Sustainable Design Guidelines to Support the Washington State Ferries Terminal Design Manual: Stormwater and Material Issues

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Michael Wolcott
Cara Poor
Liv Haselbach

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Submitted by:

Michael P. Wolcott
Cara Poor
Liv Haselbach
Washington State University
Pullman, WA 99164

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16. ABSTRACT

In an effort to assist the developers of the terminal design manual in potentially addressing sustainable design issues, the overall goal is to produce Sustainable Design Guidelines that will specifically address the unique needs and requirements of ferry terminals. In support of the development of these Sustainable Design Guidelines, the specific objectives of this project are to:

1. Review applicable sustainable design guidelines and rating systems.
2. Assess specific needs as perceived by WSF Terminal Engineering staff.
3. Compile standards and metrics potentially applicable to WSF terminals with a focus on materials use, site design, and consequences.
4. Prepare a draft Sustainable Design Guideline.
5. Provide specific methods to address stormwater quality and quantity using LID methods.
6. Provide specific recommendations where composite materials may provide unique solutions to material needs.

The outcomes of the project are expected to be complementary to the current SMS and other environmental documentation in place, or under consideration at WSF.

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1. Introduction

This report presents Sustainable Design Guidelines to support the Washington State Ferries Terminal Design Manual. As noted in the proposal, the Washington State Ferries (WSF) Terminal Engineering Division of the Washington State Department of Transportation (WSDOT) is currently developing a terminal design manual that will guide new projects towards meeting appropriate standards for terminals. This manual is not currently expected to fully address sustainable design standards. However, WSDOT is currently challenged with two major initiatives that could potentially impact terminal design:

1. Governor Christine Gregoire issued Executive Order 09-05 (Washington's Leadership on Climate Change) that directed the WSDOT to coordinate with regional entities to develop a sustainable transportation plan. Although not explicitly called out in the Executive Order, sustainable design standards have a clear influence on Sustainable Transportation and are being investigated elsewhere within WSDOT (PCHB 2008).
2. The use of Low Impact Development (LID) techniques to control stormwater has recently become the preferred options in Washington State after two Pollution Control Board rulings (PCHB 2009).

These initiatives address both the energy and water use of the facilities. Although WSF is not explicitly bound by either of these developments, it is prudent to investigate the likely sustainable design issues facing terminal development.

In an effort to assist the developers of the terminal design manual in potentially addressing sustainable design issues, the overall goal is to produce Sustainable Design Guidelines that will specifically address the unique needs and requirements of ferry terminals. In support of the development of these Sustainable Design Guidelines, the specific objectives of this project are to:

1. Review applicable sustainable design guidelines and rating systems.
2. Assess specific needs as perceived by WSF Terminal Engineering staff.
3. Compile standards and metrics potentially applicable to WSF terminals with a focus on materials use, site design, and consequences.
4. Prepare a draft Sustainable Design Guideline.
5. Provide specific methods to address stormwater quality and quantity using LID methods.
6. Provide specific recommendations where composite materials may provide unique solutions to material needs.

The outcomes of the project are expected to be complementary to the current SMS and other environmental documentation in place, or under consideration at WSF. We currently

envision a continual improvement where the Sustainability Guidelines become a component of the SMS and are implemented as a part of the EMS process as outlined below.

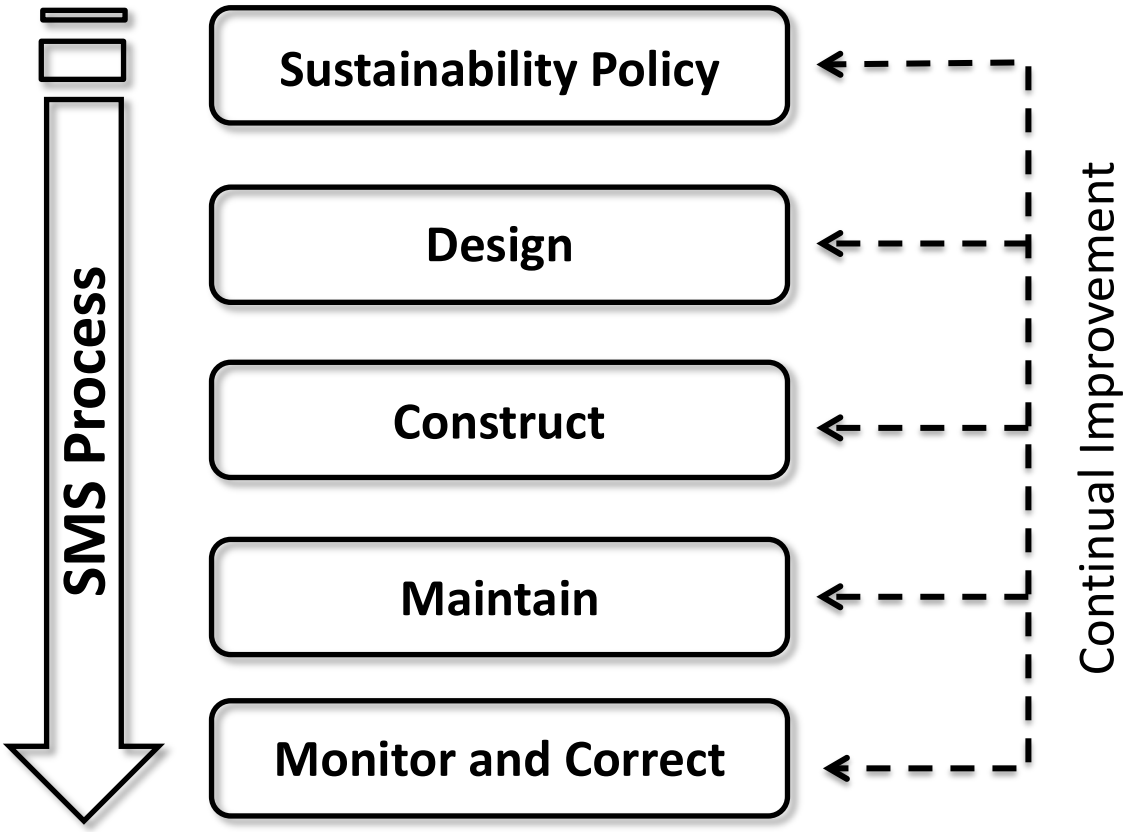

Figure 1.1. Illustration of the proposed relationship of sustainability guidelines to the WSF SMS process

1.1. Stakeholders

The stakeholders in the development of these guidelines include Washington Ports and Washington State Department of Transportation, other regulatory agencies, the public and other users of the ferry systems.

1.2. Summary of Report

An overall summary of the report structure includes:

1. This introductory section.
2. A background section on marine development including previous studies on applicable facilities, studies applicable to the Puget Sound, and specific regional and terminal site information.
3. A background section on sustainability guidance and tools, and also applicable codes and legislation.

4. A detailed section on stormwater infrastructure and practices, particularly those that might be considered for landside and waterside use as per the following 'Identified Areas of Importance'.
5. A detailed section on materials used for the terminal, particularly those which might be considered for landside and waterside use as per the following 'Identified Areas of Importance'.
6. A section on the proposed strategies for the guidelines, in a general format and with more detailed information with respect to the stormwater and materials guidance.
7. Various appendices, references, and supporting information.

1.3. Identified Areas of importance

This report will present an overview of sustainability guidelines applicable to the proposed development of sustainability standards, but also presents a more in-depth review and findings of special identified areas of importance. The two identified areas to be addressed in this project are stormwater and infrastructure materials. They have been thus identified in order to take a proactive approach to preventing additional contaminants from entering Puget Sound and other sensitive waters whether these contaminants come from sources at the terminals or from outside sources.

The stormwater infrastructure will be addressed separately on the landside of the facilities and on the waterside of the facilities. The intention is to address the landside stormwater issues with more conventional low impact development (LID) practices and technologies such as those being developed for other applications in the Puget Sound region. These typical LID practices cover both stormwater quantity control and stormwater quality control. However, unique to the WSF terminals and other facilities at marine interfaces, there are special considerations and alternative practices, which might be considered when structures reside directly over water. Many of these facilities are built over the water such as the elevated trestles, which in many cases are the major areal portion of a WSF terminal. Over water, the issue with stormwater is not quantity control, as the rainwater would be entering the water body anyway, but rather stormwater quality control to prevent additional contaminants from entering the waters at the marine and terminal interface. Some of these pollutants come from offsite, particularly with respect to those, which might be transported to the terminal by the users of the facility. Some of these pollutants may have sources at the terminal, and thus the second identified area includes the infrastructure materials, both at the waterside and on the landside. Some examples are hydrocarbons used for the equipment and the metals used in the construction of the trestles, railings and other facilities. WSF also must deal with constraints associated with ferry terminals. These constraints include limited loading space and traffic management requirements. Also, safety, security, and possible terrorist threats must be considered. Finally, due to budget concerns, a low cost strategy needs to be chosen for maintenance requirements and life cycle analysis should be taken into consideration whenever construction needs to be done.

1.4. Future Phases and Considerations

As noted in the proposal, this project is expected to be the first in a three-part effort. Following a successful development of this draft design guideline, Washington State University (WSU) will beta-test the draft guideline while conducting a "20% Design" of a Washington State Ferry terminal in a Phase II effort. Finally, specific solutions that present unique opportunities will be deployed in Phase III.

2. Background on Marine Development

There are a handful of studies, which have addressed some of the sustainability issues at various terminals, or at other marine facilities, which have similar stormwater and material issues as the WSF terminals. These have been reviewed for applicability to this project and a brief synopsis of the most applicable studies, or sections thereof, are provided herein. In addition, since the WSF terminals are in or near Puget Sound, some specific sound studies are also included. Finally, this section gives some details of the terminals that have been included in the study.

2.1. Previous Applicable Research on Marine Facilities

A format for the development of sustainability guidelines for passenger ferry terminals was proposed at WSU and is entitled; ***Development of Sustainability Guidelines for Infrastructure and Their Application to Passenger Ferry Terminals*** (de Sainte Marie d'Agneaux 2009). This thesis gives a proposed format specifically for passenger terminal rating systems with overall environmental impact categories and with applicable detailed sections of Water Management and Materials Management. However, the water management section focuses mostly on landside stormwater and the focus on the selection of materials is based on cradle to grave and disposal impacts, not as much on the use phase. This project will expand the stormwater section to include waterside practices and recommendations and will expand the materials section to the user phase impacts. Overall, we expect to include additional sections, such as the traffic and parking portions, of the format as a partial template for the sustainability guidelines (In conjunction with MVeP and LEED guidelines for vessels and landside buildings respectively as will be discussed later.).

Herrera Environmental Consultants, Inc. prepared ***A Ferry Terminal Stormwater Runoff Characterization Study (QAPP)*** or Washington Department of Transportation (WSDOT 2007). This ferry terminal study provides direction for monitoring and water quality sampling, specific to ferry terminals and their contaminants. WSF is under the WSDOT Municipal Permit for water quality and monitoring, but this study can serve as a guideline for areas not directly covered in the WSDOT Municipal Permit. This will be useful for suggesting long-term testing, monitoring, and water quality methods. Some specifics from the study, which will be useful in suggesting and implementing sustainability guidelines include the following items:

- Monitoring locations at Seattle Pier 52 and Bainbridge Island Eagle Harbor Terminal; at the Seattle station it is closest to vehicle departure and at Bainbridge it is closest to the vehicle holding lanes.
- Acceptability of storms for sampling is characterized as more than 0.25 inches over a 24 hour period (although 0.15 can be accepted as long as the other criteria are

met), less than 0.04 inches of precipitation in the preceding 6 hours, and ending in a 6 hour continuous period of no rainfall.

- Flow monitoring is performed through modified catch basins that are removed after each storm event. These basins include a baffle system and weir to allow for accurate flow measurements. Flow measurements are collected continuously and logged in 15-minute intervals. Provided is a diagram of the catch basin insert used at Pier 52. The feasibility of using modified catch basins for water quality control at the trestles without freezing and similar cold weather concerns may be evidenced by the success of these monitoring adaptations.
- Water quality monitors are also located in the flow monitoring modified catch basin insert, and are connected to a power supply. Samplers are outfitted with flow splitters to collect multiple samples simultaneously. Samples are collected with 1L for first flush and 250 mL thereafter. Ideally samples will be collected from at least 75% of the storm hydrograph, although the rising limb of a long storm is considered acceptable. In addition to collected samples, field observations are conducted.
- Water quality laboratory testing is in compliance with accepted US EPA testing standards and reporting is compiled into annual reports for the two years of the study.

A major resource for applicable waterside stormwater treatment options has been found to be a report entitled ***All Known Available and Reasonable Technology (AKART) Water Quality Studies for SR 520 Replacement Floating Bridge*** by the Federal Highway Administration in collaboration with the Washington Department of Transportation (WSDOT 2010). The AKART Study reports on the research prior to, during, and after the SR520 bridge replacement, with a focus on influences to runoff, water quality, and treatment techniques. Pertinent sections include:

- A section on characteristics that influence runoff including impervious surface, traffic, precipitation characteristics, and amount of offsite "run-on." Pollutants of concern assessed by WSDOT from highway sites are total suspended solids (TSS), dissolved copper, and dissolved zinc. In the 2006 Addenda; lead, cadmium, and oil and grease concentrations were added with the assumption that there is uniform pollutant loading on the floating bridge and approaches with uniform precipitation. The comparative pollutant loads were estimated using the Federal Highway Administration (FHWA)-WSDOT method. Stormwater volumes for water quality were calculated using the Natural Resources Conservation Service (formerly Soil Conservation Society or SCS) method. Pollutant estimates are presented in Table 2.2 of the *AKART and Water Quality for SR520 Floating Bridge Replacement.*
- Section 3 for available technologies with a waterside focus. The initial literature review to identify AKART for this study was done in 2002. An update was performed to the AKART in 2005 that reviewed the 2005 Stormwater Management Manual for Western Washington, as well as the updated web site for approved emerging technologies (http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html). Appendix D of the study contains 16 groups that the approved treatment technologies were sorted into. In the 2005 update, nine technologies were added to

these categories. A screening was done to eliminate all technologies not feasible for a floating bridge. Technologies were screened based on safety, maintenance, engineering, environment, and cost. Four categories were designated to classify the 15 appropriate groups. These categories are: media filtration vaults, catch basin media filtration, high-efficiency sweeping, modified catch basins and cleaning.

Media Filtration Vaults
Media filtration vaults contain filtration media specific to target pollutants. According to the study, slow filtration is effective at removing metals and fine sediments. However, they are poor at removing large particles, oil, and grease. Pre-treatment is required for using media filtration vaults. All filtration media vaults would be placed on a pontoon deck below the roadway. Three configurations are identified by the AKART SR520 study. These are as follows:

- Configuration 1: Enclosed vaults located on the pontoon deck contain horizontal media filter beds that work through vertical filtration action of the permeable media and gravity.
- Configuration 2: Using pre-engineered StormFilter™ media cartridges in the media vaults on the pontoon deck allow for treatment of water by passing runoff through each cartridge. Stormwater is drawn into the cartridges through a siphon activated by a float. Discharge is through a perforated pipe in the bottom of the filtration vault and the flow is controlled using small orifice plates.
- Configuration 3: A porous concrete slab is placed inside of a precast manhole.

Catch Basins with Filtration
All of these catch basin options require replacement and/or cleaning when the filter media is saturated/plugged. All options consist of a filtration media/absorbent pillow placed inside of individual catch basins. Two of the three configurations are commonly known as catch basin inserts and consist of gravity fed flows to a catch basin unit with disposable filters/pillows or replaceable bags. The third option uses a submerged replaceable media cartridge with a siphon function similar to the media vault filtration described previously.

High Efficiency Sweeping
The AKART study refers to the Stormwater Management Manual for Western Washington already reviewed elsewhere in this document for the definition of high efficiency sweeping. Basically, most pollutants are removed from the pavement surfaces on a periodic basis.

Modified Catch Basin Cleaning
Enlarged catch basins sized for trapping large particulates are cleaned on a regular schedule.

Four alternative combinations of these technologies were approved. For

development of alternatives it was assumed that for the floating bridge a minimum of two treatment technologies would need to be employed. The four alternatives are as follows:

Alternative 1- Media filtration vaults with conventional sweeping
Alternative 2- Catch basin filtration with conventional sweeping
Alternative 3- Modified catch basin cleaning with conventional sweeping
Alternative 4- High efficiency sweeping and modified catch basin cleaning

Detailed assessments of all four alternatives are presented in the AKART document. A summary of cost effectiveness for these four alternative technologies is also presented. A direct comparison of the four alternatives looking at effectiveness, technical feasibility, cost, and cost effectiveness is considered. Based on these comparisons Alternative #4 was selected for the bridge.

- Sections on various water quality studies, useful for water and interface stormwater considerations. Some applicable information includes the use of spill containment lagoons that are designed to sit below the road structure and contain all runoff. These filter lagoons are designed by data from three precipitation events: low volume storm (10th percentile), mean annual storm (50th percentile), and water quality treatment storm (91 percentile). The stormwater runoff discharge concentrations were developed based on WSDOT, Caltrans, and FHWA protocols. Some pertinent assumptions include the pollutants of concern from highways as being TSS, oil and grease, cadmium, copper, lead and zinc. The targeted body of water is Lake Washington, which has an identified pollutant of concern as TSS. In addition, water quality compliance is set forth by the Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A) and the protection of aquatic species in the mixing zone were determined by a comparison of acute and chronic chemical criteria from project discharge to water quality standards for the state. Finally, the water quality treatment storm volume is based on the six month storm as defined by the SCS method (72 percent of the 2 year storm). Details of pontoon sizing, modeling, and construction are contained throughout Section 3 and 4.

A resource for material consideration is the ***New Jersey Green Marine Products Study.*** This study provides a look into the inventory and environmental impact assessment for use as a guideline in selecting marine materials with low environmental consequences. Applicable portions ofhis study will be combined with other material recommendations such as the FSC certification for interface and waterside material selection and considerations.

There are also several other background studies with pertinent information. A study by Gray et al. (2010) ***LID Concepts for Container Terminals*** covers the combined LID methods that were explored when looking into modifying the Port of Tacoma container terminal. Techniques are narrowed down by existing site and operational constraints to propose suitable development options. The project was put on hold due to funding, but has good methods to draw from. Gupta (2005) examines possible sources of some pollutants

including dredging, solid waste disposal, sanitary disposal, waterside development, and vehicle and maritime traffic which are all activities associated with ports and harbors that can produce natural and anthropogenic environmental pollutants. Oil, bilge, sewage, and waste leakages are all contributors of pollutants in harbors and ports. Additionally, vehicular pollutants are associated with ports through loading and unloading, vehicle emissions, and construction. These pollutants occur in the construction, renovation, and maintenance phase, as much as in the operations phase, resulting in a high level of importance associated with the operations and maintenance of port and harbor facilities. Once diffused into the waters, toxic chemicals are difficult to trace or remediate. In order to prevent this source control, BMPs have been developed by the Washington State Department of Ecology to prevent pollutants from contaminating stormwater for the purpose of minimizing or eliminating treatment needs (Ecology 2005).

As noted previously, dredging is identified in several studies (Gupta 2005; Ecology 2009) as an activity associated with air and water pollutants. Short and long term environmental effects are realized from dredging and associated activities. High levels of suspended sediments are found around dredgers, reclamation outfalls, and dumping grounds (Gupta 2005). Additionally, turbidity can decrease light penetration and inhibit processes relying on photosynthesis (Gupta 2005). Toxic contaminants can potentially be reintroduced to the water column resulting in bioaccumulation in fish and other marine life, a temporary decline dissolved oxygen content, and many other negative impacts (Gupta 2005; Ecology 2009). Maintenance dredging is often more environmentally harmful than initial construction dredging since maintenance dredges sediment on the surface, which is likely to contain contaminants since it has been recently deposited (Gupta 2005). In Puget Sound the top 10 cm of sediment contain toxic chemicals that have the potential to leach into surface waters, or to be introduced into the food web through consumption by marine life (Ecology 2007). This is not a big issue at WSF.

Solid and sanitary waste disposal, as well as proper disposal of bilge and refuse waters, are identified as areas of importance for environmental management plans and port BMPs (Gupta 2005). These issues are addressed in ENVN 0090 of the SMS.

In addition, vehicular traffic in and around ports contributes dust from the re-suspension of road dirt, as well as contaminants from tire wear and other sources listed in Table 1. Additionally, a rain event after a dry period can force a myriad of vehicle and urban contaminants into the Sound in higher concentrations. Employment of traditional BMPs and LID methods can be used for the containment and processing of polluted stormwater on the landside of ports and harbors. In order to use these methods it is necessary to prevent any polluted waters from draining directly to the Sound, or receiving waters, before treatment. Another method that can be used is the prevention of allowing stormwater to be polluted by practicing maintenance methods such a sweeping. This would take care of the road dirt and contaminants from tire wear before polluting the rain water.

Finally, propeller scour is identified in the Mukilteo multimodal project documents as an environmental consideration for nearby beaches or shorelines, but is not a part of this current study..

2.2. Previous Research on Puget Sound Stormwater

The Washington Department of Ecology has reported results for loadings to Puget Sound, ***Phase 1: Initial Estimate of Toxic Chemical Loadings to Puget Sound*** (Ecology 2007). This Phase I identifies contaminant sources and pathways specific to Puget Sound. Through identification of these pathways, solutions that are applicable from both BMPs and modified LID practices can be examined. Some controversy exists in the soon to be released Phase 3 of the report, particularly with respect to hydrocarbon loadings which were apparently overestimated by an order of magnitude or so in the Phase 1 report. Phase 2 is then the Sediment Flux/Puget Sound Sediments Bioaccumulation Model – Derived Concentrations for Toxics Final Summary Technical Report. Release of the Phase 3 information is important for future modifications of the guidelines. However, other portions of the Phase 1 report are still applicable such as the following contaminant pathway information:

- Surface Runoff: For the purpose of this report, overland flow from non-point sources such as rainwater and urban activities contribute to the surface runoff pathway. "Sources of toxic chemicals that surface runoff transports to Puget Sound include motor vehicle operations, galvanized structures, illegal dumping, aerial deposition of air pollutants onto the land, pesticide and fertilizer applications, construction materials, and stockpiled materials." "The National Pollutant Discharge Elimination System (NPDES) program of the federal Clean Water Act regulates stormwater discharges from some developed areas. Ecology has issued more than 3,000 stormwater NPDES permits, including 120 municipal separate storm sewer system Phase I and II permits, 1,100 industrial stormwater permits, and more than 2,000 construction stormwater permits. Not all stormwater permits require monitoring for toxic substances."
- Aerial Deposition: Although this report focuses on the stormwater runoff component of this study, aerial disposition is an important element since contaminants from all over Puget Sound can be deposited onto land surfaces via winds originating from anywhere upwind of Puget Sound. Additionally, ocean going vessels contribute a significant amount of VOCs and PM2.5 to the air emissions, which are likely to deposit on surfaces in the area. The burning of diesel and other emission sources from the vessels will be a part of a complementary rating system for vessels, which will be recommended for incorporation into the ferry sustainability guidelines in subsequent sections of this report. This complementary rating system has the acronym MVeP that stands for Marine Vessel Environmental Performance Assessment (SNAME 2010a and 2010b).
- Direct Spills to Marine Systems: Direct spills to marine systems are applicable to this study when looking at operations and maintenance procedures for spill containment. Additionally, upland spills are considered in Phase I for contaminants from stormwater runoff. The biggest contaminant of concern from spills is polycyclic aromatic hydrocarbons (PAHs).

2.3. Site and regional background

Some pertinent regional information includes the small frost depth along the coast in Washington of only 10-25" (WSDOT Freeze Maps) with the lowest at the coast. This aids in the application of more below-trestle LID practices (instead of below ground) since the water in the Sound keeps these portions of the facilities warmer. Of course, the precipitation levels in the Puget Sound region are high, which is one reason that the stormwater issues are a priority at this time. Due to the uncertainties associated with climate variability it is even more important to prioritize stormwater impacts. It is also advisable to consider future protection for freezing as part of the proposed technologies.

WSF has provided the team with information on the ports in Puget Sound. General information is contained in the Ferries Long-Range Plan, which includes current and future expectations of ridership and future plans (WSDOT 2009). In general, ridership is expected to increase significantly from now until 2030, including an increase in vehicles. This expected increase substantiates the need for consideration of stormwater issues as the expected increase will also signify a potential increase in pollutant sources. The plan also identifies more specific information about the ports of interest. The four ports identified by WSF as focal areas based on their needs for replacement and upgrades to structures, both marine and land based, are as follows (Note that the Mukilteo Multi-modal Project construction is slated to begin in 2015 and finish by 2019, only a few comments are noted below).

- Bainbridge:
    - (a) Identified needs:
        1. Overhead loading walkway replacement
    - (b) Identified resources:
        1. QAPP report Appendix A, drainage inventory map
        2. Aerial map provided by WSF
        3. Existing stormwater and drainage location map from WSF
- Seattle Colman
    - (a) Identified needs:
        1. Dock trestle replacement
        2. Terminal building replacement
        3. Slip 3 transfer span and overhead loading replacement
    - (b) Identified resources:
        1. Aerial map provided by WSF
        2. Existing stormwater and drainage location map from WSF
- Vashon
    - (a) Identified needs:
        1. Trestle replacement
        2. Terminal building replacement
    - (b) Identified resources:
        1. Aerial map provided by WSF
        2. Existing stormwater and drainage location map from WSF
- Fauntleroy

(a) Identified needs:
    1. Trestle replacement
(b) Identified resources:
    1. Aerial map provided by WSF
    2. Existing stormwater and drainage location map from WSF

- Mukilteo

  Revised alternatives were analyzed in FTA/WSF NEPA/SEPA DEIS and the most prevalent environmental impact cited in the alternatives is to build within the Tank Farm footprint so that creosote treated piers can be removed and replaced with either steel or concrete piers. In addition, Table 7. *Design Criteria for Cost Estimating Purposes* outlines design standards such as width of right of way and construction methods that the project costs are based off of. A full NEPA/SEPA EIS is required, but the WSU team has not acquired this document yet. This may not be completed since the environmental process is cited on the project website as 2010-2012.

Site visits and other communications with WSF have also resulted in the following summary of stormwater issues pertinent to the project. The goal of low impact development (LID) aims to manage stormwater for the purpose of keeping the local hydrologic cycle as close to pre-development as possible. This is challenging on ferry terminals because most LID practices require the use of land while ferry terminals are frequently over water structures. Due to the almost nonexistent distance between the ferry terminal and Puget Sound, most efforts of stormwater pollution reduction focus on source prevention. It is also important to consider the maintenance costs associated with the pollution reduction methods.

Common sources of stormwater pollutants include leaks and sediments from passenger vehicles, which are often required to wait for extended periods of time on the terminal trestle or in other staging areas. Another common source of stormwater pollutants is from uncoated metals used in railings, fencing, and building roofs. Uncoated metals can be associated with high levels of zinc. Other possible sources of pollutants include leaks from garbage facilities and hydraulic systems, animal fecal matter, and sand and salt used for deicing. Pest control agents and practices are addressed in the Integrated Pest Management (ENVN 0100).

Of course, at any facility that handles chemicals and petroleum products, there is always the potential for spills. These spills have been addressed with engineered changes such as catch trays along with periodic inspections. Emergency spill kits are located at all terminals and hazardous materials are stored in special units. Most spills that occur are small spills caused by customer automobiles.

One possible approach to stormwater treatment is reverse slope. This approach would divert a portion of the stormwater that lands on the trestle back towards the land where it can be treated for pollutants more readily using conventional LID techniques. However, when stormwater is conveyed to the land, stormwater quantity must also be considered and mitigated in some way. Also, the stormwater treatment system on the land might have

additional stormwater inputs from the roads and hills leading to the ferry terminal. This would greatly increase the quantities of stormwater that need to be treated along with adding the corresponding liabilities.

Fauntleroy terminal consists of a single pier and slip with the right of way ending at the edge of the dock. The terminal is in close proximity to a salmon-bearing creek. It is at the Fauntleroy terminal where sewage is pumped out of the vessel and into the King County treatment system. The stormwater that falls directly onto the terminal and walk-on passenger building is directed into through drains on the deck, roof gutters and downspouts, and scuppers on the side of the terminal that drain directly into the Sound. Stormwater that lands near Fauntleroy Way is handled by the county sanitary sewer system.

The ***Vashon Island*** ferry terminal is comprised of two vessel slips as well as a walkway for walk-on customers. The ferries are fueled at Vashon Island from a fuel truck using a gravity fed system. The Washington State Ferry right of way ends at the edge of the dock. Precipitation that falls on the terminal is drained directly into Puget Sound by use of through drains, roof drains, and scuppers. The Vashon Island stormwater system has an outlet pipe that drains into the Sound from underneath the ferry terminal. Environmental issues at this terminal include potential landslide areas and geoducks.

