INTEGRATING GREEN RATING SYSTEMS: A CASE STUDY FOR FERRY TERMINAL STORMWATER PROJECTS

By

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I would like to acknowledge myself for being incredibly awesome.

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Abstract

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Washington State Ferries (WSF) has unique challenges when it comes to dealing with sustainability, particularly with stormwater pollution. WSF terminals are intermodal facilities, include over water structures (trestles), and are close to the Puget Sound. These factors present difficulties when (1) using sustainability rating tools, and (2) when mitigating stormwater runoff. Most developing sustainability tools are use specific, and none specifically apply to ferry terminals. Stormwater pollution from the terminals might affect environmentally sensitive species in Puget Sound. Conventional low impact development practices (LID) for stormwater mitigation tend to promote dispersed practices, which is difficult at terminals due to limited land availability and proximity to the water.

When considering sustainable construction, there are a multitude of different guides and rating systems available, several of which may in part be related to WSF facilities from the marine side, at the intermodal interface, for buildings and other infrastructure, and through upland transportation modes. The five following rating systems were chosen as being representative for WSF: GreenLITES, LEED, Sustainable Sites Initiative, the Port Authority of NY/NJ Sustainable Infrastructure Guidelines, and the Marine Vessel Environmental Performance Assessment (MVeP). Integration of the five rating systems

and a proposed WSU Ferry Sustainability Guide with the Safety Management System (SMS) of the agency was developed into a Green Rating Integration Platform (GRIP) through reorganization of the systems and then incorporation into a spreadsheet presentation. Future work could expand the GRIP for other intermodal applications, and to include regulations and standards, further helping WSF and other agencies to make sustainable decisions.

Stormwater focused aspects of sustainability through LID were then investigated through two innovative strategies proposed for the Vashon Island Terminal; (1) a reverse slope on the trestle with capture and treatment landside, and (2) the use of a pervious concrete trestle overlay in conjunction with high efficiency sweeping. Different design options were analyzed for each of these strategies, and a decision support tool created relating design to water quality implications and other factors. Both strategies were further analyzed using the GRIP to see what credits they would be eligible for in each of the selected rating systems.

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Dedication

This thesis is dedicated to myself because I’ve always wanted a thesis to be dedicated to me.

1. INTRODUCTION

1.1 Problem Statement

Washington State Ferries (WSF) is faced with the difficult challenge of treating the stormwater which falls on the ferry trestles. Ferry terminals are generally comprised mostly of over-water structures, and are extremely close to the Puget Sound. These factors present difficulties when attempting to treat stormwater runoff for pollutants. Some of the rain falls on the building roofs while other rain falls on the paved areas of the trestle. The precipitation which lands on the trestles is usually directed into Puget Sound via through drains on the deck. A few terminals are set up with special catch basins which filter some pollutants out of the stormwater before releasing into Puget Sound. The rain water which lands on the terminal buildings is caught by gutters and then deposited into the Puget Sound by roof drains which do not go through any filter system. It is important that the stormwater is treated as the Puget Sound contains many environmentally sensitive species that would be adversely affects by the addition of pollutants into their environment.

Stormwater runoff is defined as water that flows over land and does not percolate into the ground. Stormwater is generated by precipitation in the form of rain or snow. There are four different mechanisms which can contribute to overland runoff. Runoff can occur if the precipitation rate is greater than the speed which water can infiltrate into the ground, assuming that any available depression storage has already been filled. This is especially likely in paved areas. Runoff can also occur due to saturation excess when the soil is so saturated it cannot infiltrate any more stormwater. A third cause of runoff is a high antecedent soil moisture level, forcing the soil to become more quickly saturated than is typical. Finally, subsurface return flow can cause runoff by water running laterally though the soil, saturating the soil and sometimes even becoming runoff, usually at a downhill location.

It is especially common for stormwater runoff to occur in urbanized areas with increased impervious surfaces such as buildings and pavement where infiltration rates are close to zero. When stormwater runoff occurs on impervious surfaces, it is most often routed through a curb and gutter system and then deposited into a nearby water body. This runoff consists not only of stormwater, but also contains debris, chemicals, sediments, and other pollutants picked up from the impervious surface. These pollutants may degrade the quality of the water as it is discharged into the water body. As a result, the Environmental Protection Agency (EPA) requires stormwater to be controlled and treated by use of best management practices (BMPs) (EPA 2009).

BMPs include six minimum control measures which must be addressed. These include public education, public participation, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention/good housekeeping (EPA 2008). A subset of BMPs used for post-construction runoff control is the application of low impact development (LID) techniques in stormwater control. LID uses features of the hydrologic cycle, such as infiltration, evaporation, transpiration, ground storage, etc. This is done as close to the stormwater source as possible and includes benefits such as watering the vegetation in the area and supporting groundwater recharges. LID aims to manage stormwater for the purpose of keeping the local hydrologic cycle as close to pre-development conditions as possible (EPA 2011).

It is challenging for ferry terminals to apply many conventional LID practices because most LID practices require the use of land while ferry terminals usually consist of mostly trestles, which are over-water structures. Due to the almost nonexistent distance between the stormwater source and body of water into which it is deposited, the space is too limited for the use of most standard stormwater filtering systems. As a result of this environment, it is necessary to examine different methods to reduce pollution. This could include treatment, as well as prevention or entirely new LID techniques as well.

Common sources of stormwater pollutants at ferry terminals include leaks and sediments from passenger vehicles on the paved areas, which are often required to wait for extended periods of time on the trestle. Another common source of stormwater pollutants is from uncoated metals used in railings, fencing, and building roofs. Uncoated metals are associated with high levels of zinc. Metals could be coated and different roofing materials could be used to reduce pollution. Other possible sources of pollutants include leaks from garbage facilities and hydraulic systems, animal fecal matter, sand and salt used for deicing, and pest control agents.

In addition, WSF, which is a division of the Washington State Department of Transportation (WSDOT), is challenged with addressing multiple environmental, social, and economic impacts relating to its designs and operations with sustainability in mind. Due to this sustainability minded approach, WSF is interested in incorporating green rating initiatives into the design and operations of ferry terminals. Ferry terminals present a unique challenge because they are intermodal facilities incorporating buildings, automobile, and marine vessels. Trestles can be built over land or water, and are sometimes a combination of both.

In order to consider the use of LID at ferry terminals the concepts and goals of LID need to be intermixed with ferry terminal design and operation practices. When considering sustainable construction, there are a multitude of different guides and rating systems available. No rating system specifically applies to the unique situation occurring at ferry terminals, but several can be related to them in some form or fashion. While each of these rating systems may be helpful in some way, having to examine each one individually for every situation could become overwhelming.

A common subject among green rating systems is stormwater. In addition, stormwater is also associated with many environmental and social aspects of sustainability. It is useful to have a system created which will allow one to examine guidelines over multiple rating systems with greater ease than reading through each one separately. A format which could be used for this purpose was created and will be presented later in this thesis with specific application to a more comprehensive LID stormwater approach.

1.2 Proposed Steps and Objectives

Objective 1:

First, available rating systems should be examined to see what is available and what is applicable to ferries. Currently there are a multitude of different rating systems which outline different low impact development practices. In order to fulfill the proposed steps, a literature search will be done of rating systems.

Objective 2:

These rating systems will be integrated in order to make them applicable for ferries. An outline on a matrix for integrating LID practice decisions into other green design and operational goals of ferry terminals will be developed.

Objective 3:

Next, for the purpose of this thesis, each rating system should be examined for the portions which focus on stormwater pollution treatment and prevention. The stormwater aspects of the integrated green rating systems will be detailed. Detail work will also be done on WSF's Safety Management System (SMS) and Stormwater Pollution Prevention Plan (SWPPP). This will make it possible to integrate the green rating systems with the SMS and SWPPP provided by WSF.

Objective 4:

In addition, due to the unique combination of characteristics and challenges at WSF terminals, novel LID prevention and treatment trains might need to be considered. As a result of the unique circumstances surrounding stormwater and ferry terminals, it is important that creative approaches be taken to the management of stormwater. This thesis is an investigation into two different strategies which could be implemented at the Vashon Island Terminal located in Vashon, Washington. The two strategies to be examined are reverse slope on the trestle with capture and treatment land side (reverse slope-land treatment) and the use of a treatment train on the trestle including pervious concrete and high efficiency sweeping (pervious concrete/sweeping). Reverse slope is a technique suggested by WSF.

Objective 5:

Finally, these systems should be overlaid to relate to the stormwater practices that WSF already has in place. Once the previously mentioned two approaches have been investigated, they can be compared to various green rating systems to see what credits they may be eligible for.

1.3 Format of Thesis

The remainder of Chapter 1 in this thesis consists of a literature review. This literature review will include several different rating systems which were analyzed to see if they are applicable to ferries, fulfilling Objective 1. The literature review also includes a summary of the WSF SMS and SWPPP as well as containing information about similar sites and current LID practices to lay the groundwork for Objective 3.

Chapter 2 covers the selection of rating systems which best apply to ferry terminals and integrates them together in fulfillment of Objective 2. The chapter goes on to look at the stormwater guidelines of each of these rating systems and relates them to current WSF SMS procedures, creating a Green Rating Integration Platform as discussed in Objective 3.

The third chapter gives background information on the example site used in Objective 4, the Vashon Island terminal. The two strategies discussed in Objective 4 are analyzed in Chapters 4 and 5.

Chapter 4 looks at the reverse slope design and begins by giving some background information on reverse slopes. The hydrological calculations are than presented to show how rainfall and runoff was determined. This is followed by calculations of runoff from the trestle. The next section discusses water quality calculations. Chapter 4 finishes up looking at landside calculations if the strategy was extended to include treating water for both the trestle and the land.

The pervious concrete method is examined in Chapter 5. First, some background information is given on pervious concrete's pollutant removal potential. Then, three different options for using a pervious concrete overlay on the trestle are discussed.

Objective 5 is achieved in Chapter 6 when the two strategies discussed in Chapters 4 and 5 are analyzed by several green rating systems to see what credits they are eligible for. A section is devoted to each the reverse slope method and the pervious concrete method.

The final chapter, Chapter 7, wraps up the thesis with a brief summary and recommendations.

1.4 Literature Review

The literature review is separated into four sections covering different topics. Section 1.4.1 discusses several different sustainability rating systems which have been examined. Section 1.4.2 describes procedures already in place at WSF, specifically the SMS and the SWPPP. Section 1.4.3 looks at two similar sites; the SR 520 floating bridge and the Bainbridge Island terminal. Finally, Section 1.4.1 looks at LID practices which have been successfully used to reduce pollutants found in stormwater.

1.4.1 Sustainability Rating Systems

One of the most well known ratings systems is Leadership in Energy and Environmental Design (LEED) for new construction and major renovation, which has been developed by the US Green Building Council (USGBC 2009). This rating system applies mostly towards buildings on the land, making it useful for the land side of a ferry terminal. LEED for retail is a subset of the LEED new construction system. LEED retail is more consumer based and addresses parking issues as well as other additional criteria that might fit well with WSF.

Another rating system, which was developed by the Green Building Initiative, is Green Globes (GBI 2011). Green Globes easily applies to different project sizes and both new and existing buildings. It has been specifically used for several public buildings. For ports, the most applicable sections are those that address building design and maintenance and operations. However, the similarly applicable LEED system is more commonly used in the United States.

Another possible rating system source is from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) set of standards. As the name suggests, ASHRAE is a good source of energy system standards such as testing methods and performance criteria (ASHRAE 2011). This could be applied to specific energy topics that WSF may need to address. ASHRAE standards are also included in LEED.

The Sustainable Sites Initiative (SITES) is an interdisciplinary effort that provides guidelines for sustainability in the areas of land design, construction, and management (SSI 2009). It focuses on how a project can be sustainably beneficial when it is implemented into a community by enhancing social and community aspects. When transferring the ideas presented in SITES to a WSF terminal, it is mainly applicable to the land side. The SITES rating system seems to focus greatly on stormwater management which is why it could be valuable for this study.

New York State Department of Transportation has a rating system known as GreenLITES, designed to address multiple forms of transportation. GreenLITES lists different techniques used to measure sustainability performance in addition to promoting stormwater best management practices (BMPs), and possible areas of improvement in the planning, design, and construction phases. The main areas of focus are sustainable sites, water quality, materials and resources, and energy and atmosphere (NYDOT 2011). The tool is more readily applied to highways and may be difficult to apply to WSF. GreenLITES use at WSF may be limited to the transportation network upland of the ferry terminal.

The Federal Highway Administration of the US Department of Transportation has its own sustainability tool known as the Infrastructure Voluntary Evaluation Sustainability Tool (IN-VEST). As of this writing it is in the pilot test phase with version 1.0 scheduled to be released in 2012. This tool is expected to be available nationally and currently has three main sections focusing on systems and project planning, project development, and operations and maintenance (FHWA 2011). This tool is mainly focused on state and highway systems but may apply to the interface at the terminal including the upland roadway leading to the ferry terminal.

The Institute for Sustainable Infrastructure recently released version 1.0 of EnvISIon for feedback. EnvISIon is expected to be approved and available for use in early 2012. According to their announcement, EnvISIon evaluates the sustainability of a wide range of infrastructure projects vital to our communities, to economic competitiveness, and to protecting the environment (ISI 2011).

Another land side application which focuses on roads and highways is the Greenroads rating system. This system, like others, does a good job addressing stormwater treatment on roads which could apply to the landside area of a ferry terminal. In addition to stormwater, Greenroads also focuses on which materials would be more sustainable choices when constructing new projects (Greenroads 2011).

Another sustainability checklist referring to transportation was developed by Lochner and is known as Sustainable Transportation Environmental Engineering and Design (STEED) guidelines. These guidelines mainly cover roadways and separates the guidelines into the four stages processing, planning, design, and construction (Lochner 2011). It would be difficult to relate the majority of the information in these guidelines to WSF.

