	X	Truck
Kingston	X			X	X	Pier 15
Lopez				X	X	N/A*
Mukilteo	X	X	X	X	X	Truck
Orcas				X	X	N/A*
Point Defiance	X	X	X	X	X	Truck
Port Townsend	X	X	X	X	X	Truck
Seattle	X	X	X	X	X	Pier 15
Shaw				X	X	N/A*
Southworth	X			X	X	Truck
Tahlequah				X	X	Truck
Vashon	X			X	X	Truck

*No fueling takes place at terminal. Vessels are fueled by truck in Anacortes or Friday Harbor.

WSF Ferry Terminal Vessel Utilities
Exhibit 330-7

(a) Potable Water

Provide one domestic water line per slip for filling freshwater tanks. Most vessel freshwater systems utilize 4-inch pipe. Size the shore-side freshwater fill piping to be consistent with the terminal service piping, usually 1½-inch or 2-inch. The vessels will be provided with the necessary fittings to connect to the size provided on the transfer span. Connect to the municipal system. See Section 560.04 Potable Water for additional information.

Incorporate in each transfer span domestic water line a backflow preventer in a heated enclosure or room near the transfer span hinge line. As an alternative, the backflow preventer may be protected from freezing with heat tape and insulation.

(b) Sewer Pump-out

Provide one 4-inch sewer pump out per slip. Connect to municipal system. Verify discharge rate with respect to the existing system capacity with local sewer district. See also Section 560.04 Sanitary Sewer for additional information.

(c) Solid Waste

Consider combining vessel solid waste collection area with terminal building garbage collection area. Provide vehicular service access to the collection area(s).

(d) Shore Power

Provide one 200-amp, 480-volt service connection per slip. Terminals designed for Jumbo and Jumbo Mark II design vessels require two 200-amp, 480-volt service connections per slip. See Section 560.09 Site Power for additional information.

(e) Shore Power Backfeed

Provide one vessel shore power backfeed per slip.

(f) Fuel

Vessel fueling is either via truck delivery or takes place at Pier 15 off of Harbor Island. All of the island terminal vessels are fueled in Anacortes with the exception of the inter-island vessel which is fueled via truck at Friday Harbor. Refer to the USCG Safety Management System (SMS) procedures for vessel fueling requirements. Containment booms are required where fueling operations occur.

(4) Vessel Routes and Terminal Locations

Exhibit 330-8 identifies the existing WSF ferry system routes and corresponding terminal locations. Appendix P and Appendix Q contain additional route and terminal reference data.