The ***Seattle*** terminal consists of multiple buildings and three vessel slips. The entire terminal is over water with a seawall running near the end of the right of way. Sewage is pumped out of the vessel and into the King County metro sewage treatment system at the Seattle terminal. The north portion of the ferry terminal drains the dock by use of through drains and scuppers. The south end of the dock collects rain water by use of catch basins and treats most of the flow with an oil-water separating L-pipe setup before allowing the stormwater to enter Puget Sound. Some of the catch basins on the south end also drain directly through the deck into the Sound. The elevated walkway connecting the terminal building to the ferry slip has downspouts that also drain directly into the Sound.

The ***Bainbridge*** terminal is unique in that Washington State Ferries has right of way for some overland areas, specifically a vehicle holding area, terminal building, and parking lot. The highway that runs between the vehicle holding area and terminal building is part of the WSDOT right of way. The terminal includes two ferry slips. Similar to the other docks, rainwater that falls directly on the dock is discharged directly into the sound via through drains, downspouts, and scuppers. Rainwater that falls on the vehicle holding area is collected in a vault at the bottom of the hill where it is run through a filter before being released into Puget Sound. The parking lot uphill from the terminal building is a steep slope with a trench drain at the bottom and catch basins along the shoreline. The water is then drained from the side of the hill above the sound. The aforementioned vault has recently been accepted as a proven technology and will be included in the available technology recommendations in the final report.

2.4. Additional examples external to Puget Sound (BMP's)

There are also BMP's outside of the Puget Sound area located at other coastal ports that have been considered. References for the Alaska Marine Highway were not very detailed. Contact was also made with the environmental manager of the largest navy facility in Japan, and little considerations have yet to be established outside of the standard SMS practices. However, the New York/New Jersey Port Authority lists a few BMPs that may be useful at ferry terminals. These include pervious pavements, marking storm drains, sand filters, and rainwater neutrality

3. Background on Other Guidelines and Tools

3.1. Overview on Other Existing Rating Systems, Guidelines and Tools

This section includes a brief summary of applicable parts of rating systems and tools we have reviewed. In the following LEED, ASTM, and EnvISIon seem to be the most applicable for use as templates for some of the upland sustainability issues, with inclusion of the ISO 14000 series.

- LEED for New Construction and Major Renovation (NC), US Green Building Council (USGBC 2009): LEED NC is the flagship of a suite of rating systems which provide guidelines for achieving a lower environmental impact, mostly geared towards building. However, the Sustainable Sites section of NC, and a sister rating system labeled ND (Neighborhood Development) can lend insight to methods that could be modified, or used in part, for ports. For instance, there are sections on vehicular transportation and parking, stormwater, and exterior lighting. Neighborhood Development may lend some insight to master planning of the ports. LEED for Existing Buildings: Operations and Maintenance may also provide some background for continued operation of the buildings (USGBC 2008).
- Green Globes: Green Globes is a series of rating systems by Green Building Initiative. It is specifically for public buildings and has several rating systems. For ports, the most applicable sections are the Design of New Buildings or Significant Renovation, as well as the Management and Operation of Existing Buildings.
- ASHRAE: ASHRAE writes standards to provide approved testing methods and standards mostly related to energy systems, as well as to establish performance criteria, outlined in a manner that can be easily interpreted. Most will not apply here except in the specific energy topics.
- ASTM: Sustainability standards are under development for product material declarations, and a team member is part of the E60 Sustainability committee and will follow the progress to see that any pertinent sections, which are developed during this time, will be summarized. Applicable materials testing will be applied for the materials critical interface with the waterside.
- Forest Service Handbook: Chapter 70-Sustainable Buildings: The handbook provides standards for new buildings designed and constructed by and for the Forest Service. Some of the ideas and methods can be translated to buildings included in ports.
- Sustainable Sites Initiative (SSI), ASLA (2009): SSI is a voluntary system that provides guidelines and benchmarks for sustainable land design, construction, and management. Some areas are pertinent to land-side stormwater management and

will be reviewed for applicability. Little information is included for the use of materials.

- GreenLITES, New York State Department of Transportation: New York State Department of Transportation's GreenLITES tool represents multi-modal transportation in a very diverse state. It involves a measurement of sustainability performance, promotes best practices, and identifies areas of improvement. It is a self-certification program, but has had outside reviews and has an internal review team. It includes design, projects, and planning. It is not prescriptive and encourages every staff member to include sustainability. There are project team decisions on what is included in each case. It is a collection of scorecards, metrics, and spreadsheets that grew out of background research into what sustainability aspects are already included at the agency. The sustainability aspects focus on sustainable sites, water quality, materials and resources, and energy and atmosphere, in addition to encouraging innovation. It mainly focuses on roads, but does include fleets and some multimodal aspects such as rail projects. New York uses it to assess regional sustainability in transportation (Krekeler 2010). This type of tool would be useful as an integrated tool for regions or Departments of Transportation with an emphasis on terminal considerations. The scorecards and metrics may be evaluated for applicability to inclusion in the Port's work in future phases of the project. The potential use of the this tool for upland issues might be considered as part of a green rating integration process introduced in Chapter 6 of this document.
- Infrastructure Voluntary Evaluation Sustainability Tool (IN-VEST): The Federal Highway Administration has recently introduced the FHWA sustainable highway rating system, with a working title of IN-VEST, the Infrastructure Voluntary Evaluation Sustainability Tool. This rating system focuses on highways, but does address some interfaces of other modes such as pedestrians and bicycles. The tool is not complete but is still being developed and has three main sections; systems and project planning, project development, and operations and maintenance. The intent is for it to be a tool available nationally. There has been much review and interaction with AASHTO during its ongoing development. Important parts include satisfying functional requirements and also addressing the triple bottom line of the environment, society, and economists. There are currently 68 criteria based on best practices, with the intent to keep it simple. There has also been interaction with the ASCE (American Society of Civil Engineers) tool, which will be addressed later, with the intent of keeping consistency, but acknowledging that the FHWA tool serves the states and highway systems. It is a web-based tool (Shepherd 2010). This tool may have several aspects and criteria that may be useful for ferry terminal sustainability, providing consistency at the interface of the terminal and the roadway network leading up to it. We will follow its progress to see if any sections are developed that are useful for future phases of the project. Institute for Sustainable Infrastructure (EnvISIon): One of the most comprehensive efforts currently underway for addressing sustainable infrastructure for many applications is a combined effort of ASCE, ACEC and APWA. It is referred to as the EnvISIon (Institute for Sustainable Infrastructure) rating tool. It requires both raters and verifiers. Training courses by EnvISIon on how to use the rating tool are planned for the future, in addition to the

many offered through ASCE and other sources. A catalog has been developed and will be available soon online (Erickson 2010). This rating system will be under the umbrella of the nonprofit institute specifically developed for this purpose. There are more than 900 sector specific rating systems that the EnvISIon has already identified in the nation. The intent is to allow the sector specific aspects to be collaboratively included in the use of the EnvISIon rating system. The intent is for it to address all infrastructure projects and to be both scalable and broadly applicable. A third party verification component is also included. Just as important for sustainability in the ferry terminal sector, the EnvISIon is also acknowledging that the tool will go beyond the well-developed project phase (such as with LEED) and address operations and performance. There are several proposed levels of application, from a small local project with a simple checklist self-evaluation, through larger projects and finally to full program evaluations (Binney 2010). This idea of having multiple levels of application will be considered to address the varying needs and financial constraints of the range of terminal facilities in the State of Washington. Unfortunately the rating system is not yet available for use, but suggestions on the varying levels of application and operations inclusion are useful for future phases of this project. The rating system has been released for public comment in July of 2011. It has been used on four case studies, including one at the nearby SeaTac airport, but none of the case studies were over water structures.

- Greenroads: The Greenroads rating system provides direction for more sustainable new roads, as well as rehabilitation of existing roads, for a cleaner driving infrastructure. Stormwater is addressed in a similar fashion to other rating systems for landside applications. Materials are also mainly focused on the landside. Some of Greenroads' insight may be useful into the intersection of the ports and adjoining roads for future materials selection for items such as pavements.
- STEED: STEED is a tool developed by Lochner, and has some unique features in that it promotes continual improvement. It also covers mainly roadways, is project focused, and is voluntary. It parallels the main four stages of a process, planning, environmental, design, and construction; and the project is evaluated at all of the four stages and records the continual improvement. It thus becomes a roadmap for possible delivery of more sustainable future projects (Demich 2010). However, with its road focus it is not very pertinent to the project ahead.
- Illinois Livable and Sustainable Transportation (ILAST): The ILAST (Illinois Livable & Sustainable Transportation) system is more a guidance than a rating system. It focuses on design level decisions and feedback to the project teams. It is not a mandate and can be implemented without policy changes. It is also for roadways and used the NY State GreenLITES as a starting point (Knuth 2010). It does not appear as useful as some of the other infrastructure proposed tools for this venture.
- ISO 14000 Series: Terminology and procedures recommended will be consisted with the ISO EMS and LCA standards. This is particularly important as the WSF Safety Management System has incorporated an Environmental Management System (EMS) based on ISO 14001 into its library of policies and procedures.
- **MVeP** (Marine Vessel Environmental Performance Assessment) is currently under development by the Society of Naval Architects and Marine Engineers (SNAME

2010a and 2010b). It is expected to be a premier guidance and rating system with checklists for marine vessels. Phase 1 is complete and work is progressing rapidly.

- **The Port Authority** of NY and NJ Sustainable Guidelines: This draft was developed in 2006 to address projects outside the building envelope. This is probably the most closely related to WSF of all the tools addressed. However, it is not fully comprehensive for ferry terminals and it is still under development and review.

Summary

ASCE ISI rating tool might integrate with this guide, but it will not be developed sufficiently yet for terminals whereas the NYNJ Port Authority has begun to address these multimodal locations and is recommended to be interfaced with the work herein. The MVeP Assessment tool is applicable to the vessel side of the WSF terminal applications. This tool is recommended to interface with the ferry guidance documents. LEED, SSI, and other applicable guidelines might be useful mainly for the landside, but most lack material and operations aspects. Also, LID technologies are more advanced than those currently in LEED and SSI. Therefore, the overall tool developed for ferry terminals at WSU will probably serve as the template for an interfacial guide with additional details as presented in this report. The guide will be consistent with the ISO 14000 Series and the WSF SMS. A vision of the system might be as follows:

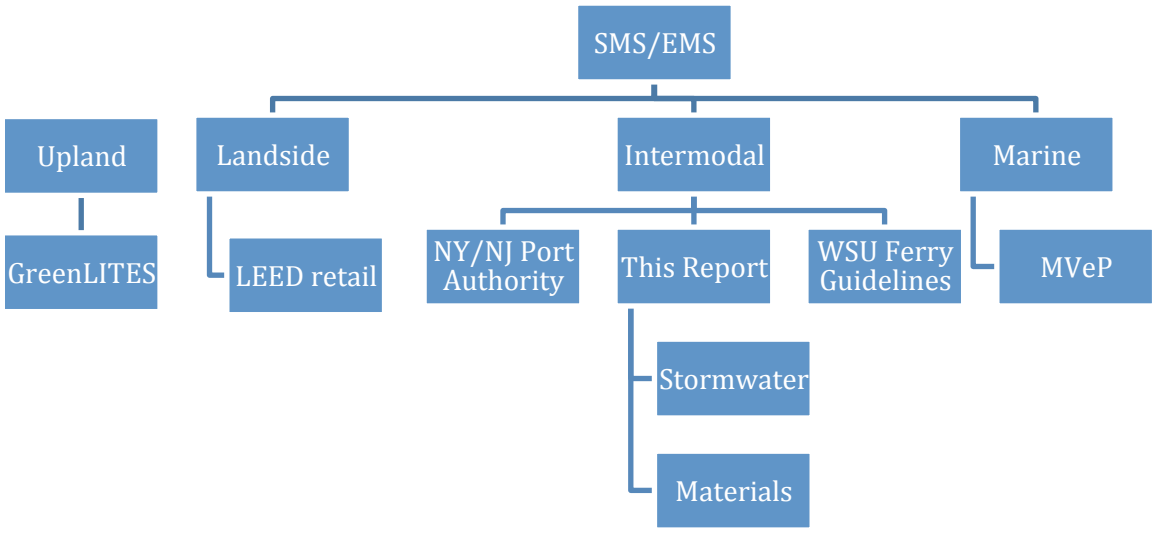

Figure 3.1. Relationship between different rating systems

3.2. Manuals, Codes, Policies and Legislation

There are many codes, policies, manuals and ordinances which are applicable to designs and discharges in the Puget Sound region. Some pertinent ones are outlined in the following.

3.2.1 Miscellaneous Manuals

Washington State Department of Transportation (WSDOT) Permitting is the overriding permit for WSF. When considering adjacent metropolitan planning organizations (MPOs) some of the manuals that should be considered are summarized as followed. Full summaries can be found in Appendix C.

- **King County Surface Water Design Manual:** KCSWDM (King County 2009). This manual lists eight core requirements and five special requirements for projects requiring drainage review
    - Core Req. #1- Discharge at Natural Location
    - Core Req. #2-Offsite Analysis
    - Core Req. #3- Flow Control
    - Core Req. #4- Conveyance System
    - Core Req. #5- Erosion and Sediment Control (ESC)
    - Core Req. #6- Maintenance and Operations
    - Core Req #7-Financial Guarantees and Liability
    - Core Req. #8-Water Quality
    - Special Requirements #1- Other Adopted Area-Specific Requirements
    - Special Requirements #2- Flood Hazard Area Declination
    - Special Requirements #3- Flood Protection Facilities
    - Special Requirement #4- Source Control
    - Special Requirements #5- Oil Control
- **Stormwater Manual (Vol. 3): Stormwater Flow Control & Water Quality Treatment Technical Requirements Manual, City of Seattle (Seattle, 2009)** provides some minimum requirements. Ferries projects would be defined as "joint" projects since they include improvements in the right of way, as well as a parcel based design that is not single family residential. The downstream condition is a "designated receiving water" since they will drain to Puget Sound or another large body of water. These projects must comply with minimums for both parcel based developments and roadway developments. This includes minimum water quality standards as set forth in Section 2.4.5. These minimums include installing treatment facilities that remove pollutants through settling basins, biologic uptake, soil absorption, filtration, or any combination thereof. The treatment must accommodate 91 percent of the total runoff volume for the simulation based on daily runoff volume. Oil treatment is required for high use sites.

  Flow Control minimums are outlined by minimum requirements. For WSF these requirements are: Implement Green Stormwater Infrastructure detailed in Section 4.4, Wetland Protection, and Peak Flow Control which specifies a 25 year return occurrence interval cannot exceed 0.4 cubic feet per second per acre, and a 2 year recurrence interval cannot exceed 0.15 cubic feet per second per acre.

  Minimum treatment requirements coincide with other standards in that enhanced basic treatment is required for the removal of metals generated from high use sites. Additionally, oil separators and phosphorus treatments must be employed as well.

To the largest extent possible natural drainage patterns should be maintained, with discharges at natural points. Additionally, pollution prevention during construction activities, as well as amended soils is required where feasible. Source control BMPs must be installed for specific pollutant generating activities as set forth by the Directors Rule.

Chapter 4: Flow control design is of particular interest to this project because it outlines the Green Stormwater Infrastructure BMPs. It is important to note that this manual does not consider infiltration basins, trenches, or drywells as Green Stormwater Infrastructure, even though they utilize infiltration. Examples of techniques included are permeable paving, bio retention facilities, and green roofs.

Project specific designs should follow guidance in the following chapters as applicable:

- 3: Site Planning, Site Assessment and Drainage Control Review
- 5: Water Quality Treatment Design
- 6: Hydrologic Analysis and Design

- **Stormwater Management Manual for Western Washington (Ecology 2005) Volume IV, Source Control BMPs** has several source control BMPs in Chapter 2 which are summarized as follows. Some might be applicable to ferry terminals.
    - **BMPs for Landscape and Vegetation Management**
        - Pest Management Plan (PMP) free of pesticides or used as last resort
        - Pesticide use plan with list of approved pesticides, using the least toxic available for the application
        - No pesticides within 100 ft. of open water including wetponds, detention ponds, etc.
        - Use pesticide alternatives
    - **BMPs for Loading and Unloading of Liquid and Solid Materials**
        - Sweep areas around loading frequently to prevent debris buildup
        - Drip pans or other containment where leaks or spills are likely to occur
        - Marine loading as per Coast Guard Appendix IV-D R.5
        - Berm, slope or dike loading and unloading areas to prevent escape of spill before treatment
        - Curbs along edge of shoreline to prevent stormwater from spilling over the edge
        - Prevent pooling on loading/unloading structures
    - **BMPs for Maintenance of Stormwater Treatment and Drainage Systems**
        - Clean treatment and drainage systems regularly to prevent sediment buildup and drain obstructions.
        - Inspect and repair BMP treatment systems, catch basins, conveyances etc. regularly so issues can be easily identified.

    - Perform repairs promptly including replacement of catch basin lids, rocks in spillway, and clean-out gates.
    - Prevent heavy sediment discharge to ensure that stormwater capacities are not exceeded.
- **BMPs for Mobile Fueling of Vehicles and Heavy Equipment**
    - Perform all fueling in accordance with local codes, Washington State codes, coast guard specifications and fire regulations.
    - Place drip pad/pan to retain spills and drips; spill pads/drains must have a five-gallon minimum capacity.
    - Maintain a spill remedy kit on site for minor spills. Kit includes non-water absorbents capable of absorbing 15 gallons of diesel, storm drain plugs or covers, non-water absorbent containment boom of at least ten feet with a 12 gallon absorbance capacity, a non metallic shovel, and two 5 gallon buckets with lids. These seem small for marine applications, but are a good start to proposing a cleanup kit.
    - Maintain and replace hoses and nozzles to prevent equipment failure.
    - Provide adequate lighting at fueling area.
    - Follow Coastguard requirements for marine transfer of petroleum products per Federal Regulations 33 CFR Parts 153, 154 and 155.
- **BMPs for Parking and Storage of Vehicles and Equipment**
    - If the parking lots are washed, dispose of wastewater to sanitary sewer or other approved wastewater treatment system.
    - Sweep parking lots, driveways, and storage areas regularly to prevent buildup of contaminants and debris.
    - An oil removal system or oil and water separator in the form of a catch basin, or other approved separating and treatment system, is required for high-use sites.
- **BMPs for Roof/Building Drains at Manufacturing or Commercial Buildings**
    - Sample and analyze stormwater runoff from buildings if leaching or building emissions are potentially causing stormwater pollution.
    - If source is identified, implement necessary BMPs and source control measures through material modification, operational changes, etc.
- **BMPs for Spills of Oil and Hazardous Substances**
    - Create, implement, and maintain an emergency Spill Control Plan.
    - Have spill kits available.
- **BMPs for Urban Streets**
    - Perform efficient sweeping regularly, where available and appropriate, to prevent sediment and debris build-up. Vacuum sweepers are recommended. Regenerative air sweepers, or tandem sweepers, can be used for curbed streets. Regenerative and tandem sweepers only provide moderate pollutant reductions.

The least effective sweepers are mechanical sweepers. They can be used on curbed streets, but will only provide minimal pollutant reduction.
- Sweep at frequencies, and technique, deemed economical optimal for the balance of pollutant reduction to maintenance effort.
- Do not wash streets into storm drains.

- **Stormwater Pollutants and Their Adverse Impact (Appendix IV-B)** is contained in the appendix and lists the primary pollutants. "The stormwater pollutants of most concern are total suspended solids (TSS), oil and grease, nutrients, pesticides, other organics, pathogens, biochemical oxygen demand (BOD), heavy metals, and salts (chlorides) (US EPA 1995, Field and Pitt 1997, Strecker et al. 1997)"-(Ecology 2005)
    - **TSS**
    - **Oil and Grease**
    - **Nutrients**
    - **BOD**
    - **Toxic Organics**
    - **Heavy Metals**
    - **pH**
    - **Bacteria and Viruses**

- **Stormwater Management Manual for Western Washington: Volume V, Runoff Treatment BMPs** is a vast resource for treatment methods. Chapter 2, Treatment Facility Selection Processes has a Table 2.1-Suggested Stormwater Treatment Methods for New Development and Redevelopment from which we can deduce that the terminals are going to be in the **high use parking/driveway** category. Associated pollutants of concern are high levels of oil and grease, TSS, Cu, Zn, and PAHs. It is required to have enhanced treatment to treat these at any port that is considered to be a commercial/industrial site, which discharge directly to a water or conveyance systems that are fish bearing (As required at the ferry repair facility on Bainbridge Island). For enhanced treatment an oil and water separator or catch basin insert can be used with a biofilter, wetpond, or wet vault and a sand filter.

- **Highway Runoff Manual (HRM), Washington State Department of Transportation (WSDOT 2008).** The HRM is referenced in the WSF SMS and is considered to be a good resource for transportation facilities, particularly landside. Future plans include updating the HRM to be more inclusive of LID practices.

- **Hydraulics Manual, Washington State Department of Transportation** (WSDOT 2010a) provides guidance on hydraulics calculations used for the design of WSDOT facilities.

- **Puget Sound LID Manual** (PSAT 2005) is a well-referenced guidance on the principles and techniques of low impact development BMPs. It is currently under revision.

- **Prince George County LID Manual** (Prince George 1999) is the original flagship manual on LID and is the basis for many of the other manuals since developed on these practices. Since its release in 1999, many of the technologies have evolved further.

Summary

These manuals mainly give valuable information on land based stormwater management, but techniques for marine focus and treatment have been highlighted. Consideration will also be given to the following codes, legislation and manuals.

3.2.2 Building Codes and Legislation

Applicable codes and legislation that are the basis for this report include Executive Order 09-05, Washington's Leadership on Climate Change, which states that WSDOT must coordinate with regional entities to develop a sustainable transportation plan. Sustainable design methods and guidelines will influence the outcomes of this. Also pertinent are Washington State Public Building Requirements, the International Building Code and the International Green Building Code if adopted in the Puget Sound region.

Various other policies and regulatory decisions may affect the decision process for sustainable ferry terminals. One example is the WSDOT conveyances lawsuit which dealt with liability in the Tacoma area.

4. Stormwater Infrastructure and Practices

This section identifies applicable low impact development techniques that could potentially be implemented at the terminals. Stormwater practices that are currently in use by Washington State Ferries for their terminals are described in Section 2.3.

4.1. Applicable Low Impact Development (LID) Techniques

LID outlines a category of Best Management Practices (BMP) that are geared towards handling stormwater and site development in ways that have a lower environmental impact. These are strategies specific to handling stormwater at the small scale, on site, to reduce the load on municipal systems. Some jurisdictions have adopted LID techniques for their stormwater and development manuals. Potential benefits specific to Washington State Ferries that can be achieved with LID are a reduction in pollutant loads, runoff volume, peak flow, and sediment transport.

For our purposes, the LID methods are organized according to quantity and quality considerations. This organization will assist in choosing methods, which are specific to the Washington State Ferries identified goals of managing stormwater volume and contaminants.

The following conventional land-side LID techniques may be applicable to the Washington State Ferry terminals.

4.1.1 Filter Systems

Sand Filters – Sand filters are commonly used to remove solids from water. They are particularly efficient at removing pathogens and suspended solids. Sand has a low efficiency for metal absorption or removal (US EPA 1999). Figures 1-3 in Appendix B show the three basic sand filter designs that differ by location in relation to grade, area requirements, surface filter areas, and the water quality achieved (US. EPA 1999).

Organic Material Filters – Organic material filters are commonly used in wastewater applications to remove nitrogen. The organic material provides a carbon source for bacteria. Organic material filters can be composed of alfalfa, sawdust, woodchips, leaf mulch, wheat straw, and/or newspaper. Nitrogen removal of >95% from wastewater has been observed with Biologic Filters (Kim et al. 2007). Leaf mulch also reduced nitrogen by around 60 percent (Kim et al. 2007).

It has been shown that sands with little mineral coating tend to have a poor binding capacity when trying to remove phosphorus from stormwater (Harris et al. 1996). When comparing the pollutant removal effectiveness of quartz sand, peat, limerock, and wollastonite as filter media, it was found that peat was the most successful in removing heavy metals from stormwater while wollastonite was the most effective in total phosphorus removal from stormwater (DeBusk et al., 1997).

In a similar study done by Seelsaen et al. (2006), it was found that out of sand, packing wood, ash, zeolite, enviro-media, and compost that compost was the most successful in the sorption of metal ions from the stormwater. An effective medium for the treatment of dissolved metals commonly found in stormwater is a combination of traditional materials such as sand and alternative materials. Also, when recycled organic materials are used it increases the life cycle value of the filter system. Table 1 below details the effectiveness of different sorbents in the removal of metals and leaching on dissolved organic carbon.

Table 4.1. Metal removed for copper (Cu) and zinc (Zn) and the dissolved organic carbon (DOC) concentration for different filter media (Seelsaen et al. 2006)

	Metal removal		DOC leached	
Sorbent	Zn(%)	Cu(%)	Leaching (%)	Sorbed (%)
Compost	97	92	2419	-
Packing wood	90	88	3197	-
Enviro-media	75	90	36	-
Ash	51	97	-	48
Zeolite	95	52	-	10
Fine glass	69	39	371	-
Sand	16	29	-	27
Coarse glass	16	26	28	-

Anthracite Filters – Anthracite is a mineral that contains more than 80% carbon. Its irregular shape provides a large surface area per volume which enables high filtration rates. Anthracite is commonly used to remove bacteria and suspended solids. It has been shown that anthracite combined with sand has phosphorus removal efficiencies of 80%. It is also superior in terms of pressure drop and breakthrough when compared to filters containing only sand or only anthracite (Xie et al. 2005).

Tire Crumb Filters – Tire crumb filters are typically used to treat ballast water and wastewater. Removal efficiencies can be comparable to sand filters. Shin et al. (1999) used scrap vehicle tire chips to remove chlorinated hydrocarbons. They saw a 98% reduction of 2,4-dichlorophenol to 4-chlorophenol. A study done by Lisi et al. (2004) compared the use of a tire rubber subbase against a typical sand-based root zone on a golf course. Nitrate was reduced by 58.6% in field profiles containing crumb rubber, a statistically significant amount. When used to treat septic tank effluent, there was an average TN removal rate of 97%, 96%, and 65% for three different filters. Reduction in carbonaceous biochemical oxygen demand was above 94% in all three filters (Smith 2009).

Clay Filters – Clay is a naturally occurring and abundant material. Clay filters are simple water filters that have become increasingly common in developing countries. Typical solids removal rates are >90%.

Zeolite Filters – Zeolite is a naturally occurring material that has very good cation exchange capabilities. It is often used to remove heavy metals from water. Zeolite can be incorporated into a sand filter for the purpose of improving water quality by assimilating and transforming organic, inorganic, and toxic constituents through processes such as infiltration, sorption, precipitation, and binding by organic colloidal material or adsorption of metal–ligand complexes (Davis et al. 2001). As seen in Table 1, zeolite has moderate absorption capacities for both copper and zinc.

Sulfur/Limestone Filters – Sulfur media is used to facilitate anaerobic bacterial growth, which results in high rates of denitrification. Limestone is a naturally occurring material that has very good cation exchange capabilities. It is often used to remove arsenic from drinking water. In a study done by Zhang (2002), it was determined that a sulfur/limestone filter can be effectively used to denitrify ponds if the chemical oxygen demand to nitrate ratio is low, the granules are not covered by sediment, and there is an adequate amount of dissolved oxygen present. Sulfur/limestone filters have been demonstrated to be effective as a small scale, low cost, low maintenance method for treating nitrate contaminated water (Sengupta et al. 2006). Marble chips and oyster shells have also been used in place of limestone (Shan and Zhang, 1998).

Fiber Mat Filters – Made from a fibrous material such as glass fibers or coconut fibers, fiber mat filters are commonly used to develop microbial growth and thus remove nutrients from water. Fiber mat filters are durable and recyclable. In a study conducted by Kim et al. (2007), lignocellulosic fiber mats were used to test applicability for rainwater treatment. It was concluded that the fiber mats that were chemically

altered with aluminum oxide removed both particles and nutrients making it an appropriate filter for various first flush conditions. A study done by Kim et al. (2006) shows high removal efficiencies for organics, heavy metals, nutrients, and particles when the fiber mat filter has been modified by chemical pretreatment techniques. Average removal rates for heavy metals were 92% for iron, 74% for copper, and 82% for zinc. 79% of total nitrogen was removed while 66% of total phosphate was removed

Polymeric Membrane Filters – Polymeric membrane filters consist of polymer films with specific pore ratings. They have the widest available range of pore sizes, which allows the filter to be designed according to the specific application. Membranes remove particles and pathogens by physically retaining anything larger than their pore size. Cost of polymeric membrane filters is reported to be substantial and typically not economically feasible (Kim et al. 2006). However, they have been shown to give removal rates greater than 98% for both COD and turbidity (Till et al. 1998).

Metal Membrane Filters – Metal membrane filters work similar to polymeric membrane filters; the small pore size traps pathogens and particles that are larger. These filters can be made from any type of metal. Common metals used for these filters include silver and stainless steel. Due to the high flux, low cost, and long lifetime, stainless steel is a feasible option for many projects. Metal membranes are shown to lower turbidity by 18% for 5 micrometers and a 54% decrease in turbidity for 0.5 micrometers. COD was decreased between 56 and 67% (Kim et al. 2006).

