Chapter 600 Trestle

600.01 General

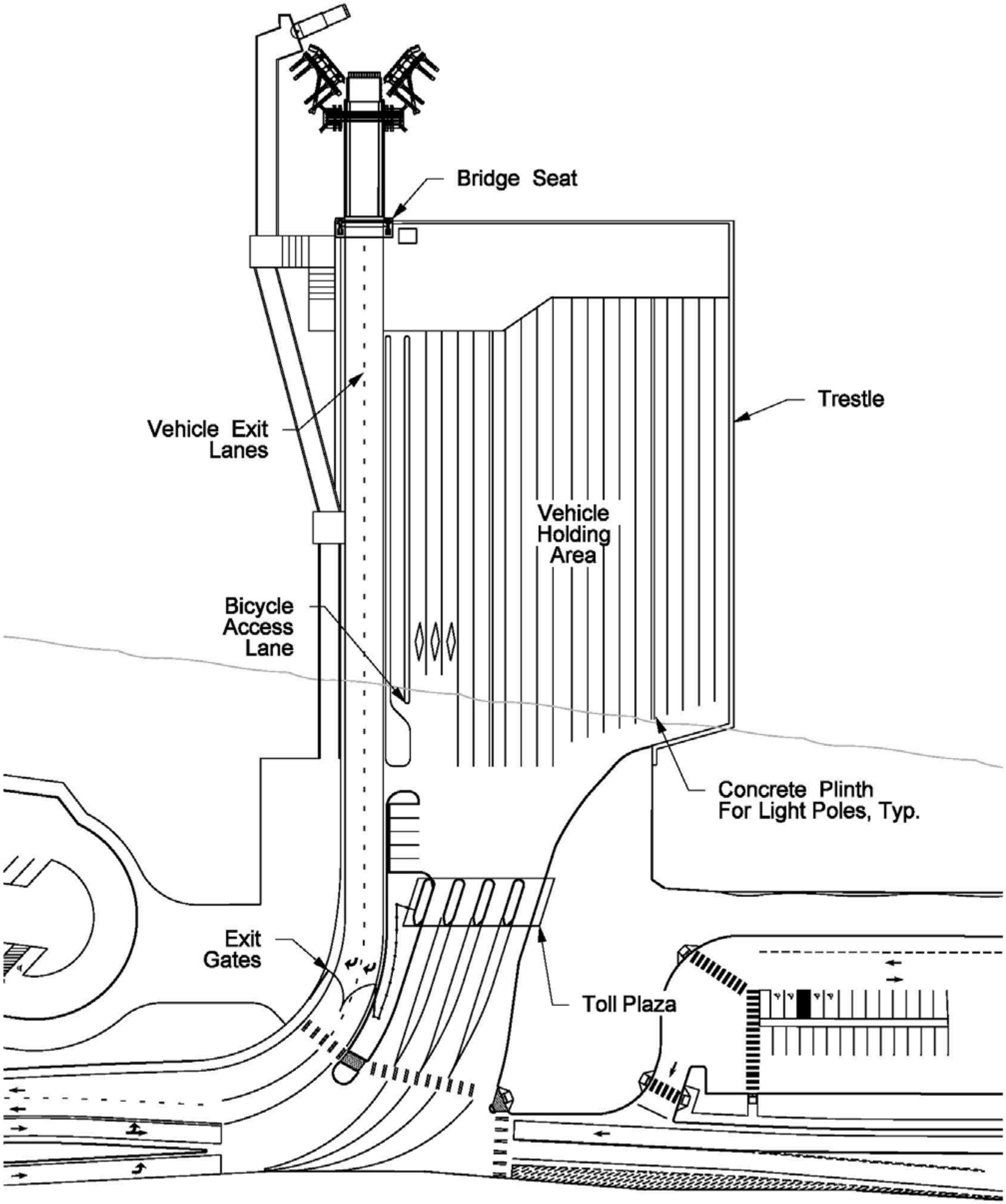
This chapter provides guidance on the design of trestles, bridge seats, and bulkheads. The trestle is a pile-supported structure, as shown in Exhibit 600-1, which serves as a roadway connection from the bulkhead to the vehicle transfer span (VTS). For some terminals, the vehicle holding area is fully or partially located on the trestle. Various terminal outbuildings, enclosures and support areas may also be located on the trestle. Exhibit 600-2 and Exhibit 600-3 show an example layout of a trestle in plan and cross section, respectively. In this example, the vehicle holding area is exclusively located on the trestle.

The trestle may also provide a pedestrian access path from the bulkhead to the terminal building. Further, the trestle may serve as the support structure for the overhead loading (OHL), VTS, terminal buildings, and various utilities, related equipment and structures. Use the trestle to run utilities from the land to the vehicle transfer spans. For recommendations on routing utilities, locating light posts and trench drains, refer to Section 600.09.