WSF Ferry System Routes and Terminal Locations
Exhibit 330-8

(5) Vessel Security and Safety Zones

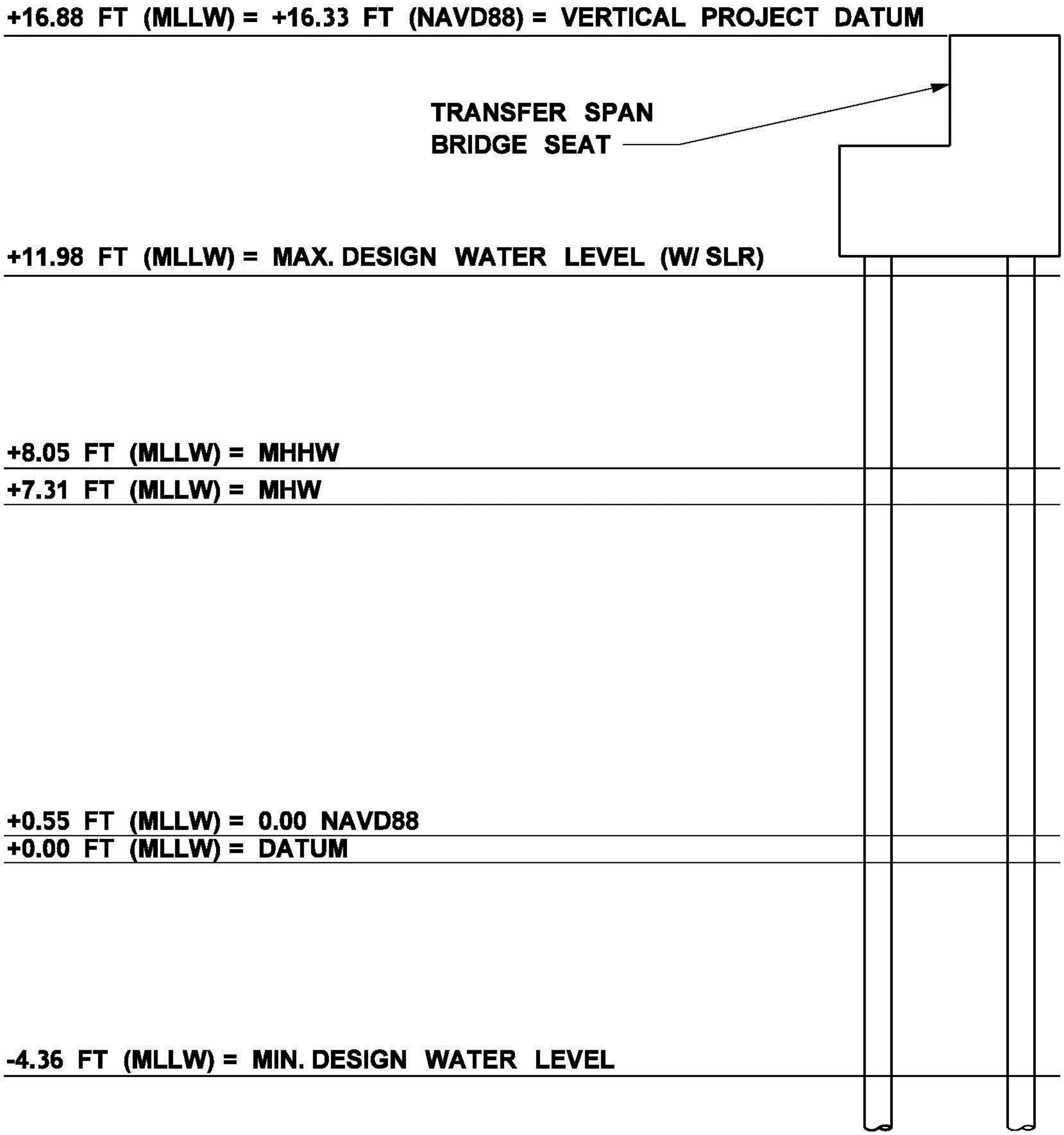
Per 33 CFR Part 165.1317, "there is established a large passenger vessel security and safety zone extending for a 500-yard radius around all large passenger vessels located in the navigable waters of the United States in Puget Sound, WA, east of 123°30' West Longitude. [Datum: NAD 1983]." Consider requirements of the moving security zone, established by Captain of the Port Puget Sound, as follows:

- Vessels within 500 yards must operate at minimum speed necessary to maintain safe course and respond to directions of the WSF Watch Officer or on-scene official patrol officer.
- Vessels and persons are prohibited from approaching within 100 yards (underway) unless authorized by WSF or the on-scene patrol officer.
- Vessels and persons are prohibited from approaching within 25 yards of any WSF vessel docked at a terminal, without authorization.

330.06 Tidal Information

(1) Terminal Tidal Datums

The general arrangement of terminal tidal datums is illustrated in Exhibit 330-9. Tidal datums are tabulated in Exhibit 330-10. The North American Vertical Datum of 1988 (NAVD 88) datums were determined from a survey of the terminals by the WSDOT GeoMetrix Geodetic Survey Office. Mean High Water (MHW) and Mean Higher High Water (MHHW) were calculated using VDatum 3.2 software provided by the National Oceanic and Atmospheric Administration (NOAA). Elevations for NAVD 88, MHW, and MHHW are given with respect to the datum MLLW = 0.00 feet. Coordinates used to determine datums correspond to each terminal's main slip bridge seat as tabulated in Exhibit 340-3. See Appendix X for additional information.