Table 4.2 illustrates the removal efficiencies of the aforementioned filter media.

Table 4.2. Removal Efficiencies of Filter Media

System Config	TP	TSS	Cu	Cd	Pb	Zn	"Heav	O/G	PAH Total	Price	Source	Notes
Lignocellulosic fiber mats with aluminum oxide modification	32										Kim et al., 2007	The fiber mats also decreased turbidity by 33 percent, and total nitrogen (TN) by 22 percent.
Metal membrane filters-Stainless Steel		X								140-250	Kim et al,. 2007	In addition to trapping sediment, the metal membrane filter decreased turbidity between 18-54 percent.
Delaware Sand Filter	71.1	70.2									Bell et al. 1995; Chang et al., 2010	TKN (59.9 percent) was also removed by the Delaware sand filter. Ammonia was also decreased by 6 percent.
Sand	41.4[1],	96 [2]	30 [3]		96[2]	15 [3]		96 [2]			[1] DeBusk et al., 1997, [2] Hseih and Davis 2005 [3] Seelsaen et al 2006	
Fe Coated Sand			>70		>70						US EPA, 1993	Fe Coated Sand relies on a pH dependent surface charge. In addition Fe coated sand also removed >70 percent of Cn.
Mg Oxides										3x the cost of a sand filter	Liu et al., 2005	pH dependent surface. 3x the cost of sand filter, polymeric media, uncoated cementitious media
Clay-In Filter				X	X						Lazaridis 2003*	Additionally, Ni is removed by the clay.
Polymeric Media												
Hazelnut Shells				92.4		87.9					Cimino et al. 2000	Values represent highest removal achieved, removal decreased with increased loading. Cr was also removed by the shell substrate.
Peanut Shells												
Banana and Orange Peels			X		X	X					Annadurai et al., 2003	Co and Ni were also removed by the peels.
Aspen (*Populus tremula*) Fibers									18.5-36		Boving and Zang, 2004; Boving and Neary, 2007;	Variations in total PAH removal are attributed to temporal differences in field experiments, and length of experiment.
Juniper Fiber				X							Han et al. 2004	The Cd+ absorption varied by number of days soaked, as well as whether the jute was treated with the sodium hydroxide base treatment.
Compost (Maple and Elm Leaf)		90	X				80-98	85	X		Richman, 1997; Chang et al., 2010, Ecology 2005	
Wallastonite	87.8		81.4	97.7							DeBusk et al., 1997	Additionally wallastonite removed 80.3 percent of Ni.
Vermiculite (Hydrophobized)								57-93			Viraraghavan et al. 2005	Refinery Effluent (57), Standard Mineral Oil (79), Kutwell Oil (90), Cannola Oil (93)
Vermiculite (Expanded)								43-58			Viraraghavan et al. 2005	Refinery Oil (43), Kutwell Oil (47), Canola Oil (58), Standard Mineral Oil (56)
Oil and Water Separator	X								X		Ecology 2005	
Limestone	41.4										DeBusk et al., 1997	
Pumice												
Fine Glass			40			68					Seelsaen et al. 2006	
Sphagnum Peat Moss	44		X	X		X					DeBusk et al., 1997; Clark et.al 2001; Clark et al. 2000; Couplan and Lalancette, 1976	1.5lb of peat can purify 250 gallons of wastewater with 10ppm of metals or less. Brown et al. Table 2 contains an extensive list of studies done on peat. In addition to the pollutants of concern, peat removed Nickel and Chromium as well.
Sphagnum Peat Moss (poorly humidified)-Laundry wastewaters			80			30-60					Oborn et al. 2002	Removal results came from a laundry wastewater, however removal of metals from landfill leachate was low.
Sphagnum Peat Moss (poorly humidified)-Sulfide mine waters			80-100			37-77					Oborn et al. 2002	The removal is attributed to removal by attachment to particles, explaining the higher removal rates in waters with higher particulate matter.
Carex Peat (poorly humidified)			85-100			97-99					Oborn et al. 2002	Removal of metals from sulfide mine leachate.
Aspergillus niger dead fungal matter (non specified)											Park JM et al. 2005	Converted Cr(VI) to Cr(III) therefore downgrading the toxicity, but not removing it.
Aspergillus niger dead fungal matter (beads)											Viraraghavan and Kapoor 1998	Contains removal in mg/g of metals by various fungi.
Mucor rouxii fungus-alive				87	95	97					Viraraghavan and Yan, 2003	Nickel was absorbed as well.
Mucor rouxii fungus-dead				72	86	71					Viraraghavan and Yan, 2003	Nickel was absorbed as well. Dead fungi with a pH of 5 was used for comarison.
Bone Char				X							McKay et al. 2001	Bone Char has absorptive properties in wastewater scenarios for cadmium.
Cassava waste biomass				67.5		58.42					Horsfall and Abia 2003	
Grape Stalks			95								Villaescusa et al. 2004	Additionally the grape stalks removed 90 percent of the nickel in the metals solution.
Green Algae *Spirogyra*											Gupta et al. 2001	Green algae
Spillage			100		92						Schneegurt et al. 2001	Also bound 100 percent of Mo.
Gorund Corn Cob			90		85						Schneegurt et al. 2001	Also bound 68 percent of Mo.

4.1.2 Buffer Strips

Vegetated – Often used along the sides of roadways, vegetated buffer strips remove sediment, nutrients, and metals from stormwater runoff. Highway buffer strips have been used extensively. Grass buffer strips have been shown to remove 78 % to 83% of suspended sediments (Sheridan et al. 1999). The size of the buffer must be greatly increased to achieve removal rates over 90%. Wong and McCuen (1982) estimate a buffer width must be doubled to increase the removal rate from 90% to 95%. Up to 85% of phosphorus found in rainwater is bound to sediments, and can thus be effectively removed using vegetated filters (Karr and Schlosser, 1997). In terms of fecal coliform, Grismer (1981) showed 60% removal rates in his study of vegetated buffer strips.

4.1.3 Pervious Paving

Pervious pavement has the ability to store a significant amount of stormwater. This stormwater eventually evaporates and does not contribute to runoff during smaller storm events. During larger events, the runoff is significantly reduced. Due to the tortuous pathways in pervious pavement, pollutants are also removed. In a study done by Barrett (2008), he compared the stormwater pollutants from a typical impervious asphalt highway to the same highway with a porous asphalt overlay. The study showed decreases in pollutant levels of 93% for TSS, 36% for phosphorus, 52% for copper, 88% for lead, and 79% for zinc.

Pervious Asphalt and Concrete – Pervious asphalt and concrete have become more common as a feasible solution to treating and storing stormwater runoff from roadways. The following are three feasible materials for the trestles:

1. Pervious Concrete or Porous Asphalt

Pervious concrete or porous asphalt are usually developed in either of two ways, full depth allowing circuitous vertical flow into water storage or soils below, or as a top coat with more horizontal flow to discharge on the sides. The latter are also referred to as Porous Friction Course (PFC) or Open-Graded Friction Course (OGFC) and would be most likely candidates for placement on the trestles, whereas the former will be most likely used landside.

2. Cementitious Pavers also known as interlocking concrete pavers. These are generally impervious pavers (although there are some manufacturers who produce pervious pavers). Water may flow through to water storage or soils below. These would predominantly be used landside.
3. Vegetated or Gravel Pavers have a grid with either grass or aggregrate in the middle, and similar to the pavers allow water to flow into storage or soils below, but usually soils. These too would predominantly be used landside as the usually promote vertical flow.

4.1.4 Building Stormwater Controls

Various methods can be used to prevent or reduce the amount of stormwater entering Puget Sound. This section discusses the different options for reducing stormwater volumes on the building itself.

Living Walls – Living walls are vegetated walls that are able to take up the stormwater runoff from roof areas. Storage of stormwater occurs in the soil and the plant. Evaporation and transpiration also occurs in a living wall. Other benefits of living walls include lowering the "urban heat island" effect from the building as well as creating an aesthetically pleasing building for ferry riders. It is important to note that living walls will add weight to the wall and will have to be factored in during structural calculations. The walls work best when facing the south or southwest towards the sun. It is advised to avoid plants with fruits and berries to minimize maintenance. Some plants that have been successfully used on living walls in the United States include different types of wildflowers, ferns, vines, and grasses.

One successfully implemented living wall in the area is the Vancouver aquarium. It is 500 square feet and supported with a steel frame which makes it easy to replace parts when necessary. It is noted as serving as a noise buffer from the city street. Another successful living wall is located at the Sydney International Airport and is said to help lessen the stress from travel with its atheistic appeal. Living walls are also used extensively in Japan and are known to contribute to building cooling.

Green Roofs – Green roofs are similar to living walls; they are able to store and retain the majority of rainwater and significantly reduce the runoff from buildings. Green roofs store a significant amount of stormwater in the soil, allowing the slower plant uptake process to occur after a rain event. Evaporation and transpiration will aid in the reduction of runoff. In a study by VanWoert (2005) the mean percent rainfall retention ranged from 48.7% for a standard gravel ballast roof to 82.8% for a fully vegetated roof. Green roofs are especially effective at providing stormwater management for small, frequent storm events (Carter and Rasmussen, 2006). The filtering of stormwater through the soil also aids in pollutant removal. One common concern about green roofs is whether the roof structure can withstand the additional load from the impermeable layer and soil. The weight load of a green roof ranges from as low as 12 psf for an extensive green roof to over 50 psf for an intensive green roof. One example of a nearby green roof in the Ballard library green roof, built in 2005. This roof occupies around 20,000 square feet at an estimated cost of $\$20/ft^2$. Stormwater is filtered through the roof or absorbed by the plants.

Rainwater Harvesting – Stormwater from roof structures are often relatively clean and, depending on the application, require little to no treatment. Harvested rainwater is often used for non-potable uses such as toilet flushing and landscape irrigation. Rainwater harvesting can reduce or completely eliminate required treatment and storage of stormwater runoff. Rainwater is held in a cistern either above or below ground. Above ground cisterns must be tightly sealed to prevent animal or sunlight contamination. Guidelines on rainwater harvesting as well as rain barrel purchasing information is available on the Seattle Public Utilities website.

However, many of these aforementioned options add additional loads to the trestles. Pier size considerations are important, and may be constrained, with respect to the construction techniques which might affect marine life in the area.

4.1.5 Constructed Wetlands

Constructed wetlands have become more common in the past 20 years as a low impact treatment method for wastewater and stormwater. Their combination of plant uptake, aerobic and anaerobic degradation, absorption, and adsorption enables wetlands to remove nutrients and metals. Wetlands are typically categorized as surface, subsurface, or hybrid (a combination of surface and subsurface). Constructed wetlands can be used as a secondary treatment of wastewater. Wetlands are usually used as secondary treatments or simple pretreatment systems in small communities (Kadlec and Wallace 2009). The effectiveness of constructed wetlands in removing pollutants varies widely on a case by case basis, as well as seasonally, but some general numbers can be gleaned from a collection of studies compiled by Kadlec and Wallace (2009). The median reduction of TSS is 87% with fluctuations depending on the season. In terms of BOD, if the influent concentration was greater than 100 mg/L, there was about a 75% reduction. If the influent was below 100 mg/L the effluent was around 30 to 40 mg/L, indicating a 60-70% reduction. Organic nitrogen was reduced by 50% on average, TKN by 38%, TN by 41%, ammonia nitrogen by 53%, and nitrate by 65%. Total phosphorus had a median reduction rate of 53%. The effectiveness of wetlands in treating salts and metals is currently too limited to draw any conclusions. It is thought that they will be successful it up taking metals at first, but the accumulation of metals in the plants may eventually be maximized and the wetland will become no longer useful in this area.

4.1.6 Bioswales

Bioswales are a low impact conveyance channel. Nutrient and metal removal occur in a bioswale due to the vegetation present in the channel. In addition, some stormwater can infiltrate or be stored in the channel. A study done by Xioa and McPherson (2009) compared two sites, one with a BMP bioswale and one which acted as a control site. The bioswale reduced surface runoff by 88.8% and nutrient, metal, organic carbon, and solids by 95.3%, 86.7%, 95.5%, and 95.5%, respectively.

4.1.7 Bioretention Ponds/ Raingardens

Bioretention ponds and Raingardens are commonly used to infiltrate and treat stormwater. The LID techniques can significantly reduce runoff, as well as remove nutrients and metals from stormwater. Bioretention ponds typically have ponded water in them the majority of the time, and contain plants that can survive in saturated soils. The stormwater slowly infiltrates into the soil. Raingardens typically have ponded water in them only during very wet conditions. Stormwater infiltrates into the soil and either drains into a perforated pipe or percolates into the groundwater table. Davis et al. (2003) did one of the first studies on the removal efficiency in bioretention ponds. Synthetic runoff was applied to different bioretention areas and the effective removals were compared between the two areas for the purpose of determining variability. Dietz and Clausen (2006) constructed a replicate rain garden to treat roof runoff. The gardens were constructed to hold one inch of runoff. Another field study was done by Rossen et al. (2006) to compare multiple LID designs. Treatment

strategies were uniformly sized to target a rainfall-runoff depth equivalent to 90% of the annual volume of rainfall. Finally, Hunt et al. (2006) evaluated three different field sites with varying fill media type and drainage configuration. The removal efficiencies gathered from these studies are shown below in Table 3.

Table 4.3. Summary of bioretention pollutant retention (Dietz 2007)

Location	TSS	NO_3-N	NH_3-N	TKN	TP	TN	ON	Cu	Pb	Zn	Reference
Haddam, CN	-	67	82	26	-108	51	41	-	-	-	Dietz and Clausen 2006
Greenbelt, MD	-	16	-	52	65	49	-	97	>95	>95	Davis et al. 2003
Largo, MD	-	15	-	67	87	59	-	43	70	64	Davis et al. 2003
Durham, NH	96	27	-	-	-	-	-	-	-	99	Roseen et al. 2006
Greensboro, NC	-170	75	-1	-5	-240	40	-	99	81	98	Hunt et al. 2006
Chapel Hill, NC	-	13	86	45	65	40	-	-	-	-	Hunt et al. 2006

Many factors need to be considered when choosing the final design for a terminal. Available land area, maintenance requirements, seasonal changes, and treatment efficiencies should all be considered. The following is a discussion of studies that evaluate different LID techniques based on removal efficiencies and various factors that need to be considered during design.

In a study conducted by Roseen et al. (2009), the efficiencies of 6 LID treatment systems (a surface sand filter, two bioretention systems, a subsurface gravel wetland, a street tree, and porous asphalt) in addition to a stone-lined bioswale, a vegetated bioswale, and 7 proprietary systems were evaluated during the winter months. These studies were conducted in New Hampshire, where the average temperature during the winter is 9 degrees C, with a 48-52" frost depth. The LID system findings conclude that smaller treatment systems relying on a settling pond or separating pool as part of the treatment train experienced decreased rates of settling during the colder weather, but had little seasonal variation in removal efficiencies. In comparison the stone-lined swale was the only monitored system to see a marked decrease in peak flow and lag time during the winter months, which was attributed directly to the increase of Manning's roughness coefficient from the presence of snow and ice. The stone-lined swale, vegetated swale, and hydrodynamic separators all saw marked seasonal efficiency declines, with TSS removal efficiency drops of 80% to 8%, 68% to 13%, and 37% to 15%, respectively, from summer to winter.

4.2. Unique Marine Technologies

This section encompasses technologies on the waterside dealing with water quality and treatment as the main foci and special practices that will be evaluated starting with those recommended in the 520 AKART study and any studies reviewed at a later time.

4.2.1 AKART

The AKART study focused on the most effective way to manage stormwater on the State Route 520 floating bridge across Lake Washington. Four different stormwater management methods were considered and compared for technical feasibility and cost-effectiveness. The four alternatives were:

Alternative 1: Media filtration vaults and modified catch basins/cleaning (with conventional sweeping)

Alternative 2: Catch basin filtration (with conventional sweeping)

Alternative 3: Modified catch basins/cleaning (with conventional sweeping)

Alternative 4: High-efficiency sweeping and modified catch basin/cleaning

Of these four alternatives it was concluded that alternative 4 was the most applicable. Some benefits of this alternative include:

- It can provide an effective level of water quality protection for sediments and metals.
- Its implementation is more visually apparent.
- It takes advantage of the bridge's flat gutterlines, which make it possible to retain sediments for longer periods increasing the opportunity for their removal before they are discharged into catch basins.
- It does not have an unreasonable or unknown level of risk associated with operation and maintenance—a characteristic of the other technologies.

4.2.2 Modified LID at Marine Interface

Currently the KriStar system has been used at the Bainbridge Island terminal. Data has shown that the system has been effective in removing pollutant associated with stormwater runoff from the holding area. This system could be implemented at other terminals where there is overland area available.

The BMPs and LID techniques identified in Table 2 are only those that impact the intersection of the port with the marine environment, and can potentially be modified for marine use. The purpose of this study is not to elaborate landside BMPs and LID applications, but to identify the applicability to establishing marine guidelines. Table 2 covers source control and permanent structural BMPs and LID methods.

Table 4.4. BMP and LID Methods Applicable to Ferry Terminals

Stormwater Pollution/Prevention Technique	BMP	LID	Function
Pervious Pavement		X	Infiltrates stormwater
Bio-retention Ponds/Raingardens		X	Retains water, allowing for sediments to settle out and stormwater to infiltrate over a period of several days. Any excess runoff is

			drained to an approved stormwater system
Stormwater detention pond		X	A pond that detains water until sediment has settled, then allows for water to be drained out from the top of the pond to an approved stormwater drain
Constructed Stormwater Wetland		X	Constructed Wetland for the purpose of detaining and treating runoff
Bio-infiltration Swales	X	X	Vegetated swales that allow for the collection of sediment and infiltration of stormwater through percolation
Buffer Strips	X	X	Buffer strips can be vegetated, or not, and allow for sediment and pollutants to catch in the buffer material allowing then to filter and degrade versus going down storm drains
Wheel Wash/Prohibit Dirty Vehicles	X		A wheel wash installed at the entrance of the ferries to prevent pollutants on tires from dropping on parking areas.
Silt Curtain	X		Reduces sediment impact to surrounding waters
Suction Dredger	X		Used instead of a bucket dredger it can reduce sediment impact to surrounding waters
Sediment Traps	X		Dewaters fines to reduce sediment impact to surround areas
Prohibit Dredging	X		Ceasing dredging activity in times of storms or breading seasons of fish stocks or protected species to limit sediment impact to marine ecosystems

Temporary or Permanent Bunds	X		Using bunds is common in India to control the flow of rivers. By employing temporary or permanent bunds, waters from construction activity or stormwater can be redirected to retention ponds or other treatment beds
Spill Containment Pads	X		Portland Cement, or other equivalent impervious material, that slopes to an approved drain system
Modified Grades or Raised Sills or Open Grade Trenches Around Spill Containment Pads	X		Modified grading, raised sills or open trenches prevent a spill from leaving the containment pad. In a similar fashion, it may be advantageous to treat the holding area as a spill containment area to prevent petroleum products due to minor leaks from entering the sound. Care should be taken when considering these options in locations where they might become a tripping hazard.
Drip Pan with Rails	X		A drip pan attached to a rail system to prevent leakage from fueling, leaking rail cars, etc. from entering stormwater drains.
Preserving Natural Vegetation by Retaining Vegetative Cover and using Erosion Mats	X		All of these are covered in Erosion and Sediment Control for reducing erosion, and protecting potential erosion areas
Linear Sand Filter	X		Long shallow, two celled vaults. The First vault consists of a settling chamber, the second of a sand filter for the removal

			of total suspended solids (TSS), phosphorous, and insoluble organics (including oils)
Stormfilter® CDS/MFS Vault	X		Manufactured storm drain systems
Sand Filter Vault	X		Below grade presettling chamber and sand filters accessible by grates

Source: Ecology 2005, 2005a; Gupta 2005

4.2.3 Adapted Treatment Trains

Although there are few examples of LID methods used in port settings, there are some studies (Gray et al 2010) that begin to explore how to modify traditional approaches in reference to the needs of ports. In addition to the exploration of sand filters by Gray et al. (2010), there is room for exploration of using terraced raingardens to catch runoff between where the land uses end and marine uses begin. Employing source control BMPs, such as containment pads, to the entire layout of queuing and parking within ports, lends insight to containing pollutants from the vehicular activities associated with ports. Bunds, man-made embankments, or contaminant sills could all be viable design methods for containment of polluted runoff from land uses and redirection to treatment areas. Area limitations make some BMPs more difficult than others in port settings; however, these methods can still be used in part. An example of this would be the potential to use narrow elongated bio-retention ponds around the perimeter of the parking structure, which outflows to a sand filter or other method of final polishing instead of discharging to municipal storm sewers. Operational BMPs will have a large impact on the success of implemented LID or BMP applications, due to the nature of these solutions to be monitored and maintained effectively.

Reducing the amount of runoff from a building that needs to be treated should also be considered. Living walls, green roofs, and rainwater harvesting are all viable options. Reducing runoff from the building itself can reduce the extent of other BMP and LID technologies that would be required to treat all rainfall falling on the site. In addition to consideration of applicable LID and BMP applications, reducing runoff from the building will also be considered and discussed.

High treatment trains are required for high use sites where a single stormwater treatment technique will not be enough. A treatment train should consist of multiple elements which treat different aspects of the stormwater. One example of a treatment train could include sweeping to remove large particles, a reverse slope towards an oil/water separator, and a sand filter for tertiary treatment. Another example would be using pervious concrete to trap heavy metals which then drains to an oil/grit separator. Finally a disconnect approach could be used by placing a roof over an area of the terminal to prevent the stormwater from being contaminated by pollutants on the surface. The pollutants on the ground could be treated with a sweep and wash technique.

5. Unique challenges to materials in ferry ports

Results of previous research (de Sainte Marie d'Agneaux 2009) indicated that sustainable infrastructure could be designed with suitable guidelines and information. However, existing building guidelines may not be applicable for designing a ferry terminal, which is mainly located on the seawater or marine interface. This creates unique challenges when designing a sustainable ferry terminal. One way to address these unique challenges is through construction material selection and use. Durable materials, which can withstand both marine and high precipitation exposures while providing the required material performance, need to be selected. However, most of these durable materials are mainly chemically treated, i.e. treated wood lumber, galvanized steel, etc. These materials could possibly release chemicals into the ocean over time, which is known as weathering or aging. In addition, management of hazardous materials is a priority in the SMS for managing critical infrastructure risks (Parnell 2007). Both of these, facilities for hazmat management and also the materials used for the terminal facilities need to be considered with their proximity to the marine environment. Currently, only limited information and guidance is provided for material selection on ferry terminals. In order to enable the selection of appropriate materials, the exposures, uses, and performance, requirements need to be identified and categorized. Additionally, current material selection criteria and guidelines and their applicability to ferry terminals are identified and assessed.

5.1. Marine Interface

Structural degradation typically through weathering, corrosion, and biological attack are significant items to consider in the selection of materials to be used in marine environments. Additionally, adverse environmental impacts resulting from chemical releases related to material weathering are also important considerations of sustainability. This section identifies and discusses specific material challenges encountered along the marine interface in structures associated with ferry terminals.

5.1.1 Material degradation in marine environments

Materials used in the marine interface are exposed to hydro/hydrothermal conditions, salt water, wave action, ultraviolet (UV) light, biological attack, etc. Under this severe condition, not only mechanical degradation of materials by cracking and moisture is seen, but also surface erosion is found after wave action and/or rain wash. The materials must withstand associated agents of degradation and limited release materials into the environments due to there are potential hazardous chemicals/compositions in the materials could have adverse environmental impacts. During weathering, cracking were most common issue on the materials of polymeric materials and concretes (Feldman, 2002; NRMCA, 2011; Mehta, 1991) that deteriorate mechanical properties and provide a pathway for moisture or salt water penetration into the materials. Moisture is also a factor of properties deterioration. Additionally, Feldman (2002) indicate that UV light leads to polymer chain scission. This could be observed on the surface of polymeric materials in outdoor applications. With continuous wave action, materials corrosion and subsequent surface erosion occurs, and the potential hazardous chemicals, which are added for preventing weathering and biological attack, could be released and/or discharged into the water.

5.1.2 Pollutants resulting from material weathering

Through material weathering, potential chemicals here are also seen as pollutants that have high possibility to release in the marine environment and/or interface. After literature reviewed, the materials to avoid and preferable materials are listed out in the Green Rating Integration Platform (GRIP) and diagrammed in Section D.2 of Appendix D. The potential materials/products with their hazmat are listed below:

a) Chemical-preserved wood :

Nature of wood, aging is a drawback to use wood as outdoor applications after weathering. For this reason, applying preservatives become necessary to prevent deterioration from weathering. However, most of the preservatives are containing heavy metals. Water-borne based preservatives, an example of chromated copper arsenate (CCA), could be potential hazard to the environment. Studies (Wood handbook, 2010; Lebow, *et al*, 2004) indicated that certain amount of the preservatives leached out of wood in years with multi-factors effects on the rate of leaching. The un-reacted and/or water soluble preservatives have highly potential to be leaked out. The components (copper, arsenate, chromium, *et al.*) of preservatives are bio-accumulative could hazard to vary of organisms and plants. The chemical components were detected in soil, sediment samples, rainfall water, and seawater in multiple concentrations (Lebow, *et al*, 2004).

b) Concrete and reinforced concrete:

Comparing with steel or other construction materials, many advantages, such as low maintenance, rust-free, durable, high strength (by added fly ash), and cast-able, leads concrete is most major material to be used on marine port or bridges applications, i.e. piling, column, foundation, *et al*. As performance requirement, pre-casted concrete provides a higher strength and fewer defects than cast-in-place concrete because it is mostly cured or casted under a conditioned environment. On waste management, the method of cast-in-place could be possible to cause reminding construction waste more than that of pre-casted concrete. Moreover, in marine interface, a major consideration for designing and selecting the methods of casting structural concrete element is weathering by moisture, sea water, ocean wave, severe weather cycling, etc. After weathering, the lessened constituent components of concrete, i.e. fly ash, chemical admixtures, can be released into the environment by wave action and rain wash into storm water and the ocean. Borm (1997) pointed out that fly ash, a by-product from coal-fire power plan, is possibly constituted with pollutants, i.e. heavy metals, polycyclic aromatic hydrocarbons (PAHs), and silica. His review indicates that considering with pollution risk, the contaminations of fly ash are potentially hazard to human if containing in water. Additionally, in the case of steel bar reinforced concrete, under marine condition, after surface erosion and salt water diffused, corroded steel could expose to seawater and thereby release the rusted metal debris into the ocean (Mehta, 1991).

c) Galvanized steel :

Galvanizing processes, such as hot-dip, is commonly applied for corrosion protection on commercial or industrial steel articles. Zinc is a well-know highly reactive metal and has low corrosion rate, which benefits zinc-coated steel (galvanized steel) has outstanding corrosion resistance. This is because the thin layer of zinc hydroxide/carbonate kept out moisture contacts with steel or iron during exposure to the environment (Rahrig, 2003; Zamanzadeh, 2011). This outstanding corrosion resistance helps the galvanized steel widely used in marine environment. However, zinc can still react with moisture under hydro/hygro-condition and resulting in a slow rate of corrosion (Rahrig, 2003). Under marine condition, multiple influencing factors such as chlorides from salt water, temperature, and pH value are seeing to accelerate the corrosion. If the metal or steel article is used in marine interface, the corroded metals and rust could be removed and washed into the ocean by wave action and rain washing (Rahrig, 2003). Reed *et al.* (1980) claimed that certain level of zinc content in water could still cause toxicity and influence life of fishes or aquatic organisms, even zinc is comment element in animal, soil, water, etc. This is further pointed out that if galvanized steel is applied in marine interface, the potential impacts could occur to aquatic organism in marine environment.

d) Asphalt pavements:

Asphalt is commonly used on road surfaces and parking lots for many decades because of its outstanding waterproofing and binding performance (Freemantle, 1999). Asphalt is a highly complex thermoplastic material, which may contain saturated and unsaturated aliphatic and aromatic compounds, and physically reacts like plastic during temperature change. As the thermoplastic behavior, temperature cycling from weathering becomes an issue. Asphalt is highly absorbing heat from solar energy, and then the high temperature soften the asphalt, even flow deformation. However, asphalt starts aged over the time. Most likely, it is losing its volatile low molecular weight constituents by oxidation during heating up from solar energy or washed out by rain. The leakage of these constituents is another issue to using asphalt in many locations, especially marine interface. On the other hand of aging, during night time or even winter time, the cold temperature turns the asphalt becomes brittle. With the heavy traffic load, stress induces cracks on asphalt, known as thermal and/or fatigue cracking (Freemantle 1999). Study (Norin and Strömvall, 2004) indicated that PAHs were found in urban underground water, which creates a highly risk to use asphalts near water or marine interface. Additionally, heavy metal elements were determined in an accepted level according with a drinking water standard (Legret, *et al*, 2005), but since the heavy metals is bioaccumulative, it is still potentially hazard to animals, mammal, and human.

e) Hydraulic Fluid/ lubricant:

Petroleum-based lubricant and fluid are mainly used in marine transportation and hydraulic systems in ferry ports. Hydraulic systems are commonly used for gate and/or terminal control system in ferry port. With potentially risk of leakage and spilling, the fluid and/lubricant have drastic impacts on terrestrial, aquatic

environments, and underground sources of drinking water, especially in marine interface. Kinston (2002) reported that after mineral oil spilled, the contamination of the oil could be highly possible to remain and persist in the marine environment for years to decades because the mineral oils are not biodegradable. The oil therefore causes long-term environmental impacts (negative effects on the ecosystem) and confined to community structure anomalies. As most of hydraulic system is capping by rubber/silicate gasket, expecting that the gasket aged by the UV light, heat, and pressure from hydraulic fluid. Once the gasket aged, the leakages are expected and may cause marine environmental impacts.