The State of Illinois has a guidance which lists practices that bring sustainable results to highway projects known as the Illinois Livable and Sustainable Transportation (ILAST). It was developed by using the NY State GreenLITES (IDOT 2010).

The International Organization for Standardization (ISO) has created the environmental series of standards for the purpose of providing a framework for organizations when they are creating environmental policy, plans, and actions (ISO 2011). This directly applies to WSF because the Safety Management System (SMS) which WSF employs has incorporated the environmental management system portion of ISO 14001 standards.

A good source for intermodal guidelines is the Port Authority of NY and NJ Sustainable Infrastructure Guidelines. These guidelines were developed in 2006 for the purpose of addressing projects that occur outside the building envelope (TPA 2010). Due to this intermodal approach, the Sustainable Infrastructure Guidelines apply quite well to the WSF system, although it is not completely comprehensive. However, the Sustainable Infrastructure Guidelines are currently still in draft status and are still under development and review.

The Marine Vessel Environmental Performance Assessment (MVeP) which is under development by the Society of Naval Architects and Marine Engineers (SNAME) applies to the waterside of WSF (SNAME 2010). MVeP is expected to be the best set of guidelines for marine vessels and can be implemented specifically for the ferries at WSF.

1.4.2 Current WSF Policies

Section 1.4.2 is further divided into two sections. Section 1.4.2.1 discusses the Safety Management System (SMS) at WSF while Section 1.4.2.2 summarizes the purpose of the Stormwater Pollution Prevention Plan (SWPPP) at WSF.

1.4.2.1 Safety Management System

WSF currently has a system in place which covers many best management practices. The safety management system (SMS) is set up in such a way that one can pull out chapters as needed when the appropriate situation arises. Some chapters of the SMS correspond well with the Stormwater Pollution Prevention Plan (SWPPP) that WSF is currently applying for stormwater quality purposes. The chapters that integrate into SWPPP are as follows:

- 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

A table provided by WSF fully outlines how these SMS chapters integrate into the SWPPP. This table can be found in Appendix A.

1.4.2.2 Stormwater Pollution Prevention Plan

The stormwater pollution prevention plan was created specifically for the following WSF terminals:

- Anacortes
- Bainbridge
- Bremerton
- Colman Dock (Seattle, Pier 52)
- Edmonds
- Fauntleroy
- Mukilteo
- Point Defiance
- Southworth
- Tahlequah
- Vashon

The SWPPP covers different BMPs that have been or soon will be implemented at the previously stated terminals. This was done to meet the requirements of the WSDOT Municipal Permit according to the National Pollutant Discharge Elimination System (NPDES). This SWPPP is used as a training guide for WSF employees on policies and procedures associated with stormwater management.

1.4.3 Similar Sites and Challenges

An example of managing stormwater on an over-water infrastructure is the nearby State Route 520 floating bridge across Lake Washington. Washington State Department of Transportation (WSDOT) recently developed alternatives for possible replacement of this bridge (WSDOT 2010). One of the environmental concerns the SR 520 report focused on was the most effective stormwater treatment available based on All Known, Available and Reasonable Technology (AKART). After initially examining 15 different technologies, four alternatives were selected for further investigation to see which one was best applied. The four alternatives were:

- Media filtration-vaults
- Catch basin media filtration
- Modified catch basins/cleaning
- High-efficiency sweeping

The first three alternatives all make use of storing water for filtration underneath the bridge. In many areas at this latitude storing water is accompanied with concerns about freezing possibilities. However, due to the extremely close proximity to Lake Washington, freezing is not an issue when storing water underneath the floating bridge. A ferry trestle on the Puget Sound is a similar situation in this respect so the same solutions might be effectively applied at WSF.

The first alternative, media filtration-vaults, focused on treating stormwater by the use of media beds. These beds are stored horizontally on the deck underneath the highway. Different configurations of this setup were attempted but all used a pre-treatment to remove oil and grease followed by media such as sand, pearlite, peat, and zeolite to treat major pollutants typically found in stormwater. The media is periodically cleaned or replaced.

The catch basin media filtration alternative uses filters such as media pillows, filter bags, or cartridges which are placed inside catch basins. These inserts are set up with overflow capabilities. During high flows they will only treat the first flush of stormwater and allow the remaining flow to bypass the filter so as to maintain an adequate draining speed. These require some maintenance in that they must be replaced from time to time.

The third alternative is the modified catch basin sweeping and cleaning, including extra large catch basins to increase the amount of sediments that can be trapped. Oil/grease trapping would occur due to submerged outlets and large sumps would increase the residence time for sediments allowing for less regular cleaning of the filters.

Finally, the fourth alternative refers to the Western Washington Stormwater Manual and its new generation sweeping technology. This sweeping technology consists of a regenerative air sweeper and a return vacuum. The sweeper blows air directly down onto the pavement while vacuuming up the air and pollutants. This has been shown to reduce the dirt particles with a diameter of less than 250 microns by 25 to 50 percent (Sutherland 1998).

Of these four alternatives it was concluded that a combination of high-efficiency sweeping and modified catch basins and cleaning was the most applicable. Some benefits of this combination 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.

Another example of stormwater treatment on a similar site can be seen at the WSF Bainbridge Island terminal. It is at this terminal that the KriStar stormwater detention basin has been put in to treat stormwater. The system is designed to capture and retain sediment, oils, and metals, reducing the total discharge load. Data has shown that the system has been effective in removing pollutants associated with stormwater runoff from the upland holding area. The Kristar system is made from polymeric components and contains a polymer-coated steel support screen which allows different media to be used depending on the targeted pollutants. The system earned the General Use Level Designation from the Washington State Department of Ecology (Kristar 2010). This system is an example of a type of treatment/storage facility which could be implemented at other terminals where overland area is available. A diagram illustrating the system setup at the Bainbridge Island terminal is shown in Figure 1.1.

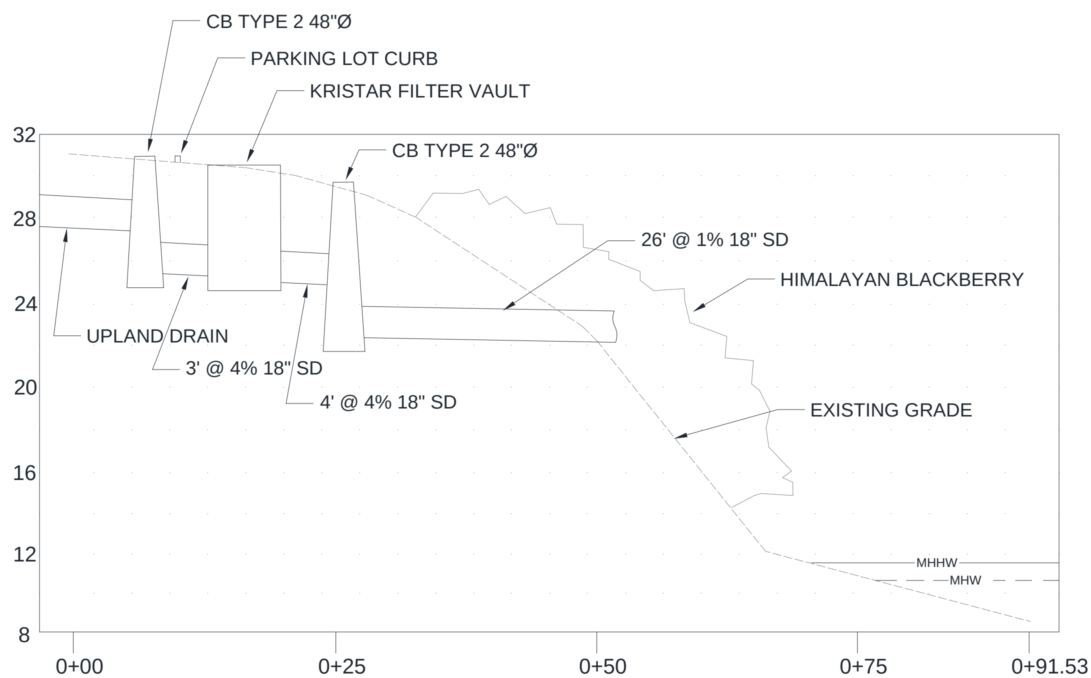

Figure 1.1: Side view of Kristar system at the Bainbridge Island terminal

The Kristar stormwater vault collects rainwater running off of the holding area through the already in place stormwater catch basins and pipes. After filtering out pollutants the water is than released through a large pipe on the side of the hill. The hill is vegetated to allow the water to infiltrate and take out other pollutants before entering the Puget Sound.

1.4.4 LID practices

Several LID/BMP methods are applicable for ferry terminals. One of the possible LID techniques that could be used is pervious pavement, which vertically infiltrates stormwater at the source or is used as an overlay over existing pavement to filter the stormwater through horizontal flow. 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 (Rushton 2001; Battebo and Booth 2003; Bean et. al 2007). 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 Total Suspended Solids (TSS), 36% for phosphorus, 52% for copper, 88% for lead, and 79% for zinc.

When land is available, an available LID technique is a bio-retention pond or rain garden. These are set up to retain water and allow stormwater pollutants to settle out and infiltrate over a period of time. These are typically designed with an overflow system for large events, so that only the first flush is treated.

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. The first area was in Greenbelt, MD and resulted in a 16% retention rate for nitrate, 52% for Total Kjeldahl Nitrogen (TKN), 65% of total phosphorus and 49% of total nitrogen. There was also over 95% retention of copper, lead, and zinc. The second site looked at by Davis et al., in Largo, MD, had similar reduction rates for nitrogen and phosphorous, but heavy metal retention rates ranged from 43% for copper to 70% for lead.

Dietz and Clausen (2006) constructed a replicate rain garden to treat roof runoff. The gardens were constructed to hold one inch of runoff. The gardens were constructed in Haddam, CN and reduction rates of all types of nitrogen ranged from 26% for TKN to 82% for ammonia. Phosphorous levels increased.

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. The pollutants examined in this study were total suspended solids, which was reduced by 96%, and nitrate which was reduced by 27%.

Finally, Hunt et al. (2006) evaluated three different field sites with varying fill media type and drainage configuration. The Greensboro, NC site resulted in a reduction in heavy metals between 81 and 99 percent with no reduction in nitrogen while the Chapel Hill, NC site resulted in reduction in nitrogen-based pollutants ranging from 13% for nitrate to 86% for ammonia. This data shows how the LID techniques have a wide range of results depending on location and design. The results of the previously stated studies are shown in Table 1.1.

Table 1.1: Summary of bioretention pollutant retention

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

Another possible treatment method if there is adequate land available is constructed wetlands. This is a low maintenance method which treats stormwater by allowing plants to take up and remove pollutants from the water. Similar to bio-retention ponds and rain gardens, wetlands also have a wide variety in removal efficiencies. 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 in metals uptake at first, but the accumulation of metals in the plants may eventually be maximized and the wetland will no longer remove metals.

Bioinfiltration swales can be considered a best management practice or low impact development technique that consists of some vegetation where sediments collect as the stormwater is directed through the vegetation to a storm drain. These have been shown to reduce TSS by 81%, total nitrogen by 84%, total phosphorus by 34%, copper by 51% and zinc by 71% (Winer 2000). A very similar technique is a buffer strip which removes pollutants as stormwater flows through the vegetation before going into a storm drain. A study by Sheridan et al. (1999) showed that grass buffer strips used along highways reduce the total suspended solids in stormwater by around 80%. Karr and Schlosser (1997) concluded in their article that an 85% reduction of phosphorus in stormwater can be achieved by use of a vegetated buffer strip. Also, another study showed that buffer strips are also successful in removing fecal matter at a 60% removal rate (Grismer, 1981).

In addition to the previously stated LID techniques, there are also a few best management practices which can be applied to help with stormwater pollution prevention on the trestle. One practice could be prohibiting dirty or leaking vehicles from parking on the trestle, or simply providing a wheel wash at the entrance to minimize the pollutants located on tires from accumulating on the holding areas. Another is silt curtains could be applied along the side of the trestle in front of the scuppers to absorb some of the sediment before the stormwater is deposited directly into Puget Sound.

2. RATING SYSTEM AND DEVELOPMENT OF GREEN RATING INTEGRATION PLATFORM

This chapter first discusses the different rating systems that are applicable for ferry terminals in Section 2.1. Section 2.2 integrates these rating systems together to show how credits relate across the rating systems. Section 2.3 then further looks at the stormwater portion of this integration. Current WSF procedures are added to this integration in Section 2.4. Finally, Section 2.5 combines all these together to create one final stormwater Green Rating Integration Platform.

2.1 Rating Systems

Five of the rating systems detailed in section 1.4.1 were chosen as being applicable to WSF. The GreenLITES system was chosen to focus on the upland area of ferry trestles due to its applicability with multiple forms of transportation and its focus on highways, as well as its availability compared to the other rating systems with a focus on transportation. The next rating system that seemed applicable was the LEED retail system for new construction. As one of the most well known and recognizable systems, it was important to include this system to help show how other rating systems are similar. The LEED system is focused more on the landside of the ferry trestle, especially any terminal buildings that may be located on the trestle. Sustainable Sites Initiative was the third rating system chosen due to its excellent focus on stormwater management as well as integration of a construction project into a community. This rating system will also be more focused on the land side of the ferry terminal.

The Port Authority of NY/NJ Sustainable Infrastructure Guidelines was chosen due to its intermodal focus and thereby relevant to the WSF situation. While this is still in draft status and not completely comprehensive, its focus on construction projects outside the building envelope makes it valuable when developing a system for WSF. Finally, the MVeP guidelines were chosen for the marine side of ferry trestles due to its focus on water vessels. The rating systems chosen are shown below in Table 2.1.