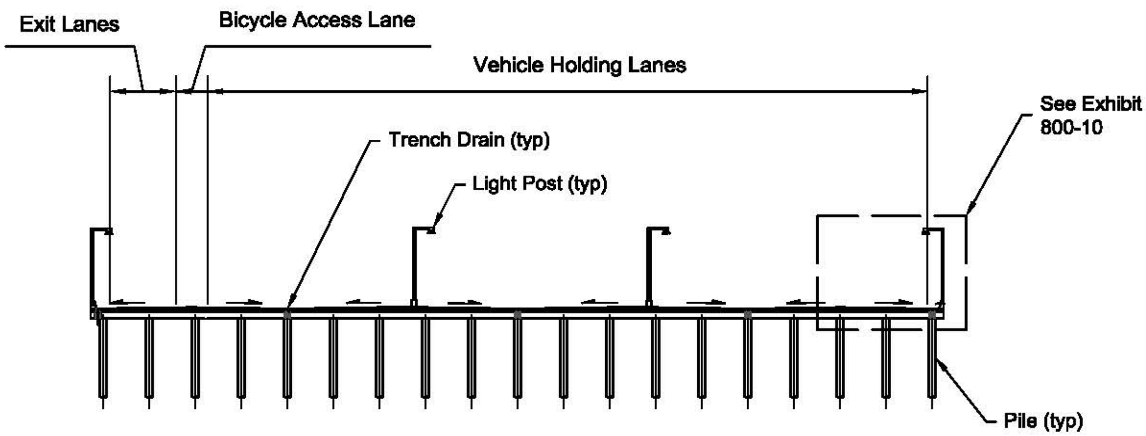
Clinton Trestle Substructure
Exhibit 600-1

For additional information, see the following chapters:

Chapter	Subject
300	Accessibility
310	Security
320	Environmental Considerations
330	Marine
340	Civil
360	Electrical
440	Maintenance Buildings, Enclosures and Support Areas
500	Access, Approaches, and Exits
510	Toll Plaza
520	Vehicle Holding and Support Areas
560	Site Utilities
570	Signage and Wayfinding
610	Vehicle Transfer Span
620	Passenger Overhead Loading



Example Trestle Plan
Exhibit 600-2



Example Trestle Cross Section
Exhibit 600-3

600.02 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*

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

WAC 296-24 *General safety and health standards*

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

WAC 296-876 *Ladders, portable and fixed*

(2) Design Codes and Specifications

AASHTO *LRFD Bridge Design Specifications* (AASHTO *LRFD Specification*), American Association of State Highway and Transportation Officials, Washington DC

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

Bridge Design Manual LRFD, M 23-50

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

General Special Provisions

Highway Runoff Manual M 31-16

Reference Drawings, WSF

Regional General Special Provisions, WSF

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

(3) Supporting Information

Life Cycle Cost Model (LCCM), WSF

600.03 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 terminal 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

(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) Civil

Refer to Chapter 340 for general civil design criteria pertaining to the trestle. Below are links to relevant sections by topic.

- Design Vehicles: 340.07(6)
- Vehicle Turning Analyses: 340.07(7)

(5) Marine

Refer to Chapter 330 for marine criteria pertaining to the trestle. Below are links to relevant sections by topic.

- Operations and Maintenance: 330.04(4)
- Proprietary Items: 330.04(6)
- Long Lead Time Items: 330.04(7)
- Corrosion Mitigation: 330.04(9)
- Scour and Mudline Elevations: 330.04(10)
- Geotechnical Requirements: 330.04(11)
- Materials Specification: 330.04(12)
- Miscellaneous Considerations: 330.04(13)
- Tidal Information: 330.06
- Wave, Flood, and Coastal Storm Loading: 330.09(1)
- Paving: 340.08

(6) Electrical

Refer to Chapter 360 for general electrical design criteria pertaining to trestles. Below are links to relevant sections by topic.

- Wiring and Protection: 360.04
- Wiring Methods and Materials: 360.05
- Equipment: 360.06

(7) 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.

- Trestle Substructure: 75 years
- Trestle Superstructure: 75 years
- Bulkhead: 75 years

(8) Elevation

The trestle elevations are controlled by the bulkhead elevation at the onshore end of the trestle, the bridge seat elevation at the offshore end of the trestle and any slope required for stormwater conveyance/treatment. Consider the following when selecting the bridge seat elevation: (1) resulting vehicle transfer span slopes; (2) trestle constructability; (3) trestle inspection needs; (4) anticipated sea level rise; (5) existing road profile/grade at shoreline/bulkhead; (6) storm surge/wave exposure.

Provide an elevation which is a compromise between keeping the trestle sufficiently high out of the seawater to keep it constructible (to avoid floating pile cap forms at high tide) and to minimize the potential for damage to the trestle/trestle utilities (from waves, sea level rise, storm surge and floating debris), and keeping it low enough to minimize the steepness of the vehicle transfer span at extreme low tides. It is advisable to provide adequate room beneath the trestle for post-seismic event inspections. Refer to Section 330.06(3) for information on anticipated sea level rise.

(9) Operational Classification

WSF trestles are operationally classified per the AASHTO LRFD *Specification* Section 1.3.5 as typical, not critical or essential, unless noted otherwise. The performance objective for "typical" bridges is life safety. See Section 600.06(1)(c) Limit States for use of this classification.

(10) Seismic Design

Perform seismic design of the trestle using a displacement-based design method in accordance with the AASHTO *Guide Specification* and supplemented as described herein. Design trestle for a design level earthquake (DLE) corresponding to a 7-percent probability of exceedance in 75 years (approximately a1000-year return period) with a life safety protection/collapse prevention performance objective. It is expected that the trestle will continue to support gravity loads after the DLE but may suffer significant damage and that significant disruption to service is possible.