(Values are from Anacortes Ferry Terminal. For values at other terminals see Exhibits 330-11, 330-12, and 340-3)

General Arrangement of Terminal Tidal Datums,
Design Water Levels and Vertical Project Datum
Exhibit 330-9

Datums:
MHHW: Mean Higher High Water
MHW: Mean High Water
NAVD 88: North American Vertical Datum of 1988
MLLW: Mean Lower Low Water

Terminal	MLLW (Datum) (Feet)	NAVD88 (Feet)	MHW (Feet)	MHHW (Feet)
Anacortes	0.00	0.55	7.31	8.05
Bainbridge Island	0.00	2.51	10.52	11.31
Bremerton	0.00	2.50	10.86	11.74
Clinton	0.00	2.05	10.23	11.10
Coupeville	0.00	1.12	7.78	8.59
Edmonds	0.00	2.05	10.07	10.93
Fauntleroy	0.00	2.52	10.67	11.55
Friday Harbor	0.00	0.49	7.08	7.72
Kingston	0.00	2.05	10.14	10.99
Lopez	0.00	0.53	7.11	7.82
Mukilteo	0.00	2.06	10.19	11.05
Orcas	0.00	0.58	7.11	7.88
Point Defiance	0.00	2.49	11.06	11.94
Port Townsend	0.00	1.11	7.86	8.55
Seattle	0.00	2.33	10.49	11.36
Shaw	0.00	0.53	7.14	7.84
Southworth	0.00	2.52	10.69	11.58
Tahlequah	0.00	2.49	11.01	11.89
Vashon	0.00	2.53	10.66	11.53

Terminal Tidal Datums
Exhibit 330-10

(2) Design Tidal Ranges

Design tidal ranges are tabulated in Exhibit 330-11. They were developed using NOAA-verified tide data from the past 17 years. The use of verified tide data means that the effects of storm surge, atmospheric pressure and other weather effects are included with the predicted astronomical effects.

Maximum Design Water Levels include a medium estimate of Sea Level Rise (SLR) of 13 inches and are intended for all structures including those with 50 and 75-year design lives. Structures with 50-year design lives include berthing structures (wingwalls and dolphins). Structures with 75-year design lives include vehicle and pedestrian loading structures (trestles, vehicle transfer spans, and overhead loading systems). Structures with design lives shorter than 50 years need not include SLR. Design Water Levels are referenced to the datum MLLW = 0.00 feet. See Section 330.06(3) and Appendix X for additional information.

Terminal	Design Tidal Range (Feet MLLW) Minimum Water Level	Maximum Water Level	Maximum Water Level (Incl. SLR)
Anacortes	-4.36	10.90	11.98
Bainbridge Island	-4.98	14.60	15.68
Bremerton	-4.88	15.18	16.26
Clinton	-4.83	14.16	15.24
Coupeville	-4.46	11.60	12.68
Edmonds	-4.83	14.02	15.10
Fauntleroy	-4.93	14.89	15.97
Friday Harbor	-4.09	10.90	11.98
Kingston	-4.88	14.16	15.24
Lopez	-4.05	10.79	11.87
Mukilteo	-4.83	14.16	15.24
Orcas	-3.92	10.44	11.52
Point Defiance	-4.93	15.33	16.41
Port Townsend	-4.36	11.60	12.68
Seattle	-4.88	14.60	15.68
Shaw	-4.32	10.44	11.52
Southworth	-4.83	14.89	15.97
Tahlequah	-4.93	15.33	16.41
Vashon	-4.93	14.89	15.97

Terminal Design Tidal Ranges
Exhibit 330-11

(3) Sea Level Rise

Sea level rise (SLR) due to climate change will continue to modify terminal tidal levels in the 21st century. At present the rate of future sea level rise can only be estimated.

In Puget Sound WSDOT projects an estimated medium change in sea level of 6 inches (with a range of 3 to 22 inches) by the year 2050 and an estimated medium change in sea level of 13 inches (with a range of 6 to 50 inches) relative to 2000 by the year 2100. These estimates are based on the reference document Climate Impacts Vulnerability Assessment Report Appendix A (November 2011) (see Appendix X). More recent research by the National Academy of Sciences Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (2012) projects an estimated change in sea level of 24 inches (with a range of 4 to 56 inches) relative to 2000 by the year 2100.

Design all marine structures (with either a 50 or a 75-year design life) to accommodate a medium estimate of SLR of 13 inches. Provide a plan to adapt or replace the marine structures to accommodate a high estimate of 50 inches in a worst-case SLR scenario. As more information becomes available regarding projected SLR refer to Appendix X to adjust the Design Tidal Ranges accordingly. Adjustments may be necessary on a biennial basis.

Another phenomenon related to climate change is the increase in significant wave height and storm surge due to more intense storms. According to the Climate Impacts Vulnerability Assessment Report Appendix A, significant wave height events on the Washington coast are projected to increase approximately 2.8 inches per year through the 2020's. However, because this value is based on extrapolation of past data, not on modeling, there is low confidence in this value. In addition, the projected increase within Puget Sound is unknown. Therefore, the effects of increases in wave height and storm surge have not been accounted for in the Design Tidal Range.