5.1.3 Challenges to construction methods affecting material selection

Material selection must also consider associated construction methods as some methods may have adverse ecological consequences. This section identifies material specific methods of construction that may be associated with adverse environmental problems.

a) Traditionally, chemically treated lumber was widely used on decking. During construction, most decks are built-in-place. Saw dust has highly potential remaining on the ground or possibly washed and blew into the ocean. Currently, wood plastic composites (WPC) are engineered by blending plastic (virgin or recycled plastic) and wood flour as a durable composites material for outdoor applications. With similar mechanical properties as wood, the engineered WPC has been successfully applied and replaced the chemically treated lumber. This is suggesting that by using WPCs to replace the potential hazard lumber for construction materials in ferry terminals can reduce the potential environmental risk.
b) Pre-casted concrete is commonly used as piling material. It suggests that capping with an impact resistance layer on concrete piles can prevent impact from wave actives and also reduce the weathering induced from surface erosion and moisture penetration. However, it has a challenge to geologically install concrete pile in hard soil layer. By using steel as piling material can be easier for piling on hard soil layer than concrete. Commonly, impact and vibration driven piling processes, vibration helps to reduce the construction time, may be adverse interaction with marine mammals due to sound waves influence the navigation system of marine mammals. Engineers developed bubble curtain methods that can mitigate environmental impact from the sound waves. However, steel it corrodes with the time. To prevent the steel corrosion, in consideration of 50 to 70 years life design, coating (galvanized) and/or painting is needed during the steel manufacturing. By combination of steel and concrete, it is possibly to drive steel pipe as piles and fill with reinforced concrete to form a composite piling system.
c) As galvanized steel has been considered to release zinc which may influence the aquatic life, it is possible to paint or coat on the galvanized steel during its manufacturing process, which is to prevent the chemicals and/or organic solvents release during on-site painting/coating progress. The painting/coating

layer is seeing to prevent zinc react with moisture and release into the ocean. The paint and coating condition needs to be checked frequently to see if any possibility of re-paint or any maintenance.

d) Using bio-oil mixed asphalt, warm-mix asphalt, and thin surface paving technique can reduce the possibility of releasing PAHs and VOCs to the environment and oil consumption. This is also suggested that not to use asphalt near waterline due to the PAHs may be washed out and released into the ocean and storm water. In this case, porous pavement is suggested to use in these area, including parking lots, to rapidly discharge water into the ocean or storm water system.

e) During the construction, bio-based hydraulic fluid is suggested for use in the ferry terminals. The bio-based fluid is biodegradable in the marine condition. This can reduce the environmental impacts if any spill or leakage occurred during the construction.

5.2. Inventory of current materials in use at ferry ports

Categories of structures and the associated materials used in the pier structures at the four ferry ports visited are listed below by terminal.

Fauntleroy terminal consists of a single pier and slip with the right of way ending at the edge of the dock. The terminal is in close proximity to a salmon-bearing creek. The terminal building is situated above water on the pier and is near the end of the pier. The staging area for automobiles is on the pier over the water.

Table 5.1. Materials used at Fauntleroy Terminal

Structure/Use Category	Materials Used
Pilings	• Treated wood • Concrete repair work on some piles
Dolphins	• Steel piles • Steel beam walls • UHMW wear surfaces
Fenders/Bumpers/Rub Rails	• Steel beams • Treated wood beams • UHMW wear surfaces
Decking on Piers and Walkways	• Treated wood • Asphalt
Area/Spatial Dividers	• Painted wood walkway/traffic divider • Painted lines on asphalt • Galvanized steel fencing

Railings	• Treated Wood • Painted Wood
Miscellaneous	• Galvanized steel shielding of land to pier piping and services • Galvanized steel fencing • Steel light posts

The ***Vashon Island*** ferry terminal is comprised of two automobile slips as well as a slip for walk-on customers. The terminal building is situated above water on the pier and is near the end of the pier. The staging area for automobiles is on the pier over the water.

Table 5.2. Materials used at Vashon Terminal

Structure/Use Category	Materials Used
Pilings	• Treated wood • Concrete repair work on some piles • Concrete piles for pedestrian ferry pier
Dolphins	• Steel piles • Steel beam walls • UHMW wear surfaces
Fenders/Bumpers/Rub Rails	• Galvanized steel beams • Treated wood beams • UHMW wear surfaces
Decking on Piers and Walkways	• Treated wood • Asphalt • Concrete for pedestrian pier
Area/Spatial Dividers	• Painted lines on asphalt • Painted steel railings • Painted steel fencing and gates
Railings	• Treated Wood • Painted Wood • Painted Steel
Miscellaneous	• Galvanized steel shielding of land to pier piping and services • Steel light posts • Wood light posts

The ***Seattle Coleman*** terminal consists of multiple buildings and three automobile slips. The entire terminal is over water with a seawall running near the end of the right of way. The staging area for automobiles is also over the water.

Table 5.3. Materials used at the Seattle Coleman Terminal

Structure/Use Category	Materials Used
Pilings	• Treated wood • Concrete • Steel
Dolphins	• Concrete platforms • Steel beams • Wood impact structures • UHMW wear surfaces
Fenders/Bumpers/Rub Rails	• Steel beams • Treated wood beams • UHMW wear surfaces
Decking on Piers and Walkways	• Treated wood • Asphalt • Concrete • Coated steel
Area/Spatial Dividers	• Painted lines on asphalt • Painted steel railings • Painted steel fencing and gates • Galvanized steel fencing • Painted wood • Concrete curbs • Concrete barriers
Railings	• Treated Wood • Painted Wood • Painted Steel • Anodized aluminum
Miscellaneous	• Steel light posts

The ***Bainbridge*** ferry terminal is comprised of two automobile slips. The terminal building, automobile staging areas, and a parking lot are situated on land.

Table 5.4. Materials used at the Bainbridge Terminal

Structure/Use Category	Materials Used
Pilings	• Concrete • Steel
Dolphins	• Steel piles • Steel beam walls • UHMW wear surfaces
Fenders/Bumpers/Rub Rails	• Steel beams • Treated wood • UHMW wear surfaces

Decking on Piers and Walkways	• Treated wood • Asphalt • Concrete • Coated steel
Area/Spatial Dividers	• Painted lines on asphalt • Galvanized steel railings • Galvanized steel fencing • Galvanized steel gates • Treated wood • Concrete curbs • Concrete dividers with anodized aluminum railing
Railings	• Treated Wood • Galvanized Steel • Anodized aluminum
Miscellaneous	• Steel light posts

5.3 Applicability of current green design specifications

Currently most green building specifications address structures which built on landside, but do not specifically cover over water structures such as trestles and ferry ports/terminals. However, the portions of the current guidelines that deal with structures and materials use may are useful and applicable for portions of ferry ports.

5.3.1 Material Ratings: red, green, yellow, and general lists of ratings

Currently, it is impossible to list all the true environmental impacts associated with the built environment. Many of the known adverse impacts can be traced back to resource deletion, embodied energy, and pollution associated with the production and use of certain materials. In order to begin to address some of the known adverse impacts associated with materials, some organizations have compiled lists of materials that should be avoided in the built environment

The Living Building Challenge Material List – CRGBC (2006) produced the Living Building Challenge Material Red List, which contains a list of materials to be avoided in the construction of the built environment. To be considered part of the Living Building Challenge, the project must not have any of the following materials or chemicals present on the site:

- Cadmium
- Chlorinated Polyethylene and Chlorosulfonated Polyethylene
- Chlorofluorcarbons (CFCs)
- Chloroprene (Neoprene)
- Formaldehyde (added)
- Halogenated Flame Retardants
- Hydrochlorofluorocarbons (HCFCs)

- Lead
- Mercury
- Petrochemical Fertilizers and Pesticides
- Phtalates
- Polyvinyl Chloride (PVC)
- Wood treatments containing Creosote, Arsenic, or Pentachlorophenol

Build LACCD - The Los Angeles Community College District (LACCD) has developed a materials red list using the Living Building Challenge material red list and adding endangered wood species.

USFS Sustainable Building Principles – In accordance with Sustainable Buildings in USFS Buildings and Related Facilities Handbook (2008), for new construction and major renovations and/or existing buildings, minimizing the environment impact of materials can be done by multiple methods. For examples, to design flexible interiors may be converted to other use and reduce the need for redesign and reconstruction of interior spaces. Encourage visitor and employee recycling through well-placed and marked containers and through awareness programs. Seek building materials with high recycled content and low "embodied energy". Consider using as many green products as possible.

a. Recycle content
   Use products meeting or exceeding EPA's recycled content recommendations for EPA-designated products. For other products, use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 10 percent (based on cost) of the total value of the materials in the project. If EPA-designated products meet performance requirements and are available at a reasonable cost, a preference for purchasing them should be including in all solicitations relevant to construction, operation, maintenance of, or use in the buildings.

b. Biobased materials and content
   Use products meeting or exceeding USDA's biobased content recommendations for USDA-designated products. Use biobased products made from rapidly renewable resources and certified sustainable wood products for other products. If these designated products meet performance requirements and are available at a reasonable cost, a preference for purchasing them should be included in all solicitations relevant to construction, operation, maintenance of or use in the building.

c. Construction waste
   Identify local recycling and salvage operations that could process site related waste during a construction project's planning stage. Recycle or salvage at least 50 percent construction, demolition, and land clearing waste, excluding soil, where markets or on-site recycling opportunities exist.

d. Waste and materials management
Provide reuse and recycling services for building occupants, where markets or on-site recycling exist. Provide salvage, reuse, and recycling services for waste generated from building operations; maintenance, repair, and minor renovations; and discarded furnishings, equipment, and property. This may include such things as plastic, paper, and so forth from building occupants, outdated computers from an equipment update, and construction materials from a minor renovation.

e. Environmentally preferable products
Using products, such as low-emitting materials or products containing no toxic metals, that have a lesser or reduced effect on human health and the environment when compared with competing products or services the serve the same purpose.

f. Ozone depleting compounds
Eliminate the use of ozone depleting compounds during and after construction where alternative environmentally preferable products are available, consistent with either the Montreal Protocol and Title VI of the Clean Air Act Amendments of 1990, or equivalent overall air quality benefits that take into account life cycle impacts.

New Jersey Green Marine Products Study - This study provides a look into the inventory and environmental impact assessment for use as a guideline in selecting marine materials with low environmental consequences. Within the report, several types of materials commonly used in docks and ports are identified and assigned qualitative ratings. The ratings are provided for attributes considered important to product use as well as environmental impact. The general attributes are identified as: harvesting and extraction, processing, delivery/shipment, installations, utilization and lifecycle. Ratings are provided for individual subcategories within each attribute. In addition to specific product and material ratings, the report contains a list of references, which were examined in order to define important attributes and develop material ratings. These references will be useful for interface and waterside material selection and considerations.

The Engineering Guide to Leadership in Energy and Environmental Design (LEED) - New Construction - This study (Haselbach, 2010) is providing more understanding and application of green building design concepts for the engineering and development community. With covering using LEED-NC rating system on such as sustainable, water efficiency, energy, materials and resources, indoor environment quality, design process, construction, low-impact development, etc, this study is applicable to use on large construction projects. In the category of the materials and resources, this rating system is provided for attributes of the many considerations of using recyclable and reusable materials, recycled content, waste management, regional materials, rapidly renewable materials, and certified wood. Each of the considerations has clearly defined on how

and what on rating examination and attributes. This material and resource rating system are applicable for material selection and considerations of vessel, ferry ports/terminals, and buildings.

a) Storage and collection of recyclables
   Providing storage and collection of different category of recyclable wastes intent to facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.
b) Building reuse
   This intends to extend the life cycle of the existing buildings stock, resources, reduce waste and environmental impacts for the new buildings. This requires from 55 to 95% of existing building structure. In interior non-structure elements, it requires using at least 50% of the elements of the completed building.
c) Construction waste management
   Divert construction and demolition debris from disposal in landfills and incinerators. Redirect recyclable or reusable materials to appropriate sites or processes. Recycle and/or salvage at least 50% of non-hazardous debris from demolition.
d) Material reuse
   Reusing building materials and products to decrease waste capacity and virgin material dependence, thereby reducing environmental impact and consumption resource. Based on cost of material, at least 5% of the total value of material is required.
e) Recycle content
   Reducing impacts from processing of virgin materials by increasing demand of recycle material content which used in building project. It suggests that in the building projects, materials need to be constituted by at least 10% of sum of post-consumer recycle content plus one-half of the pre-consumer content of the total value of the materials.
f) Regional materials
   Reducing impact from material transportation by increasing demand of materials manufactured and/or produced in the region of building project. Materials are should be produced (extracted, harvested, recovered, manufactured) within 500 miles of the project sites for at least 10% of the total materials value. If only a fraction of a product or material is made locally, then only that percentage (by weight) can contribute to the regional value.
g) Rapidly renewable materials
   Using rapidly renewable material to replace the material, which are finite raw materials and long-cycle renewable materials for reducing use and prevent depletion. Suggest that 2.5% of total value of all building materials and products used in the projects are needed to use rapidly renewable materials that are made from plants, typically harvested within a 10-year or shorter cycle.
h) Certified wood
   This intends to encourage on supporting sustainable forest management. Using a minimum of 50% of the Forest Stewardship Council's (FSC) Principles and

Criteria certified wood-based materials and products for wood building components.

5.3.2 Design guideline applicability

Several green building specifications currently address structures built on landside but do not specifically cover over water structures such as trestles and ferry ports/terminals. However, the portions of the current guidelines that deal with structures and materials are applicable for portions of ferry ports. Specifically, terminal buildings can use specifications aimed at energy efficiency, indoor air quality as well as indoor material usage.

The state of Washington currently has a law enacted which requires public buildings exceeding 5,000 square feet to meet the Green Building Council's Leadership in Energy and Environmental Design (LEED) standards. All of the provisions of LEED that address indoor air quality, energy efficiency, water conservation, and materials selection and/or exclusion, and recycled material contents are applicable to terminal buildings at ferry ports.

5.3.3 Material Selection

Unfortunately, there currently is no comprehensive list that contains all possible materials and their attributes ranked by sustainable attributes. Additionally, contributions to the literature and knowledge base are ongoing and thus knowledge about material attributes and their environmental impacts continually evolve. Therefore, making educated selection of materials will require efforts beyond referencing a static, ranked material list. CalReycle (2011) has constructed a generalized approach to material selection that may be useful.

Specific product section can begin after the establishment of project-specific environmental goals. The environmental assessment process for building products involves three main steps (Froeschle, 1999; CalRecycle, 2011):

1. Research. This step involves gathering all technical information to be evaluated, including manufacturers' information such as Material Safety Data Sheets (MSDS), Indoor Air Quality (IAQ) test data, product warranties, source material characteristics, recycled content data, environmental statements, and durability information. IN addition, this step may involve researching other environmental issues, building codes, government regulations, building industry articles, model green building product specifications, and other sources of product data. Research helps identify the full range of the project's building material options.
2. Evaluation. This step involves confirmation of the technical information, as well as filling in information gaps. For example, the evaluator may request product certifications from manufacturers to help sort out possible exaggerated environmental product claims. Evaluation and assessment is relatively simple when comparing similar types of building materials using the environmental criteria. For example, a recycled content assessment between various manufacturers of medium density fiberboard is a relatively straightforward "apples to apples" comparison. However, the evaluation process is more complex when comparing different

products with the same function. Then it may become necessary to process both descriptive and quantitative forms of data.

A life cycle assessment (LCA) is an evaluation of the relative "greenness" of building materials and products. LCA addresses the impacts of a product through all of its life stages. Although rather simple in principle, this approach has been difficult and expensive in actual practice.

One tool that uses the LCA methodology is BEES (Building for Environmental and Economic Sustainability) software. It allows users to balance the environmental and economic performance of building products. The software was developed by the National Institute of Standards and Technology's Building and Fire Research Laboratory.

3. Selection. This step often involves the use of an evaluation matrix for scoring the project-specific environmental criteria. The total score of each product evaluation will indicate the product with the highest environmental attributes. Individual criteria included in the rating system can be weighted to accommodate project-specific goals and objectives.

5.3.4 Design for deconstruction

In accordance with the Sustainable Site Initiative - Guidelines and Performance Benchmarks (2009), design for deconstruction, also known as design of disassembly, is the design of buildings or products to facilitate future change and the eventual dismantlement (in part or entire) for recovery of systems, components, and materials. To accomplish this goal, developing the assemblies, components, materials, construction techniques, and information and management system are included in this design process. The design is further been seen to benefit increasing rate of building and material reuse, reducing wastes from demolition, and reduce the energy consumption.

6. Proposal Strategies

The strategies are divided into sections covering:

- Site Issues
- Structures and Service
- Operations and Maintenance
- Treatment Technologies
- Materials
- Monitoring
- Rating Systems
- Incorporation into WSF procedures (SMS and SWPPP)
- Education and Outreach

This section includes final recommendations and an overall summary.

6.1. Site

Site hydrology considerations are the focus of this section, with primary considerations for handling the first flush of pollutants and source control. The possible source of some pollutants will be examined in this section including dredging, solid waste disposal, sanitary disposal, waterside development, and vehicle and maritime traffic which are all activities associated with ports and harbors that can produce natural and anthropogenic environmental pollutants (Gupta 2005). Oil, bilge, sewage, and waste leakages are all contributors of pollutants in harbors and ports. Additionally, vehicular pollutants are associated with ports through loading and unloading, vehicle emissions, brake pads, and construction. These pollutants occur in the renovation, construction, and maintenance phase, as much as in the operations phase, resulting in a high level of importance associated with the operations and maintenance of port and harbor facilities. Once diffused into the waters, toxic chemicals are difficult to trace or remediate; to prevent this source control BMPs have been developed by the Washington State Department of Ecology to prevent pollutants from contaminating stormwater to minimize or eliminate treatment needs (Ecology 2005).

6.2. Consideration of Long Term Plan

Consideration needs to be given to various developmental and service needs that might impact the stormwater and materials in the landside, waterside, and interfacial zones.

On the landside, some of the future impacts that might be considered are an increase in staging for less traveled return routes and an increase in mass transit ridership or parking for all sites based on walk-on increases (Exhibit 8, Long Term Plan). On the waterside, special consideration should be given to any floating structures. Expected impacts at the marine interface are an increase in vehicular traffic which will increase pollutants at the interface at all sites from increased vehicular ridership.

6.3. Operations and Maintenance

This section includes a compilation of some of the operational and maintenance needs which should be considered with respect to recommendations on stormwater measures and materials used (see SWPPP in Appendix A for a detailed description). Some of the activities that might be affected include the following:

- Protection of systems such as electrical, plumbing, and mechanical
- Spill Prevention Control and Counter Measure (SPCC) Plan Considerations
- Seasonal Considerations: For instance deciding the needs of conditions such as severe cold and wet weather extremes.
- Maintenance Activities: Such as the frequency of technology inspections, replacement of damaged technologies, and special considerations for stormwater technologies such as high efficiency street sweepers.

6.4. Pollution Prevention and Treatment Technologies

This section summarizes the various pollutants and typical sources, but then focuses on the main pollutants of concern. Recommended treatment technologies will include those as approved in the Washington Department of Ecology (Ecology) TAPE (Technology Assessment Protocol – Ecology) program, and others which will be recommended to be considered for this program. The evaluation of new technologies was under Ecology and is now under the direction of the Washington Stormwater Center. There is a section discussing pollution prevention approaches as well as sections discussing different waterside, landside, and intermodal treatment techniques and treatment trains that can be applied. It is recommended that the pollution prevention and treatment technology practices be adopted now as routine for design, development, and operational procedures in anticipation of more stringent water quality regulations being adopted in the future. A proactive approach in the adoption of these practices will most likely prevent more costly practices for retrofit in the future and will additionally provide better environmental quality in the interim.

6.4.1 Specific Pollutants

Some of the pollutants that might typically be found at ferry terminals are summarized in Table 3 based on the literature reviews.

Table 6.1. Pollutant Source Identification (See also the SWPPP Summary in Appendix A)

Pollutant	Source
Copper	Brake pads, pesticides, boat paint, plumbing
Petroleum	Motor oil leaks/drips, minor gasoline spills, improper disposal of used oil, major petrol spills
Polycyclic aromatic hydrocarbons (PAHs)	Patron vehicle and load sources, creosote-treated wood ties/piling/poles, vehicle emissions, parking lot sealcoats, industrial effluent
Zinc	Roofing materials, tire wear, fertilizers, plumbing, brake pads, industrial/commercial sources
Sediment	Soil erosion, fertilizer, metals, construction activity, airborne particulates

Source: Ecology 2011; Mahler et al. 2005

The preliminary list of specific pollutants and considerations is as follows:

- Total Suspended Solids (TSS)
- Oil and Grease
- Metals
    - Copper (Dissolved/Undissolved)
    - Zinc (Dissolved/Undissolved)
    - Cadmium

- Nutrients
    - Nitrogen
    - Phosphorous (Dissolved/Undissolved)
- Polycyclic aromatic hydrocarbons (PAHs)

Sorption medias for phosphorous removal include sands rich in iron, calcium, or magnesium; gravel; limestone; shale; lightweight aggregates; zeolite; pellet clay; opaka; pumice; wollastonite; fly ash; blast furnace slag; alum; goethite; hematite; dolomite; calcite (Korkusuz et al. 2007). Calcium and ferrous ions can remove phosphorous by absorption or precipitation, which is why wallastonite has good removal efficiencies for phosphorus (DeBusk et al. 1997).

6.4.2 Pollution Prevention

In addition to the pollution prevention activities already included in the SWPPP, the AKART study concluded that a very effective technique is high efficiency sweeping, preventing the stormwater from becoming polluted instead of having to treat it after it had picked up the pollutants. Some benefits of this alternative include:

- It can provide an effective level of water quality protection for sediments and metals.
- Its implementation is more visually apparent.
- It does not have an unreasonable or unknown level of risk associated with operation and maintenance—a characteristic of the other technologies.

Another appropriate pollution prevention method is a path disconnect by the use of roofs. A roof over the holding area would prevent the stormwater from picking up the pollutants deposited by patron's cars during their time on the trestle.

An additional method to prevent stormwater being treated on the trestles is a reverse slope on the pavement surfaces, which redirects the waters to more conventional LID practices on the landside.

Finally, another pollution prevention technique is the use of silt curtains or booms around spill and sediment areas to prevent the pollutants from reaching the surrounding water.

6.4.3 Treatment Technologies

This section lists the technologies that will work best at a ferry terminal. A summary of those being focused on follows; divided into sections on waterside technologies, interfacial (trestle) technologies, and land technologies.

- Waterside Technologies: These include filters that can be attached under the trestle at thru drain locations or to the side of the trestle at the scupper locations. Extensive research has been conducted on sand filters and are the most proven, but any type of filter that is shown to successfully remove hydrocarbons can be used effectively. Another waterside treatment would be the use of pervious pavement. Pervious

pavement has the ability to store a significant amount of stormwater. This stormwater eventually evaporates and does not contribute to runoff during smaller storm events. During larger events, the runoff is significantly reduced. Due to the tortuous pathways in pervious pavement, pollutants are also removed. Depending on the permeable pavement used some treatment may occur such as microbial degradation of hydrocarbons or metal adsorption.

- Interfacial Technologies: Viable interfacial technologies include the treatment of stormwater by use of living walls or green roofs. Living walls are vegetated walls that are able to take up the stormwater runoff from roof areas. Storage of stormwater occurs in the soil and the plant. Evaporation and transpiration also occurs in a living wall. The walls work best when facing the south or southwest towards the sun. Green roofs are similar to living walls; they are able to store and retain the majority of rainwater and significantly reduce the runoff from buildings. Green roofs store a significant amount of stormwater in the soil, allowing the slower plant uptake process to occur after a rain event. Evaporation and transpiration will aid in the reduction of runoff.
- Landside Technologies: These would include the Drainage Technologies as per Table 4.5, Stormwater Management Manual for Western Washington Volume 5, those as recommended in the WSDOT Highway Runoff Manual, and those developing Low Impact Development technologies such as listed in the Puget Sound LID Manual (2011 update not yet available). A focus will be on keeping the landside and the interfacial systems separate as the former includes both quantity and quality control and the latter only quality control.

6.4.4 Integrated Management Practices (IMPs) and Treatment Trains

As previously mentioned, high treatment trains are required for high use sites where a single stormwater treatment technique will not be enough. A treatment train should consist of multiple elements, which treat different aspects of the stormwater. One example of a treatment train could include sweeping to remove large particles, a reverse slope towards an oil/water separator, and a sand filter for tertiary treatment. Another example would be using pervious concrete to trap heavy metals which then drains to an oil/grit separator. In addition a combination of various pollutant prevention and treatment practices might most effectively be customized to each site. One example is the aforementioned disconnect approach such as placing a roof over an area of the terminal to prevent the stormwater from being contaminated by pollutants on the surface at that location and then fewer treatment practices on other areas of the trestle. Another example currently being proposed is a reverse slope for portions of the trestle considered to be stormwater pollutant hot spots such as the holding areas, combined with conventional treatment landside, and then less intense or no stormwater treatment facilities would be necessary for other areas of the trestle which do not have such high pollutant loads. These combinations of pollution prevention and treatment practices are commonly referred to as Integrated Management Practices (IMPs).

IMPs need not have the same sustainability goals. One additional example that may have multiple other applications is the use of roofs or covers over the holding areas on a

trestle. This would disconnect the stormwater from the pollutants being generated from the vehicles. The roofs could have other benefits. An example is the conceptualization of a green space covering part of the Seattle Coleman trestle as an extension of pedestrian and tourist areas in the City. Another example is using roofs to hold photovoltaic cells (PVC) for electricity generation. These roofs would count towards many LEED credits including that for reduction of the heat island effect for pavements. In addition, WSF actively works on decreasing the carbon footprint of its operations and those of the customers it serves. Combining this PVC setup with charging stations at certain preferred locations in the holding area may aid in incentivizing intermodal electric vehicle use with the ferry operations.

6.5. Materials

The severe condition of marine environment results in an acceleration of materials degradation. After exposed materials at the marine interface, it has been found different level of degradation on the materials. Additives, chemicals, and potential hazardous materials may be released into the marine environment via ocean waves and/or stormwater runoff. Many green design guidelines identify environmentally hazardous materials, and have placed them on a "Red" list. Currently, these materials cannot be used under any conditions due to the adverse impacts to the human, mammal, aquatic, and environment. On the other hand, "Green" materials, known as environmental friendly materials, have also been listed in the guidelines. In this section, the "materials to avoid" and "preferred materials" are listed and detailed in the GRIP (diagrammed in Section D.2 of Appendix D) instead using the "Red" and "Green" lists. Furthermore, by concluding different materials sections of different design guidelines, a recommendation of the material selection in this report is concluded and listed as a reference for material selection in designing ferry terminals. The material selection has two main categories that are 1) to reduce materials consumption and 2) to use environmental preferable materials. The more explanation of each sub-category could be seen in the Section D.4.

6.6. Monitoring

Currently the QAPP Report provides guidelines for stormwater quality monitoring, but it is recommended that it be cross-referenced with the SWPPP and the procedures in the SMS in the future as monitoring requirements are implemented at WSF.

6.7. Proposed Sustainability Guidelines (Stormwater and Materials)

The ferry sustainability guidelines will tentatively be based on the format outlined by Ines de Sainte Marie d'Agneaux (2009). Building upon this study, this report expanded the waterside and interface technologies, use phase materials and pollutant prevention practices for these guidelines (Stormwater and Materials sections). To ensure that they are incorporated into the WSF SMS (Safety Management System) and SWPPP (Stormwater Pollution Prevention Plan) policies and procedures, the overall integration format for sustainability can again be visualized by the following Figure 6.1. Note that in this figure ferry procedures and recommended guidelines are also related to other sustainability rating systems or guidelines that WSF might interface with. An overview of the

sustainability guideline's relationship with WSF procedures is in Section 6.8. The development of a metric for the guidelines and integration into the other green rating programs (Green Rating Integration Platform/GRIP) is presented in Section 6.9. The checklist metric for the stormwater and materials portion of the future WSF sustainability guidelines is provided in Section D.1 of Appendix D.