Structures shall also be checked for an operational level earthquake event (OLE). This is an event in which no damage or only minor structural damage will occur, but a temporary interruption in service may occur.

This event corresponds to a 50-percent probability of exceedance in 75 years (approximately a 100-year return event). Expansion joint design and locations where the relative displacement of different structures could cause damage shall be checked for this level earthquake event. Soil parameters for developing seismic response spectra will be provided by the WSDOT Geotechnical Branch.

The designer shall identify in the general structural notes of the contract drawings the anticipated structural failure mode and locations for both the OLE and the DLE.

For seismic design of pile foundations, plastic hinging is limited to above ground and near-ground locations. In-ground plastic hinging is not permitted.

For geotechnical requirements, refer to Chapter 330.

(11) Accelerated Bridge Construction

Accelerated bridge construction methods such as precast concrete or steel bridge seat and trestle pile caps in the design are options where the duration of slip closures must be kept to a minimum. Use of these methods minimizes interruptions during construction and can be cost effective at terminals with high traffic volume.

(12) Expected Material Properties

Assess member capacities for earthquake loads using expected material properties in accordance with the AASHTO *Guide Specification*. Supplement expected material properties only where necessary by ASCE/COPRI 61-14.

(13) Signage and Wayfinding

Refer to Chapter 570 for requirements.

600.04 Trestle Components

(1) Superstructure

(a) Concrete Deck

Design the trestle deck to consist of precast prestressed concrete deck panels. A variety of deck panel types have been used successfully at WSF terminals. Design deck panel end connections for moment continuity over the pile caps to resist seismic forces and negative moments from super-imposed dead and live loads. Design the deck as a capacity-protected element, such that no inelastic deformations will occur. Yielding of the pile-to-cap connection is allowed.

Adjacent deck panels should be locked together by means of shear keys to allow for load sharing.

The depth of concrete deck members may be limited to prevent damage from floating logs and other debris at high tide.

(b) Pile Caps

The majority of trestle pile caps constructed at WSF terminals have been cast-in-place concrete. Precast concrete pile caps may be a feasible option for reducing environmental impacts associated with placing cast-in-place concrete over seawater and for accelerating the construction schedule. Two-stage pile caps consisting of precast base sections with cast-in-place connection pours may also be considered. Design pile caps as capacity-protected elements such that no inelastic deformations will occur.

Pile cap widths should be sufficient to allow for seated connection of deck panel ends above and for a concrete closure pour.

(2) Substructure

(a) Piling

Steel pipe piling and solid precast prestressed concrete piling have been used successfully at WSF.

Solid precast prestressed concrete piles are preferred due to their lower initial cost, resistance to corrosion, lower long term maintenance costs, and fewer requirements related to noise attenuation during impact driving. Permitting restrictions may prohibit pre-boring or jetting of pilot holes during the installation of solid precast concrete piles. However the difficulty in driving this type of pile into glacial till prevents them from being specified for most WSF projects.

Hollow precast prestressed concrete piles are not permitted due to concerns with their performance during an earthquake and the inability to inspect the interior of the piling afterwards.

Impact driving of steel piling will require the use of bubble curtains or other noise attenuation methods to reduce the impacts of pile driving on marine life. Steel and concrete pile capacities are to be verified (proofed) by driving at least the final portion of the pile with an impact hammer.

The optimal pile and bent spacing is based on providing the most efficient structural system with an emphasis on seismic performance and minimizing the number of piles required.

Documentation is required to demonstrate that the selected piling will achieve the design life specified in the LCCM.

(b) Plumb Piles

A ductile plumb pile system is the preferred foundation type.

(c) Batter Piles

Batter piles have performed poorly in past earthquakes. However, the use of batter piles is permitted provided the structure satisfies all force, displacement, and compatibility requirements due to seismic loading. In addition, the following restrictions apply:

1. Yielding of the tension batter pile at the cap connection is permitted in the DLE provided the hysteretic performance of the connection is considered. If sleeved dowels are used as a fusing mechanism for either solid concrete piles or pipe piles with a plug connection, calculate the permitted elongation in the dowels by multiplying the sleeve length by 50 percent of the strain limits in Exhibit 600-4.
2. Deck and pile caps are to be capacity-protected. Design deck and pile caps to resist 1.3 times the displacements associated with the lower bound geotechnical capacity of the piles and 1.3 times the forces associated with the upper bound geotechnical capacity of the piles.
3. It is prohibited to use pile buckling as a method of fusing the compression pile.

(3) Pile-to-Cap Connections

Pile-to-cap connections may be designed as full or partial moment connections provided they satisfy all displacement limits, ductility limits, strength, and lateral stability requirements.

During preliminary design, include consideration of a concrete plug connection created by extending dowels (reinforcing bars) into the cap from the pile. For steel pipe piles, anchor the dowels into a concrete plug cast into the pile. For prestressed concrete piles, grout the dowels into corrugated metal sleeves cast into the pile. The top of the pile may be isolated from the cap by placing a compressible material on the top and edges of the pile and a portion of the dowel lengths may be sleeved to debond them.

Connections created by extending prestressing tendons into the cap are not permitted.

Connections created by welding reinforcing bars to the steel pile are not permitted due to concerns about brittle fracture of the dowel.

Connections created by welding the top of a pipe pile to a steel plate embedded in a pile cap are not permitted.

Other connection types not discussed in this document will be permitted provided that the performance of the connection has been verified by testing, research, or analysis.