330.07 Slips

(1) General

A ferry slip is a specialized docking facility, consisting of wingwalls and dolphins that guide and hold a vessel, and vehicle and pedestrian structures that provide access to and from the vessel. This chapter discusses the three types of slips at WSF's facilities: main, auxiliary and tie-up. Main slips are those intended for regular every-day use. Auxiliary slips are used less frequently for special service and for backup during maintenance and/or repair of a main slip. Both main and auxiliary slips may also be used for overnight moorage. Main and auxiliary slips are served by a vehicle transfer span. Tie-up slips are used for overnight moorage and are served by a gangplank that is generally used only by WSF personnel.

Exhibit 330-12 identifies the existing slips at each ferry terminal. Refer to Appendix R for existing terminal plans showing the slip locations.

Terminal	Slip Number and Function			
	1	2	3	4
Anacortes	Main	Main	Tie-up	Tie-up
Bainbridge Island	Main	Auxiliary	Tie-up	-
Bremerton	Main	Auxiliary	-	-
Clinton	Main	Auxiliary	-	-
Coupeville	Main	-	-	-
Edmonds	Main	-	-	-
Fauntleroy	Main	-	-	-
Friday Harbor	Main	Tie-up	-	-
Kingston	Main	Main	Tie-up	
Lopez	Main	-	-	-
Mukilteo	Main	-	-	-
Orcas	Main	-	-	-
Point Defiance	Main	-	-	-
Port Townsend	Main	Auxiliary	-	-
Seattle	Main	Auxiliary	Main	-
Shaw	Main	-	-	-
Southworth	Main	-	-	-
Tahlequah	Main	-	-	-
Vashon	Main	Main	Tie-up	-

Existing Slips
Exhibit 330-12

(2) Slip Layout

(a) Slip Spacing and Orientation

Slip spacing and orientation are functions of several factors including: geometry of existing or planned overhead loading, size of existing or planned trestle, route approach geometry, environmental (wind, tide and current) conditions, and vessel size. Parallel slip spacings have varied from 132.75 feet at Seattle, to 135 feet at Bainbridge Island, Anacortes, and Kingston. At Clinton, the distance between the south Slip 1 and the bridge seat constructed for a future Slip 3 is 145 feet.

The current standard distance of 145 feet between operating slips assumes the slips are parallel to each other. This spacing is required to allow different vessel approach angles depending on the wind and tidal condition while providing a safe buffer between vessels that are either approaching or departing adjoining operating slips. It also accommodates a dual overhead loading system.

A parallel slip configuration may reduce the number of marine berthing structures required, which can reduce capital costs. For example, at the Seattle Terminal, one double-sided floating dolphin is utilized between Slips 2 and 3 for the off-shore navigational/berthing structure rather than providing several single-sided dolphins to support each operating slip.

When providing double-sided dolphins between parallel slips, consult with WSF to determine the appropriate slip spacing and dolphin width.

The alignment of the slips can have an effect on the turning radius for vehicle access to or egress from the vessels. Providing slips in a parallel alignment allows the use of common terminal holding area and exit lanes facilities. Refer to Chapter 340 for channelization requirements in the holding areas.