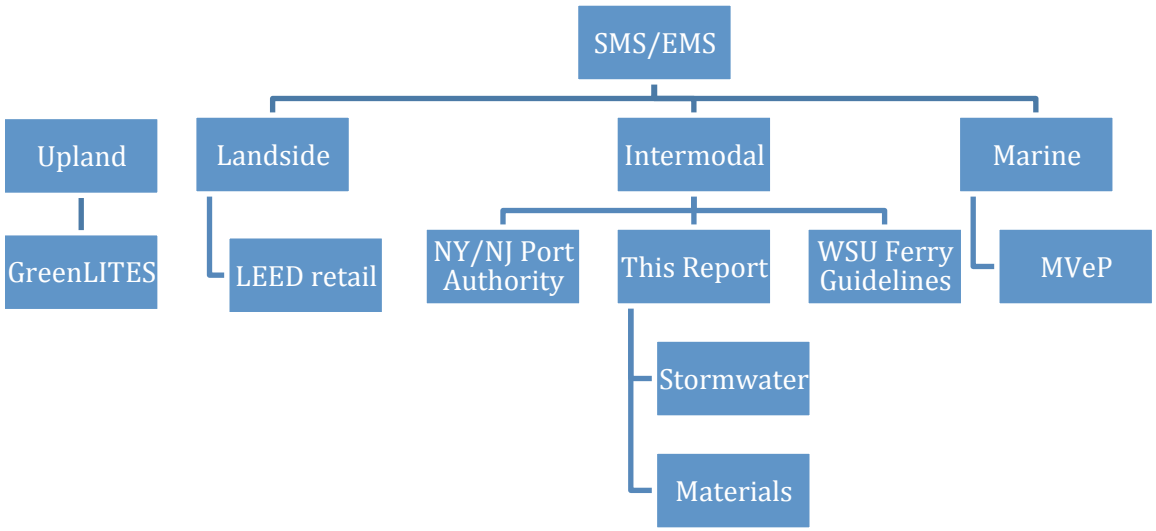

Figure 6.2. Relationship between different rating systems

6.8. Incorporation into WSF Procedures

This section gives a summary of the WSF SMS and incorporates the recommendations from the WSF SWPPP as outlined in Table 2 of the SWPPP. A proposed metric for incorporation of the SMS into the stormwater and materials portion of the sustainability guidelines is outlined in Section 6.9 and diagrammed in Section D.2 of Appendix D, the Green Rating Integration Platform (GRIP).

- SMS

The WSF SMS is divided into various sections. Some details on subsections applicable to the environmental issues covered can be found in Appendix E of this report along with a listing of the acronyms used. A listing of the main sections (volumes) follows.

Book 1.1: Safety Management System Manual 1.1 (Overall Principles)
Book 1.2: Covers policies and procedures to comply with specific programs such as safety/security, emergency preparedness/response and environmental protection.
Book 2 Human Resources Manual (HRSM) Not applicable
Book 3 Operations Center Manual (OPCT) Not applicable
Book 4 Emergency Operations Center Manual (EOCT) Not applicable
Book 9 Eagle Harbor Manual (EHBR) Not applicable
Book 10 Terminal Operations Manual (TERM)

Book 11 Engineering and Maintenance Manual (ENGR)
This is currently more comprehensive with respect to an engineering manual, whereas maintenance considerations are being developed. This manual is where most of the recommendations from this report will be included.
Book 12 vol I Deck Operations Manual (DECK)
Book 12 vol II Fire and Safety Training Manual (FAST)
Book13 Route Manual (ROUT)
Books 14-20, 25-38, 41-42 are specific to the various vessels.

Some additional items from the SMS books or discussion with the department are the following:

- Other standards that are referred to currently include the WSDOT HRM.
- Some special issues are for when there is a building above such as:
  - Fire rating
  - Coast Guard regulations for not allowing trucks under roofed areas with respect to explosives etc.
  - Currently dogs are used for the detection of explosives prior to boarding while queuing on the trestles. Conflicts in the scheduling/logistics of this need to be considered.
- Some possible solutions might be:
  - Roofed areas without buildings. Economics? Perhaps consider using for solar panels.
  - Restricting roofed areas to passenger vehicles only, which would also reduce costs since need much less clearance.
- Fecal matter is a consideration as there are many dogs at the terminals plus other passenger pets. Special pet areas might be considered.
- Issue of plugs of electric vehicles onboard. Perhaps encouraging electric vehicles is a benefit with respect to GHG considerations. These might be on the trestles.
- WSF has tariffs with savings for vehicles less than 14ft in length, of which many will be electric or other fuel-efficient vehicles. This might improve GHG estimates with offsets for customers with fuel-efficient vehicles.

- SWPPP

The SWPPP was recently prepared in accordance with State requirements. WSF has developed a table of how the SWPPP integrates into the SMS (Table 2). In like manner, any other recommendations from this report such be cross-referenced to the SMS and be consistent with the SWPPP. The SWPPP also firmly integrates technologies with maintenance and operational procedures for continued source and pollutant control. The SWPPP/SMS Table 2 is in Appendix A.

6.9. Integration of Rating Systems, WSF SMS and Recommendations from this Report

As previously diagrammed in Figure 6.1, the recommendations from this report and the SMS should also be interfaced with the various green rating tools that may affect WSF and its operations now and in the future. In order to facilitate this, a green rating integration

metric (GRIP) is being proposed which provides more details for the items in Figure 6.1. This includes additional sustainability considerations for intermodal activities at the terminal, buildings and various land-side practices at the terminal, and the upland interface with other modes of transportation. It also considers marine side guidelines currently being developed for vessels. A formal presentation of the GRIP can be found in Appendix D.2 and a summary view is provided in Figure 6.2.

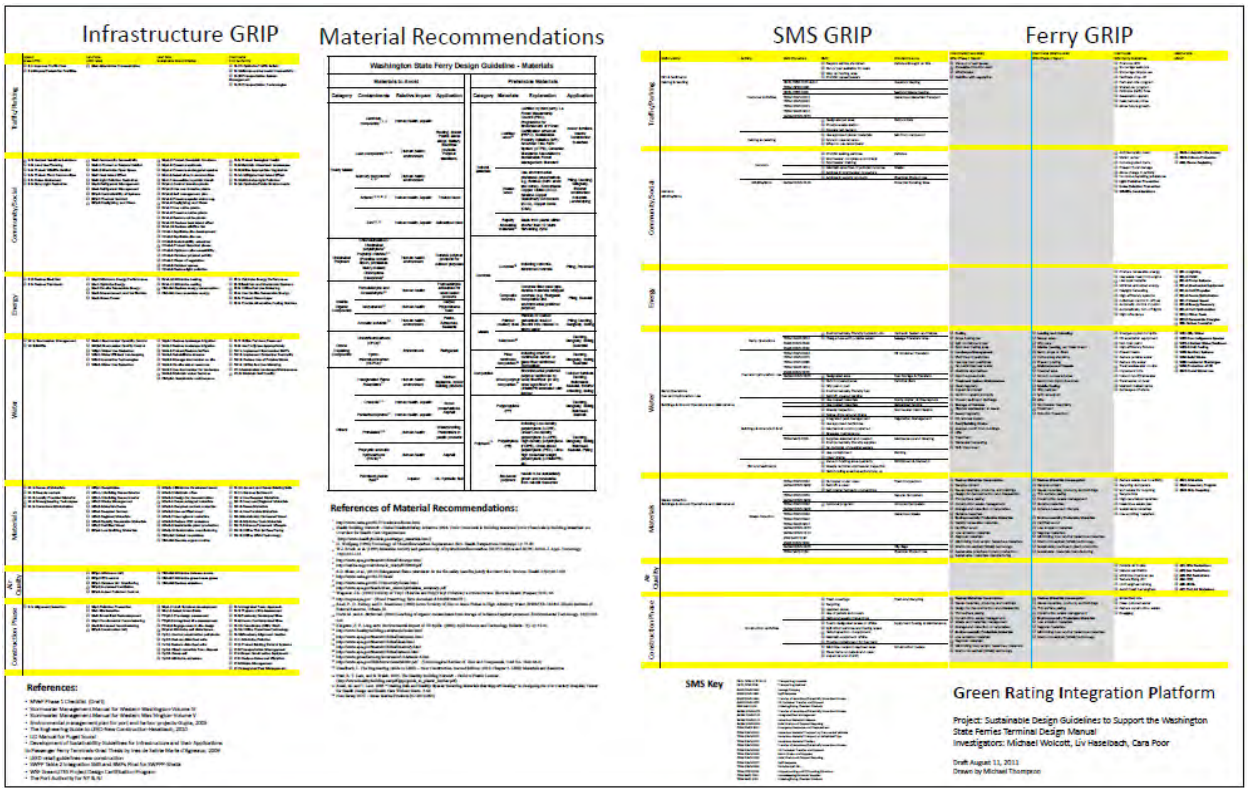

Figure 6.3. Summary view of the GRIP

The various practices and checklist items of the proposed ferry guidelines, and various related rating systems have been segregated into broad categories for sustainability consideration which currently include:

- Traffic/Parking
- Community/Social
- Energy
- Water
- Materials
- Air Quality
- Construction Phase

The proposed metric methodology is in the form of various checklists as outlined in the GRIP and should be used in the following fashion. When folded in half, with the left and right quarters visible, the tool depicts how the guidelines developed in this report fit across major sustainability categories in the following rating systems:

- Draft of the marine side MVeP for vessels
- Draft WSU Ferry Guidelines (de sainte marie 2009)
- Intermodal Guidelines as proposed by the NY/NJ Port Authority
- LEED for new construction and retail
- Upland GreenLITES highway rating system

An example diagram for this metric tool and how it can be cross-referenced to the various rating systems is presented in Figure 6.3. More detailed checklist tools for each of the aforementioned rating systems can also be found in Appendix D.3.

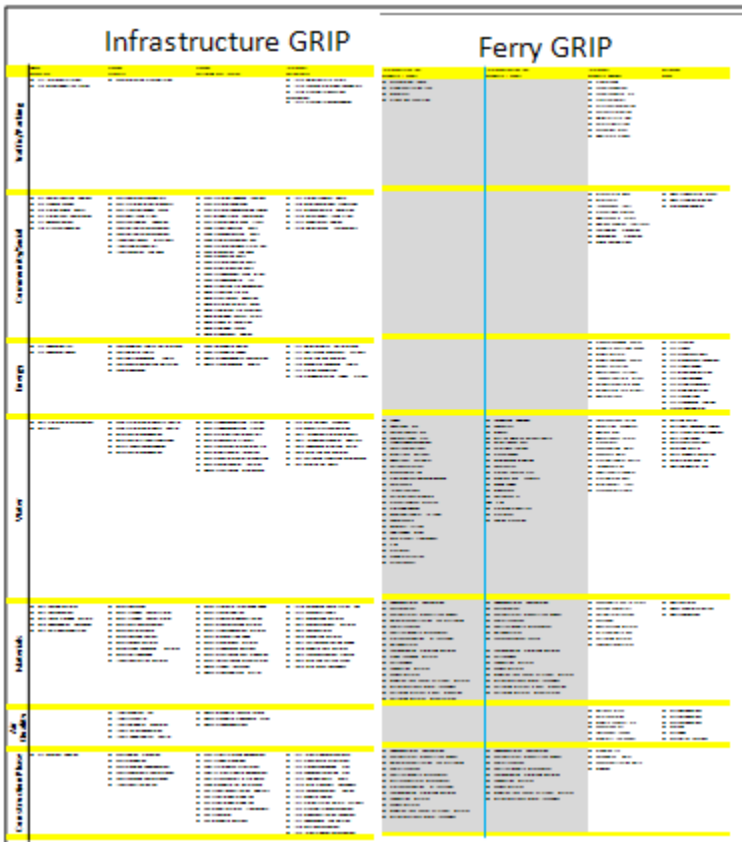

Figure 6.4. GRIP view when being cross-referenced with various sustainability rating systems

The Green Rating Integration Platform tool can also be used to detail how the recommendations from this report and the proposed WSU Ferry Guidelines might interface with the WSF SMS and the Best Management Practices (BMPs) of the SWPPP. This is done by unfolding the diagram in Appendix D.2 and focusing on the right half (SMS and Ferry GRIPs). In addition, a key for the SMS acronyms and a reference list are provided on the GRIP. Figure 6.4 overviews how the ferry guidelines and the SMS broadly interface across the main sustainability categories.

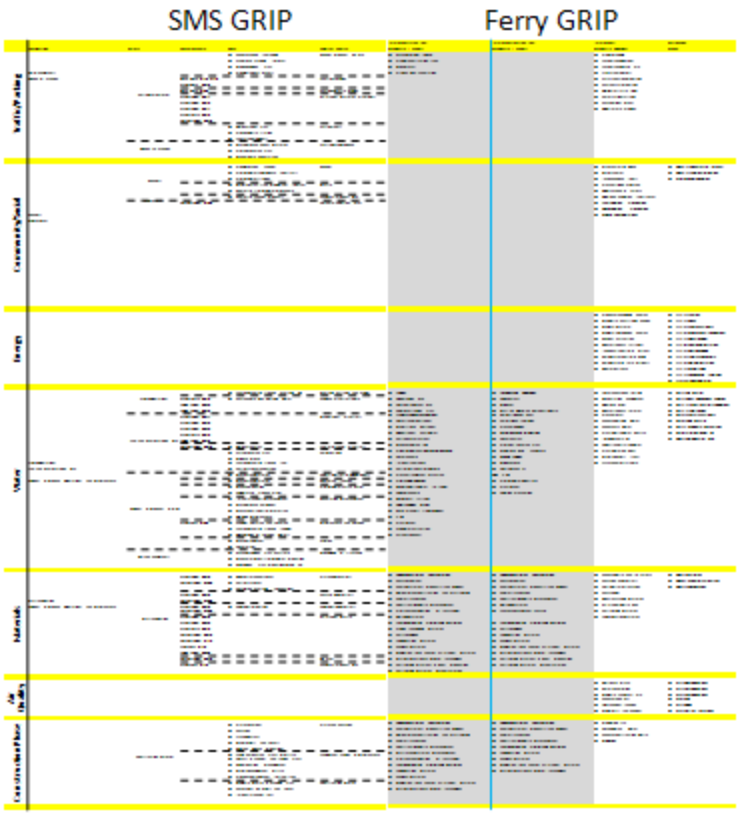

Figure 6.5. GRIP showing how this report interfaces with the SMS

It is intended that the proposed tool in the future also be detailed in areas beyond stormwater and materials affecting water quality in a manner that likewise can be cross-referenced to the other rating systems, the WSF SMS and its SWPPP as the ferry sustainability guidelines are developed further. Notably, a material recommendations section can be seen in the GRIP (Figure 6.2). This section provides details of the preferable materials and materials to avoid for selecting materials use and design. Additional recommendations for use and improvement of the tool include the development of a database to correlate various design, construction, maintenance and operational practices to the checklist items across the GRIP. This might be used to efficiently understand multiple sustainability benefits and improve program performance and integration.

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8. Appendix A

Table 8.1. Integration of Safety Management System and Best Management Practices (Courtesy WSF April 2011)

Activity	Pollutant Sources	Associated SMS Procedure	To Be Implemented Best Management Practice(s); Procedure; Retrofits
Waste Collection	Trash Compactors	**TERM ENVN 0050** Solid Waste Disposal and Recycling **SMSM ENVN 0090** Solid Waste Disposal and Recycling	◆ Trash and recycling dumpsters to be placed under cover where possible. ◆ Retrofit a cover for dumpsters at all terminals ◆ Retrofit self closing hydraulic connections for trash compactors ◆ Address in Terminal Stormwater Procedures
	Recycle Dumpsters	**TERM ENVN 0050** Solid Waste Disposal and Recycling **SMSM ENVN 0090** Solid Waste Disposal and Recycling	SMS covers this source.
	Compost Dumpsters	**TERM ENVN 0050** Solid Waste Disposal and Recycling **SMSM ENVN 0090** Solid Waste Disposal and Recycling	◆ Seattle only at this time has a compost program; anticipate other terminals will be required to compost in future; ◆ Address in Terminal Stormwater procedure or update SMSM ENVN 0090
	Hazardous Waste; Hazardous Waste Locker	**TERM ENVN 0030** Transfer of Hazardous/Potentially Hazardous Wastes **TERM ENVN 0040** Storm Drains and Scuppers **TERM EMER 0010** Emergency Response and Preparedness **SMSM ENVN 0070** Transfer of Hazardous/Potentially Hazardous Waste **SMSM ENVN 0110** Hazardous Materials Release **T** **ERM SAFE 0150** Ordering/Using Chemical Products	SMS covers this source.

		ENGR ENVN 0060 Transfer of Hazardous/Potentially Hazardous Waste	
	Oily Rags;	**SMSM ENVN 0070** Transfer of Hazardous/Potentially Hazardous Waste	SMS covers this source.
	Chemical Product Use	**TERM SAFE 0150** Ordering/Using Chemical Products	SMS covers this source.
Vendors	Vehicles		◆ Address in Terminal Stormwater procedure by prohibiting vehicles that are repeat leakers. ◆ Vendor Stormwater Compliance Contract Clauses need to be incorporated in future contracts ◆ Vendor stormwater training needs to be initiated
	Waste		◆ Address in Terminal Stormwater procedure. Contract clause that Vendors must maintain area free of items (or elevate and cover) that could contact stormwater and pollute.
	Chemical Product Use		◆ Address vendors in Stormwater procedure. ◆ Address in vendor contracts.
Ramp Operations	Hydraulic System and Cables	MPET Scheduled	◆ Need to track developments in the use of environmentally friendly hydraulic fluid lubricating oils (recent review resulted in going to a less human toxic formulation).
	Sewage Transfers Hose Leaks & Connectors	**TERM EMER 0010** Emergency Response and Preparedness **ENGR ENVN 0040** Sewage Pumping **ENGR ENVN 0050** Spill Response	◆ Investigate if inspection is adequate and whether or not procedure needs to include charging hose with potable water before pumping

Fuel and Hydrocarbon Use	Oil Container Transfers Petroleum products	**TERM ENVN 0035** Oil Container Transfer and Disposal **TERM ENVN 0070** Spill Response **TERM ENVN 0080** Portable Spill Kits **TERM EMER 0010** Emergency Response and Preparedness **ENGR ENVN 0070** Oil Container Transfer and Disposal	Covered in SMS procedures.
	Fuel Storage & Transfers 5 gallon plastic containers in paint locker	**SMSM ENVN 0070** Transfer of Hazardous/Potentially Hazardous Waste	◆ Need to designate area for fueling in terminal's Site Plan ◆ Address in Terminal Stormwater procedure
	Terminal Bulls		◆ Address in Terminal Stormwater procedure include: o Park in covered area o Place drip pad or pan beneath terminal bulls if leaking o Use environmentally friendly hydraulic fluid ◆ Retrofit Covered Parking areas at some terminals
Customer Activities	Vehicles brought on site		◆ Address in Terminal Stormwater Procedure o Vehicle shutdown required at holding lanes o Have pan or pad available if leak is noticed o Inspect holding area for leaks and mop up daily o Prohibit vehicles that are repeat leakers
.	Livestock hauling	DECK OPER 0170 & 210 Transporting Livestock TERM OPER 0030 Unique Loading and Off-Loading Situations	◆ Address in Terminal Stormwater Procedure
	Seafood Waste Hauling	DECK OPER 0200 Transporting Seafood	◆ Address in Terminal Stormwater Procedure

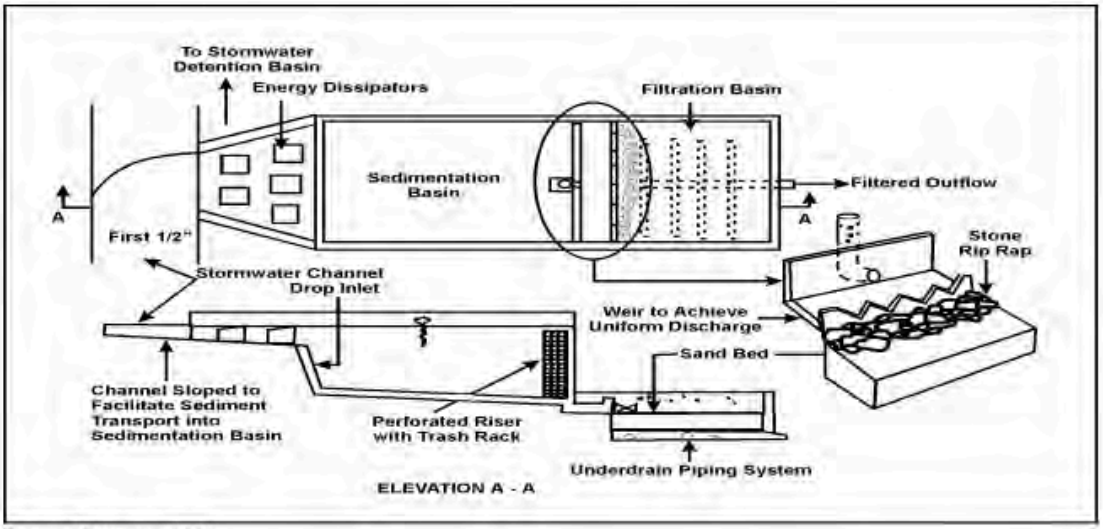
	Hazardous Materials Transport	**TERM ENVN 0015** Hazardous Material Transport by Commercial Vehicles **TERM ENVN 0020** Hazardous Material Transport on Scheduled Trips **TERM ENVN 0025** Hazardous Material Charters **TERM EMER 0010** Emergency Response and Preparedness **SMSM ENVN 0070** Transfer of Hazardous/Potentially Hazardous Waste	Covered adequately by SMS procedures
	Patrons Pets walked at terminals		◆ Address in Terminal Stormwater Procedure o Designate Pet Potty Area o Provide waste station o Educate the pet owners
Buildings & Grounds Operations and Maintenance	Roofs, Walls, Gutters & Downspouts		◆ Address in Terminal Design Manual o Use coated materials on roofs and associated conveyance systems
	Galvanized fencing and railing for perimeter and vehicle control		◆ Address in Terminal Design Manual o Use coated materials when building new or retrofitting

	Stormwater Catch Basins		◆ Address in Terminal Stormwater Procedure o Weekly inspection ◆ Retrofit by marking in yellow circle all drains that directly go into Puget Sound
	Vegetation Management	Vegetation management is not included in the integrated pest management procedure.	◆ Address bioswale management in Terminal Stormwater Procedure o Integrated Pest Management o Use approved herbicides o Mechanical control preferred o Bioswale maintenance
	Maintenance and Cleaning;	**TERM SAFE 0100** Housekeeping/Janitorial Supplies (Does not address stormwater contact of materials)	◆ Address in Terminal Stormwater Procedures o Keep supplies elevated and covered o use environmentally friendly supplies o No dumping of cleaning waters down storm sewers
.	Painting; paint locker	EHBR SAFE 0200 Painting and Surface Preparation	◆ Address in Terminal Stormwater Procedures o Use containment o Cover drains
Wildlife/Birds	Potential roosting sites	**SMSM ENVN 0100** Integrated Pest Management	Addressed in existing SMS procedures

Dirt and Sediments	Windblown from surrounding area & tracked in by vehicles		◆ Address in Terminal Stormwater Procedures o Vacuum sweep holding area at least quarterly and possibly monthly depending on terminal needs o Weekly stormwater inspection of terminal o Daily stormwater inspection of holding areas and mop up
Deicing and Sanding	Salt from compound used to deice ramp during cold spells		◆ Address in Terminal Stormwater Procedure o Use approved deicer materials o Store deicer in covered area and on pallets or in a manner that stormwater will not run onto it o When to use deicer/sand
Construction Activities	Trash and Recycling		◆ Address in Terminal Stormwater Procedure ◆ Address in standardized contract clauses re stormwater o Trash Coverings o Recycling o Laydown Areas o Use of pallets and covers o Daily and Weekly Inspections

	Equipment Fueling & Maintenance	◆ Address in Terminal Stormwater Procedure Address in standardized contract clauses re stormwater o Fuel in designated areas or offsite o Spill kits in vehicles and fueling area o Daily Inspect ion of equipment o Maintain equipment off site o Provide containment sized to hold fuel tank amount of equipment
	Construction steel , metals, and other items with potential to contaminate stormwater	◆ Address in Terminal Stormwater Procedure ◆ Address in standardized contract clauses re stormwater o Minimize time construction steel and metals are at the laydown area to daily or weekly use o Place all items on pallets and cover unless in use o Inspect at end of shift and maintain signed daily/weekly stormwater inspection log

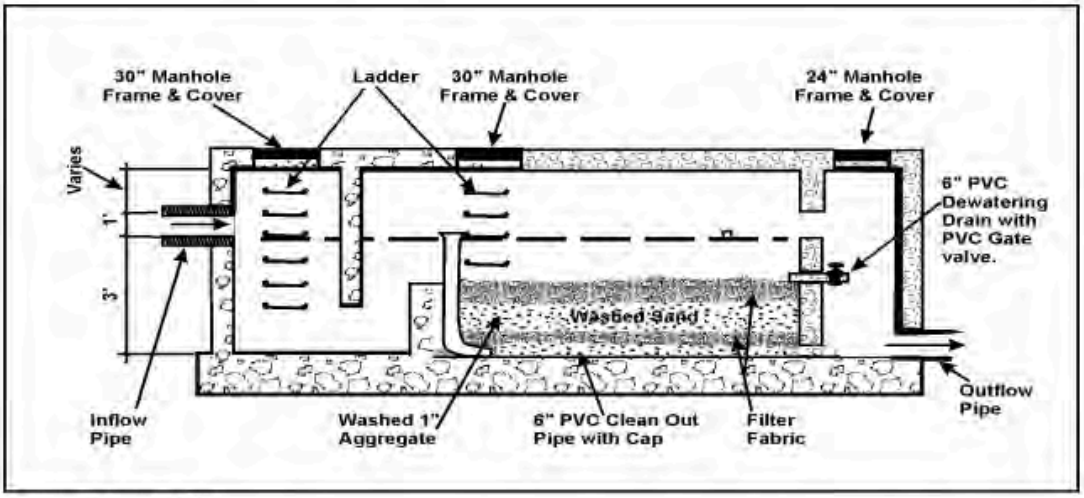
9. Appendix B



Source: Schueler, 1992.

FIGURE 1 TYPICAL AUSTIN SAND FILTER DESIGN

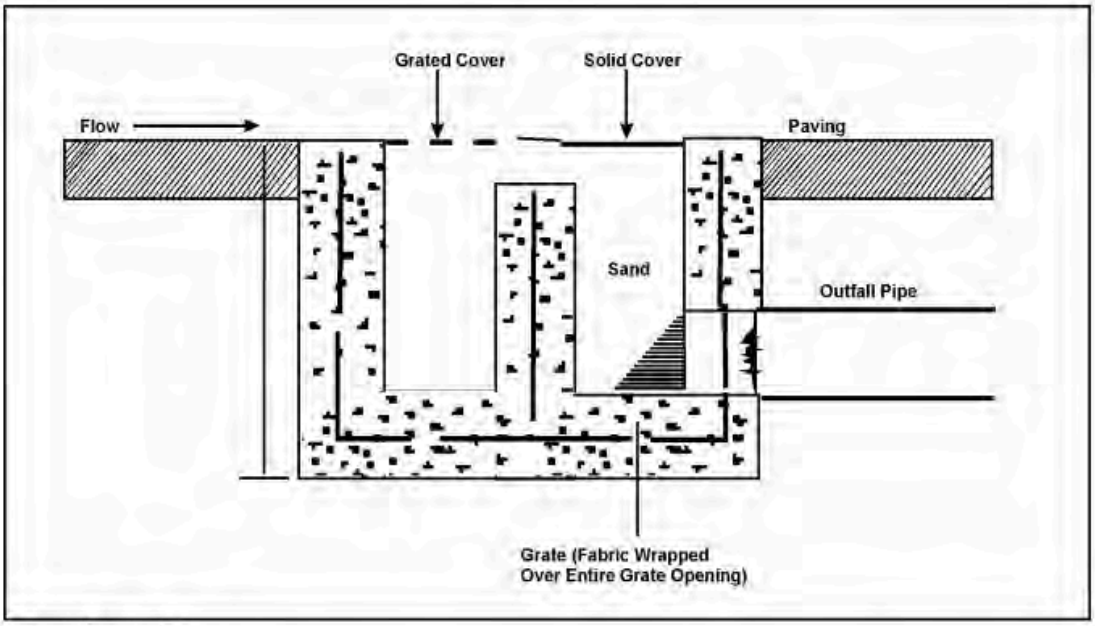
Figure 9.1 Typical Austin Sand Filter Design



Source: Troung, 1989.

FIGURE 2 TYPICAL WASHINGTON, D.C. SAND FILTER DESIGN

Figure 9.2. Typical Washington, D.C. Sand Filter Design



Source: Shaver, 1991.