(4) Curbs, Barriers, and Railings

Trestle curbs, barriers, and railings are discussed in Section 600.06(1).

(5) Bulkhead

The bulkhead retains the soil at the landside end of the trestle and provides support for the first row of trestle deck panels. The bulkhead is discussed in Section 600.07.

(6) Bridge Seat

The bridge seat supports the vehicle transfer span at the trestle. Bridge seats are discussed in Section 600.08.

(7) Life Ladders and Life Rings

Locate life ladders and life rings in accordance with WAC 296-56-60115. Design life ladders to meet the requirements of WAC 296-56-60209 and WAC 296-876. WAC 296-56 has precedence over WAC 296-876.

(8) Vehicle Holding Area and Toll Plaza

Refer to Chapter 510 (Toll Plaza) and Chapter 520 (Vehicle Holding and Support Areas) for requirements.

(9) Bicycle Access Lanes

Refer to Chapter 510 for requirements.

(10) Pedestrian Access

Refer to Chapter 500 for requirements.

(11) Exit Lanes and Exit Gates

Refer to Chapter 500 for requirements.

(12) Terminal Outbuildings, Enclosures and Support Areas

Refer to Chapter 440 for requirements.

600.05 Trestle Civil Design

This section addresses civil design elements that are specific to the trestle, including the trestle design speed, posted speed, and grading. Refer to Chapter 340 for additional civil requirements including site preparation, grading and erosion control, design vehicles, roadway design and channelization, paving, and traffic control.

(1) Design Speed and Posted Speed

Determine trestle design speed and posted speed on a terminal-by-terminal basis. Note that the trestle barrier to be used for new and replaced trestles is independent of the design speed (refer to Section 600.06).

(2) Grading

The trestle surface should be graded to provide proper conveyance of stormwater per WSDOT *Highway Runoff Manual* requirements. Additional guidelines specific to the design of ferry terminal drainage is contained in Section 600.09 and Chapter 560.

600.06 Trestle Structural Design

(1) New Structures

(a) Design Codes

Design trestle in accordance with the following:

1. Design for all loads, except seismic, is governed by the AASHTO *LRFD Specifications*.
2. Seismic design is governed by the AASHTO *Guide Specifications* and supplemented as described in these criteria.
3. The AASHTO *Guide Specifications* is the controlling specification for seismic design and takes precedence over other criteria; however, where the AASHTO *Guide* does not provide specific displacement-based design specifications, *ASCE Seismic Design of Piers and Wharves* (ASCE/COPRI 61-14) may be used to supplement the AASHTO *Guide Specifications*.
4. Supplement design with WSDOT *Bridge Design Manual LRFD* (BDM).

Design curb, barrier and railing in accordance with the AASHTO *LRFD Specifications*. Provide TL-4 barrier for new trestle design regardless of trestle design speed.

Design ladders in accordance with WAC 296-56, WAC 296-876 and ANSI/AISC 360. WAC 296-56 has precedence over WAC 296-876.

WSF must approve any deviation from these design codes not specified below. Include a signed deviation in the Project File (PF)/Design Documentation Package (DDP). Refer to Section 220.05 for details on the PF/DDM.

(b) Design Life

Design life of the trestle is based on deterioration from corrosion and/or fatigue in accordance with Section 600.03(7). The design life of all structural elements, including steel piling, must be documented by analysis, testing, and/or research to demonstrate how the trestle design life identified in the LCCM will be met.

(c) Limit States

Utilize Limit States as specified in the AASHTO *LRFD Specifications*, Section 1.3.

Factor Relating to Ductility:	$\eta_D = 1.0$	For Conventional Designs and Details Complying with the AASHTO *LRFD Specifications*. Notify WSF if the value of η_D is not 1.0.
Factor Relating to Redundancy:	η_R	Determine During Design
Factor Relating to Operational Importance:	$\eta_I = 1.0$	For Typical Bridges

(d) Design Loads

The permanent and transient loads listed below apply.

1. **Permanent Loads**

DC **Dead Load of Structural Components and Nonstructural Attachments**

DW **Dead Load of Wearing Surfaces and Utilities**

CR **Force Effects Due to Creep**

DD **Downdrag Force**

EH **Horizontal Earth Pressure Load**

SH **Force Effects Due to Shrinkage**

2. **Transient Loads**

BR **Vehicular Braking Force**

Place braking force in all design lanes but do not combine with seismic loading.

CV **Vessel Collision**

Collision between a vessel and trestle need not be considered.

EQ **Earthquake Load**

Refer to Seismic Design in Section 600.03.

FL **Fatigue Load**

Design fatigue load in accordance with the AASHTO *LRFD Specifications*. WSF will provide site-specific $ADTT_{SL}$ and ADO.

LL **Vehicular Live Load**

Design trestle for HL-93 loading. The number of design lanes is equal to the number of traffic lanes. Design loading may be oriented in more than one direction on the trestle. Consider the orientation causing the maximum forces on the structural members for design.

For the DLE, use a vehicular live load of 640 pounds per feet (distributed over 10-foot lanes) and a vehicular live load factor γ_{EQ} of 0.5. The associated mass of live load need not be included in the dynamic analysis. (***Note:*** Truck Lane Loading with HL-93 trucks need not be considered for DLE load combinations.)