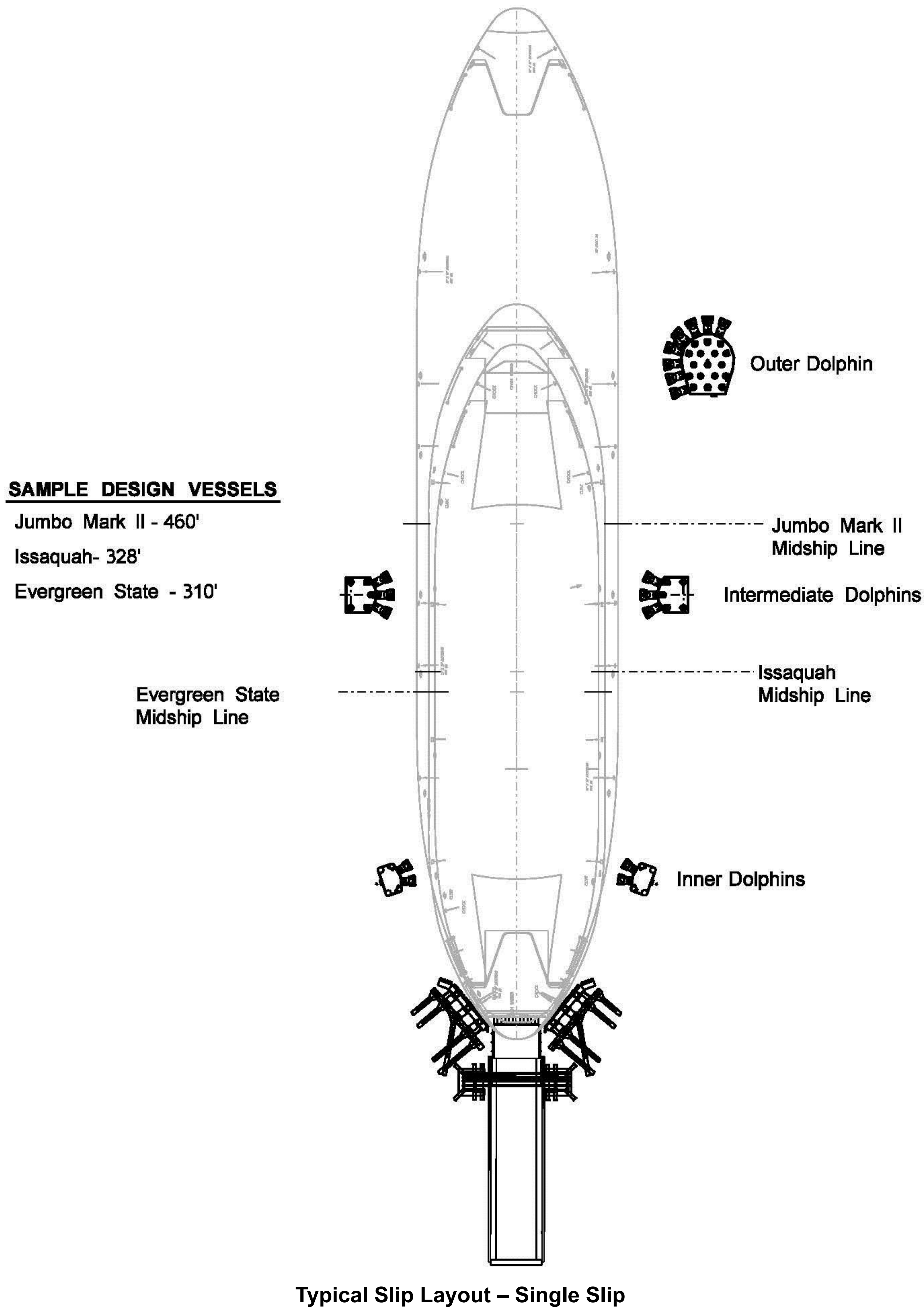
(b) Dolphin Locations

Consult with WSF Operations staff to determine the location of fixed and floating dolphins.