Table 2.1: Rating systems chosen for the Green Rating Integration Platform

Rating System	**Focus Area**	**Source**
GreenLITES	Upland	New York DOT
LEED retail	Landside	US Green Building Council
Sustainable Sites Initiative	Landside	American Society of Landscape Architects; University of Texas; United States Botanical Garden
Sustainable Infrastructure Guidelines	Intermodal	Port Authority of NY/NJ
MVeP	Waterside	Society of Naval Architects and Marine Engineers

2.2 Rating System Integration

All five of these rating systems were then organized based upon a previous work done by Washington State University in 2009 for WSF (D'Agneaux 2009). The previous work was done by graduate student Ines De Sainte Marie D'Agneaux under Dr. Wolcott and entailed creating a guideline system for ferries. This report was split into seven areas of focus entitled:

- Traffic and Parking

  This section focuses on increasing capacity and customer satisfaction while decreasing the negative impacts of vehicles on the surrounding area.

- Integration in the Community

This category focuses on practices which supports positive impacts on the surrounding community in order to increase general acceptance. Some examples include reducing light and noise pollution and improving aesthetics of the terminal.

- Energy Management

  This category focuses on reducing energy use and energy related pollution while limiting the dependence on the energy grid.

- Water Management

  This section focuses on both the use of potable water as well as limiting stormwater runoff.

- Materials Management

  This focus area attempts to limit the overall use of resources, and replace materials with reused and recycled options when possible.

- Site Selection

  Mainly, the use of gray or brownfield sites where appropriate.

- Air Quality

  This focuses both on limiting the air pollution produced from the site as well as improving indoor air quality in any buildings on the site.

For this report the site selection category was renamed construction phase and expanded to include all aspects of construction instead of only being limited to site selection. The five rating systems were separated into the above listed categories to help ease the integration across the systems. This Green Rating Integration Platform is shown in Table 2.2.

The GreenLITES rating system is divided into the five categories of sustainable sites, water quality, materials and resources, energy and atmosphere, and an unlisted innovation category. One of the sustainable sites credits fit well into the construction phased category while the other four more address the community/social aspects as opposed to the construction phase aspects. The water quality and materials and resources sections transpose well into the water management and materials management sections respectively. Finally, the energy and atmosphere section has two credits which may correlate with the energy management section, two which fit with traffic and parking, and two which deal with community/social aspects. GreenLITES lacks credits which fit specifically into the air quality section.

The LEED retail system is divided into seven separate categories. The five main categories of sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality are joined by two other areas of innovation and regional priority. The sustainable sites category has credits applicable for four different sections outlined in the WSU Ferry Guidelines. Three of the credits having to do with pollution prevention and site selection fit well with the construction phase category. One credit about transportation went into the traffic/parking section while two stormwater credits landed in the water management category. The majority (five) of the sustainable sites credits were placed in the community and social section. All four of the water efficiency prerequisites and credits transferred over into the water management section. A majority of the energy and atmosphere credits went into the energy management section with the two atmosphere focused credits were instead placed in the community/social section. Similar to the water efficiency section, all of the materials and resources credits fit into the materials management category. Finally, indoor environmental quality was divided with five credits fitting into the air quality category, three fitting into community/social, and one credit in each of the material management and construction phase categories.

Sustainable Sites Initiative (SITES) has the most applicable credits of any rating system examined in this thesis as well as the most categories in which the credits are divided into. The eight categories in the SITES rating system are: site selection, assessment and planning, water, soil and vegetation, materials selection, human health and well being, construction, and operations and maintenance. Similar to GreenLITES the site selection category contains elements which transfer to both the community/social and construction phase sections of the WSU Ferry Guidelines. The assessment and planning category is technically pre-design but was included in the construction phase category. The water, materials, human health and well being, and construction sections transfer completely to the water management, materials management, community/social, and construction phase categories respectively. The soil and vegetation section contains elements which fit in each of the community/social, energy management, and construction phase categories. Finally, the operations and maintenance category contains BMPs involving energy management, water management, materials management, and air quality. The Sustainable Sites Initiative has its majority of credits fall into the community/social category and none which fall into the traffic/parking category.

The draft Port Authority of NY/NJ Sustainable Infrastructure Guidelines (Port) has similar sections to the WSU Ferry Guidelines. This rating system is divided into six categories of site, water, energy, materials, construction, and maintenance and operations. The site section is the only section of the six to be divided when transferred into the WSU Ferry Guidelines format. The Port site section has credits which fall into the categories of traffic/parking, community/social, water management, materials management, and construction phase. The Port water, energy, material, and construction sections expectedly fit into the water management, energy management, materials management, and construction phase categories in the WSU Ferry Guidelines. Finally, the maintenance and operations category deals with watering landscaping and is thereby placed in the water management category. The Port rating system also does not have credits which fit directly into the air quality category.

The MVeP rating system, which is focused on vessels and waterside, is divided into the four categories of energy efficiency, air emissions, water emissions, and general measures. The energy efficiency and water emissions can be placed entirely within energy management and water management respectively. The air emissions category fits mostly into the air quality category with one credit addressing ozone depletion fitting into the community/social category. Finally the general measures section contains credits which fit into the community/social, water management, and materials management categories. There are no credits regarding vessels which fit into traffic/parking or construction phase categories.

Table 2.2: Green Rating Integration Platform of five green rating systems with WSU Ferry Guidelines

	Upland	Land Side	Land Side	Intermodal	Intermodal	Marine Side
	GreenLITES	LEED retail	Sustainable Sites Initiative	Port Authority	WSU Ferry Guidelines	MVeP
Traffic/Parking	☐ E-1: Improve Traffic Flow	☐ SSc4-Alternative Transportation		☐ IS-17: Optimize Traffic Safety	☐ Promote HOV	
	☐ E-4:Bicycle/Pedestrian Facilities			☐ IS-19:Enhance Intermodal Connectivity	☐ Encourage walk-ons	
				☐ IS-20:Transportation System Management	☐ Encourage bicycle use	
				☐ IS-21:Transportation Technologies	☐ Facilitate drop-off	
					☐ Park-and-ride program	
					☐ Shared-car program	
					☐ Optimize traffic flow	
					☐ Reservation system	
					☐ Peak periods prices	
					☐ Allow future growth	
Community/Social	☐ S-2: Context Sensitive Solutions	☐ SSc2-Community Connectivity	☐ SSp1.2-Protect floodplain functions	☐ IS-5: Protect Ecological Health	☐ Architecturally blend	☐ GM3.1-Aquatic Life Impact
	☐ S-3: Land Use Planning	☐ SSc5.1-Protect or Restore Habitat	☐ SSp1.3-Preserve wetlands	☐ IS-6:Maintain Absorbent Landscapes	☐ Visitor center	☐ GM3.2-Shore Protection
	☐ S-4: Protect Wildlife Habitat	☐ SSc5.2-Maximize Open Space	☐ SSp1.4-Preserve endangered species	☐ IS-8:Utilize Appropriate Vegetation	☐ Include guided tours	☐ AE6-Ozone-Depleting
	☐ S-5: Protect Plant Communities	☐ SSc7-Heat Island Effect	☐ SSc1.6-Select sites in communities	☐ IS-14: Mitigate Heat Island Effect	☐ Prevent flood damage	
	☐ E-5: Noise Abatement	☐ SSc8-Light Pollution Reduction	☐ SSc1.7-Accessible to public transit	☐ IS-15:Minimize Light Pollution	☐ Allow change in activity	
	☐ E-6: Stray Light Reduction	☐ EAp3-Refrigerant Management	☐ SVp4.1-Control invasive plants	☐ IS-16: Optimize Public Environments	☐ No ozone depleting substances	
		☐ EAc4-Refrigerant Management	☐ SVp4.2-Use non-invasive plants		☐ Light Pollution Prevention	
		☐ IEQc6-Controllability of Systems	☐ SVp4.3-Soil management plan		☐ Noise Pollution Prevention	
		☐ IEQc7-Thermal Comfort	☐ SVc4.5-Preserve special status veg.		☐ Wildlife Considerations	
		☐ IEQc8-Daylighting and Views	☐ 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			
Energy	☐ E-2: Reduce Electrical	☐ EAp2-Minimum Energy Performance	☐ SVc4.10-Minimize heating	☐ IE-1: Optimize Energy Performance	☐ Produce renewable energy	☐ EE1.1-Lighting
	☐ E-3: Reduce Petroleum	☐ EAc1-Optimize Energy	☐ SVc4.11-Minimize cooling	☐ IE-2:Electrical and Mechanical Systems	☐ Use waste heat from engine	☐ EE1.2-HVAC
		☐ EAc2-On-site Renewable Energy	☐ OMc8.4-Reduce energy consumption	☐ IE-3: Utilize End Use Metering	☐ Use local material	☐ EE1.3-Pump Systems
		☐ EAc5-Measurement and Verification	☐ OMc8.5-Use renewable energy	☐ IE-4: Use On-Site Renewable Energy	☐ Minimal embodied energy	☐ EE1.4-Mechanical Equipment
		☐ EAc6-Green Power		☐ IE-5: Protect Ozone Layer	☐ Daylight harvesting	☐ EE1.5-Hull/Propeller
				☐ IE-6: Provide Alternative Fueling Stations	☐ High-efficiency systems	☐ EE1.6-Route Optimization
					☐ Individual control in offices	☐ EE1.7-Vessel Speed
					☐ Automatic control in public	☐ EE1.8-Energy Recovery
					☐ Automatically turn off lights	☐ EE1.9-Hull Optimization
					☐ High reflectance	☐ EE2.1-Other Fuels
						☐ EE2.2-Renewable Energies
						☐ EE3-Carbon Footprint
Water	☐ W-1: Stormwater Management	☐ SSc6.1-Stormwater Quantity Control	☐ Wp3.1-Reduce landscape irrigation	☐ IS-7: Utilize Pervious Pavement	☐ Emergency plan for spills	☐ WE1-Oily Water
	☐ W-2:BMPSs	☐ SSC6.2-Stormwater Quality Control	☐ Wc3.2-Reduce landscape irrigation	☐ IS-9: Use Turfgrass Appropriately	☐ Oil separation equipment	☐ WE2-Non-Indigenous Species
		☐ WEp1-Water Use Reduction	☐ Wc3.3-Protect/Restore buffers	☐ IW-1: Implement Stormwater BMPs	☐ Non toxic paint	☐ WE2.1-Ballast Water/Sediment
		☐ WEc1-Water Efficient Landscaping	☐ Wc3.4-Rehabilitate streams	☐ IW-2: Implement Rainwater Neutrality	☐ High-efficiency fixtures	☐ WE2.2-Hull Fouling
		☐ WEc2-Innovative Technologies	☐ Wc3.5-Manage stormwater on site	☐ IW-3: Reduce Use of Potable Water	☐ Prevent leaks	☐ WE3-Sanitary Systems
		☐ WEc3-Water Use Reduction	☐ Wc3.6-On-site water resources	☐ IW-4: Utilize End Use Metering	☐ Reduce potable water	☐ WE4-Solid Waste
			☐ Wc3.7-Use stormwater for landscape	☐ IO-1:Sustainable Landscape Maintenance	☐ Reduce city water	☐ WE5-Incidental Discharges
			☐ Wc3.8-Maintain water features	☐ IO-2: Maintain Soil Quality	☐ Treat wastewater on-site	☐ WE6-Protection of Oil
			☐ OMp8.1-Sustainable maintenance		☐ Implement LIDs	☐ GM2-Hotel Water Use
					☐ Collect runoff/rainwater	
					☐ Treat water on boat	
					☐ Maintain ballast tanks	
					☐ Exchanges off-shore	
Materials	☐ M-1: Reuse of Materials	☐ MRp1-Recyclables	☐ MSp5.1-Eliminate threatened wood	☐ IS-10: Amend and Reuse Existing Soils	☐ Reduce waste due to activity	☐ GM1-Materials
	☐ M-2: Recycle content	☐ MRc1.1-Building Reuse-Exterior	☐ MSc5.2-Maintain often	☐ IS-11: Balance Earthwork	☐ Recycling dumpsters	☐ GM4-Inventory Program
	☐ M-3: Locally Provided Material	☐ MRc1.2-Building Reuse-Interior	☐ MSc5.3-Design for deconstruction	☐ IM-1: Use Recycled Materials	☐ Sort waste for recycling	☐ GM5-Ship Recycling
	☐ M-4: Bioengineering Techniques	☐ MRc2-Waste Management	☐ MSc5.4-Reuse salvaged materials	☐ IM-2: Use Local/Regional Materials	☐ Recycle bins	
	☐ M-5: Hazardous Minimization	☐ MRc3-Materials Reuse	☐ MSc5.5-Recycled content materials	☐ IM-3: Reuse Materials	☐ High-recyclable materials	
		☐ MRc4-Recycled Content	☐ MSc5.6-Use certified wood	☐ IM-4: Use Durable Materials	☐ Hazardous waste plan	
		☐ MRc5-Regional Materials	☐ MSc5.7-Use regional materials	☐ IM-5:Sustainably Harvested Wood	☐ Sustainable materials	
		☐ MRc6-Rapidly Renewable Materials	☐ MSc5.8-Reduce VOC emissions	☐ IM-6: Minimize Toxic Materials	☐ Low-emitting materials	
		☐ MRc7-Certified Wood	☐ MSc5.9-Sustainable plant production	☐ IM-7: Enhance Pavement Lifecycle		
		☐ IEQc4-Low-Emitting Materials	☐ MSc5.10-Sustainable manufacturing	☐ IM-8: Utilize Thin Surface Paving		
			☐ OMp8.2-Collect recyclables	☐ IM-9: Utilize WMA Technology		
			☐ OMc8.3-Recycle organic matter			
Air Quality		☐ IEQp1-Minimum IAQ	☐ OMc8.6-Minimize tobacco smoke		☐ Outside air intake	☐ AE1-NOx Reductions
		☐ IEQp2-ETS control	☐ OMc8.7-Minimize greenhouse gases		☐ Natural ventilation	☐ AE2-Sox Reductions
		☐ IEQc1-Outdoor Air Monitoring	☐ OMc8.8-Reduce emissions		☐ Minimize chemical use	☐ AE3-PM Reductions
		☐ IEQc2-Increased Ventilation			☐ Reduce flying dirt	☐ AE4-VOC
		☐ IEQc5-Indoor Pollutant Control			☐ Limit engines running	☐ AE5-GHGs
					☐ Avoid fossil fuel engines	☐ AE7-Port Air Emissions
Construction Phase	☐ S-1: Alignment Selection	☐ SSp1-Pollution Prevention	☐ SSp1.1-Limit farmland development	☐ IS-1:Integrated Team Approach	☐ Brownfield site	
		☐ SSc1-Site Selection	☐ SSc1.5-Select brownfields	☐ IS-2: Prepare a Site Assessment	☐ Clean polluted water	
		☐ SSc3-Brownfield Redevelopment	☐ PDp2.1-Pre-design assessment	☐ IS-3:Previously Developed Sites	☐ Reduce construction waste	
		☐ EAp1-Fundamental Commissioning	☐ PDp2.2-Integrated site development	☐ IS-4:Known Contaminated Sites	☐ Dredging	
		☐ EAc3-Enhanced Commissioning	☐ PDc2.3-Engage users in site design	☐ IS-12: Coordinate Utility Work		
		☐ IEQc3-Construction IAQ	☐ SVp4.4-Minimize soil disturbance	☐ IS-13: Utilize Trenchless Technology		
			☐ Cp7.1-Control construction pollutants	☐ IS-18:Roadway Alignment Section		
			☐ Cp7.2-Restore disturbed soils	☐ IC-1: Minimize Pollution		
			☐ Cc7.3-Restore disturbed soils	☐ IC-2: Protect Existing Natural Systems		
			☐ Cp7.4-Divert materials from disposal	☐ IC-3:Transportation Management		
			☐ Cp7.5-Reuse soil	☐ IC-4:Green Construction Equipment		
			☐ Cp7.6-Minimize emissions	☐ IC-5: Reduce Noise and Vibration		
				☐ IC-6:Waste Management		
				☐ IC-7:Integrated Pest Management		