TG **Force Effect Due to Temperature Gradient**

TU **Force Effect Due to Uniform Temperature**

ULL **Uniform Live Load**

WSF project specific trestle structural design criteria will specify what areas, if any, of the trestle are to be designed for a uniform live load of 250 psf.

Distribute loading to produce maximum forces. Compare the design for ULL with the design for LL; the loading causing the maximum forces on the structural members will control. Do not apply dynamic load allowance to ULL or to HL-93 design lane load. ULL is to accommodate future construction on the trestle such as buildings.

WA **Wave, Flood, and Coastal Storm Loading**

Refer to Section 330.09(1) for wave, flood, and coastal storm loading criteria.

WL **Wind on Live Load**

WS **Wind Load on Structure**

Design wind load on structure in accordance with the WSDOT *Bridge Design Manual LRFD* and the AASHTO LRFD Specification. The design water level elevation is 0.00 feet corresponding to Mean Lower Low Water (MLLW).

(e) Load Combinations

Apply load combinations and load factors in accordance with AASHTO LRFD *Specification*. WSF does not require evaluation of an owner specified design vehicle.

(2) Retrofitted Structures

< Section pending completion>

600.07 Bulkhead Structural Design

The bulkhead provides the transition between the upland and the trestle. It retains the upland soils and supports the shoreward-most precast concrete trestle deck panels.

(1) Bulkhead Alternatives

(a) Steel Sheet Pile Wall System

The most common type of bulkhead used in past trestle construction consists of steel pipe piles and steel sheet piles connected at their tops by a cast-in-place concrete cap. The pipe piles provide the principal vertical support for dead and live loads. The sheet piles retain the soil and resist the lateral loads resulting from traffic and seismic ground motions. Include measures to mitigate corrosion in the design of the sheet pile bulkhead through the use of coating and cladding materials.

(b) Soldier Pile Wall System

Where especially high lateral forces (e.g. liquefaction and lateral spreading) are a factor in the design of the wall, a soldier pile wall may be considered to provide greater resistance to the anticipated lateral forces.

(2) Design Criteria and Loads

Design the bulkhead in accordance with the same dead load and live load provisions as used for the trestle. Lateral earth pressures and surcharge loads will be provided by the WSDOT Geotechnical Branch.

600.08 VTS Bridge Seat Structural Design

The bridge seat supports the shoreward end of the vehicle transfer span and controls the elevation of the offshore end of the trestle (see Section 600.03(7)). Bridge seat data for existing WSF terminals are provided in Exhibit 600-6. Surveyed bridge seat elevations are provided in Exhibit 340-3.

Bridge Seat Data			
Terminal and Slip	**Date Built**	**Pile Type**	**Bridge Seat Type**
Anacortes - Slip 1	1994	Steel	Concrete
Anacortes - Slip 2	2002	Steel	Concrete
Bainbridge - Slip 1	1995	Concrete	Concrete
Bainbridge - Slip 2	2006	Steel	Concrete
Bremerton - Slip 1	1990	Concrete	Concrete
Bremerton - Slip 2	1990	Concrete	Concrete
Clinton - Slip 1	2000	Steel	Concrete
Clinton - Slip 2	2003	Steel	Concrete
Coupeville	1979	Timber/Underground	Concrete
Eagle Harbor - Slip B	2006	Steel	Concrete
Eagle Harbor - Slip E	1981	Concrete	Concrete
Edmonds	1995	Steel	Concrete
Fauntleroy	1984	Timber w/ 2 30” Steel	Timber
Friday Harbor	2005	Steel	Concrete
Kingston - Slip 1	1986/2001	Concrete/Steel	Concrete
Kingston - Slip 2	1990	Concrete	Concrete
Lopez	1998	Steel	Steel
Mukilteo	1999	Steel	Steel/Timber
Orcas	1987	Steel	Concrete
Point Defiance	1994	Steel	Concrete
Port Townsend - Slip 1	2013	Steel	Concrete
Port Townsend - Slip 2	1982	Concrete	Concrete
Seattle - Slip 1[1]	1993	Concrete	Concrete
Seattle - Slip 2	1964	Timber	Timber
Seattle - Slip 3	1989	Steel	Concrete
Shaw	2004	30” Pipe w/ Anchors	Steel
Southworth	2002	Steel	Concrete
Tahlequah	1994	Steel	Concrete
Vashon - Slip 1	1997	Steel	Concrete
Vashon - Slip 2	1993	Steel	Concrete

[1] New slip location after 1993

Bridge Seat Data for WSF Terminals
Exhibit 600-6

During preliminary design of a new trestle, consider the bridge seat to be either integral with or isolated from the trestle. Select the configuration which is most cost effective. When a new bridge seat will be adjacent to an existing timber or concrete trestle, design the bridge seat to act independently of the trestle, where possible. Provide adequate distance between the two structures to ensure no or minimal damage results during the design seismic event. Use a concrete cap supported on piles for the design of the bridge seat. Where anchored pipe piles are required (e.g., where bedrock is at or near the mudline), a steel bridge seat may be more feasible for installation of the rock anchors.

The transfer of loads from the transfer span to the bridge seat occurs via two bearings at the bridge seat. An example is the hydraulic transfer span bearing shown in Exhibit 600-7. As a primary element of a movable bridge system, design of the bearing requires the participation of a mechanical engineer to ensure the pins and related parts are sized and specified for the anticipated loads.