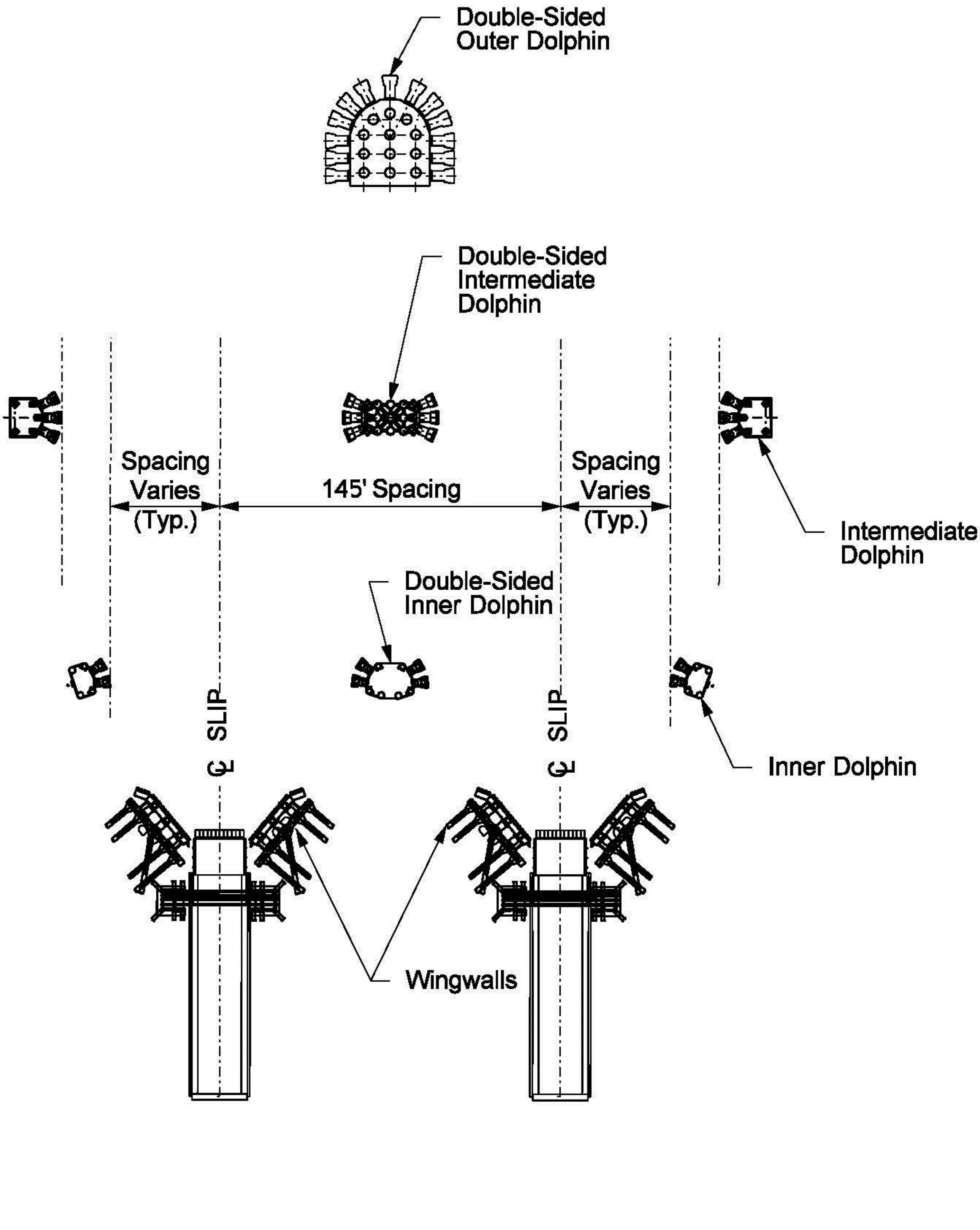
- The ideal layout of dolphins is the layout that most economically accommodates all design vessel sizes and operational requirements. This may consist of the "six pack" arrangement: one inner, one intermediate, and one outer dolphin on each side of the slip. More commonly, the intermediate and outer dolphins on one side may be combined and positioned such that vessels approaching from that side of the slip are better able to turn into the slip (the number may also be reduced for operational, wind and current, vessel assignment, geotechnical, or other reasons).
- The outer dolphins are the primary berthing and mooring structures for the longer vessels using the slip. They are typically located approximately 55 to 75 feet from the slip centerline and 240 to 300 feet from the apron (located seaward a sufficient distance to ensure the contact point is beyond the vessel's midship line).
- The intermediate dolphins are the berthing and mooring structures for shorter vessels using the slip. They are typically located approximately 50 to 65 feet from the slip centerline and 160 to 200 feet from the apron (located seaward a sufficient distance to ensure the contact point is beyond the vessel's midship line).

- The inner dolphins serve primarily to protect other structures and are not used for mooring and tie-up. They are typically located approximately 40 to 45 feet from the slip centerline and 50 to 60 feet from the apron. They are located in such a position that a vessel that is contacting an intermediate or outer dolphin will be approximately 2 to 3 feet away from the inner dolphin (to prevent a levering action that could pull the vessel out of the slip).
- At some locations a concrete floating dolphin will take the place of one or more fixed dolphins. Floating dolphins are typically used where the water depth exceeds about 50 feet. Floating dolphins are often preferred by vessel captains for their energy-absorbing capacity and their large surface area. They may be feasible in shallower water where their mooring anchors will not come in contact with vessel bottoms.
- Where two slips are adjacent, a double-sided dolphin may serve both slips.