FIGURE 3 TYPICAL DELAWARE SAND FILTER DESIGN

Figure 9.3. Typical Delaware Sand Filter Design

Source: EPA Stormwater Technology Fact Sheet 1999

10. Appendix C: Miscellaneous Manual Summaries

- **King County Surface Water Design Manual:** KCSWDM (King County 2009). This manual lists eight core requirements and five special requirements for projects requiring drainage review
    - Core Req. #1- Discharge at Natural Location
        - "If the 100-year peak discharge is greater than 0.5 cfs for either existing or developed conditions, or if a significant adverse impact to downhill properties or drainage systems is likely, then a conveyance system must be provided to convey the concentrated runoff across the downstream properties to an acceptable discharge point. 17 Drainage easements for this conveyance system must be secured from downstream property owners and recorded prior to engineering plan approval."
    - Core Req. #2-Offsite Analysis
        - Downstream analysis is required to analyze drainage downstream up to ¼ mile from the project site. The intent of the downstream analysis is to identify potential erosion, flooding, and water quality areas so that mitigation techniques can be implemented to prevent negative downstream impacts from project drainage. Water quality problems of concern are imbalanced or high bacteria, dissolved oxygen content, temperature, metals, phosphorous, turbidity, and pH.
    - Core Req. #3- Flow Control
        - This section sets guidelines for before and after flow requirements based on project location, the amount of impervious area, and conveyance systems. It is specific for the hydrologic characteristics of each project site and should be reviewed for design requirements specific to each project. In general it requires matching of peak flow requirements of pre-development for post-development for specified storms, mainly the 2 and 5 year return periods."Facilities **in Conservation Flow Control Areas** must mitigate (either directly or in effect) the runoff from the following target developed surfaces within the ***threshold discharge area*** for which the facility is required: ***Replaced impervious surface*** that is **not *fully dispersed*** on a ***transportation redevelopment project*** in which ***new impervious surface*** is 5,000 square feet or more and totals 50% or more of the existing impervious surface within the project limits." Flow control BMP's must be detailed and implemented per Section 5.2 of the KCSWDM. All design specification shall be according to Appendix C Section C.2.
    - Core Req. #4- Conveyance System
        - New systems- Design requirements for pipes, culverts, ditches, bridges and tightlines are outlined in this section.
        - Existing on-site conveyance systems- If there is no change in flow to existing systems they are exempt from being reviewed. For

systems that will experience a change in flow, design requirements are outlined in this section.
    - Existing off-site conveyance systems- Off-site conveyance systems do not have to be evaluated unless they are scheduled for improvements, or are foreseen/proposed to be used for the discharge directly to a major receiving water body.
    - System design and composition will preferably be constructed from vegetative lined channels instead of pipe systems. The systems must be accessible for maintenance and follow the guidelines for slope. Design requirements for outfalls are outlined in this section. Conveyance of polluted waters from non-roof sources must be lined with an approved liner or system for the protection of groundwater per Section 1.2.4.3 H.
- Core Req. #5- Erosion and Sediment Control (ESC)
    - This section covers all of the methods with the intent of stabilizing soils and activities to prevent erosion of soils and banks, and sedimentation of receiving waters.
    - Consideration must be given to the following categories for application to project sites: clearing limits, cover measures, perimeter protection, traffic area stabilization, sediment retention, surface water collection, dewatering control, dust control, and flow control.
    - ESC measures must be installed to prevent, to the extent possible, sediment transport from the project site to downstream waters. These methods must be designed and installed in accordance with Appendix D of the KCSWDM, with additional measures based on the authority of the supervisor to identify conditions as applicable to scenarios in Section 1.2.5.2 C.
    - Since NPDES Permits will be required for all ferries projects, this section is particularly important for collaboration of techniques to satisfy all discharge requirements.
- Core Req. #6- Maintenance and Operations
    - Drainage facilities must be maintained and operated in accordance with Appendix A of the KCSWDM.
- Core Req #7-Financial Guarantees and Liability
    - For construction and modification of drainage facilities, two financial guarantees are required. The first is a facilities restoration and site stabilization guarantee and the second is a drainage defect and maintenance guarantee. These guarantees are to ensure that the cost of improper or faulty drainage is covered. We believe that this is of little relevance to our project since the permits would already be obtained, and are therefore not going to cover anymore of this section in detail.
- Core Req. #8-Water Quality
    - Water quality facilities must be provided to treat runoff from pollutant generating impervious surfaces (PGIS). These facilities

must be selected from menu of treatment options in Section 1.2.8.1, and implemented in accordance with Section 1.2.8.2.

- An exemption for impervious surfaces of transportation redevelopment projects specified that the project is exempt if the new area is less than 50% of the existing impervious area and has less than 5,000 sq. ft. of PGIS that is not fully dispersed and less than 35,000 sq. ft. of pollutant generating pervious surfaces (PGPS) that are not fully dispersed.
- For soil treatment, the soil two feet or more below the infiltration device must have a cation exchange capacity greater than 5%, an organic content greater than 0.5%, and must meet one of two specifications for the protection of groundwater. The first specification is a measured infiltration rate of less than or equal to nine inches per hour except in groundwater protection areas where a measured infiltration rate of less than or equal to 2.4 inches per hour. The second specification is that the soil must be composed of less than 25% gravel by weight, with at least 75% of the soil passing through a #4 sieve with either 50% passing through a #40 sieve and 2% through a #100 sieve, or 25% passing through the #40 sieve and at least 5% passing through the #200 sieve.
- Water Quality treatment by area is broken into three area-specific requirements: Basic WQ Treatment Areas, Sensitive Lake WQ Treatment Areas, and Sphagnum Bog WQ Treatment areas. For WSF it seems that the Basic WQ Treatment Applications are the only applicable area-specific applications.
- Basic WQ Treatment Areas are areas specified by King County as areas where general levels of treatment are sufficient. Areas that generate high levels of metals in runoff may require additional measures. For areas where runoff originates from industrial or commercial areas, such as ferry terminals, methods from the Enhanced Basic WQ Treatment menu are to be used. The treatment goal for Enhanced Basic WQ Treatment methods is a 50% reduction in zinc. Zinc is used as an indicator for removal of metals dangerous to marine environments. Enhanced treatment targets metals, in addition to other contaminants. Methods include basic sized stormwater wetland, large sand filters, and series treatments that are detailed in Chapter 6 of the KCSWDM.
- Use of emerging technologies not detailed in Chapter 6 can be used on an experimental basis provided that evidence of successful removal efficiencies is provided. An experimental design adjustment has to be provided by King County. Any new technologies also have to be approved through the **Department of Ecology *TAPE program*.**

o Special Requirements #1- Other Adopted Area-Specific Requirements

        - Area specific requirements addressed in this section applicable to WSF include Critical Drainage Areas (CDA), Master Drainage Plans (MDP), Salmon Conservation Plans (SCP), and Stormwater Compliance Plans (SCP).
    - Special Requirements #2- Flood Hazard Area Declination
        - No applicability found to WSF.
    - Special Requirements #3- Flood Protection Facilities
        - No applicability found for WSF.
    - Special Requirement #4- Source Control
        - This section references the *Stormwater Pollution Prevention Manual.*
    - Special Requirements #5- Oil Control
        - -Oil controls are required for high use sites, such as those sites for WSF. The intent of the oil prevention is to reduce any visible sheen from runoff leaving the site. Additionally, the total petroleum hydrocarbons (TPH) must be below 10mg/L.

    Treatment facility options include catch basins, linear sand filters, and oil/water separators.

- **Stormwater Manual (Vol. 3): Stormwater Flow Control & Water Quality Treatment Technical Requirements Manual, City of Seattle (Seattle, 2009)** provides some minimum requirements. Ferries projects would be defined as "joint" projects since they include improvements in the right of way, as well as a parcel based design that is not single family residential. The downstream condition is a "designated receiving water" since they will drain to Puget Sound or another large body of water. These projects must comply with minimums for both parcel based developments and roadway developments. This includes minimum water quality standards as set forth in Section 2.4.5. These minimums include installing treatment facilities that remove pollutants through settling basins, biologic uptake, soil absorption, filtration, or any combination thereof. The treatment must accommodate 91 percent of the total runoff volume for the simulation based on daily runoff volume. Oil treatment is required for high use sites.

  Flow Control minimums are outlined by minimum requirements. For WSF these requirements are: Implement Green Stormwater Infrastructure detailed in Section 4.4, Wetland Protection, and Peak Flow Control which specifies a 25 year return occurrence interval cannot exceed 0.4 cubic feet per second per acre, and a 2 year recurrence interval cannot exceed 0.15 cubic feet per second per acre.

  Minimum treatment requirements coincide with other standards in that enhanced basic treatment is required for the removal of metals generated from high use sites. Additionally, oil separators and phosphorus treatments must be employed as well.

  To the largest extent possible natural drainage patterns should be maintained, with discharges at natural points. Additionally, pollution prevention during construction activities, as well as amended soils is required where feasible. Source control BMPs

are also required to be installed for specific pollutant generating activities as set forth by the Directors Rule.

Chapter 4: Flow control design is of particular interest to this project because it outlines the Green Stormwater Infrastructure BMPs. It is important to note that this manual does not consider infiltration basins, trenches, or drywells as Green Stormwater Infrastructure, even though they utilize infiltration. Examples of techniques included are permeable paving, bio retention facilities, and green roofs.

Project specific designs should follow guidance in the following chapters as applicable:

- 3: Site Planning, Site Assessment and Drainage Control Review
- 5: Water Quality Treatment Design
- 6: Hydrologic Analysis and Design

- **Stormwater Management Manual for Western Washington (Ecology 2005) Volume IV, Source Control BMPs** has several source control BMPs in Chapter 2 which are summarized as follows. Some might be applicable to ferry terminals.
    - **BMPs for Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots**
        - Vacuum or wet sweep fine dirt and skid control materials from paved roads soon after winter weather ends or when needed.
        - Use traction sand that is prewashed to avoid additional dust
        - Use windbreaks
        - Stabilize soil with vegetation
    - **BMPs for Fueling**
        - Slope fueling pad to drain
        - Design cement pad as a spill containment pad with sill or curb
        - Roof over fueling area to limit spill area to precipitation
    - **BMPs for Landscape and Vegetation Management**
        - Pest Management Plan (PMP) free of pesticides or used as last resort
        - Pesticide use plan with list of approved pesticides, using the least toxic available for the application
        - No pesticides within 100 ft. of open water including wetponds, detention ponds, etc.
        - Use pesticide alternatives
        - Mulch exposed soils
        - Till fertilizers instead of dumping or broadcasting
        - Till top soil or compost organic into soils to encourage deep roots and draught resistant plantings
        - Amend soils with compost etc. for pest control
        - 8” top soil with 8% organic material
        - Selection of turf grass for climate
        - See Volume 2 for additional measures such as plastic covering, temporary seeding, coverings etc.

    - Lawn aeration maintenance
    - Mowing at highest acceptable level to reduce stress on turf
    - Pest Management Plan
- **BMPs for Loading and Unloading of Liquid and Solid Materials**
    - Sweep areas around loading frequently to prevent debris buildup
    - Drip pans or other containment where leaks or spills are likely to occur
    - Marine loading as per Coast Guard Appendix IV-D R.5
    - Berm, slope or dike loading and unloading areas to prevent escape of spill before treatment
    - Curbs along edge of shoreline to prevent stormwater from spilling over the edge
    - Prevent pooling on loading/unloading structures
- **BMPs for Maintenance and Repair of Vehicles and Vessels**
    - Conduct all maintenance in a covered area with an impervious cover for ease of cleanup
    - Mobile equipment must be stored in a covered containment area when not in use
    - Use aqueous cleaners and non-chlorine solvents, avoid toxic liquid chemicals
- **BMPs for Maintenance of Public and Private Utility Corridors and Facilities**
    - Vegetated, gravel, or thin cover in electrical and utility covers
    - Containment of drainage
    - Consideration for environmental impact of poles and equipment (Material degradation and location in proximity to environmentally sensitive areas)
- **BMPs for Maintenance of Roadside Ditches**
    - Inspect ditches regularly to identify areas that are prone to erosion or need to be cleaned.
    - Maintain ditches by proactively cleaning or repairing sediment buildup and erosion.
    - Vegetate as much of the ditch as possible, covering at least the top of the slope, but preferably all the way up to the concrete paving.
    - After ditch cleaning occurs, be sure to remove any debris and sediment from the road surface. All leavings not contaminated by spills, or other contaminants can be separated into vegetation and soils, with the soil going back to the site and vegetation either disposed of or composted.
    - Regularly inspect and maintain culverts to ensure inlet and outlet is functioning properly so as not to cause additional stress on ditches.
    - Employ bio-swales or filter strips wherever practical, with engineered topsoil for improved vegetative cover.
- **BMPs for Maintenance of Stormwater Treatment and Drainage Systems**

- Clean treatment and drainage systems regularly to prevent sediment buildup and drain obstructions.
- Inspect and repair BMP treatment systems, catch basins, conveyances etc. regularly so issues can be easily identified.
- Perform repairs promptly including replacement of catch basin lids, rocks in spillway, and clean-out gates.
- Prevent heavy sediment discharge to ensure that stormwater capacities are not exceeded.

o **BMPs for Mobile Fueling of Vehicles and Heavy Equipment**
  - Perform all fueling in accordance with local codes, Washington State codes, coast guard specifications and fire regulations.
  - Place drip pad/pan to retain spills and drips; spill pads/drains must have a five gallon minimum capacity.
  - Maintain a spill remedy kit on site for minor spills. Kit includes non-water absorbents capable of absorbing 15 gallons of diesel, storm drain plugs or covers, non-water absorbent containment boom of at least ten feet with a 12 gallon absorbance capacity, a non metallic shovel, and two 5 gallon buckets with lids. These seem small for marine applications, but are a good start to proposing a cleanup kit.
  - Maintain and replace hoses and nozzles to prevent equipment failure.
  - Provide adequate lighting at fueling area.
  - Follow Coastguard requirements for marine transfer of petroleum products per Federal Regulations 33 CFR Parts 153, 154 and 155.

o **BMPs for Painting/Finishing/Coating of Vehicles/Boats/Buildings/ Equipment**
  - Provide training to employees for careful application of paints and finishes to minimize overspray and dripping.
  - Educate employees on preventative operations such as the use of drop cloths and proper contaminant disposal. Include proper material disposal, contaminant clean-up and spill procedures.
  - Prohibit spraying, blasting and sanding in areas where debris could be blown into the water, or on windy/stormy days.
  - Encourage maintenance procedures such as the use of filter cloths or basin inserts to prevent sediment and contaminants from entering storm systems
  - Encourage the recycling of paints, thinners, etc. when possible.
  - Establish a purchasing plan to obtain paints, sealants, etc. with recycled content. Whenever possible use water-based paints and solvents.
  - Dispose per Appendix IV-C

o **BMPs for Parking and Storage of Vehicles and Equipment**
  - If the parking lots are washed, dispose of wastewater to sanitary sewer or other approved wastewater treatment system.

        - Sweep parking lots, driveways, and storage areas regularly to prevent buildup of contaminants and debris.
        - An oil removal system or oil and water separator in the form of a catch basin, or other approved separating and treatment system, is required for high-use sites.
    - **BMPs for Roof/Building Drains at Manufacturing or Commercial Buildings**
        - Sample and analyze stormwater runoff from buildings if leaching or building emissions are potentially causing stormwater pollution.
        - If source is identified, implement necessary BMPs and source control measures through material modification, operational changes, etc.
    - **BMPs for Spills of Oil and Hazardous Substances**
        - Create, implement, and maintain an emergency Spill Control Plan.
        - Have spill kits available.
    - **BMPs for Urban Streets**
        - Perform efficient sweeping regularly, where available and appropriate, to prevent sediment and debris build-up. Vacuum sweepers are recommended. Regenerative air sweepers, or tandem sweepers, can be used for curbed streets. Regenerative and tandem sweepers only provide moderate pollutant reductions. The least effective sweepers are mechanical sweepers. They can be used on curbed streets, but will only provide minimal pollutant reduction.
        - Sweep at frequencies, and technique, deemed economical optimal for the balance of pollutant reduction to maintenance effort.
        - Do not wash streets into storm drains.
    - **BMPs for Washing and Steam Cleaning Vehicles/Equipment/ Building Structures**
        - Cover and/or contain cleaning and washing activities to prevent drainage of untreated contaminants to stormwater systems. Ideally cleaning would occur inside of a building structure with appropriate sloped impervious floor with a spill curb directed to an approved drainage system.
        - Consider recycling wastewater.
        - Use phosphate-free cleaning agents where possible.

- **Stormwater Pollutants and Their Adverse Impact (Appendix IV-B)** is contained in the appendix and lists the primary pollutants. "The stormwater pollutants of most concern are total suspended solids (TSS), oil and grease, nutrients, pesticides, other organics, pathogens, biochemical oxygen demand (BOD), heavy metals, and salts (chlorides) (US EPA 1995, Field and Pitt 1997, Strecker et al. 1997)"-(Ecology 2005)
    - **TSS**
    - **Oil and Grease**
    - **Nutrients**

- **BOD**
- **Toxic Organics**
- **Heavy Metals**
- **pH**
- **Bacteria and Viruses**

- **Stormwater Management Manual for Western Washington: Volume V, Runoff Treatment BMPs** is a vast resource for treatment methods. Chapter 2, Treatment Facility Selection Processes has a Table 2.1-Suggested Stormwater Treatment Methods for New Development and Redevelopment from which we can deduce that the terminals are going to be in the **high use parking/driveway** category. Associated pollutants of concern are high levels of oil and grease, TSS, Cu, Zn, and PAHs. It is required to have enhanced treatment to treat these at any port that is considered to be a commercial/industrial site, which discharge directly to a water or conveyance systems that are fish bearing (As required at the ferry repair facility on Bainbridge Island). For enhanced treatment an oil and water separator or catch basin insert can be used with a biofilter, wetpond, or wet vault and a sand filter.

  Table 2.2- Ability of Treatment Facilities to Remove Key Pollutants, identifies the removal effectiveness of treatment facilities to remove targeted pollutants which can assist in the selection of methods where pollutant loads may differ. Table 2.3-Screening Treatment Facilities Based on Soil Type, reminds us that it is important to remember that not all solutions are appropriate for all sites. Soil characteristics limit many of the available solutions. It further summarizes appropriateness of infiltration, wetpond, or biofiltration by soil type. Treatment technologies which rely on soil characteristics are usually only appropriate for upland applications.

  Chapter 4 of this volume provides the General Requirements for Stormwater Facilities. Table 4.1-Treatment Facility Placement in Relation to Detention, illustrates the order in which treatment facilities must be placed to ensure proper pollutant removal and stormwater treatment. Table 4.5-Maintenance Standards for Drainage Facilities, outlines regular maintenance required for each element of the drainage component of treatment facilities.

  Chapter 5 covers On-site Stormwater Management and the best management practices (BMPs) included in this section are preserving natural vegetation and increasing site permeability. Although applicable, they are covered in other reports (PSAT 2005) and are mainly pertinent only to upland facilities.

  Chapter 6 covers pretreatment which is required for protection of systems involving sand or bio filters, or where the basic system may become damaged by non-targeted pollutants. Presettling basins are the main focus.

  Chapter 7, Infiltration and Bio-infiltration Treatment Facilities, covers more traditional BMPs such as for trenches and basins and refers to Volume 3. It also covers bio infiltration swale BMPs.

Chapter 8, Sand Filtration Treatment Facilities, provides basic sand filter layouts and technologies. Some specific types are discussed in detail. They are sand filter vaults and linear sand filters. Sand filters are cited as good for both new construction and retrofits.

Chapter 9, Biofiltration Treatment Facilities, covers the following: basic biofiltration swales, wet biofiltration swales, continuous inflow biofiltration swales, basic filter strips and compost amended strips, and narrow area filter strips.

Chapter 10, Wetpool Facilities, covers wet ponds (both basic and large), wetvaults, stormwater wetlands, combined detention and wetpool facilities and emergent wetland plant species recommended for wetponds. Most of these would not be applicable to ferry terminal facilities due to the small land areas available.

Chapter 11, Oil and Water Separators, covers practices which are likely to be most prevalent for the WSF trestles and upland paved areas. These include the American Petroleum Institute (baffle) and Coalescing Plate (CP) type separators.

Chapter 12 covers Emerging Technologies such as media filters, amended sand filters, catch basin inserts, manufactured storm drain structures and high efficiency street sweepers. Many of these have been recommended in the AKART study and will most likely be included in the list of preferred options for stormwater treatment on the trestles.

- **Highway Runoff Manual (HRM), Washington State Department of Transportation (WSDOT 2008).** The HRM is referenced in the WSF SMS and is considered to be a good resource for transportation facilities, particularly landside. Future plans include updating the HRM to be more inclusive of LID practices.

- **Hydraulics Manual, Washington State Department of Transportation** (WSDOT 2010a) provides guidance on hydraulics calculations used for the design of WSDOT facilities.

- **Puget Sound LID Manual** (PSAT 2005) is a well referenced guidance on the principles and techniques of low impact development BMPs. It is currently under revision.

- **Prince George County LID Manual** (Prince George 1999) is the original flagship manual on LID and is the basis for many of the other manuals since developed on these practices. Since its release in 1999, many of the technologies have evolved further.

11. Appendix D Green Rating Integration Platform (GRIP)

Section D.1: WSU Phase 1 Report

Landside:

1. Traffic and Parking
    - Vacuum or wet sweep fine dirt and skid control materials from paved roads
    - Use traction sand that is prewashed to avoid additional dust
    - Use windbreaks
    - Stabilize soil with vegetation
2. Integration in the Community
3. Energy Management
4. Water Management
    - ☐ **Fueling**
        - Slope fueling pad to drain
        - Design cement pad as a spill containment pad with sill or curb
        - Roof over fueling area to limit spill area to precipitation
    - ☐ **Landscape and Vegetation Management**
        - Pest Management Plan (PMP) free of pesticides or used as last resort
        - Use less toxic pesticides
        - No pesticides within 100 ft. of open water
        - Use pesticide alternatives
        - Mulch exposed soils
    - ☐ **Maintenance of Stormwater Treatment and Drainage Systems**
        - Clean treatment and drainage systems regularly
        - Inspect and repair BMP treatment systems regularly
        - Perform repairs promptly
        - Prevent heavy sediment discharge
    - ☐ **Parking and Storage of Vehicles and Equipment**
        - If the parking lots are washed, dispose of wastewater to sanitary sewer.
        - Sweep parking lots, driveways, and storage areas regularly
        - An oil removal system or oil and water separator in the form of a catch basin
    - ☐ **Roof/Building Drains at Manufacturing or Commercial Buildings**
        - Sample and analyze stormwater runoff from buildings
    - ☐ **LIDs**
        - Pervious Pavement
        - Bio-retention Ponds/Swales
        - Constructed stormwater wetland
        - Buffer strips
        - Dispersion
        - Vegetated roofs

        - Rainwater harvesting
        - Reverse slope sidewalks/path disconnect
        - Minimal excavation foundations
5. Materials Management
    - ☐ **Apply material suggestion from green designs**
        - Minimize harmful compounds
        - Recycle content
        - Biobased/rapidly renewable material
        - Environmental preferable/certified products
        - Regional material
    - ☐ Use durable materials
        - Paint galvanized materials
        - Engineered wood decking
    - ☐ Design for deconstruction
6. Air Quality
7. Construction Phase
    - ☐ **Reduce on-site construction process**
        - Use precast concrete
        - Reused building materials
        - Use manufactured materials
        - Reduce construction wastes
    - ☐ **Use low impact materials**
        - Use bio-based materials
        - Use solvent-free materials
        - Use concrete for pavement
    - ☐ **Controlling environmental impacts**
        - Reduce noise by cover
    - ☐ **Designed for deconstruction**

Marine side:

1. Traffic and Parking
2. Integration in the Community
3. Energy Management
4. Water Management
    - ☐ **Loading and Unloading of Liquid and Solid Materials**
        - Sweep areas around loading frequently to prevent debris buildup
        - Drip pans or other containment where leaks or spills are likely to occur
        - Marine loading as per Coast Guard Appendix IV-D R.5
        - Berm, slope or dike loading and unloading areas to prevent escape of spill

        - Curbs along edge of shoreline to prevent stormwater from spilling over the edge
        - Prevent pooling on loading/unloading structures
    - ☐ **Maintenance and Repair of Vehicles and Vessels**
        - Conduct maintenance in a covered area with an impervious cover
        - Store mobile equipment in a covered containment area when not in use
        - Use aqueous cleaners and non-chlorine solvents, avoid toxic liquid chemicals
    - ☐ **Mobile Fueling of Vehicles and Heavy Equipment**
        - Place drip pad/pan to retain spills and drips
        - Maintain a spill remedy kit on site for minor spills.
    - ☐ **LIDs**
        - Stormwater Neutrality (Roofed/disconnecting)
        - Treatment
        - Pollution Prevention
5. Materials Management
    - ☐ **Use durable materials**
        - Painted/coated galvanized steel
        - Steel/composite pile
    - ☐ **Apply material suggested from green designs**
        - Minimize harmful compounds
        - Recycle content
        - Biobased/rapidly renewable material
        - Environmental preferable/certified products
        - Regional material
6. Air Quality
7. Construction Phase
    - ☐ **Reduce on-site construction process**
        - Use precast concrete
        - Reused building/materials
        - Use manufactured materials
    - ☐ **Controlling environmental impacts**
        - Reduce piling noise by bubble curtain
        - Use bio-based hydraulic fluid/lubricant