Bainbridge Island Terminal H-Span Bridge Seat
Exhibit 600-7

600.09 Trestle Utilities

The trestle is used to convey several utilities which may include storm drainage facilities, sanitary sewer, domestic and fire water, gas, mechanical, electrical (power and lighting), and communications. These utilities support the ferry vessels in the slips and various other functions on the trestle. This section provides design guidance for trestle storm drainage conveyance and treatment, trestle lighting locations, and methods for routing utilities along the trestle. For guidelines on the type and size of trestle utilities, refer to Chapter 340 and Chapter 560.

(1) Stormwater Conveyance

Provide for conveyance of stormwater on the trestle. Stormwater conveyance systems consist of constructed facilities that provide for the flow of stormwater. Stormwater conveyance methods should be evaluated for each terminal individually and selected based on site parameters. Design conveyance systems following guidelines in the WSDOT *Highway Runoff Manual* (HRM) and the WSDOT *Hydraulic Manual*. The following conveyance options should be considered; however, more options do exist.

(a) Trench Drains

Trench drains collect surface runoff along linear areas and convey the runoff just below the deck elevation to its intended destination (refer to Exhibit 600-8). This approach alleviates grading constraints associated with draining large areas for a modest tradeoff in available treatment head. Grade pavement towards trench drains at a minimum of 1.5 percent slope as shown in Exhibit 600-9. The length of a given trench drain run is likely to be limited by the trestle structure due to the structure's flatness. This requires that drains must include their own slope and get progressively deeper. Wider non-sloped drains may be considered, but tend to introduce additional maintenance burdens due to sediment and debris accumulation. This approach is ideal for use with a consolidated treatment strategy that maintains a manageable trench drain length to convey runoff to each facility.

Design grates for trench drains and inlets for drains to accommodate bicycles and anticipated foot traffic (e.g. high heels).

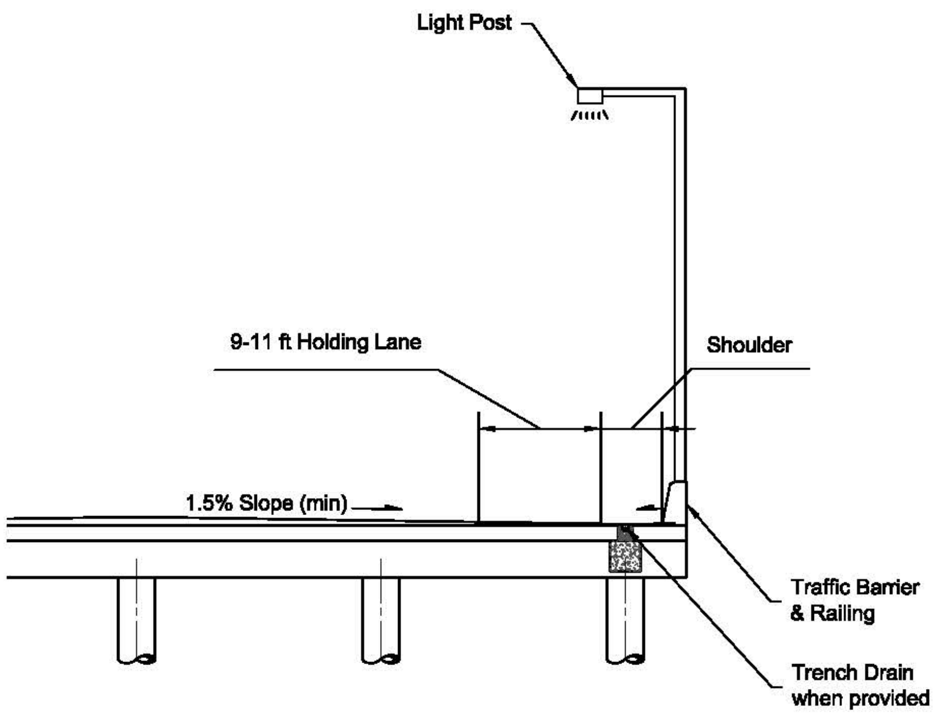
(b) Channelization

This approach relies on runoff being conveyed to treatment structures via sheet flow or shallow channelized flow. Its applicability is generally limited by deck grading constraints and concerns regarding flow depth. Limiting conveyance to surface runoff is advantageous for avoiding structural interference and maximizing the head available for passing the runoff through a treatment facility. (In other words, treatment facilities often have a minimum vertical flow distance measured from the inlet elevation of the structure to its outlet. Confining runoff to the surface maintains the outlet elevation of the treatment structure at its highest/shallowest potential). Drainage basins are generally limited in size, however, due to the grading and flow depth concerns. This approach is ideal for use with a localized treatment strategy.

(c) Underdeck Drain Piping

Underdeck drain piping alternatives suspend or otherwise incorporate drain piping under the deck to convey runoff to the intended destination. This approach provides slightly more flexibility with regard to trestle structure design, but requires additional inlet structures to capture the runoff. Underdeck piping is at risk of increased corrosion and damage from floating debris. It also provides the least available treatment head compared to the surface and trench drain conveyance alternatives. Under a flat trestle concept the challenge of providing adequate slope remains. This approach might be considered for conveying runoff from the trestle to an upland site, but is not otherwise a preferred approach for an overwater structure.