While these are general guidelines, all of the dolphins for a slip are located in close consultation with the users (i.e., the vessel captains) and are based on their needs. These include: vessel characteristics, customary approach and departure angles and velocities, the wind and current environment, overhead loading and other operational features, and crew preferences.



Typical Slip Layout – Single Slip
Exhibit 330-13



Typical Slip Layout - Two Parallel Slips
Exhibit 330-14

(c) Redundancy

As can be observed in Exhibit 330-12, some terminals have a single operating slip whereas others have multiple operating slips. The number of operating slips is typically a function of the ferry ridership and number of destinations served by a given terminal. When only one operating slip exists at any facility, the reliability and dependability of the service is at a higher risk. Equipment breakdowns, unforeseen damage to the marine structures/transfer span and preventive/routine maintenance all have an effect on the reliability of service. Where multiple slips are present, it is common to provide a higher degree of structural reliability in one slip to function during extreme circumstances such as seismic conditions.

(d) Navigation

Coordinate with WSF Operations in design of slip location, orientation and layout. It may be advantageous to rotate slips from the "standard" parallel orientation based on site and/or environmental conditions including wind, waves and current.

Each WSF ferry terminal presents unique navigational challenges for the ferry vessel depending on available water depths, waves, currents, wind conditions, and adjacent structures or obstacles to navigation. Consult with WSF Operations regarding these challenges and develop the slip layout to best address the challenge given the capabilities of the design vessel(s).

(3) Slip Depth

Adequate water depth within the slip is required to ensure that any vessel can operate in the slip safely and with minimal environmental impact to the surrounding area. Of primary importance is protecting the vessel hull from contacting the sea floor or from creating excessive plumes of sediment that could damage the propulsion system. Secondarily, adequate depth is needed to prevent plumes from drifting and settling on adjacent environmentally sensitive areas (e.g., eelgrass beds).

Research suggests that a minimum mudline elevation of -30 feet MLLW at the throat of the slip will ensure that all vessel classes can safely operate at any terminal at the lowest tide. In practice numerous slips with less extreme low tides and with shallower-drafted vessels can operate safely with a shallower slip mudline. For example, tie-up slips that accommodate Lay-up vessels (i.e., vessels carrying no passengers or vehicles) may be safely operable with a mudline elevation in the range of -22 to -28 feet MLLW. Operations staff will provide assistance in determining the appropriate design vessel(s).

While historically dredging has been used to create a channel for newly constructed slips, alternatives should be explored when feasible due to the extensive permitting process required for dredging projects. Where dredging is the only alternative, careful consideration should be given to proper design of the depth and side slopes to ensure the dredged slip remains stable.

(4) Emergency Use

<Pending development – future manual update>

(5) Private Aids to Navigation

Navigation aids located on marine structures (including the navigation lights and fog horns on the outer dolphins and warning buoys, but excluding the wingwall fog lights) are regulated by the U.S. Coast Guard in accordance with 33 CFR Part 66. Coordinate all additions or modifications to the aids with Terminal Engineering Maintenance staff.

330.08 Berthing and Mooring Criteria

(1) Berthing and Mooring Structures

Wingwalls and dolphins are the primary berthing and mooring structures within each slip. They are subject to dynamic forces from vessel impacts during berthing and, to a lesser extent, to static forces from wind and/or currents on vessels moored to them. Bow lines attached to the transfer span bridge seat are used during operations as a safety measure (to prevent the vessel from drifting out of the slip should it lose power), and to secure the bow for overnight moorage.

Operating slip wingwalls are subject to a variety of impacts ranging from a typical landing at an approach velocity of approximately 1.5 knots to harder landings due to a variety of causes including low visibility, high winds and/or currents, and vessel malfunction. Tie-up slip wingwalls are typically designed for a lower approach velocity of 1.0 knots since these landings are less frequent and not dependent on the service schedule.

Under normal operating conditions, there are only light impacts on the dolphins. However, dolphins are designed for reasonable impacts resulting from difficult landing conditions, such as strong winds and/or currents. Difficult landing conditions may bring the vessel in contact with one or more dolphins during the berthing operation.

See Sections 630.04, 640.04, and 650.04 for additional information on design criteria (including design loads) for wingwalls and dolphins.