Section D.2: GRIP

This page is a placeholder for the 22x34 GRIP

Infrastructure GRIP

	Upland GreenLITES	Land Side LEED retail	Land Side Sustainable Sites Initiative	Intermodal Port Authority
Traffic/Parking	☐ **E-1: Improve Traffic Flow** ☐ **E-4:Bicycle/Pedestrian Facilities**	☐ **SSc4-Alternative Transportation**		☐ **IS-17: Optimize Traffic Safety** ☐ **IS-19:Enhance Intermodal Connectivity** ☐ **IS-20:Transportation System Management** ☐ **IS-21:Transportation Technologies**
Community/Social	☐ **S-2: Context Sensitive Solutions** ☐ **S-3: Land Use Planning** ☐ **S-4: Protect Wildlife Habitat** ☐ **S-5: Protect Plant Communities** ☐ **E-5: Noise Abatement** ☐ **E-6: Stray Light Reduction**	☐ **SSc2-Community Connectivity** ☐ **SSc5.1-Protect or Restore Habitat** ☐ **SSc5.2-Maximize Open Space** ☐ **SSc7-Heat Island Effect** ☐ **SSc8-Light Pollution Reduction** ☐ **EAp3-Refrigerant Management** ☐ **EAc4-Refrigerant Management** ☐ **IEQc6-Controllability of Systems** ☐ **IEQc7-Thermal Comfort** ☐ **IEQc8-Daylighting and Views**	☐ **SSp1.2-Protect floodplain functions** ☐ **SSp1.3-Preserve wetlands** ☐ **SSp1.4-Preserve endangered species** ☐ **SSc1.6-Select sites in communities** ☐ **SSc1.7-Accessible to public transit** ☐ **SVp4.1-Control invasive plants** ☐ **SVp4.2-Use non-invasive plants** ☐ **SVp4.3-Soil management plan** ☐ **SVc4.5-Preserve special status veg.** ☐ **SVc4.6-Daylighting and Views** ☐ **SVc4.7-Use native plants** ☐ **SVc4.8-Preserve native plants** ☐ **SVc4.9-Restore native plants** ☐ **SVc4.12-Reduce heat island effect** ☐ **SVc4.13-Reduce wildfire risk** ☐ **HHc6.1-Equitable site development** ☐ **HHc6.2-Equitable site use** ☐ **HHc6.3-Sustainability education** ☐ **HHc6.4-Protect historical places** ☐ **HHc6.5-Optimum site accessibility** ☐ **HHc6.6-Outdoor physical activity** ☐ **HHc6.7-Views of vegetation** ☐ **HHc6.8-Outdoor spaces** ☐ **HHc6.9-Reduce light pollution**	☐ **IS-5: Protect Ecological Health** ☐ **IS-6:Maintain Absorbent Landscapes** ☐ **IS-8:Utilize Appropriate Vegetation** ☐ **IS-14: Mitigate Heat Island Effect** ☐ **IS-15:Minimize Light Pollution** ☐ **IS-16: Optimize Public Environments**
Energy	☐ **E-2: Reduce Electrical** ☐ **E-3: Reduce Petroleum**	☐ **EAp2-Minimum Energy Performance** ☐ **EAc1-Optimize Energy** ☐ **EAc2-On-site Renewable Energy** ☐ **EAc5-Measurement and Verification** ☐ **EAc6-Green Power**	☐ **SVc4.10-Minimize heating** ☐ **SVc4.11-Minimize cooling** ☐ **OMc8.4-Reduce energy consumption** ☐ **OMc8.5-Use renewable energy**	☐ **IE-1: Optimize Energy Performance** ☐ **IE-2:Electrical and Mechanical Systems** ☐ **IE-3: Utilize End Use Metering** ☐ **IE-4: Use On-Site Renewable Energy** ☐ **IE-5: Protect Ozone Layer** ☐ **IE-6: Provide Alternative Fueling Stations**
Water	☐ **W-1: Stormwater Management** ☐ **W-2:BMPSs**	☐ **SSc6.1-Stormwater Quantity Control** ☐ **SSC6.2-Stormwater Quality Control** ☐ **WEp1-Water Use Reduction** ☐ **WEc1-Water Efficient Landscaping** ☐ **WEc2-Innovative Technologies** ☐ **WEc3-Water Use Reduction**	☐ **Wp3.1-Reduce landscape irrigation** ☐ **Wc3.2-Reduce landscape irrigation** ☐ **Wc3.3-Protect/Restore buffers** ☐ **Wc3.4-Rehabilitate streams** ☐ **Wc3.5-Manage stormwater on site** ☐ **Wc3.6-On-site water resources** ☐ **Wc3.7-Use stormwater for landscape** ☐ **Wc3.8-Maintain water features** ☐ **OMp8.1-Sustainable maintenance**	☐ **IS-7: Utilize Pervious Pavement** ☐ **IS-9: Use Turfgrass Appropriately** ☐ **IW-1: Implement Stormwater BMPs** ☐ **IW-2: Implement Rainwater Neutrality** ☐ **IW-3: Reduce Use of Potable Water** ☐ **IW-4: Utilize End Use Metering** ☐ **IO-1:Sustainable Landscape Maintenance** ☐ **IO-2: Maintain Soil Quality**
Materials	☐ **M-1: Reuse of Materials** ☐ **M-2: Recycle content** ☐ **M-3: Locally Provided Material** ☐ **M-4: Bioengineering Techniques** ☐ **M-5: Hazardous Minimization**	☐ **MRp1-Recyclables** ☐ **MRc1.1-Building Reuse-Exterior** ☐ **MRc1.2-Building Reuse-Interior** ☐ **MRc2-Waste Management** ☐ **MRc3-Materials Reuse** ☐ **MRc4-Recycled Content** ☐ **MRc5-Regional Materials** ☐ **MRc6-Rapidly Renewable Materials** ☐ **MRc7-Certified Wood** ☐ **IEQc4-Low-Emitting Materials**	☐ **MSp5.1-Eliminate threatened wood** ☐ **MSc5.2-Maintain often** ☐ **MSc5.3-Design for deconstruction** ☐ **MSc5.4-Reuse salvaged materials** ☐ **MSc5.5-Recycled content materials** ☐ **MSc5.6-Use certified wood** ☐ **MSc5.7-Use regional materials** ☐ **MSc5.8-Reduce VOC emissions** ☐ **MSc5.9-Sustainable plant production** ☐ **MSc5.10-Sustainable manufacturing** ☐ **OMp8.2-Collect recyclables** ☐ **OMc8.3-Recycle organic matter**	☐ **IS-10: Amend and Reuse Existing Soils** ☐ **IS-11: Balance Earthwork** ☐ **IM-1: Use Recycled Materials** ☐ **IM-2: Use Local/Regional Materials** ☐ **IM-3: Reuse Materials** ☐ **IM-4: Use Durable Materials** ☐ **IM-5:Sustainably Harvested Wood** ☐ **IM-6: Minimize Toxic Materials** ☐ **IM-7: Enhance Pavement Lifecycle** ☐ **IM-8: Utilize Thin Surface Paving** ☐ **IM-9: Utilize WMA Technology**
Air Quality		☐ **IEQp1-Minimum IAQ** ☐ **IEQp2-ETS control** ☐ **IEQc1-Outdoor Air Monitoring** ☐ **IEQc2-Increased Ventilation** ☐ **IEQc5-Indoor Pollutant Control**	☐ **OMc8.6-Minimize tobacco smoke** ☐ **OMc8.7-Minimize greenhouse gases** ☐ **OMc8.8-Reduce emissions**	
Construction Phase	☐ **S-1: Alignment Selection**	☐ **SSp1-Pollution Prevention** ☐ **SSc1-Site Selection** ☐ **SSc3-Brownfield Redevelopment** ☐ **EAp1-Fundamental Commissioning** ☐ **EAc3-Enhanced Commissioning** ☐ **IEQc3-Construction IAQ**	☐ **SSp1.1-Limit farmland development** ☐ **SSc1.5-Select brownfields** ☐ **PDp2.1-Pre-design assessment** ☐ **PDp2.2-Integrated site development** ☐ **PDc2.3-Engage users in site design** ☐ **SVp4.4-Minimize soil disturbance** ☐ **Cp7.1-Control construction pollutants** ☐ **Cp7.2-Restore disturbed soils** ☐ **Cc7.3-Restore disturbed soils** ☐ **Cp7.4-Divert materials from disposal** ☐ **Cp7.5-Reuse soil** ☐ **Cp7.6-Minimize emissions**	☐ **IS-1:Integrated Team Approach** ☐ **IS-2: Prepare a Site Assessment** ☐ **IS-3:Previously Developed Sites** ☐ **IS-4:Known Contaminated Sites** ☐ **IS-12: Coordinate Utility Work** ☐ **IS-13: Utilize Trenchless Technology** ☐ **IS-18:Roadway Alignment Section** ☐ **IC-1: Minimize Pollution** ☐ **IC-2: Protect Existing Natural Systems** ☐ **IC-3:Transportation Management** ☐ **IC-4:Green Construction Equipment** ☐ **IC-5: Reduce Noise and Vibration** ☐ **IC-6:Waste Management** ☐ **IC-7:Integrated Pest Management**

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- Environmental management plan for port and harbor projects-Gupta, 2005
- The Engineering Guide to LEED-New Construction-Haselbach, 2010
- LID Manual for Puget Sound
- Development of Sustainability Guidelines for Infrastructure and their Applications to Passenger Ferry Terminals-Grad Thesis by Ines de Sainte Marie d'Agneaux, 2009
- LEED retail guidelines-new construction
- SWPP Table 2 Integration SMS and BMPs Final for SWPPP-Shelia
- WSF GreenLITES Project Design Certification Program
- The Port Authority for NY & NJ

Material Recommendations

Washington State Ferry Design Guideline - Materials

Materials to Avoid

Category	Contaminants	Relative impact	Application
Heavy Metals	Cadmium compounds[1, 2, 17]	Human health, aquatic	Roofing, Solder, Paints, Metal alloys, Battery, Electrical products, Polymer stabilizers,
	Lead compounds[2, 8, 18]	Human health, environment	
	Mercury compounds[2, 9, 19]	Human health, environment	
	Arsenic[12, 16, 20, 21]	Human health, aquatic	Treated wood
	Zinc[13, 22]	Human health, aquatic	Galvanized steel
Chlorinated Polymers	Chlorosulfonated / Chlorinated polyethylene[2] Polyvinyl chloride[2,11] (Possible contain dioxin, phthalates, heavy metals)	Human health, environment	Durable polymer products for outdoor purposes
	Chloroprene (Neoprene)[3]		
Volatile Organic Compounds	Formaldehyde and Acetaldehyde[2,6]	Human health	Formaldehyde adhesives for wood-based products
	Isocyanates[2,6]	Human health	Carpet, Polyurethane foam
	Aromatic solvents[2,6]	Human health, environment	Paints, Adhesives, Sealants
Ozone Depleting Compounds	Chlorofluorocarbons (CFCs)[7]	Environment	Refrigerant
	Hydro-chlorofluorocarbon (HCFCs)[7]		
Others	Halogenated Flame Retardants[2,7]	Human health, environment	Kitchen appliance, Indoor building products
	Creosote[2,13]	Human health, aquatic	Wood preservatives, Asphalt
	Pentachlorophenol[12]	Human health, aquatic	
	Phthalates[2,10]	Human health	Waterproofing, Plasticizers in plastic products
	Polycyclic aromatic hydrocarbons (PAHs)[14]	Human health	Asphalt
	Petroleum-based fluid[15]	Aquatic	Oil, Hydraulic fluid

Preferable Materials

Category	Materials	Explanation	Application
Natural Materials	Certified wood[23]	Certified by third party, i.e. Forest Stewardship Council (FSC), Programme for Endorsement of Forest Certification schemes (PEFC), Sustainable Forestry Initiative (SFI), American Tree Farm System (ATFS), Canadian Standards Association's Sustainable Forest Management Standard	Indoor furniture, Interior Construction materials
	Treated wood	Use environmental preferable preservatives, e.g. Borates (boric acids and borax), Ammoniacal Copper Citrate (ACC), Alkaline Copper Quaternary Ammonium (ACQ). Copper Azole (CBA).	Piling, Decking, Gangway, Exterior construction materials, Landscaping
	Rapidly renewable materials[23]	Made from plants within shorter than 10 years harvesting cycle	
Concrete	Concrete[26]	Including concrete, reinforced concrete	Piling, Pavement
	Composite concrete	Concrete filled steel pipe, durable materials wrapped concrete (e.g. fiberglass composites and environmental preferred polymer)	Piling, Seawall
Metals	Painted (coated) steel	Painted or Coated galvanized steel to prevent zinc release to storm water	Piling, Decking, Gangway, Siding
	Aluminum[26]		Decking, Gangway, Siding, Guardrail
Composites	Fiber reinforced composites[24]	Including short or continuous carbon or glass fiber reinforced composites	Decking, Gangway, Siding, Guardrail
	Wood-polymer composites[24]	Environmental preferred polymer reinforced by wood fiber/flour (or any other agro-fiber) or UHMWPE laminated with lumber	Outdoor furniture, Decking, Bulkheads, Seawall, Exterior shielding, Siding
Polymers[25]	Polypropylene (PP)		Decking, Gangway, Siding, Bulkhead, Seawall,
	Polyethylene (PE)	Including Low-density polyethylene (LDPE), Linear Low-density polyethylene (LLDPE), High-density polyethylene (HDPE), Cross-linked polyethylene (PEX), Ultra-high molecular weight polyethylene (UHMWPE), etc.	Decking, Gangway, Siding, Bulkhead, Seawall, Piping
	Bio-based polymers	Needs to be sustainably grown and renewable from natural resources	

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5. http://www.epa.gov/ttnatw01/hlthef/chloropr.html
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20. http://www.epa.gov/ttnatw01/hlthef/arsenic.html
21. http://www.greenfacts.org/en/arsenic/1-2/arsenic-6.htm
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25. Rossi, M. and T. Lent. 2006 "Creating Safe and Healthy Spaces: Selecting Materials that Support Healing" in Designing the 21st Century Hospital, Center for Health Design and Health Care Without Harm. P.66
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SMS GRIP

	SMS location	Activity	SMS Procedure	BMP	Pollutant Source
Traffic/Parking	Dirt & Sediments Deicing & Sanding	Customer Activities	DECK OPER 0170 &210 TERM OPER 0030	☐ Require vehicle shutdown ☐ Pan or pad available for leaks ☐ Mop up holding area ☐ Prohibit repeat leakers	Vehicles Brought on Site
			DECK OPER 0200		Livestock Hauling
			TERM ENVN 0015 TERM ENVN 0020 TERM ENVN 0025 TERM EMER 0010 SMSM ENVN 0070		Seafood Waste Hauling Hazardous Materials Transport
				☐ Designate pet area ☐ Provide waste station ☐ Educate pet owners	Patrons Pets
		Deicing an Sanding		☐ Use approved deicer materials ☐ Store in covered area ☐ When to use deicer/sand	Salt from compound
Community/Social	Vendors Wildlife/Birds	Vendors		☐ Prohibit leaking vehicles ☐ Stormwater compliance contracts ☐ Stormwater training	Vehicles
				☐ Maintain area free of pollutant sources ☐ Address in stormwater procedure ☐ Address in vendor products	Waste Chemical Product Use
		Wildlife/Birds	SMSM ENVN 0100		Potential Roosting Sites
Energy					
Water	Ramp Operations Fuel and Hydrocarbon Use Buildings & Ground Operations and Maintenance	Ramp Operations		☐ Environmentally friendly hydraulic oils ☐ Charge hose with potable water	Hydraulic System and Cables Sewage Transfers Hose
		Fuel and Hydrocarbon Use	TERM EMER 0010 ENGR ENVN 0040 ENGR ENVN 0050		
			TERM ENVN 0035 TERM ENVN 0070 TERM ENVN 0080 TERM EMER 0010 ENGR ENVN 0070 SMSM ENVN 0070		Oil Container Transfers
				☐ Designated area ☐ Park in covered area ☐ Drip pan or pad ☐ Environmentally friendly fuel ☐ Retrofit covered parking	Fuel Storage & Transfers Terminal Bulls
				☐ Use coated materials ☐ Use coated materials	Roofs, Gutter, & Downspouts Galvanized fencing
		Buildings & Grounds O & M		☐ Weekly inspection ☐ Yellow circle around drains ☐ Integrated pest management ☐ Use approved herbicides ☐ Mechanical control preferred ☐ Biowaie maintenance	Stormwater Catch Basins Vegetation Management
			TERM SAFE 0100	☐ Supplies elevated and covered ☐ Environmentally friendly supplies ☐ No dumping of cleaning waters	Maintenance and Cleaning
				☐ Use containment ☐ Cover drains	Painting
		Dirt and Sediments		☐ Vacuum holding area quarterly ☐ Weekly terminal stormwater inspection ☐ Daily holding area inspection/mop up	Windblown & tracked in
Materials	Waste Collection Buildings & Ground Operations and Maintenance	Waste Collection	TERM ENVN 0050 SMSM ENVN 0900	☐ Dumpster under cover ☐ Retrofit a cover ☐ Self closing hydraulic connections	Trash Compactors
			TERM ENVN 0050 SMSM ENVN 0900		Recycle Dumpsters
			TERM ENVN 0050 SMSM ENVN 0900	☐ Compost program	Compost Dumpsters
			TERM ENVN 0030 TERM ENVN 0040 TERM EMER 0010 SMSM ENVN 0070 SMSM ENVN 0110 ERM SAFE 0150 ENGR ENVN 0060		Hazardous Waste
			SMSM ENVN 0070 TERM SAFE 0150		Oily Rags Chemical Product Use
Air Quality					
Construction Phase		Construction Activities		☐ Trash coverings ☐ Recycling ☐ Laydown areas ☐ Use of pallets and covers ☐ Daily and weekly inspections	Trash and Recycling
				☐ Fuel in designated areas or offsite ☐ Spill kits in vehicles and fueling areas ☐ Daily inspection of equipment ☐ Maintain equipment offsite ☐ Provide containment for fuel tank	Equipment Fueling & Maintenance
				☐ Minimize metals in laydown area ☐ Place items on pallets and cover ☐ Inspect at end of shift	Construction metals

Ferry GRIP

	Intermodal (Land side) WSU Phase 1 Report	Intermodal (Marine side) WSU Phase 1 Report	Intermodal WSU Ferry Guidelines	Marine Side MVeP
Traffic/Parking	☐ Vacuum or wet sweep ☐ Prewashed traction sand ☐ Windbreaks ☐ Stabilize with vegetation		☐ Promote HOV ☐ Encourage walk-ons ☐ Encourage bicycle use ☐ Facilitate drop-off ☐ Park-and-ride program ☐ Shared-car program ☐ Optimize traffic flow ☐ Reservation system ☐ Peak periods prices ☐ Allow future growth	
Community/Social			☐ Architecturally blend ☐ Visitor center ☐ Include guided tours ☐ Prevent flood damage ☐ Allow change in activity ☐ No ozone depleting substances ☐ **Light Pollution Prevention** ☐ **Noise Pollution Prevention** ☐ **Wildlife Considerations**	☐ **GM3.1-Aquatic Life Impact** ☐ **GM3.2-Shore Protection** ☐ **AE6-Ozone-Depleting**
Energy			☐ Produce renewable energy ☐ Use waste heat from engine ☐ Use local material ☐ Minimal embodied energy ☐ Daylight harvesting ☐ High-efficiency systems ☐ Individual control in offices ☐ Automatic control in public ☐ Automatically turn off lights ☐ High reflectance	☐ **EE1.1-Lighting** ☐ **EE1.2-HVAC** ☐ **EE1.3-Pump Systems** ☐ **EE1.4-Mechanical Equipment** ☐ **EE1.5-Hull/Propeller** ☐ **EE1.6-Route Optimization** ☐ **EE1.7-Vessel Speed** ☐ **EE1.8-Energy Recovery** ☐ **EE1.9-Hull Optimization** ☐ **EE2.1-Other Fuels** ☐ **EE2.2-Renewable Energies** ☐ **EE3-Carbon Footprint**
Water	☐ **Fueling** ☐ Slope fueling pad ☐ Spill containment pad ☐ Roof over fueling area ☐ **Landscape Management** ☐ PMP free of pesticides ☐ Use less toxic pesticides ☐ No pesticides near water ☐ Pesticide alternatives ☐ Mulch exposed soils ☐ **Treatment System Maintenance** ☐ Clean regularly ☐ Inspect and repair ☐ Perform repairs promptly ☐ Prevent sediment discharge ☐ **Storage of Vehicles** ☐ Dispose wastewater to sewer ☐ Sweep regularly ☐ Oil removal system ☐ **Roof/Building Drains** ☐ Analyze runoff from buildings ☐ **LIDs** ☐ Treatment ☐ Rainwater harvesting ☐ Path disconnect	☐ **Loading and Unloading** ☐ Sweep areas ☐ Drip pans ☐ Marine Loading per Coast Guard ☐ Berm, slope or dikes ☐ Curbs along shoreline ☐ Prevent pooling ☐ **Maintenance of Vessels** ☐ Covered area ☐ Store in a covered area ☐ Avoid toxic liquid chemicals ☐ **Mobile Fueling** ☐ Drip pad/pan ☐ Spill remedy kit ☐ **LIDs** ☐ Stormwater Neutrality ☐ Treatment ☐ Pollution Prevention	☐ Emergency plan for spills ☐ Oil separation equipment ☐ Non toxic paint ☐ High-efficiency fixtures ☐ Prevent leaks ☐ Reduce potable water ☐ Reduce city water ☐ Treat wastewater on-site ☐ Implement LIDs ☐ Collect runoff/rainwater ☐ Treat water on boat ☐ Maintain ballast tanks ☐ Exchanges off-shore	☐ **WE1-Oily Water** ☐ **WE2-Non-Indigenous Species** ☐ **WE2.1-Ballast Water/Sediment** ☐ **WE2.2-Hull Fouling** ☐ **WE3-Sanitary Systems** ☐ **WE4-Solid Waste** ☐ **WE5-Incidental Discharges** ☐ **WE6-Protection of Oil** ☐ **GM2-Hotel Water Use**
Materials	☐ **Reduce Materials Consumption** ☐ Recycle content ☐ Reuse materials, products, and buildings ☐ Design for deconstruction and disassembly ☐ Thin surface paving ☐ Construction waste management ☐ Storage and collection of recyclables ☐ Durable materials ☐ **Environmentally Preferable Materials** ☐ Rapidly renewable materials ☐ Certified wood ☐ Low emission materials ☐ Regional materials ☐ Minimizing toxic and/or hazardous materials ☐ Warm-mix asphalt (WMA) technology ☐ Sustainable practices in plant production ☐ Sustainable materials manufacturing	☐ **Reduce Materials Consumption** ☐ Recycle content ☐ Reuse materials, products, and buildings ☐ Thin surface paving ☐ Construction waste management ☐ Durable materials ☐ Enhance pavement lifecycle ☐ **Environmentally Preferable Materials** ☐ Certified wood ☐ Low emission materials ☐ Regional materials ☐ Minimizing toxic and/or hazardous materials ☐ Warm-mix asphalt (WMA) technology ☐ Sustainable practices in plant production ☐ Sustainable materials manufacturing	☐ Reduce waste due to activity ☐ Recycling dumpsters ☐ Sort waste for recycling ☐ Recycle bins ☐ High-recyclable materials ☐ Hazardous waste plan ☐ Sustainable materials ☐ Low-emitting materials	☐ **GM1-Materials** ☐ **GM4-Inventory Program** ☐ **GM5-Ship Recycling**
Air Quality			☐ Outside air intake ☐ Natural ventilation ☐ Minimize chemical use ☐ Reduce flying dirt ☐ Limit engines running ☐ Avoid fossil fuel engines	☐ **AE1-NOx Reductions** ☐ **AE2-Sox Reductions** ☐ **AE3-PM Reductions** ☐ **AE4-VOC** ☐ **AE5-GHGs** ☐ **AE7-Port Air Emissions**
Construction Phase	☐ **Reduce Materials Consumption** ☐ Reuse materials, products, and buildings ☐ Design for deconstruction and disassembly ☐ Thin surface paving ☐ Construction waste management ☐ Waste and materials management ☐ Storage and collection of recyclables ☐ **Environmentally Preferable Materials** ☐ Low emission materials ☐ Regional materials ☐ Minimizing toxic and/or hazardous materials ☐ Warm-mix asphalt (WMA) technology	☐ **Reduce Materials Consumption** ☐ Reuse materials, products, and buildings ☐ Thin surface paving ☐ Construction waste management ☐ **Environmentally Preferable Materials** ☐ Low emission materials ☐ Regional materials ☐ Minimizing toxic and/or hazardous materials ☐ Warm-mix asphalt (WMA) technology	☐ Brownfield site ☐ Clean polluted water ☐ Reduce construction waste ☐ **Dredging**	

SMS Key

DECK OPER 0170 &210	Transporting Livestock
DECK OPER 0200	Transporting Seafood
ENGR ENVN 0040	Sewage Pumping
ENGR ENVN 0050	Spill Response
ENGR ENVN 0060	Transfer of Hazardous/Potentially Hazardous Wastes
ENGR ENVN 0070	Oil Container Transfer and Disposal
ERM SAFE 0150	Ordering/Using Chemical Products
SMSM ENVN 0070	Transfer of Hazardous/Potentially Hazardous Wastes
SMSM ENVN 0100	Integrated Pest Management
SMSM ENVN 0110	Hazardous Materials Release
SMSM ENVN 0900	Solid Waste and Disposal Recycling
TERM EMER 0010	Emergency Response and Preparedness
TERM ENVN 0015	Hazardous Material Transport by Commercial Vehicles
TERM ENVN 0020	Hazardous Material Transport on Scheduled Trips
TERM ENVN 0025	Hazardous Material Charters
TERM ENVN 0030	Transfer of Hazardous/Potentially Hazardous Wastes
TERM ENVN 0035	Oil Container Transfer and Disposal
TERM ENVN 0040	Storm Drains and Scuppers
TERM ENVN 0050	Solid Waste and Disposal Recycling
TERM ENVN 0070	Spill Response
TERM ENVN 0080	Portable Spill Kits
TERM OPER 0030	Unique Loading and Off-Loading Situations
TERM SAFE 0100	Housekeeping/Janitorial Supplies
TERM SAFE 0150	Ordering/Using Chemical Products

Green Rating Integration Platform

Project: Sustainable Design Guidelines to Support the Washington State Ferries Terminal Design Manual

Investigators: Michael Wolcott, Liv Haselbach, Cara Poor

Draft August 11, 2011

Drawn by Michael Thompson

Section D.3: Detailed Checklists
GreenLITES:

1. Traffic and Parking
   - ☐ **E-1: Improve Traffic Flow**
     - Special use lane (HOV/Bus Express)
     - Installation of a transit expresses system (queue jumper)
     - Expansion of Traffic Management/ Traveler Information System operation
   - ☐ **E-4: Improve Bicycle and Pedestrian Facilities**
     - Separated bike path or shoulder widening to provide on-road bike land
     - Create or extend nearby existing sidewalks
2. Integration in the Community
   - ☐ **S-2: Context Sensitive Solutions**
     - Incorporate local or natural materials for substantial visual elements
     - Site materials selection which reduces the overall "heat island" effect
   - ☐ **S-3: Land Use/Community Planning**
     - Use of more engaging public participation techniques
     - Projects better enabling use of public transit
   - ☐ **S-4: Protect, Enhance, or Restore Wildlife Habitat**
     - Mitigation of habitat fragmentation
     - Providing for enhancements to existing wildlife habitat
     - Use of natural-bottomed culverts
   - ☐ **S-5: Protect, Plant or Mitigate for Removal of Trees and Plant Communities**
     - Re-establishment or expansion of native vegetation into reclaimed work areas
     - Removal of undesirable/invasive plant species
   - ☐ **E-5: Noise Abatement**
     - Construction of a new noise barrier
     - Incorporate traffic system management techniques to reduce prior noise levels
     - Diamond grinding of existing PCC pavement
     - Berms designed to reduce noise
     - Provide planting to improve perceived noise impacts
   - ☐ **E-6: Stray Light Reduction**
     - Retrofit existing light heads with full cut-offs, use cut-offs on new light heads
3. Energy Management
   - ☐ **E-2: Reduce Electrical Consumption**
     - Solar/battery powered street lighting or warning signs
     - Replace overhead sign lighting with high type retro-reflective sign panels
     - Use of LED street lighting
   - ☐ **E-3: Reduce Petroleum Consumption**

- Provide park & ride lots
- Increase bicycle amenities
- Use of warm mix asphalt
- Improve shading to cut down on heat island effect and automotive air conditioning use

4. Water Management
   - ☐ **W-1: Stormwater Management (volume and quality)**
     - Improve water quality through use of stormwater retrofitting
     - Detect and eliminate any non-stormwater discharges
     - Reduce overall impervious area
   - ☐ **W-2: Best Management Practices (BMPs)**
     - Design features that make use of highly permeable soils to remove surface pollutants from runoff
     - Use wet or dry swales
     - Use sand filters or filter bag
     - Use oil/grit separators and hydrodynamic devices
     - Use underground detention systems or catch basin inserts
     - Inclusion of permeable pavement where practical
5. Materials Management
   - ☐ **M-1: Reuse of Materials**
     - Design projects so that cut-and fills are balanced
     - Reuse of excess fill within the project corridor
     - Specify rubblizing or crack and seating of PCC pavement
     - Specify the processing of demolished concrete to reclaim scrap metals and aggregate
     - Salvage removed trees for lumber
     - Use surplus excavated material on nearby state highways
     - Reuse of elements of the previous structure
   - ☐ **M-2: Recycle content**
     - Use tire shreds in embankments
     - Use recycled plastic extruded lumber or recycle tire rubber
     - Specify hot-in-place or cold-in-place recycling of hot mix asphalt pavements
     - Specify the use of recycled glass in pavements and embankments
     - Specify asphalt pavement mixes containing Recycled Asphalt Pavement (RAP)
     - Specify Portland cement pavement mixes containing Recycled Concrete Aggregate (RCA)
     - Use of Porous Pavement Systems in light duty use situations
   - ☐ **M-3: Locally Provided Material**
     - Specify locally available natural light weight fill

        - Specify local seed stock and plants
    - ☐ **M-4: Bioengineering Techniques**
        - Utilize soil bioengineering treatments along water body
        - Use vegetated crib wall, vegetated gabion, and vegetated mats
        - Use biological control methods to reduce invasive species
    - ☐ **M-5: Hazardous Material Minimization**
        - Design project to minimize need for hazardous materials
        - Design project to increase interval before reconstruction or improve durability
        - Reduce VOCs or HAPs emitted during construction
6. Air Quality
7. Construction Phase
    - ☐ **S-1: Alignment Selection**
        - Avoid previously undeveloped lands

LEED retail:

1. Traffic and Parking
   - ☐ **SSc4-Alternative Transportation**
     - Preferred parking for low-emitting and fuel-efficient vehicles
     - Install alternative fuel refueling stations
     - Institute fuel-efficient vehicle-sharing program
     - Preferred parking for carpools or vanpools
     - Provide information about alternative transportation
2. Integration in the Community
   - ☐ **SSc2-Development Density and Community Connectivity**
     - Use a previously developed site
     - Allow for pedestrian access between site and basic community services
     - Preserve habitat and natural resources
   - ☐ **SSc5.1-Site Development-Protect or Restore Habitat**
     - Use native or adapted vegetation (could be applied on green roofs)
   - ☐ **SSc5.2-Site Development-Maximize Open Space**
     - Reduce development footprint
     - Provide vegetated open space (including vegetated roofs)
   - ☐ **SSc7-Heat Island Effect**
     - Shade site hardscape
     - Use paving materials with a high Solar Reflective Index (SRI)
     - Use an open grid pavement system
   - ☐ **SSc8-Light Pollution Reduction**
     - Reduce power of interior lights which can be seen from outside
     - Light exterior areas only as required for safety and comfort
   - ☐ **EAp3-Fundamental Refrigerant Management**
     - Zero use of CFC based refrigerant0073
   - ☐ **EAc4-Enhanced Refrigerant Management**
     - Select refrigerants that minimize ozone depleting compounds
   - ☐ **IEQc6-Controllability of Systems**
     - Provide lighting system control by individual occupants or by specific groups
   - ☐ **IEQc7-Thermal Comfort**
     - Provide a thermal environment that supports productivity and well-being of building applicants
   - ☐ **IEQc8-Daylighting and Views**
     - Achieve a low glazing factor
     - Use daylight illumination
3. Energy Management
   - ☐ **EAp2-Minimum energy performance**
     - Establish the minimum level of energy efficiency