With this integration setup one can quickly see how the credits relate across rating systems. This integration only shows the title of each credit, more detailed management practices of each credit for the rating systems is located in Appendix B. This Green Rating Integration Platform currently relates different green rating systems together and integrates in guidelines as well. Future work could be done with the Green Rating Integration Platform to expand this integration to include regulations and design standards, further helping WSF to make design, construction, and operations and maintenance decisions. This will be further expanded upon in Chapter 7.

2.3 Stormwater Guidelines

For the purpose of this thesis, the focus is on stormwater treatment of ferry terminals. Focusing on the water section of Table 2.2 and the stormwater credits within that section, Table 2.3 shows stormwater guidelines across the green rating systems with additional practices below each rating credit, integrated with the WSU Ferry Guidelines.

Table 2.3: Stormwater guidelines across multiple green rating systems

Upland GreenLITES	Land Side LEED retail	Land Side Sustainable Sites Initiative	Intermodal Port Authority	Intermodal WSU Ferry Guidelines	Marine Side MVeP
☐ **W-1: Stormwater Management**	☐ **SSc6.1-Stormwater Quantity Control**	☐ **Wc3.3-Protect/Restore buffers**	☐ **IS-7: Utilize Pervious Pavement**	☐ Emergency plan for spills	☐ **WE1-Oily Water**
☐ Stormwater retrofitting	☐ Maintain predevelopment rates	☐ Design to avoid disturbance	☐ Use pervious concrete, asphalt, pavers	☐ Oil separation equipment	☐ Use separating equipment
☐ Eliminate non-SW discharge	☐ Protect streams from erosion	☐ Re-establish vegetated areas	☐ Use vegetated bioswales or ditches	☐ Non toxic paint	☐ Monitor discharge
☐ Reduce impervious area	☐ **SSc6.2-Stormwater Quality Control**	☐ Manage invasive plant species	☐ Utilize salt-splashes at roadway edge	☐ Treat wastewater on-site	☐ **WE2-Non-Indigenous Species**
☐ **W-2:BMPSs**	☐ Reduce impervious cover	☐ **Wc3.4-Rehabilitate streams**	☐ Use structural soil to enhance percolation	☐ Implement LIDs	☐ **WE2.1-Ballast Water/Sediment**
☐ Use highly permeable soils	☐ Promote infiltration	☐ Remove stream modifications	☐ **IS-9: Use Turfgrass Appropriately**	☐ Collect runoff/rainwater	☐ Ballast water treatment system
☐ Use wet or dry swales	☐ Capture and treat stormwater	☐ Don't disrupt sediment transport	☐ Resilient, resistant, low-maintenance veg.	☐ Treat water on boat	☐ Reduce NIS vector
☐ Use sand filters or filter bag		☐ **Wc3.5-Manage stormwater on site**	☐ Substitute ground covers for turfgrass	☐ Maintain ballast tanks	☐ **WE2.2-Hull Fouling**
☐ Use oil/grit separators		☐ Consider entire hydrologic cycle	☐ **IW-1: Implement Stormwater BMPs**	☐ Exchanges off-shore	☐ Clean vessel exterior
☐ Underground detention systems		☐ Minimize impervious cover	☐ Implement SW management plan		☐ Use hull coating
☐ Catch basin inserts		☐ Reduce runoff	☐ Lower peak runoff rates		☐ **WE3-Sanitary Systems**
☐ Permeable pavement		☐ **Wc3.6-On-site water resources**	☐ Treat stormwater for TSS		☐ Improve quality of treated water
		☐ Reduce impervious cover	☐ Mark storm drains		☐ Reduce water discharge
		☐ Disconnect impervious cover	☐ Bioretention systems		☐ **WE4-Solid Waste**
		☐ Provide depression storage	☐ Constructed stormwater wetlands		☐ Buy in bulk
		☐ Convey stormwater in swales	☐ Dry wells		☐ Re-usable and washable items
		☐ Use biofiltration	☐ Extended detention basins		☐ Recycle
		☐ Exapotranspire	☐ Infiltration structures		☐ Low emission handling system
		☐ Infiltrate stormwater	☐ Manufactured treatment devices		☐ **WE5-Incidental Discharges**
		☐ Minimize material pollutants	☐ Pervious paving		☐ **WE6-Protection of Oil**
		☐ Reduce pollutant exposure to SW	☐ Sand filters		☐ Structural protection
		☐ **Wc3.7-Use stormwater for landscape**	☐ Rain garden		
		☐ **Wc3.8-Maintain water features**	☐ **IW-2: Implement Rainwater Neutrality**		
		☐ Mimic natural environment	☐ Infiltrate stormwater		
		☐ Maintain compatibility	☐ Mark storm drains		
		☐ Estimate available rainwater	☐ **IO-2: Maintain Soil Quality**		
		☐ Collect/Reuse potable water	☐ Prevent soil pollution		
		☐ Maintain as natural ecosystems	☐ Protect soil and minimize erosion		
		☐ Biologically-based water treatment	☐ Recycle organic waste		
			☐ Manage snow/ice deicing or removal		
			☐ Prepare a watering schedule		

The WSU Ferry Guidelines section was expanded in a recent report developed by WSU for WSF (Wolcott et al. 2011). The report detailed several different guidelines relating to stormwater on both the landside and water side of the terminal. The additional techniques are divided into several categories for both the landside and waterside and can be found in Tables 2.4 and 2.5.

Table 2.4: WSU Ferry Guidelines stormwater BMPs for landside of terminal

Fueling	**Landscape Management**	**Treatment System Maintenance**	**Parking and Storage**	**Roof/Building Drains**	**LIDs**
Emergency plan for spills	PMP free of pesticides	Oil/water separator	Dispose wastewater to sewer	Analyze runoff from buildings	Pervious pavement
Slope fueling pad	Use less toxic pesticides	Clean regularly	Sweep regularly		Bio-retention ponds/swales
Spill containment pad	No pesticides near water	Inspect and repair	Oil removal system		Constructed stormwater wetland
Roof over fueling area	Mulch exposed soils	Repair promptly			Buffer strips
		Prevent sediment discharge			Dispersion
					Vegetated roofs
					Rainwater harvesting
					Path disconnect

Table 2.5: WSU Ferry Guidelines stormwater BMPs for waterside of terminal

Loading and Unloading	**Maintenance of Vessels**	**Mobile Fueling**	**LIDs**
Sweep areas	Maintenance in a covered area	Drip pan/pad	Stormwater neutrality
Drip pans	Store in a covered area	Spill remedy kit	Treatment
Marine Loading per Coast Guard	Avoid toxic liquid chemicals		Pollution prevention
Berm, slope or dikes			
Curb along shoreline			
Prevent pooling			

2.4 WSF Stormwater Pollution Prevention Plan

WSF already has a Safety Management System in place which corresponds well with some elements of the developing Stormwater Pollution Prevention Plan as detailed in Section 1.4.2. In the previously mentioned table, provided by WSF and located in Appendix A, four activities relate well with stormwater management. The four activities relating to water management covered in this table are:

- Ramp Operations
- Fuel and Hydrocarbon Use
- Buildings & Grounds Operations and Maintenance
- Dirt and Sediments

Each of these activities covers specific pollutant sources, lists possible BMPs, and states where the activity is covered in the SMS. This information was reorganized as seen in Table 2.6 in order to help ease the integration of current WSF practices with the above green rating systems.

Table 2.6: WSF current water management guidelines

Activity	BMP	Pollutant Source
Ramp Operations	☐ Environmentally friendly hydraulic oils	Hydraulic System and Cables
	☐ Charge hose with potable water	Sewage Transfers Hose
Fuel and Hydrocarbon Use		Oil Container Transfers
	☐ Designated area	Fuel Storage & Transfers
	☐ Park in covered area	Terminal Bulls
	☐ Drip pan or pad	
	☐ Environmentally friendly fuel	
	☐ Retrofit covered parking	
Buildings & Grounds Operations and Maintenance	☐ Use coated materials	Roofs, Gutter, & Downspouts
	☐ Use coated materials	Galvanized fencing
	☐ Weekly inspection	Stormwater Catch Basins
	☐ Yellow circle around drains	
	☐ Integrated pest management	Vegetation Management
	☐ Use approved herbicides	
	☐ Mechanical control preferred	
	☐ Bioswale maintenance	
	☐ Supplies elevated and covered	Maintenance and Cleaning
	☐ Environmentally friendly supplies	
	☐ No dumping of cleaning waters	
	☐ Use containment	Painting
	☐ Cover drains	
Dirt and Sediments	☐ Vacuum holding area quarterly	Windblown & tracked in
	☐ Weekly terminal stormwater inspection	
	☐ Daily holding area inspection/mop up	

2.5 Green Rating Integration Platform

The SMS (Table 2.6) was then combined with the five rating systems (Table 2.3) and the updated WSU Ferry Guidelines (Tables 2.4 and 2.5) into one table so that all information could be cross-referenced. The stormwater section of the green rating integration platform is shown in Table 2.7.

Table 2.7: Stormwater Green Rating Integration Platform with SMS and expanded WSU Ferry Guidelines