(2) Design Vessel Impact

WSF uses the following four classifications of berthing events to categorize damage to wingwalls and dolphins based on the technical report titled *Ferry Landing Design, Phase I: Final Technical Report* WA-RD 253.2 by Charles T. Jahren and Ralph Jones (1993), design reports titled “Edmonds Ferry Terminal Dolphin Replacements,” and “Kingston Ferry Terminal Dolphin Replacements,” and a Master’s thesis titled *The End Berthing Simulation Model* by Douglas R. Playter (1994):

(a) Type I: No Damage

A fender system should perform adequately for most berthing events for its entire service life. Repairs are limited to normal maintenance.

(b) Type IIA: Repairable Damage (No Impact to Operations or Damage to Vessel)

A fender system may see minor damage from hard berthing events, which can be repaired without impacting Operations. These repairs are generally limited to replacement of isolated portions of the structure that can be assembled or prepared off-site and installed in a limited time period. The system may need to be analyzed to identify methods of repair that minimize downtime for the structure.

(c) Type IIB: Repairable Damage (Impact to Operations)

A fender system may be damaged by unusually hard berthing events. Repairs are limited to replacement of a portion of the system. The system may be analyzed to identify probable repair requirements, and contingency plans may be made to accelerate the repair process.

(d) Type III: Catastrophic Damage

A fender system and its supporting structure may fail during a catastrophic occurrence. If the structure yields sufficiently, deceleration forces are limited as the vessel is brought to a stop. This will limit injuries and vessel damage. An example of a catastrophic occurrence is a propulsion failure as the vessel applies reverse thrust to stop.

The design philosophy and design criteria for berthing and mooring structures (wingwalls and dolphins) are in general accordance with the above event classifications. In practice all wingwalls and dolphins are designed for Type I events. Wingwalls are also designed for a Type III event to ensure the vehicle and pedestrian-loaded towers and transfer span located shoreward of the wingwalls are protected from damage.

Type II events are not explicitly designed for although details have been developed to ensure repairs are achievable as quickly as possible. These include bolted connections that make replacement of fenders and fender panels relatively easy and limited embedment of the fender piles to facilitate repositioning following displacement. Stockpiling of replacement components and development of a biennial on-call wingwall and dolphin repair contract are two ways that repairs can be accomplished as quickly as possible.

(3) Day Tie-up

Day tie-up is accomplished by a pair of lines used to secure the shore-end bow of the vessel during off-loading and loading operations. It is typically augmented with positive thrust by the vessel against the wingwalls and an outer dolphin to minimize movement of the vessel with respect to the vehicle transfer span apron and the overhead loading apron. Each line consists of a shackle attached to the apron curb and a length of nylon tie-up line that is secured to the vessel cleat. These items are typically furnished and installed by the Eagle Harbor Maintenance staff.

(4) Overnight Vessel Moorage

Determine if a slip will be used for overnight moorage, as identified in and by Operations. Moorage is considered a Type I event. Include the following for slips that will be used for overnight moorage:

- Outfit the wingwalls and intermediate and outer dolphins with wire rope mooring pendants to accommodate the proposed design vessels.
- Position mooring pendants so that vessels can be safely secured at night.

330.09 Wave, Flood, and Coastal Storm Loading

(1) Flood Design Loads

Include wave, flood, and coastal storm loading in the design of trestle, building, transfer span, and overhead loading structures. It is intended that the designed terminal structures will remain operational after the 100-year flood event.

Develop the loads and verify that the structure will be able to resist these loads. Loading shall include hydrodynamic loads, hydrostatic loads, debris impact loads, and breaking wave loads. Loads on exposed building structures, deck slabs, pile caps, piling, and underdeck structures such as utilities shall be determined and the capacity of these structures to resist these loads checked.

Loading shall be based on ASCE 7-10 and ASCE 24-14, and supplemented with FEMA P-55, Volume 2, Chapter 8.5 for all projects requiring a building permit. Consult with Terminal Engineering staff for the ASCE 24-14 design class for any buildings included in the project.

Loading shall be based on the AASHTO LRFD *Bridge Design Manual* and supplemented with the AASHTO Guide Specifications for Bridges Vulnerable to Coastal Storms for structures not requiring a building permit.

Establish the Base Flood Elevation in accordance with the local county and the Federal Emergency Management Agency (FEMA).

Adjust for Sea Level Rise based on an increase in tide level of 0.14 inch per year.

Provide a basis for selection of the average velocity of water in feet per second.

For debris impact loading determine the size of debris and potential impact force based on discussion with WSF or on a site-specific study at new terminals.