- ☐ **EAc1-Optimize energy performance**
- ☐ **EAc2-On-site renewable energy**
  - Use on-site renewable energy systems to offset building energy cost
- ☐ **EAc5-Measurement and Verification**
  - Provide ongoing accountability of building energy consumption
- ☐ **EAc6-Green Power**
  - Purchase electricity from renewable sources

4. Water Management
   - ☐ **SSc6.1-Stormwater Design-Quantity Control**
     - Maintain predevelopment peak discharge rates and quantity
     - Protect receiving stream channels from excess erosion
   - ☐ **SSC6.2-Stormwater Design-Quality Control**
     - Reduce impervious cover
     - Promote infiltration
     - Capture and treat stormwater
   - ☐ **WEp1-Water Use Reduction**
     - Use water efficient toilets and sinks
   - ☐ **WEc1-Water Efficient Landscaping**
     - Use native plants
     - Improve irrigation efficiency
     - Use captured rainwater
     - Use recycled wastewater
     - Install landscaping that does not require permanent irrigation systems
   - ☐ **WEc2-Innovative Wastewater Technologies**
     - Use water conserving fixtures
     - Use non-potable water
   - ☐ **WEc3-Water Use Reduction**
     - Use water efficient toilets and sinks
5. Materials Management
   - ☐ **MRp1-Storage and Collection of Recyclables**
     - Identify the top five waste streams
   - ☐ **MRc1.1-Building Reuse-Exterior**
     - Maintain the existing building structure and envelope
   - ☐ **MRc1.2-Building Reuse-Interior**
     - Use existing interior non-structural elements
   - ☐ **MRc2-Construction Waste Management**
     - Recycle/salvage non-hazardous construction materials
   - ☐ **MRc3-Materials Reuse**
     - Use salvaged, refurbished, or reused materials
   - ☐ **MRc4-Recycled Content**

- Use materials with recycled content

- ☐ **MRc5-Regional Materials**
  - Use building materials that have been extracted or harvested within 500 miles
- ☐ **MRc6-Rapidly Renewable Materials**
  - Use materials harvested from plants with a 10-year or shorter cycle
- ☐ **MRc7-Certified Wood**
  - Use wood certified with the Forest Stewardship Council
- ☐ **IEQc4-Low-Emitting Materials**
  - Use adhesives, sealants, and primers with low VOCs

6. Air Quality
   - ☐ **IEQp1-Minimum Indoor Air Quality**
     - Meet minimum indoor ventilation requirements
   - ☐ **IEQp2-ETS control**
     - Prohibit smoking except for designated smoking areas
   - ☐ **IEQc1-Outdoor Air Delivery Monitoring**
     - Place CO2 sensors in densely occupied areas
   - ☐ **IEQc2-Increased Ventilation**
     - Increase breathing zone outdoor air ventilation rates
   - ☐ **IEQc5-Indoor Chemical and Pollutant Source Control**
     - Employ entryway systems to capture dirt and particulates
     - Sufficiently exhaust space where chemicals are used
     - Install new air filtration media in occupied areas
     - Provide containment for hazardous waste
7. Construction Phase
   - ☐ **SSp1-Construction Activity Pollution Prevention**
     - Prevent loss of soil during construction by stormwater runoff and wind erosion
     - Prevent sedimentation of storm sewer or receiving streams
     - Prevent polluting the air with dust and particulate matter
   - ☐ **SSc1-Site Selection**
     - Choose location in order to reduce environmental impact
   - ☐ **SSc3-Brownfield Redevelopment**
     - Develop a site documented as contaminated or a brownfield
   - ☐ **EAp1-Fundamental Commissioning of the Building Energy Systems**
     - Designate a commissioning authority
     - Develop commissioning requirements into the construction documents
     - Develop a commissioning plan for HVAC, lighting, hot water, and renewable energy
   - ☐ **EAc3-Enhanced Commissioning**

- Develop a systems manual
- Verify requirements for training operating personnel and building occupants is completed
- Reviews within ten months of substantial completion

- **IEQc3-Construction IAQ Management Plan**
  - Protect stored or installed absorptive materials from moisture damage
  - Protect HVAC system, control pollutant sources, and interrupt contamination pathways

Port Authority of NY/NJ

1. Traffic and Parking
   - ☐ **IS-17: Optimize Traffic Safety**
     - Perform road safety audits
     - Review traffic crash reports
   - ☐ **IS-19: Expand of Enhance Intermodal Connectivity**
     - Provide shelter at waiting areas and bus stops
     - Provide infrastructure for transit information
   - ☐ **IS-20: Use Transportation System Management**
     - One-way streets
     - Reversible lanes
     - HOV lanes
     - Curb lane use control
     - Parking management strategies
   - ☐ **IS-21: Use Transportation Technologies**
     - Integrate transportation technologies
     - Deploy transportation technologies
2. Integration in the Community
   - ☐ **IS-5: Protect Ecological Health**
     - Installation of pollutant trap
     - Re-vegetation with native plant species
     - Removal of aquatic weeds
     - Manage stormwater on-site
   - ☐ **IS-6: Protect and Maintain Absorbent Landscapes**
     - Construct a rain garden
   - ☐ **IS-8: Utilize Appropriate Vegetation**
     - Provide maintenance for landscaping
     - Test soil prior to landscaping
     - Use bio-stimulants to enhance soil quality
     - Add compost
     - Restrict use of pesticides and fertilizers
   - ☐ **IS-14: Mitigate Heat Island Effect**
     - Use light-colored landscape
     - Use porous materials
     - Use hardscape materials with a high SRI
     - Use vegetated areas
   - ☐ **IS-15:Minimize Light Pollution**
     - Set street lights to prevent night-sky pollution
     - Enhance night-time visibility
     - Minimize light trespass and disturbance

- Coordinate lighting with security cameras

- ☐ **IS-16: Optimize Public Environments**
  - Provide enhanced pedestrian crossing treatment
  - Provide new sidewalks

3. Energy Management
   - ☐ **IE-1: Optimize Energy Performance**
     - Reduce energy consumption of infrastructure systems
     - Reduce peak load
   - ☐ **IE-2: Commission Electrical and Mechanical Systems**
     - Develop an O & M manual
   - ☐ **IE-3: Utilize End Use Metering**
     - Install energy consumption sub-meters
     - Install a monitoring systems that tracks energy use
   - ☐ **IE-4: Use On-Site Renewable Energy**
     - Use solar, wind, geothermal, hydro, biomass, or biogas
   - ☐ **IE-5: Protect Ozone Layer**
     - Use non-CFC and non-HCFC based refrigerants
     - Use fire extinguishers that do not contain ozone-depleting substances
   - ☐ **IE-6: Provide Alternative Fueling Stations**
     - Provide electric refueling stations for plug-in hybrid vehicles
     - Provide biodiesel pumping stations
     - Provide compressed natural gas
     - Provide ethanol fueling stations
4. Water Management
   - ☐ **IS-7: Utilize Pervious Pavement**
     - Use pervious concrete, asphalt, pavers
     - Use vegetated bioswales or ditches
     - Utilize salt-splashes at roadway edge
     - Use structural soil to enhance percolation
   - ☐ **IS-9: Use Turfgrass Appropriately**
     - Utilize resilient, resistant, low-maintenance vegetation
     - Substitute ground covers or meadow grass for turfgrass
   - ☐ **IW-1: Implement Stormwater BMPs**
     - Implement stormwater management plan
     - Lower peak runoff rates
     - Treat stormwater for TSS
     - Mark storm drains
     - Bioretention systems
     - Constructed stormwater wetlands
     - Dry wells

- Extended detention basins
- Infiltration structures
- Manufactured treatment devices
- Pervious paving
- Sand filters
- Rain garden

☐ **IW-2: Implement Rainwater Neutrality**
- Infiltrate stormwater
- Mark storm drains

☐ **IW-3: Reduce Use of Potable Water for Irrigation**
- Use harvested stormwater for irrigation
- Employ high efficiency irrigations systems
- Specify native or acclimatized site plantings

☐ **IW-4: Utilize End Use Metering**
- Install water meters
- Determine appropriate location for meters
- Install leak detection system

☐ **IO-1: Implement Sustainable Landscape Maintenance**
- Remove invasive species
- Recycle organic waste
- Use organic compost as fertilizer
- Reduce soil erosion/compaction from maintenance activities
- Use harvested stormwater for irrigation
- Computerized irrigation system
- Educate employees on sustainable maintenance
- Use low-toxicity pest management
- Protect against sand and de-icing chemicals in winter

☐ **IO-2: Maintain Soil Quality**
- Prevent soil pollution
- Protect soil and minimize erosion
- Recycle organic waste
- Manage snow/ice deicing or removal
- Prepare a watering schedule

5. Materials Management

☐ **IS-10: Amend and Reuse Existing Soils**
- Test soil prior to seeding
- Require compost testing
- Maximize on-site reuse

☐ **IS-11: Balance Earthwork**
- Minimize bringing in new fill

- ☐ **IM-1: Use Recycled Materials**
  - Use recycled materials
- ☐ **IM-2: Use Local/Regional Materials**
  - Use materials within a 500-mile radius
- ☐ **IM-3: Reuse Materials**
  - Incorporate used, salvaged, or refurbished materials
- ☐ **IM-4: Use Durable Materials**
  - Provide a life cycle cost analysis
- ☐ **IM-5: Use Sustainably Harvested Wood**
  - Use wood approved by FSC
  - Require COC number
- ☐ **IM-6: Minimize Use of Toxic and/or Hazardous Materials**
  - Minimize exposure to toxic and hazardous materials
- ☐ **IM-7: Enhance Pavement Lifecycle**
  - Employ preventive maintenance to extend pavement life
  - Minimize manholes and access points
- ☐ **IM-8: Utilize Thin Surface Paving**
  - Use thin surface overlay to extend pavement life
- ☐ **IM-9: Utilize Warm-Mix Asphalt Technology**
  - Use WMA with 20% RAP

6. Air Quality
7. Construction Phase
   - ☐ **IS-1: Utilize an Integrated Team Approach**
     - Identify stakeholders
     - Create a sustainable infrastructure credit checklist
     - Review sustainability goals
   - ☐ **IS-2: Prepare a Site Assessment**
     - Document existing natural features and conditions
   - ☐ **IS-3: Maximize Use of Previously Developed Sites**
     - Construct on previously developed sites
   - ☐ **IS-4: Maximize Use of Known Contaminated Sites**
     - Build on a brownfield site
   - ☐ **IS-12: Coordinate Utility Work**
     - Minimize pavement deterioration and disruption
   - ☐ **IS-13: Utilize Trenchless Technology**
     - Use least disruptive technologies for maintenance or replacement
   - ☐ **IS-18: Optimize Roadway Alignment Section**
     - Maintain a buffer between roadway and ecological sensitive areas
     - Avoid disrupting existing utilities
     - Protect natural site features

- Limit the alignment footprint

- ☐ **IC-1: Minimize Pollution From Construction Activity**
  - Prevent discharge of pollutants from the site
  - Identify ESC measures
  - Collect and utilize stormwater for construction activities
  - Proper disposal of construction site waste
  - Control offsite vehicle tracking
- ☐ **IC-2: Protect Existing Natural Systems**
  - Limit site disturbance
  - Minimize exposure of bare ground
  - Store equipment on compacted land
  - Install permanent tree protection
  - Stabilize areas to prevent erosion
- ☐ **IC-3: Utilize Transportation Management During Construction**
  - Develop traffic control plan
  - Minimize use of explosives
  - Minimize staging areas
  - Monitor mobility and safety of work zone
- ☐ **IC-4: Utilize Green Construction Equipment**
  - Use low-sulfur diesel fuel
  - Use emission control devices using BAT
  - Idling time for equipment limited to 3 minutes
  - Use electric powered equipment where available
- ☐ **IC-5: Reduce Noise and Vibration Abatement During Construction**
  - Cover debris containers with sound absorbing materials
  - Pneumatic equipment should have intake and exhaust mufflers
  - Inform public about upcoming work
  - Use noise barriers
- ☐ **IC-6: Implement Construction Waste Management**
  - Divert from landfills
  - Implement on-site sorting of demolition and construction debris
- ☐ **IC-7: Implement Integrated Pest Management**
  - Reduce water and food sources for pests
  - Use less toxic poisons

WSU Ferry Guidelines

1. Traffic and Parking
   - Promote HOV by preferred rates or faster access
   - Encourage walk-on passengers by improving multi-modal connectivity
   - Encourage bicycle use

- Facilitate drop-off
- Implement a park-and-ride program
- Implement a shared-car or renting car program
- Optimize traffic flow with path finders and signals implemented around the site
- Implement a reservation system
- Increase peak periods prices
- Allow future growth of the port

2. Integration in the Community
    - Architecturally blend the infrastructure into its area
    - Create a visitor center about the activity and infrastructures of the port
    - Include guided tours on trips
    - Prevent damage from potential flood events and water table changes
    - Allow future change in type of activity of the port
    - No use of ozone depleting substances

- ☐ **Light Pollution Prevention**
    - Limit interior lighting exiting buildings and boats
    - Limit exterior lighting to areas where needed for safety or comfort
    - Limit all lightings to brightness needed
    - Use lights under docks for fish
- ☐ **Noise Pollution Prevention**
    - Use bubble curtains during pile installation
    - Use noise barriers around site
    - Adjust the fog horn noise level to the conditions
    - Limit noise level, especially during construction works
- ☐ **Wildlife Considerations**
    - Create fish paths around the facilities
    - Include nesting platforms
    - Include native trees

3. Energy Management
    - Produce renewable energy with marine potential, solar panels, wind
    - On boats, heat up water through the waste feat from engines' exhaust
    - Use local material for construction and renovation, and local products for usual activity
    - Use materials with minimal embodied energy
    - Incorporate passive design, such as daylight harvesting
    - Incorporate high-efficient systems
    - Use individual control of temperature, ventilation, and light in offices
    - Use automatic control of temperature, ventilation, and light in public areas

- Automatically turn off unnecessary lights when there is no activity or when bright enough
- Use surfaces with high reflectance

4. Water Management
    - Implement an emergency plan in case of spills
    - Oil separation equipment
    - Use non toxic paint on boats and facilities
    - Use high-efficiency fixtures
    - Prevent leaks
    - Reduce unnecessary potable water use
    - Reduce city water use by treating port water to use it
    - Treat wastewater on-site
    - Implement LIDs
    - Collect runoff and rainwater
    - Treat released water on boats
    - Good housekeeping of ballast tanks
    - Limit exchanges to off-shore locations
5. Materials Management
    - Reduce waste due to activity
    - Provide recycling dumpsters during construction and maintenance works
    - Require boats to sort their solid waste for recycling
    - Provide recycle bins inside and outside facilities
    - Promote the use of high-recycle/recyclable content materials
    - Implement a hazardous waste handling and storage plan
    - Promote the use of sustainable materials such as certified food
    - Use low-emitting materials and paints
6. Air Quality
    - Increased outside air intake
    - Increased natural ventilation
    - Minimize the use of chemical when cleaning
    - Reduce flying dirt during construction
    - Limit the time during which passengers have their engines running
    - Avoid fossil fuel engines
7. Construction Phase
    - Rehabilitate a grayfield of brownfield site
    - Clean polluted water area
    - Improve reuse and reduce construction waste

- **Dredging**
    - Monitor dredging
    - Perform dredging when no activity

- Help habitat after dredging
- Treat and use dredged material

MVeP:

1. Traffic and Parking
2. Integration in the Community
   - ☐ **GM3.1-Lighting and Underwater Noise Aquatic Life Impact**
     - Document what species will be in close proximity to the vessel's route
     - Assess emitted light and noise
     - Evaluate whether species will be harmed
   - ☐ **GM3.2-Wake Wash and Shore Protection**
     - Identify measures to reduce shore erosion
     - Assess wake wash impacts
     - Identify shore locations that should be avoided if possible
3. Energy Management
   - ☐ **EE1.1-Lighting**
     - Use CFL or LED lighting, motion sensing switches, isolation switches
     - Identify opportunities to use natural lighting
   - ☐ **EE1.2-HVAC**
     - Use insulation factors, zone control, and demand based conditioning
     - Use natural ventilation where applicable
   - ☐ **EE1.3-Pump and Piping Systems**
     - Use insulation factors, demand based controls, materials selection
     - Use air-cooled units, no flush toilets, gravity drains, and demand based control systems
   - ☐ **EE1.4-Mechanical Equipment Operations & Maintenance**
     - Equipment overhaul upon designated loss of efficiency
     - Use conditional measures for operational adjustments
     - Consistently maintain equipment
   - ☐ **EE1.5-Hull/Propeller Operations & Maintenance**
     - Maintain regular cleanings
     - Reduce the amount or impact of hull and propeller fouling
   - ☐ **EE1.6-Route Optimization**
     - Plan voyages to promote safety of ship, crew, and environmentally sensitive areas
     - Optimize routes to use weather patterns, currents, and wind to advantage
     - Maximize cargo area utilization and reduce idle time in port
     - Quantify potential reductions in fuel consumption
   - ☐ **EE1.7-Vessel Speed Optimization**
     - Determine optimal speed for fuel efficiency
     - Relate speed to number of trips required
   - ☐ **EE1.8-Waste Heat and Energy Recovery**
     - Use engine cooling water for making water

- Use nitrogen generator instead of a combustion unit
- Use closed loop piping systems

☐ **EE1.9-Hull Optimization**
- CFD optimization for the hull form
- Find optimal size and block coefficient to move cargo most efficiently

☐ **EE2.1-Other Fuels**
- Categorize air emissions of alternate fuels relative to diesel
- Use hydrogen fuel cells or nuclear

☐ **EE2.2-Renewable Energies**
- Use wind-assisted propulsion
- Generate power from a renewable source such as wind, solar, and ocean

☐ **EE3-Carbon Footprint Reduction**

4. Water Management

☐ **WE1-Oily Water**
- Use separating equipment and discharge monitoring equipment

☐ **WE2-Non-Indigenous Species Control**

☐ **WE2.1-Ballast Water & Sediment**
- Use ballast water treatment system
- Reduce/eliminate the ballast water and sediment NIS vector

☐ **WE2.2-Hull Fouling**
- Periodically clean vessel exterior
- Use hull coating

☐ **WE3-Sanitary Systems**
- Improve quality of treated water being discharged
- Reduce the amount of contaminated water being discharged

☐ **WE4-Solid Waste**
- Buy in bulk to reduce packaging waste
- Trade off disposable items for re-usable and washable items
- Recycle
- Low emissions handling system

☐ **WE5-Incidental Discharges**

☐ **WE6-Structural Protection of Oil**
- Structural protection will reduce accidental discharge of oil

☐ **GM2-Hotel Water Use: Reduction/Reuse/Recycle**
- Reduce water use per person
- Use low flow showers and sinks, low water use toilets

5. Materials Management

☐ **GM1-Materials: Reduction/Reuse/Recycle Construction and Operations**
- Use recycled materials (steel/aluminum, joiner panels, insulation)
- Reuse items recovered from scrapped ships

- ☐ **GM4-Hazardous Materials Control-Inventory Program**
    - Inventory material for proper storing, handling, and recycling
    - Recommend preferred storage options
- ☐ **GM5-Ship Recycling**
    - Be sure recycling is safe and environmentally friendly
    - Identify materials and equipment that are likely to be re-used

6. Air Quality

- ☐ **AE1-Nitrogen Oxides (NOx) Reductions**
    - Designate minimum emissions standard
    - Reduce pollutant emissions without significant impact on other emissions
- ☐ **AE2-Sulfur Oxides (Sox) Reductions**
    - Designate minimum emissions standard
    - Reduce pollutant emissions without significant impact on other emissions
- ☐ **AE3-Particulate Matter (PM) Reductions**
    - Designate minimum emissions standard
    - Reduce pollutant emissions without significant impact on other emissions
    - Use higher efficiency engines and filters
    - Use lower sulfur fuels
- ☐ **AE4-Volatile Organic Compounds**
    - Use higher efficiency combustion engines
    - Use vapor recovery systems on tank ships
    - Designate minimum emissions standard
    - Reduce pollutant emissions without significant impact on other emissions
- ☐ **AE5-Other Greenhouse Gases (GHGs)**
    - Identify any regulations that may pertain to these gases
- ☐ **AE6-Ozone-Depleting Substances**
    - Refrigerants, cleaners, and fire-suppressants should be free of ozone-depleting substances
- ☐ **AE7-Port Air Emissions Reduction**
    - Reduce loads wherever possible
    - Shoreside electrification
    - Selective use of low sulfur fuels
    - Capture and transfer of stack emissions with shoreside equipment

7. Construction Phase

Section D. 4: Materials Checklists and Explanation

1. **Reduce Materials Consumption**
   - **Recycle content:**
     a) At least 10% (sum of postconsumer recycled content plus 1/2 of pre-consumer content) based on cost (excluding mechanical, electrical, and plumbing components)
     b) Specified materials require from 4~75% recycled content in different applications and locations (see the Sustainable Infrastructure Guidelines - Port Authority of New York and New Jersey in details)
   - **Reuse materials**
     - **Building reuse**
       Maintain 1. existing walls, floors, and roof (at least 55%); 2. interior nonstructural elements (at least 50% based on area)
     - **Material reuse**
       Reuse building materials and products (salvaged, refurbished, and reused materials) at least 5% based on cost. (Excluding mechanical, electrical, and plumbing components)
     - **Design for deconstruction and disassembly**
       Use at least 20% of materials assemblies, products, and/or product components for construction facilitate reuse and are designed for deconstruction
     - **Thin surface paving**
       Preserve bituminous pavements and prevent premature deterioration of the pavement structure. Thin asphalt concrete overlay less than 2"
   - **Waste management**
     - **Construction waste**
       Recycle and/or salvage at least 50% of non-hazardous debris from demolition and construction (excluding excavated soil and land-clearing debris)
     - **Storage and collection of recyclables**
       Provide recycling service of the recyclable wastes generated by building occupants
   - **Durable materials**
     - **Durable materials**
       Maximize use of durable materials (low maintenance costs within a long life cycle)
     - **Enhanced pavement lifecycle**
       Increase pavement lifecycle by 20% and provide design life more than 10 years

2. **Environmentally Preferable Materials**
   - **Rapidly renewable materials**
     Use rapidly renewable materials or products (made from plants within shorter than 10 years harvesting cycle) for 2.5% of total value of all building materials and products based on cost
   - **Certified wood**

Use at least 50% (by cost) of wood-based materials and products that are certified in accordance with the Forest Stewardship Council's (FSC) principles and criteria for wood building components

- **Low emission materials**
  - **Low emission materials**
    Contain reduced amount of VOCs on adhesive, sealants, paints, and coatings
  - **Regional Materials**
    Use materials or products that have been extracted, harvested, or recovered/manufactured within 500 miles at least 10 % based on cost (soil and aggregate: <50miles, plants:<250miles, all other materials: <500miles)
  - **Support sustainable practices in plant production**
    Obtain 90% of purchased plants from who reduce resource consumption and waste based on the requirements of sustainable practices in plant production
  - **Support sustainable practices in materials manufacturing**
    At least 25% (by cost) of purchased products for construction from who passed requirements (ISO 14001, inventory and public disclose all applied chemicals and residuals, and 3 of 7 sustainable practices)
- **Low toxic and/or hazardous materials**
  - **Minimizing Toxic/Hazardous Materials**
    Minimize use of materials which contain high level of toxic and hazardous materials (volatile organic compounds VOCs, hazardous air pollutants, heavy metals and other substances known to de deleterious to human health and/or the environment
  - **Warm-mix asphalt (WMA) technology**
    Use 100% of WMA, which generates 75% less emission and reduce more than 30% of fuel requirement than hot-mix asphalt, and 20% of reclaimed asphalt pavement for the pavement of parking lots

12. Appendix E: Expanded SMS Outline and Acronym Listing

Acronyms:

SMSM Safety Management System Manual
CODE Policies
ADMN Administrative Procedures
ASPS Alternative Security Program
SUBW 46 CFR Subchapter W on lifesaving equipment/procedures
EMSS Environmental Management System
SMS Policy committee (SPC) - Executive level
SMS Coordination Team (SCT) - Across departments.
SOLAS Safety of Life at Sea

Book 1.1: Safety Management System Manual 1.1 (Overall Principles)

SMSM SMSM 0001, 0002, 0003 (TOC, Record of revisions, Cross reference guide)
SMSM SMSM 0010, 0020 (WSF SMS Intro and Policy)
These sections are the policy basis for best practices for safety, emergency response, environmental, and security guidelines; with an integrated management system approach. These practices are then based on international, federal, state, local and agency rules, directives, etc. Some major ones used for the development of the SMS include the International Safety Management (ISM) Code for the Safe Operation of Ships and for Pollution Prevention (IMO Resolution A.741 (18)). Started in 1998 and even though not required everywhere, WSF later implemented it system wide. Then WA State Exec Order E 1018.00 in 2001 required an EMS (Environmental Management System) which should be incorporated into the SMS. WSF adopted ISO 14001:2004 as the format for the EMS but without third-party certification. Additional ones include the 2002 US Maritime Transportation Security Act (MTSA) and the International Ship and Port Facility Security (ISPS) Code which cover security for heightened threats. This is where WSF then used the US Coast Guard Alternative Security Program in their SMS.
The Overall Mission is to:

- Maintain/operate safely and efficiently
- Maintain an MS
- Procedures to minimize unsafe and negative impact
- Emergency preparedness
- Meet regulations
- Minimize use of hazmat and generation of pollutants

SMSM CODE sections 0000 through 0016 summarize various regulations. Some applicable sections are:

- 0002 Safety and Environmental Policy states that the policy is in SMSM SMSM 0020
- 0009 Corrective action: Follow SMSM REVU 0020 and 0030 (Report…review and appeal)
- 0011 Documentation, follows:

        - SMSM ADMN 0030 Document Control System
        - SMSM ADMN 0050 Document Distribution
        - SMSM ADMN 0060 How to Write a Procedure
    - 0012 Review and Evaluation follows SMSM REVU 0060

SMSM ASPS 0010 and 0020 cover security. (Note that all recommendations should not interfere with the controlling of access, embankments, restricted areas…monitoring, handling cargo, ship duties, etc.) These security considerations are developed using *risk-based methodology.*

SMSM EMSS 0000-0005 cover environmental procedures (EMS).

Book 1.2: Covers policies and procedures to comply with specific programs such as safety/security, emergency preparedness/response and environmental protection. Most are not detailed herein but some which might apply include:

- SMSM SAFE 0070 Respiratory Protection Program which might apply under a roof with vehicles idling
- SMSM SAFE 0080 Heat Stress (certain material choices, such as pervious concrete, might help mitigate this)
- SMSM SAFE 0090 Carbon Monoxide awareness
- ENVN 0010 EP (Environmental Protection) office
- ENVN 0020 EP AREAS
- ENVN 0090 Solid waste disposal and recycling
- ENVN 0100 Pests
- SCTY (Security) note that there are many areas passengers may not access. (These are employee or restricted access areas) the least secure are public access, then passenger access.

Book 2 Human Resources Manual (HRSM) Not applicable
Book 3 Operations Center Manual (OPCT) Not applicable
Book 4 Emergency Operations Center Manual (EOCT) Not applicable
Book 9 Eagle Harbor Manual (EHBR) Not applicable

Book 10 Terminal Operations Manual (TERM)

- TERM sections have the TOC, etc.
- ADMN sections cover recordkeeping, etc.
- COMM sections cover communications.
- EMER sections cover various emergency procedures.
- ENVN has various sections which are applicable, or where additional sections might be added depending on the recommendations from this report. Some are:
    - 0010 Envr Inspections by Ecology
    - 00020, 25, 30, 35,hazmat and oil
    - 0040 STORM DRAINS AND SCUPPERS
        - ETC
- OPER sections are varied. One applicable might be 0100 Vehicle screening

- ROUT various route considerations for the fleet.
- SAFE has various safety sections. Some that might be applicable are 0040 tractor/trailer (may need for permeable pavement usage considerations). Consideration should be given for truck loading on pavements and special lanes for larger vehicles.

Book 11 Engineering and Maintenance Manual (ENGR)
This is currently more comprehensive with respect to an engineering manual, where as maintenance considerations are being developed. This manual is where most of the recommendations from this report will be included.

- ENGR: TOC etc
- COMM: Communications
- EMER: Various sections, one of interest might be for 0150 Volcanic ash fallout (This section has been requested from WSF.)
- ENVN has various sections, mostly consistent with the previous listings
- MNTC: Maintenance has various sections. The section for preventive maintenance has been requested from WSF.)
- SAFE has various sections, many similar to those previously listed.

Book 12 vol I Deck Operations Manual (DECK)
Book 12 vol II Fire and Safety Training Manual (FAST)
Book13 Route Manual (ROUT)
Books 14-20, 25-38, 41-42 are specific to the various vessels.