Upland GreenLITES	Land Side LEED retail	Land Side Sustainable Sites Initiative	Intermodal Port Authority	SMS Activity	SMS BMP	SMS Pollutant Source	Intermodal WSU Ferry Guidelines	Marine Side MVeP
☐ **W-1: Stormwater Management**	☐ **SSc6.1-Stormwater Quantity Control**	☐ **Wc3.3-Protect/Restore buffers**	☐ **IS-7: Utilize Pervious Pavement**	Ramp Operations	☐ Environmentally friendly hydraulic oils	Hydraulic System and Cables	☐ **Fueling**	☐ **WE1-Oily Water**
☐ Stormwater retrofitting	☐ Maintain predevelopment rates	☐ Design to avoid disturbance	☐ Use pervious concrete, asphalt, pavers		☐ Charge hose with potable water	Sewage Transfers Hose	☐ Emergency plan for spills	☐ Use separating equipment
☐ Eliminate non-SW discharge	☐ Protect streams from erosion	☐ Re-establish vegetated areas	☐ Use vegetated bioswales or ditches	Fuel and Hydrocarbon Use		Oil Container Transfers	☐ Slope fueling pad	☐ Monitor discharge
☐ Reduce impervious area	☐ **SSc6.2-Stormwater Quality Control**	☐ Manage invasive plant species	☐ Utilize salt-splashes at roadway edge		☐ Designated area	Fuel Storage & Transfers	☐ Spill containment pad	☐ **WE2-Non-Indigenous Species**
☐ **W-2:BMPSs**	☐ Reduce impervious cover	☐ **Wc3.4-Rehabilitate streams**	☐ Use structural soil to enhance percolation		☐ Park in covered area	Terminal Bulls	☐ Roof fueling area	☐ **WE2.1-Ballast Water/Sediment**
☐ Use highly permeable soils	☐ Promote infiltration	☐ Remove stream modifications	☐ **IS-9: Use Turfgrass Appropriately**		☐ Drip pan or pad		☐ **Landscape Management**	☐ Ballast water treatment system
☐ Use wet or dry swales	☐ Capture and treat stormwater	☐ Don't disrupt sediment transport	☐ Resilient, resistant, low-maintenance veg.		☐ Environmentally friendly fuel		☐ Pest Management Plan	☐ Reduce NIS vector
☐ Use sand filters or filter bag		☐ **Wc3.5-Manage stormwater on site**	☐ Substitute ground covers for turfgrass		☐ Retrofit covered parking		☐ Less toxic pesticides	☐ **WE2.2-Hull Fouling**
☐ Use oil/grit separators		☐ Consider entire hydrologic cycle	☐ **IW-1: Implement Stormwater BMPs**	Buildings & Grounds Operations and Maintenance	☐ Use coated materials	Roofs, Gutter, & Downspouts	☐ No pesticides 100' to water	☐ Clean vessel exterior
☐ Underground detention systems		☐ Minimize impervious cover	☐ Implement SW management plan		☐ Use coated materials	Galvanized fencing	☐ Pesticide alternatives	☐ Use hull coating
☐ Catch basin inserts		☐ Reduce runoff	☐ Lower peak runoff rates		☐ Weekly inspection	Stormwater Catch Basins	☐ Mulch exposed soils	☐ **WE3-Sanitary Systems**
☐ Permeable pavement		☐ **Wc3.6-On-site water resources**	☐ Treat stormwater for TSS		☐ Yellow circle around drains		☐ **SW Maintenance**	☐ Improve quality of treated water
		☐ Reduce impervious cover	☐ Mark storm drains		☐ Integrated pest management	Vegetation Management	☐ Oil separation equipment	☐ Reduce water discharge
		☐ Disconnect impervious cover	☐ Bioretention systems		☐ Use approved herbicides		☐ Clean drainage systems	☐ **WE4-Solid Waste**
		☐ Provide depression storage	☐ Constructed stormwater wetlands		☐ Mechanical control preferred		☐ Inspect BMP systems	☐ Buy in bulk
		☐ Convey stormwater in swales	☐ Dry wells		☐ Bioswale maintenance		☐ Perform repairs promptly	☐ Re-usable and washable items
		☐ Use biofiltration	☐ Extended detention basins		☐ Supplies elevated and covered	Maintenance and Cleaning	☐ Prevent heavy discharge	☐ Recycle
		☐ Evapotranspire	☐ Infiltration structures		☐ Environmentally friendly supplies		☐ **Parking & Storage**	☐ Low emission handling system
		☐ Infiltrate stormwater	☐ Manufactured treatment devices		☐ No dumping of cleaning waters		☐ Dispose to sanitary sewer	☐ **WE5-Incidental Discharges**
		☐ Minimize material pollutants	☐ Pervious paving		☐ Use containment	Painting	☐ Sweep parking lots	☐ **WE6-Protection of Oil**
		☐ Reduce pollutant exposure to SW	☐ Sand filters		☐ Cover drains		☐ Oil removal system	☐ Structural protection
		☐ **Wc3.7-Use stormwater for landscape**	☐ Rain garden	Dirt and Sediments	☐ Vacuum holding area quarterly	Windblown & tracked in	☐ **Roof/Building Drains**	
		☐ **Wc3.8-Maintain water features**	☐ **IW-2: Implement Rainwater Neutrality**		☐ Weekly terminal stormwater inspection		☐ Sample SW runoff	
		☐ Mimic natural environment	☐ Infiltrate stormwater		☐ Daily holding area inspection/mop up		☐ **Loading & Unloading**	
		☐ Maintain compatibility	☐ Mark storm drains				☐ Treat water on boat	
		☐ Estimate available rainwater	☐ **IO-2: Maintain Soil Quality**				☐ Sweep loading areas	
		☐ Collect/Reuse potable water	☐ Prevent soil pollution				☐ Use drip pans	
		☐ Maintain as natural ecosystems	☐ Protect soil and minimize erosion				☐ Loading per Coast Guard	
		☐ Biologically-based water treatment	☐ Recycle organic waste				☐ Berm, slope, dike loading	
			☐ Manage snow/ice deicing or removal				☐ Curbs along shoreline	
			☐ Prepare a watering schedule				☐ Prevent pooling	
							☐ **Vehicle Maintenance**	
							☐ Maintain ballast tanks	
							☐ Ballast exchanges off-shore	
							☐ Maintain in covered area	
							☐ Store in covered area	
							☐ Use aqueous cleaners	
							☐ **Mobile Fueling**	
							☐ Place drip pan	
							☐ Spill remedy kit	
							☐ **LIDs**	
							☐ Pervious pavement	
							☐ Bio-retention ponds/swales	
							☐ Constructed SW wetland	
							☐ Buffer strips	
							☐ Dispersion	
							☐ Vegetated roofs	
							☐ Rainwater harvesting	
							☐ Reverse slope sidewalks	
							☐ Minimal excavation	
							☐ Stormwater neutrality	
							☐ Stormwater treatment	
							☐ Pollution prevention	

3. VASHON ISLAND FERRY

The Vashon Island ferry terminal is comprised of two vessel slips as well as a walkway for walk-on customers. Side and overhead views of the terminal can be seen in Figures 3.1 and 3.2. 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 underneath the ferry terminal. Environmental issues at this terminal include potential landslide areas with high erosion hazards due to upland slopes between 6 and 15%. The seabed near the terminal is environmentally sensitive to pollutants because of the geoduck harvest potential.

Figure 3.1: Looking east towards the Vashon Island terminal

Figure 3.2: Looking northwest towards the Vashon Island terminal

There are several challenges for dealing with stormwater treatment at the Vashon Island terminal. One challenge is the trestle is almost entirely an over-water structure, which limits the stormwater treatment options. Another challenge is the slope leading to the trestle from the Island is quite steep and thereby causes large amounts of upland water to make its way down towards the trestle at the water-land interface. Some of this is currently collected by the Vashon Island stormwater system and is then released via the previously mentioned outlet pipe. A third challenge that may arise is WSF is considering multiple construction funding and phasing options. This may result in only a partial trestle replacement as opposed to the trestle being replaced in its entirety. The three proposed partial replacement plans are a western trestle replacement, northern trestle replacement, and southern trestle replacement as shown in Figures 3.3, 3.4, and 3.5. These figures were provided by WSF. If a partial replacement is used it will restrict the stormwater treatment options that can be implemented.