Clinton Trestle Stormwater Trench Drain
Exhibit 600-8



Trestle Cross Section - Trench Drain
Exhibit 600-9

(2) *Stormwater Treatment*

Provide for treatment of trestle stormwater. Stormwater may be treated either on or off the trestle. Evaluate stormwater treatment options for each terminal on an individual basis based on site parameters. Consider oil control treatment for stormwater at ferry terminals. The following subsections contain stormwater treatment options that have been found practical for ferry terminal trestle applications.

(a) Sand Filter

Sand filters consist of a vault structure with a bed of sand that acts as a filter. Runoff is directed over the sand bed where it infiltrates through to a collection pipe below the bed. The primary design constraint is based on providing sufficient bed area such that the facility can be adapted to a variety of site geometries and constraints. Stormwater runoff is collected and conveyed to a sand filter using trench drains and/or underdeck piping to an upland location with a flowsplitter and underground sand filter vault. Treated stormwater is discharged via an outfall.

An upland sand filter vault would likely require extensive excavation due to its inherent size and location at the downstream end of the trestle drainage system. The discharge of the vault is typically located under the filter bed, which introduces additional challenges for design of the outfall structure. Sand filter vaults also require ventilation grates, which are not desirable within traffic areas (both in terms of wear on the grates and maintenance access to the structure).

An alternative to locating a vault upland of the trestle is to place a linear sand filter along the centerline of the trestle and grade the trestle to drain to the filter. Treated runoff is discharged via drain holes in the filter structure.

A linear sand filter located on the trestle provides a more feasible approach. This configuration is shallower and performs as both conveyance and treatment. This facility may require regular maintenance on the sand bed to perform properly, however, and extended access to the structure may disrupt traffic.

(b) Wet Vaults

Wet vaults are underground storage structures designed to detain runoff and lower runoff velocity to permit suspended solids to settle out. Such facilities require infrequent removal of sediment and are not prone to clogging or other malfunction.

Runoff can be collected and conveyed to a wet vault using trench drains and/or underdeck drain pipe. Wet vaults may either be a concrete vault or a modular pipe-based system. Size the vault to retain the appropriate treatment volume per the WSDOT HRM. Treated stormwater is discharged via an outfall.

Construction costs are fairly high with wet vaults. In addition, due to the size of the structures, wet vaults would need to be located upland, introducing similar challenges as sand filter vaults. There is, however, greater flexibility with regard to the outlet location. Ecology and various permitting agencies generally regard their performance as limited and highly discourage their use unless no other option can be feasibly provided.

(c) Media Cartridge Filter

Ecology has approved a variety of media cartridge-based filters for Basic Treatment. The filters typically consist of a catch basin or vault with one or more cylindrical cartridges filled with granular filter material (zeolite and perlite are most common). Runoff passes through the cartridges for treatment. Maintenance consists of replacing the cartridges and occasionally removing accumulated sediment from the structure. Frequency of cartridge replacement is dependent on site sediment levels and number of cartridges, but is generally no more infrequent than annually. Annual service agreements are commonly available from suppliers to replace the cartridges and maintain the structures.

Catch basins containing cartridges can be placed throughout the deck to collect and treat localized drainage basins. Treated runoff is discharged directly to the water below. Determine the number of cartridges per catch basin based on the drainage basin size and the associated online treatment flowrate.

Alternatively, runoff can be collected from the trestle and routed through a flowsplitter and a single upland vault containing the appropriate number of cartridges to treat the site. As an offline and consolidated facility, the total number of cartridges will be less than placing cartridges in individual catch basins.

Media cartridge filters provide considerable design flexibility due to their compact and modular nature. Maintenance, though fairly simple, is a concern from the standpoint that each cartridge system is proprietary and long term availability of compatible cartridges cannot be guaranteed.

(d) Bioretention Structures

Bioretention areas (aka rain gardens) are designed to treat runoff via infiltration and biological uptake using water-tolerant plants in landscaped settings. A bioretention structure provides the same function by housing such landscape within planter structures outfitted with additional drainage components for collection of runoff and connection to storm drain systems. Such structures can be custom designed based on the criteria for a bioretention area. Maintenance consists of basic landscaping efforts and mulch replacement approximately once or twice a year.

Structures can be placed along the pedestrian area to collect and treat runoff. Depending on grading limitations, lateral trench drains or underdeck piping may be used to convey runoff from the opposite side of the trestle to the unit for treatment as well. Treated stormwater is discharged directly from the structure.

Use of bioretention structures can provide an aesthetically pleasing solution for stormwater treatment. The primary challenge of this concept is avoiding undue interference with pedestrian movement along the terminal. Structure depth and plant selection may also factor in to the final feasibility.

(e) Filter Strips/ Ecology Embankments/ Pervious Pavement

These treatment options consist of narrow permeable areas (either vegetated or covered with pervious pavement) that act as media filters for runoff conveyed via sheet flow. Incorporation of this type of treatment facility on an overwater structure is unconventional but technically feasible.

A pedestrian walkway could be constructed with pervious pavement over a sand treatment layer with the trestle graded to direct sheet flow over the pavement. Runoff would infiltrate through the pavement and treatment bed to a drainage layer for collection and discharge through soffit drains spaced periodically along the walkway.

It is anticipated that construction costs associated with this concept would be higher than other treatment alternatives due to a more complex deck structure or expanded footprint.