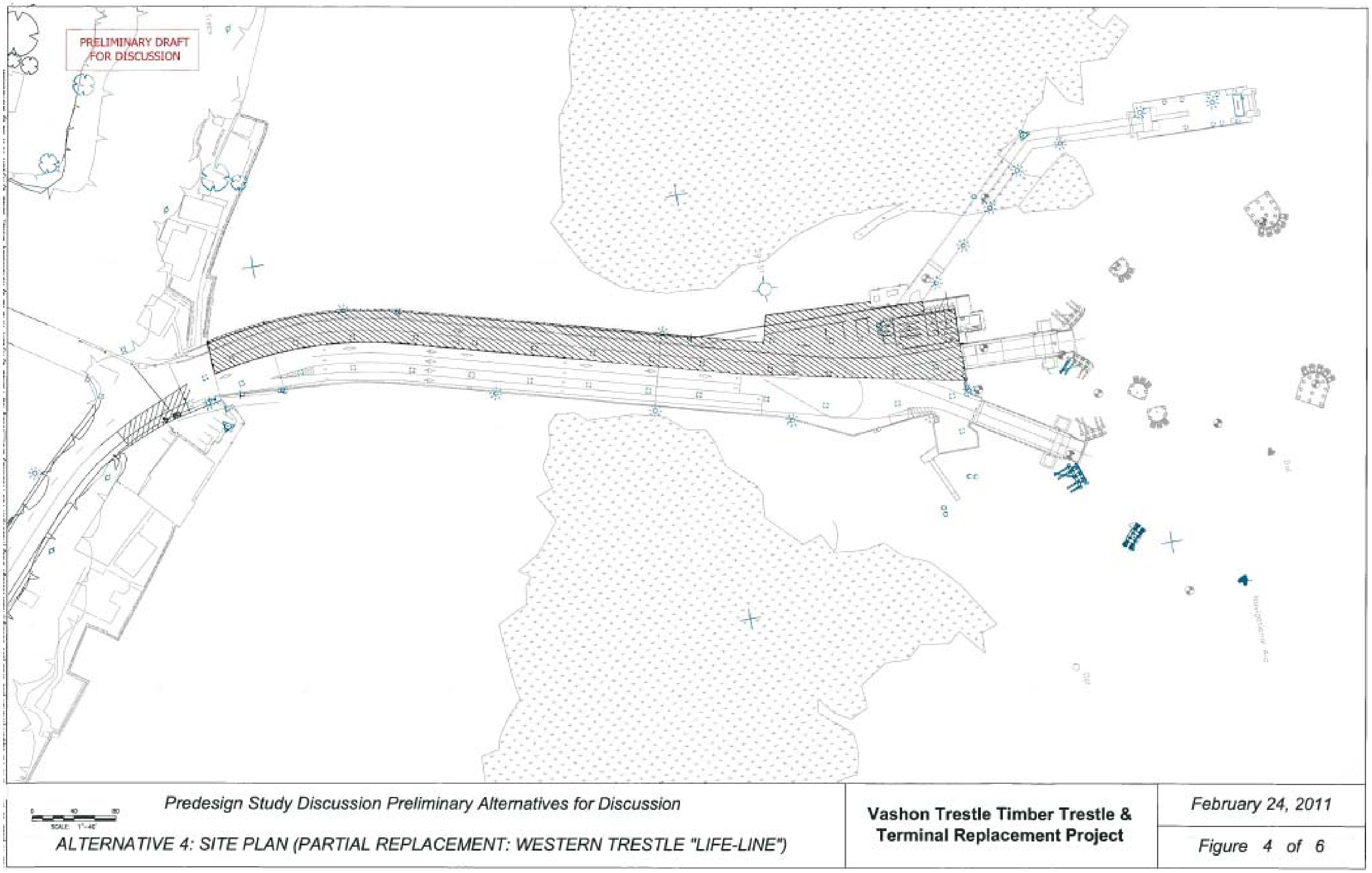

Figure 3.3: Western trestle partial replacement

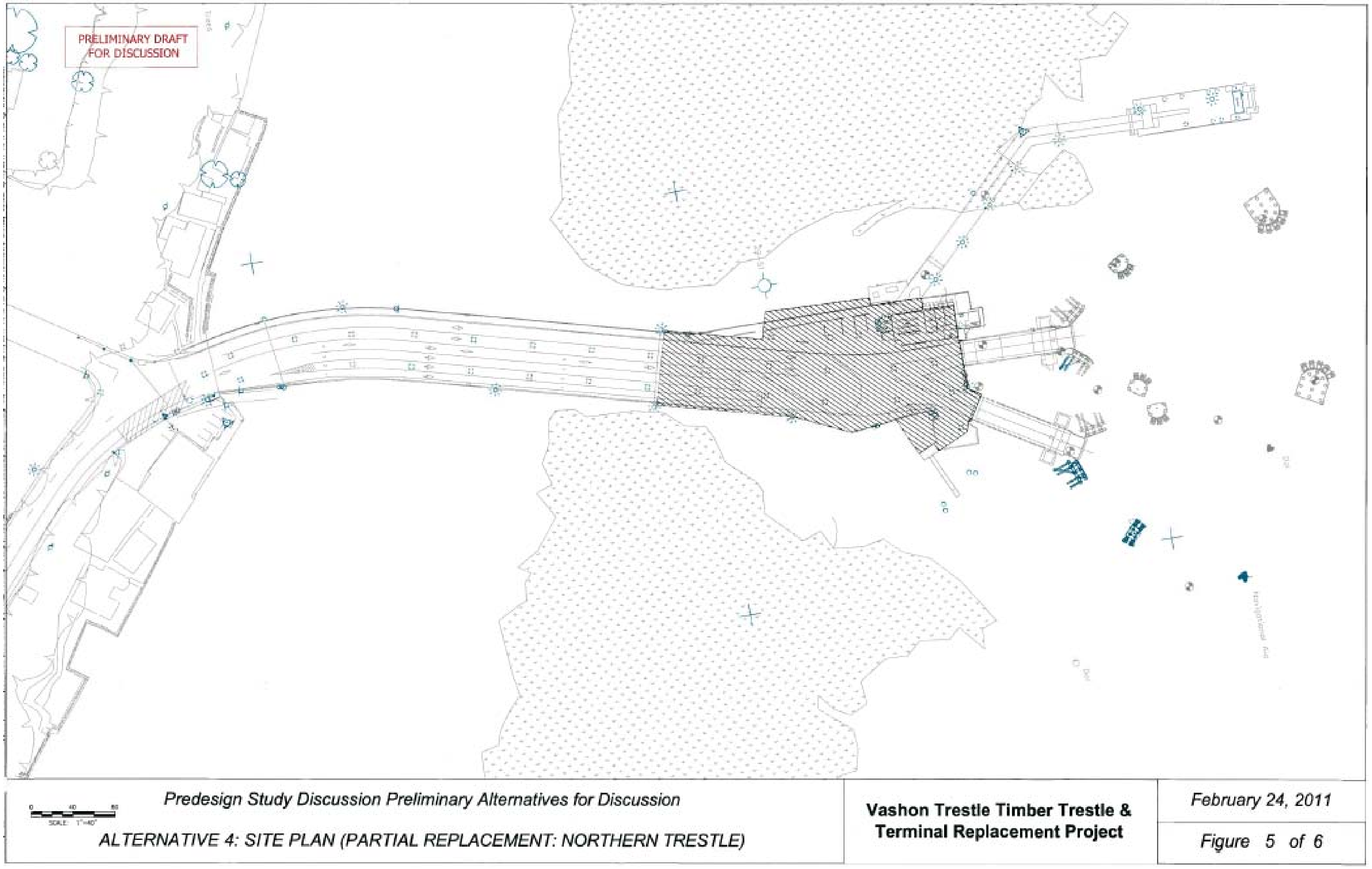

Figure 3.4: Northern trestle partial replacement

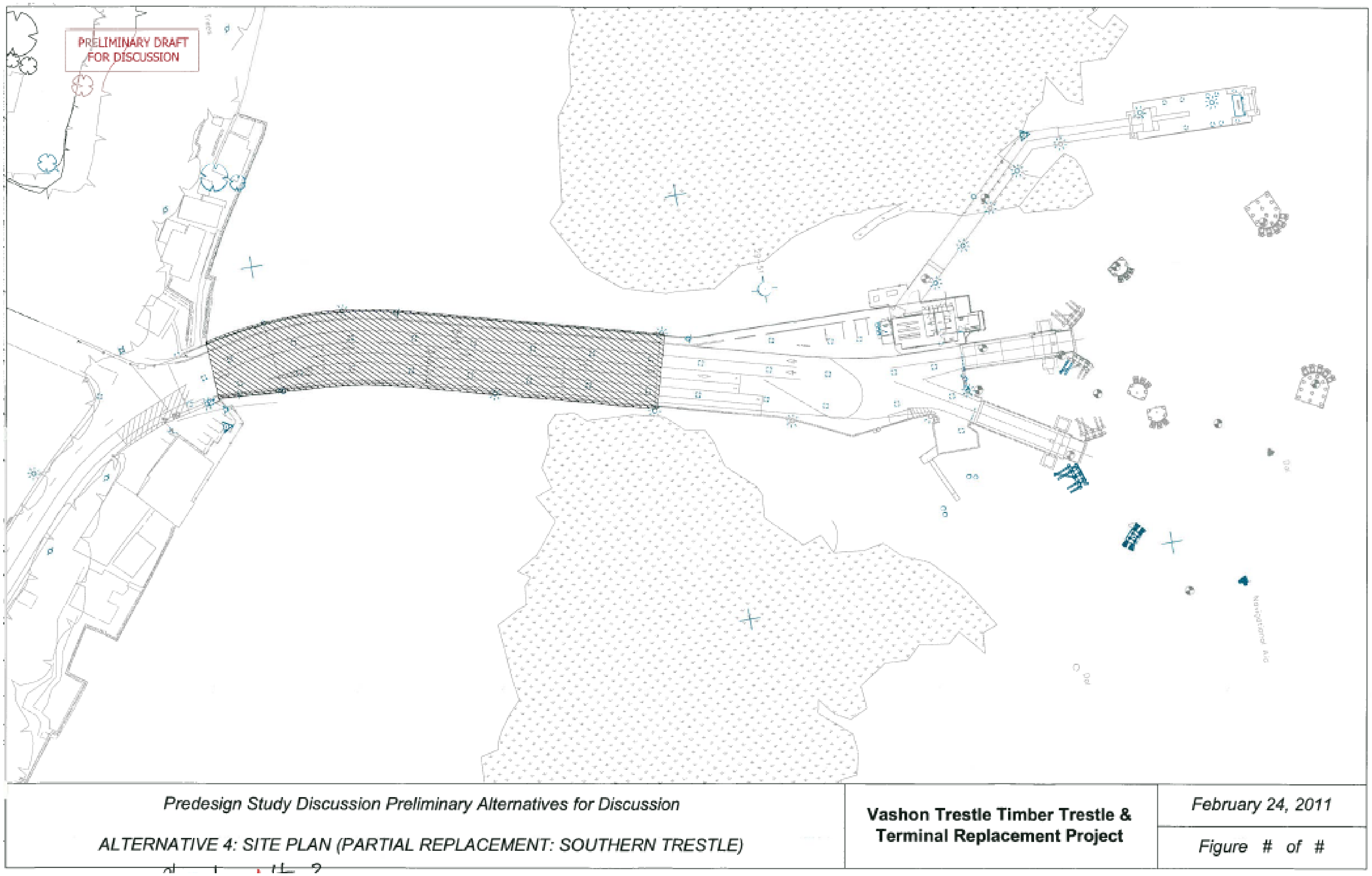

Figure 3.5: Southern trestle partial replacement

4. REVERSE SLOPE-LAND TREATMENT

This chapter begins with some background information about reverse slopes in Section 4.1. Section 4.2 goes over the hydrological calculations used based on the Stormwater Management Manual for Western Washington (Ecology 2005). Section 4.3 applies these calculations to the trestle and analyzes multiple options for the implementation of a reverse slope design. Section 4.4 further analyzes the options presented in Section 4.3 for the water quality effect each option will have. Finally, Section 4.5 analyzes the reverse slope technique if it treated stormwater coming from upland sources as well as the trestle.

4.1 Background

Currently, only reverse slope sidewalks are covered by the Western Washington Stormwater Manual. Reverse slope sidewalks are designed to drain onto vegetated areas as opposed to typical sidewalks which are designed to drain into the road gutter (Ecology 2005). By invoking a reverse slope onto the ferry terminal, this will allow precipitation which falls on the terminal to be redirected or altered towards the land where LID practices can be used effectively. Most LID techniques are applicable for land side treatment only and cannot be successfully applied on a ferry terminal that is over water.

This practice can be implemented when the terminal is replaced. When reconstructing the ferry terminal, it could be built in such a way that a portion of the trestle would be a slight uphill slope going from the land side of the trestle towards the water side of the trestle. This would cause the precipitation that falls on the trestle to run back towards the land, where it could be contained in a stormwater vault like the Kristar system used on Bainbridge Island and treated using landside LID techniques. The remaining paved areas on the trestle would be handled by some innovative treatment catch basins. This method forces water quantity regulations to be met in addition to water quality regulations. Originally, since the trestle is an overwater structure, the water which falls on the trestle would normally fall into the Sound anyway, negating the need to regulate how quickly the stormwater is released into Puget Sound. With a landside stormwater basin, the quantity of water released into Puget Sound must be taken into consideration in addition to the quality of the stormwater.

A challenge is presented when attempting to reverse slope the entire terminal because there are constant heights which need to be maintained. The marine side is constrained by the distance between the trestle and the mean high level water mark. Another constraint is on the other side where the trestle meets the Vashon highway. The height of the trestle must be maintained so that it is above tide levels and groundwater levels. Added construction would be required if the height was raised or lowered.

Another point of concern is if the stormwater is treated on the land side, WSF may be treating stormwater coming from Vashon Island as well. Stormwater from the island would greatly increase the amount of stormwater needed to be treated as well as subject WSF to the associated liabilities. The amount of water coming from land side is uncontrolled and arrives in very large amounts. It was decided to analyze the reverse slope-land treatment method for two different scenarios. First the volumes of the stormwater running off the trestle needs to be analyzed and the considerations for water quality need to be addressed. The hydrological calculations for stormwater falling on the trestle are shown in Section 4.2. This first scenario will be subdivided into three reverse slope options which are discussed in Section 4.3. Section 4.4 will calculate the water quality for each of the options addressed in Section 4.3. Finally, Section 4.5 will discuss the second scenario of treating water coming to the trestle from the island.

4.2 Hydrological Calculations

The amount of water expected from the land side of the terminal was estimated using the guidelines outlined in the Western Washington Hydraulics Manual. Based on the given Western Washington isopluvials (Figure 4.1) for 24 hour storms it was determined that a 2, 10, and 100 year storm would comprise of 2.25, 3.25, and 4.5 inches of precipitation respectively (Ecology 2005).

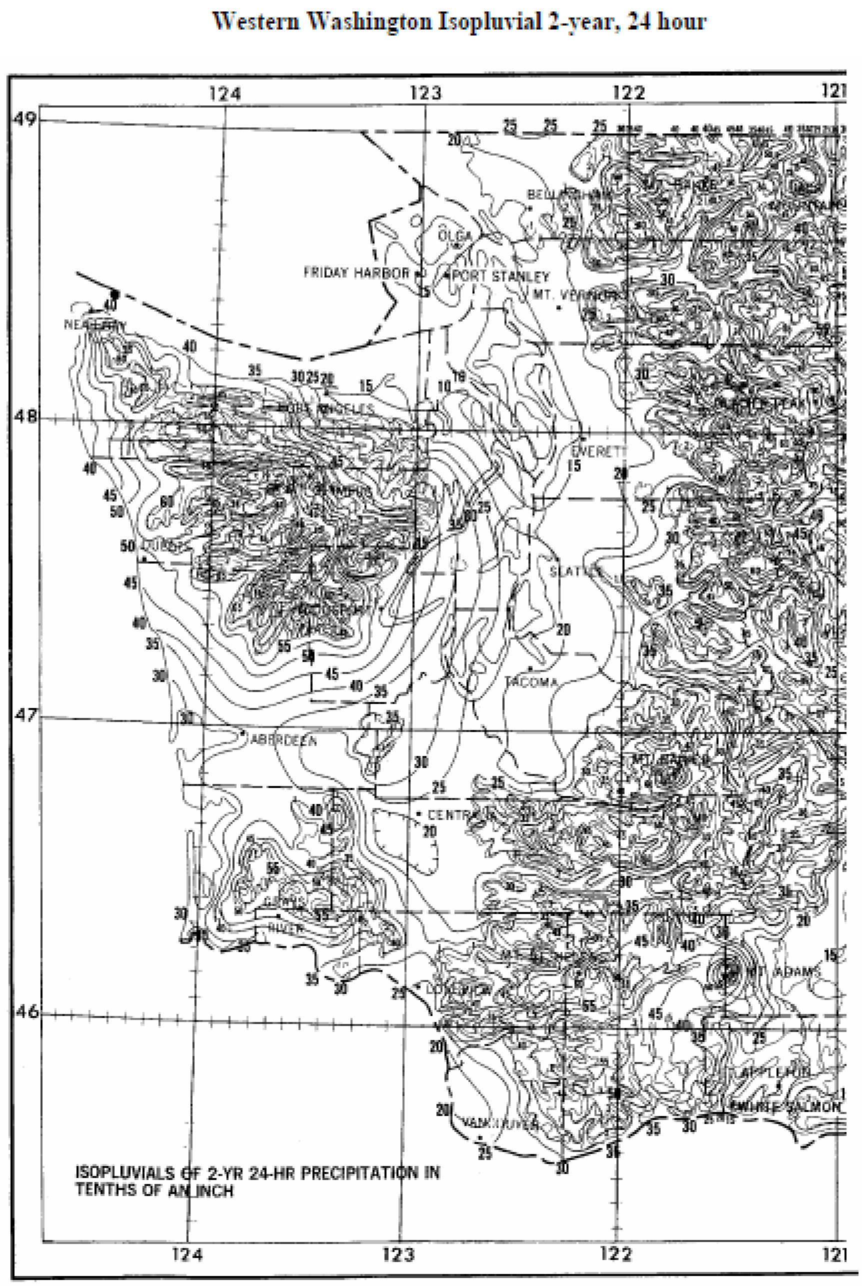

Figure 4.1: Western Washington two-year isopluvial (from: Ecology 2005)

Impervious surfaces have a curve number of 98, based on this curve number the potential for maximum natural detention is calculated using the equation (Ecology 2005):

$S = (1000/CN) - 10$

Where: S = Potential maximum natural detention (inches/area)

CN = Curve number

This gives a potential maximum natural detention of 0.20 inches per area. Runoff depth can then be calculated using the equation (Ecology 2005):

$Q_d = (P-0.2S)^2 / (P+0.8S)$

Where: Q_d = Runoff depth (inches/area)

P = Precipitation depth (inches/area)

The runoff depth for the 2, 10, and 100 year storms comes out to 2.03, 3.02, and 4.27 inches/unit area respectively.

It may not be necessary to design a detention vault for such high precipitation values. When a large rainstorm occurs, most of the pollutants are contained in the first portion of the rainstorm, known as the first flush. It is more important that this first flush receive treatment; the stormwater occurring later in the storm will have lower pollutant levels.

One set of guidelines for the design water quality volume covered in LEED-New Construction under Sustainable Sites credit 6.2: Stormwater Management-Quality Control. Vashon Island is considered a semiarid environment by LEED because it receives an annual precipitation between 20 and 40 inches. Due to this characterization, a water quality volume of 0.75" over the total site will need to be treated during each event (Haselbach 2008).

Another set of guidelines is discussed in the Stormwater Management Manual for Western Washington (SMMWW). This guideline states that the water quality design storm value can be a sixth-month, 24 hour storm event. Also, a sixth month storm event is estimated as 72% of the two year storm amount (Ecology 2005). For Vashon Island, the water quality volume according to this standard would be 1.49”.

The design would also have an overflow set up for precipitation levels greater than 0.75” for LEED guidelines or 1.49” for SMMWW guidelines. The overflow would be drained directly into the Sound through scuppers just like the current setup is now.

4.3 Trestle Calculations

This section will discuss the required vault size for three possible options for applying reverse slope on the trestle. The options discussed are an entire trestle replacement, a partial replacement of the southern part of the trestle, and an extended partial replacement of the southern part of the trestle. Each option will have two possibilities, one is putting a crown on the road and only treating the eastern part of the trestle and the other is treating both the east and west sides of the trestle.

4.3.1 Option 1: Entire trestle replacement

In total, the trestle has a paved area of 58,935 square feet and a total impervious area of 59,095 square feet. A reverse slope would not be able to treat the entire trestle due to the elevation constraints at either end. Due to these constraints the reverse slope will cause the trestle to slope upwards from either end towards the middle, with the landside portion towards the south of the trestle collecting stormwater in a vault and the waterside portion towards the north of the trestle draining into the Sound as before. The holding area on the terminal where vehicles are parked for extended periods of time is known as a pollution hotspot. Hotspots of this nature tend to have pollutant levels five times higher than streets or residential parking lots (Schueler and Holland 2000). In order to treat the area of most need, the reverse slope should be designed to treat all of the stormwater coming from the holding area.

Since the holding area is more than half of the length of the trestle, this will result in a slightly steeper slope toward the water side to compensate for the shorter length (Figure 4.3).

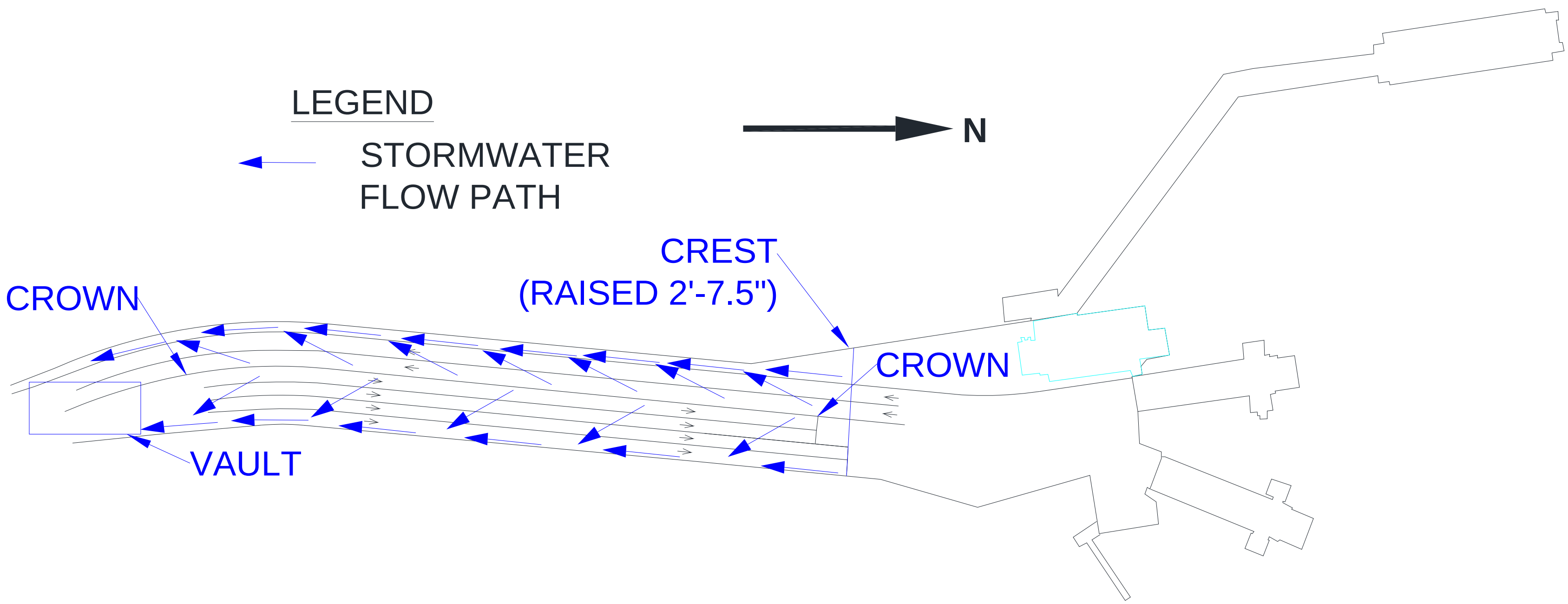

Figure 4.3: Reverse slope design for full replacement Vashon Island trestle

Under this scenario, 36,000 ft^2 of the terminal would have the stormwater diverted back towards the landside while the remaining 23,000 ft^2 would still drain into the Sound. According to the previously detailed LEED guidelines, the detention vault would need to be designed to hold 2250 ft^3 of water. The SMMWW guidelines would require the detention vault to be designed to hold 4470 ft^3 of water. If it were designed for the 2, 10, or 100 year storm events it would need to be 6100 ft^3, 9050 ft^3, and 12,800 ft^3 respectively (Table 4.1).

If a crown were implemented so that just the stormwater on the eastern portion of the trestle which contains the holding area was diverted to the detention basin, the area being diverted back towards the land side would be 20,000 ft^2. This would reduce the stormwater detention vault to 1250 ft^3 according to the LEED guidelines and 2480 ft^3 according to the SMMWW guidelines (Table 4.1).

Table 4.1: Option 1(full trestle replacement) required vault size for each design storm

Design Storm	LEED (ft^3)	SMMWW (ft^3)	2 year (ft^3)	10 year (ft^3)	100 year (ft^3)
Without Crown	2250	4470	6100	9050	12,800
With Crown	1250	2480	3380	5030	7,120

In this design the landside portion of the slope to the south has a length of 525 feet compared to 200 feet for the waterside portion of the slope to the north. The reverse slope should be designed at a slope of 0.5% (King County 2011). This would force the 200 feet at the northern part of the trestle to have a slope of 1.3%.

4.3.2 Option 2: Southern area trestle replacement

As detailed earlier, WSF may want to phase construction of the Vashon Island terminal. A reverse slope may still be implemented if the partial replacement southern trestle alternative is implemented (Figure 3.5). This could occur if one of the previously mentioned constraints could be altered. It may be possible to lower the elevation where the trestle intersects with Vashon highway. This would be accomplished by continuing the highway a little bit farther down the hill which allows the trestle to slope to a slightly lower elevation. This would allow the reverse slope method to be used if only the southern part of the trestle is replaced, with the northern portion of the trestle remaining at its current elevation (Figure 4.4).

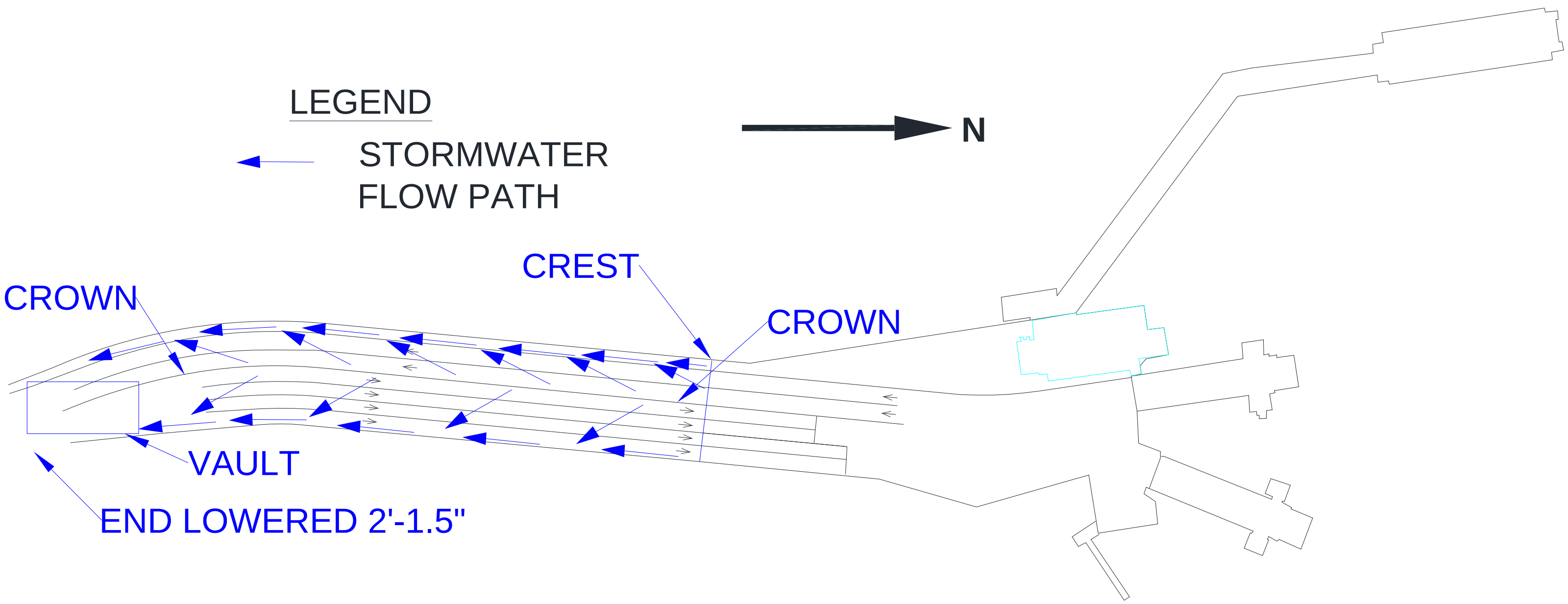

Figure 4.4: Reverse slope design for southern portion replacement of Vashon Island trestle

The total area of the trestle to be replaced in this alternative is 29,000 ft^2 of the 58,580 ft^2 of paved area on the trestle. This means that the detention vault must be around 1800 ft^3 to capture and hold all the water according to LEED guidelines and 3600 ft^3 according to SMMWW guidelines. Results for the design storms are shown in Table 4.2. The addition of a crown for this option would reduce the treated area from 29,000 ft^2 to 16,000 ft^2 and the detention vault size would also reduce by a corresponding amount (Table 4.2).

Table 4.2: Option 2 (southern area trestle replacement) required vault size for each design storm

Design Storm	LEED (ft^3)	SMMWW (ft^3)	2 year (ft^3)	10 year (ft^3)	100 year (ft^3)
Without Crown	1800	3600	4900	7300	10,300
With Crown	1000	1990	2710	4030	5690

According to King County development standards, the slope should be a minimum of 0.5% (King County 2011). Since the southern section of the trestle is 425 feet in length, the trestle would have to be lowered at the land side by 2 feet, 1.5 inches. This could be done by making the trestle start slightly closer towards the water and extending the road on the land until the natural elevation drop of the hill decreases two feet. This would treat slightly over half of the terminal.

4.3.3 Option 3: Extended southern area trestle replacement

As stated previously, the highest pollution area is the holding area where the customer vehicles are required to park for extended periods of time. Due to this area containing approximately five times as many pollutants as other areas on the trestle, it is important to ensure as much of the holding area as possible has the stormwater which runs off of it be treated. The holding area on the Vashon Island terminal compromises approximately 16,310 ft^2 towards the southeast portion of the terminal (Figure 4.5).

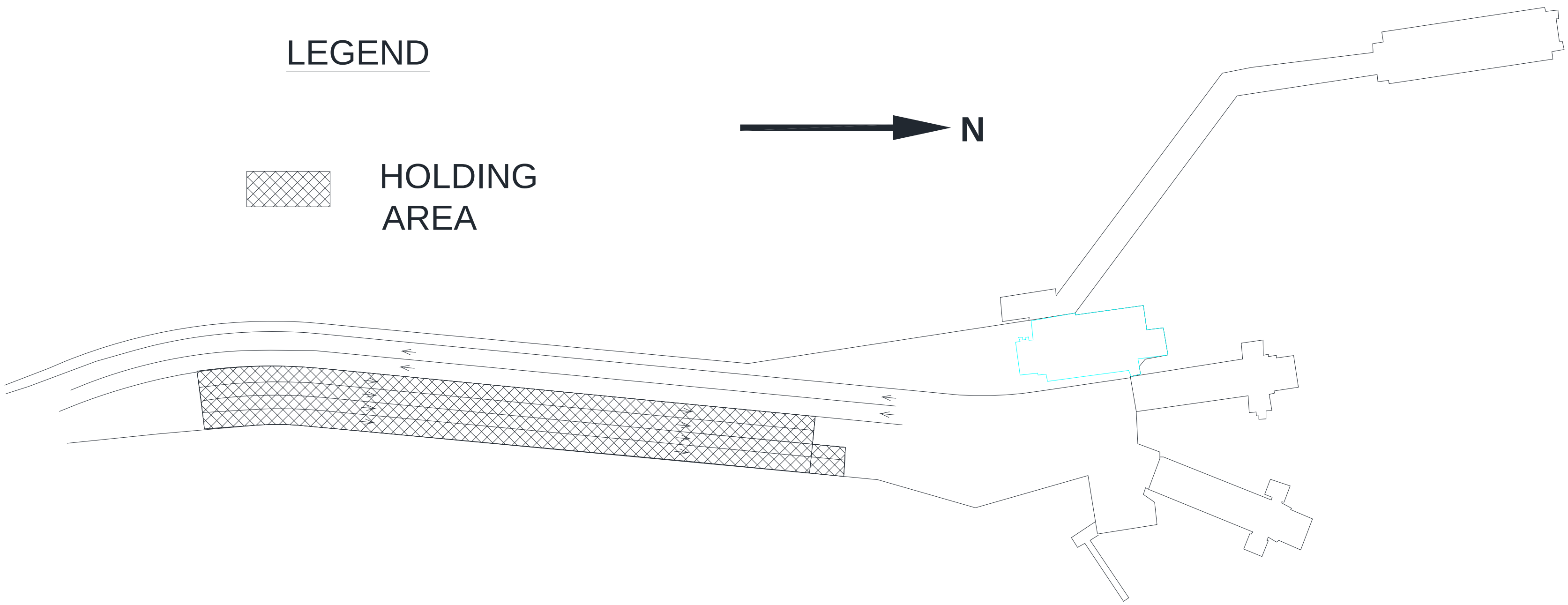

Figure 4.5: The automobile passenger holding area on the Vashon Island terminal

This portion only makes up about 28% of the terminal but is the source of the majority of pollutants. For this reason, treating stormwater which runs off of the holding area is a priority. The pollutant levels would be reduced if the southern trestle replacement area was extended 100 feet farther north in order to include the holding area in its entirety. If the partial construction alternative of the southern portion of the terminal discussed in Option 2 is used, 13,000 ft^2 of the holding area will be renovated, roughly 80%. If the partial replacement plan for the southern trestle could be extended another 100 feet over the water, increasing the total construction area to 36,000 ft^2, the entire holding area could be given the reverse slope treatment (Figure 4.6). This would increase the detention vault size to 2250 ft^3 for LEED and 3600 ft^3 for SMMWW without and crown and 1250 ft^3 for LEED and 2480 ft^3 for SMMWW with a crown. The trestle would need to be lowered at the land side by 2 feet, 7.5 inches. Results for the design storms are shown in Table 4.3.