(f) Stormwater Oil Control

Treatment is focused on removing petroleum hydrocarbons. Applicability of this treatment target is based on the type of project as follows:

- Intersections where either >15,000 vehicles (ADT) must stop to cross a roadway with >25,000 vehicles (ADT) or vice versa
- Rest Areas with an expected trip end count greater than or equal to 300 vehicles per day
- Maintenance facilities that park, store, or maintain 25 or more vehicles (trucks or heavy equipment) that exceed 10 ton gross weight each

Specific elements of a ferry terminal are classified by the HRM as Rest Area or Bridge components. Such classification does not clearly align with the stated Oil Control treatment criteria (e.g. how trip counts are applied to a ferry terminal building or whether the trestle might be considered an intersection as well). Consult with the WSDOT Regional Headquarters for further design guidance.

(3) Trestle Lighting

Trestle lighting is typically installed along the trestle barriers and between holding lanes. (refer to Exhibit 600-9 and Exhibit 600-10). Install lighting within vehicle holding area such that it does not impede traffic from moving between lanes. Avoid the use of trestle luminaire poles with slip or break away bases since the trestle is a pedestrian area. Refer to Chapter 360 for additional lighting criteria.

Clinton Trestle Utility Corridor and Light Poles
Exhibit 600-10

(4) Sanitary Sewer

Refer to Chapter 560 for requirements.

(5) Potable Water

Refer to Chapter 560 for requirements.

(6) Fire Protection

Coordinate with fire marshal and local authorities to determine any requirements for fire lines, sprinklers and hydrants. Refer to Chapter 560 for additional information.

(7) Natural Gas

Refer to Chapter 560 for requirements.

(8) Routing Methods

The following are some potential methods for routing utilities along the trestle.

(a) Inside of Trestle Railing/Barrier

Provided accessibility requirements are not compromised, consider attaching utilities to the inside of the trestle railing/traffic barrier with an enclosure such as a sheet metal shrouding to provide protection and aesthetic improvement (see Exhibit 600-11). Mounting utilities on the inside of the trestle railing along the pedestrian walkway allows for easy access without impacting the vehicle holding lanes or exit lanes. Where practical, this is generally the preferred method for routing utilities along the trestle.

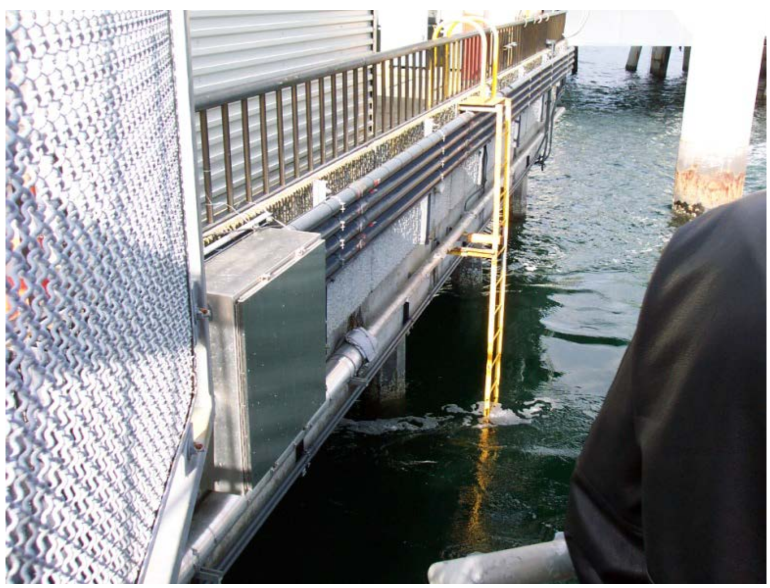
Vashon Island Utility Enclosure
Exhibit 600-11

(b) Outside of the Trestle Railing/Barrier

Consider mounting utilities along the outside of the trestle railing/traffic barrier as shown in Exhibit 600-12. Provide a means to support a temporary work platform for accessing utilities.

(c) Utility Catwalk

Consider providing a utility catwalk along the trestle. Locate an approved traffic barrier between the utility catwalk and the trestle interior. Ensure the corridor is wide enough to carry all utilities and leave the utilities uncovered. Consider providing grating as the floor of the corridor to reduce the increase in over water coverage.



Bainbridge Island Utilities Mounted on the Outside of Trestle
Exhibit 600-12

(d) Underside of Trestle

Consider hanging the utilities by installing trapeze type hanger assemblies on the underside of the trestle. Install the utilities between pile caps such that the utilities do not exist below the elevation of the bottom of the pile caps. Cast sleeves into the pile caps where necessary to convey a utility through one or more of the caps. Note that sleeves for larger utilities may not be feasible. Exhibit 600-13 shows a fire line hung under the trestle using a trapeze type hanger assembly. Note that the fire line is hung below the bottom of the pile caps, which is not recommended.

Vashon Island Utilities Suspended Under the Trestle
Exhibit 600-13

(e) Underside of Overhead Loading Structure

Where overhead loading structures are present over the trestle, subject to height restrictions, certain utilities may be attached to the underside of the overhead loading structure to minimize the space requirements to convey utilities on the trestle.

(f) Utility Corridor

WSF no longer favors the use of utility corridors in the trestle deck such as illustrated in Exhibit 600-10. These utility corridors tend to be difficult to access and are a maintenance issue due to the high volume of traffic driving over them.