Table 4.3: Option 3 (extended southern area trestle replacement) required vault size for each design storm

Design Storm	LEED (ft^3)	SMMWW (ft^3)	2 year (ft^3)	10 year (ft^3)	100 year (ft^3)
Without Crown	2250	4470	6100	9050	12,800
With Crown	1250	2480	3380	5030	7,120

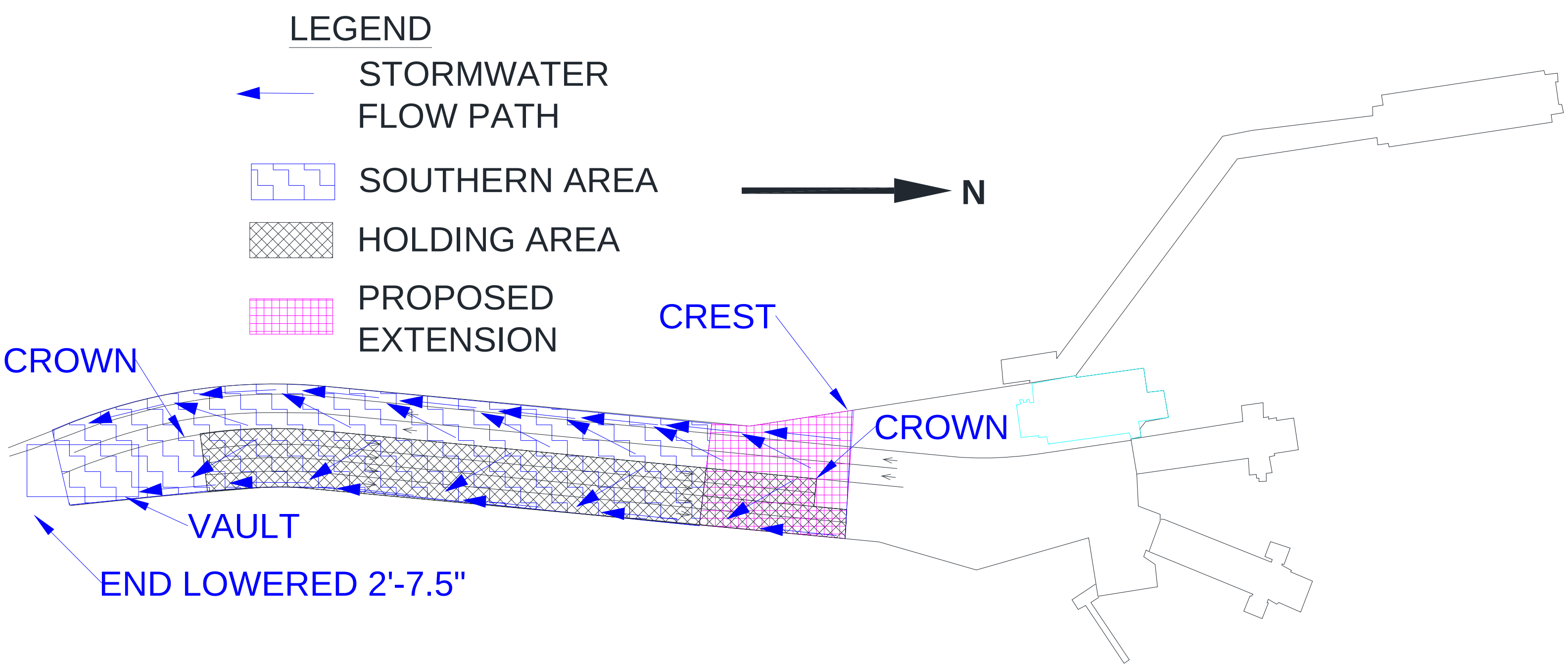

Figure 4.6: Plan for partial replacement of the southern trestle area of the Vashon Island terminal with the proposed extension

By extending the area which is going to be replaced, the treated area matches what was achieved in the entire trestle replacement discussed as Option 1. The vault sizes for all three options and all five precipitation design criteria are summarized in Table 4.4. These data will be further presented in a decision support tool in Chapter 7.

Table 4.4: Summary of vault size for various design options

Design Storm	LEED (ft^3)	SMMWW (ft^3)	2 year (ft^3)	10 yr (ft^3)	100 yr (ft^3)	Lowered Distance
Option 1: Full Trestle	2250	4470	6100	9050	12,800	0
-With Crown	1250	2480	3380	5030	7,120	0
Option 2: Southern Portion	1800	3600	4900	7300	10,300	2’ 1.5”
-With Crown	1000	1990	2710	4030	5,690	2’ 1.5”
Option 3: Extended Southern Portion	2250	4470	6100	9050	12,800	2’ 7.5”
-With Crown	1250	2480	3380	5030	7,120	2’ 7.5”

4.4 Water Quality Implications

This section looks at the amount of pollutants treated by each of the options discussed in Section 4.3. The effectiveness of each of the above options can be measured by the ratio of pollutants which are treated by the vault. This can be determined based on the areas of the terminal and the holding area comprised with the knowledge that the pollutant levels will probably be higher in the holding area than the rest of the terminal (Schueler and Holland, 2000). The holding area is defined as a hotspot area because it has a larger load of hydrocarbons and trace metals than other areas. Due to this, it is necessary to weight the areas of the project with higher pollutant loads with a hotspot factor in order to demonstrate the increased need for treatment in the area with the greater pollutant concentrations. This was done by creating the following equations:

$$P_T = (A_T - AH) * C_P + AH * F_{HS}C_P \qquad \text{Eqn. \#4.1}$$

Where: P_T = Total pollutants on the trestle per depth of stormwater

A_T = Total area of the trestle

AH = Area of the holding area

F_{HS} = Hotspot factor

C_P = Concentration of the pollutants on typical road surfaces

The amount of pollutants treated by each option is dependent on whether the area being treated is a part of the holding area or not. This can be represented by the equation:

$$P_x = (A_x - AH_x) * C_p + AH_x * F_{HS}C_P \qquad \text{Eqn. \#4.2}$$

Where: P_x = Pollutants treated by Option X per depth of stormwater

A_x = Total area treated by Option X

AH_x = Area of the holding area treated by Option X

These two equations can then be divided in order to determine the ratio of pollutants which will be treated by each option:

$$\frac{P_x}{P_T} = \frac{(A_x - AH_x) * C_p + AH_x * F_{HS}C_P}{(A_T - AH) * C_P + AH * F_{HS}C_P} \qquad \text{Eqn. \#4.3}$$

Simplifying this equation by canceling out the concentrations of the pollutants nets the following equation:

$$\frac{P_x}{P_T} = \frac{(A_x - AH_x) + F_{HS} * AH_x}{(A_T - AH) + F_{HS} * AH} \qquad \text{Eqn. \#4.4}$$

Typically, Scheuler and Holland (2000) estimate the hotspot area to have five to ten times the number of pollutants as a non-hotspot area. The exact factor will vary based on site and target pollutants. For this particular scenario, it is conservatively assumed that the holding area contains five times the concentration of pollutants as the non-holding areas on the ferry trestle so F_{HS} is assumed to be 5. Additionally, to provide insight into the amounts of pollutants treated due to varying ‘hotspot’ factors, Table 4.5 also includes final results from varying the factor from 4 to 10.

The value of A_T is known to be 58,580 ft^2 while the value of AH is known to be 16,310 ft^2. The values of A_x and AH_x are also know for all three options and thereby can be used to determine the percentage of pollutants treated by each option. Each option was analyzed both without and with a crown. Results of these calculations are shown in Table 4.5.

Table 4.5: Percentage of pollutants on the trestle treated by each option

	A_x (ft^2)	AH_x (ft^2)	P_x/P_T (%) if F_{HS} = 4	P_x/P_T (%) if F_{HS} = 5	P_x/P_T (%) if F_{HS} = 10
Option 1 (full replacement) – Without Crown	36,000	16,310	79	82	89
Option 1 (full replacement) – With Crown	20,000	16,310	64	69	81
Option 2 (southern portion) – Without Crown	29,000	13,000	63	65	71
Option 2 (southern portion) – With Crown	16,000	13,000	51	55	65
Option 3 (extended southern portion) – Without Crown	36,000	16,310	79	82	89
Option 3 (extended southern portion) – With Crown	20,000	16,310	64	69	81

By focusing on the holding area, the percentage of pollutants being treated will be greater than the percentage of trestle being replaced. These data will be further presented in a decision support tool in Chapter 7.

4.5 Landside Calculations

This section considers the stormwater from Vashon Island that could be handled by the stormwater detention vault. The upland area was estimated by looking at a topographic map thru ArcGIS. A small watershed area was created based on the most likely path water would take as is shown in Figure 4.7. The estimated area is 0.193 square miles with about 10% of it impervious area and the other 90% heavily forested.

Figure 4.7: Topographic area (ArcGIS)

There is no hydraulic soil group given for Vashon Island, so it is assumed to be comprised of soil group D, which is the soil category for nearby Seattle and Tacoma (Table 4.6).

Table 4.6: Hydrologic Soil Series for Selected Soils in Washington State (Ecology 2005)

Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group
Cassolary	C	Mashel	B
Cathcart	B	Maytown	C
Centralia	B	McKenna	D
Chehalis	B	McMurray	D
Chesaw	A	Melbourne	B
Cinebar	B	Menzel	B
Clallam	C	Mixed Alluvial	variable
Clayton	B	Molson	B
Coastal beaches	variable	Mukilteo	C/D
Colter	C	Naff	B
Custer	D	Nargar	A
Custer, Drained	C	National	B
Dabob	C	Neilton	A
Delphi	D	Newberg	B
Dick	A	Nisqually	B
Dimal	D	Nooksack	C
Dupont	D	Norma	C/D
Earlmont	C	Ogarty	C
Edgewick	C	Olete	C
Eld	B	Olomount	C
Elwell	B	Olympic	B
Esquatzel	B	Orcas	D
Everett	A	Oridia	D
Everson	D	Orting	D
Galvin	D	Oso	C
Getchell	A	Ovall	C
Giles	B	Pastik	C
Godfrey	D	Pheeney	C
Greenwater	A	Phelan	D
Grove	C	Pilchuck	C
Harstine	C	Potchub	C
Hartnit	C	Poulsbo	C
Hoh	B	Prather	C
Puget	D	Solleks	C
Puyallup	B	Spana	D
Queets	B	Spanaway	A/B
Quilcene	C	Springdale	B
Ragnar	B	Sulsavar	B
Rainier	C	Sultan	C
Raught	B	Sultan variant	B
Reed	D	Sumas	C
Reed, Drained or Protected	C	Swantown	D
Renton	D	Tacoma	D
Republic	B	Tanwax	D
Riverwash	variable	Tanwax, Drained	C
Rober	C	Tealwhit	D
Salal	C	Tenino	C
Salkum	B	Tisch	D
Sammamish	D	Tokul	C
San Juan	A	Townsend	C
Scamman	D	Triton	D
Schneider	B	Tukwila	D
Seattle	D	Tukey	C
Sekiu	D	Urbana	C
Semiahmoo	D	Vailton	B
Shalcar	D	Verlot	C
Shano	B	Wapato	D
Shelton	C	Warden	B
Si	C	Whidbey	C

Based on this soil group, the curve number associated with the forested areas of Vashon Island is 77 and the impervious area is 98, netting an average curve number of 79 (Table 4.7).

Table 4.7: Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas (Ecology 2005)

	CNs for hydrologic soil group			
Cover type and hydrologic condition.	A	B	C	D
Curve Numbers for Pre-Development Conditions				
Pasture, grassland, or range-continuous forage for grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair (Woods are grazed but not burned, and some forest litter covers the soil).	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil).	30	55	70	$\boxed{77}$
Curve Numbers for Post-Development Conditions				
Open space (lawns, parks, golf courses, cemeteries, landscaping, etc.)[1]				
Fair condition (grass cover on 50% - 75% of the area).	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious areas:				
Open water bodies: lakes, wetlands, ponds etc.	100	100	100	100
Paved parking lots, roofs[2], driveways, etc. (excluding right-of-way)	98	98	98	98
Permeable Pavement (See Appendix C to decide which condition below to use)				
Landscaped area	77	85	90	92
50% landscaped area/50% impervious	87	91	94	96
100% impervious area	98	98	98	$\boxed{98}$
Paved	98	98	98	98
Gravel (including right-of-way)	76	85	89	91
Dirt (including right-of-way)	72	82	87	89
Pasture, grassland, or range-continuous forage for grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch).	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor (Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning).	45	66	77	83
Fair (Woods are grazed but not burned, and some forest litter covers the soil).	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil).	30	55	70	77
Single family residential[3]: Dwelling Unit/Gross Acre	Should only be used for subdivisions > 50 acres	Average Percent impervious area[3,4]		
1.0 DU/GA		15	Separate curve number	
1.5 DU/GA		20	shall be selected for	
2.0 DU/GA		25	pervious & impervious	
2.5 DU/GA		30	portions of the site or	
3.0 DU/GA		34	basin	
3.5 DU/GA		38		
4.0 DU/GA		42		
4.5 DU/GA		46		
5.0 DU/GA		48		
5.5 DU/GA		50		
6.0 DU/GA		52		
6.5 DU/GA		54		
7.0 DU/GA		56		
7.5 DU/GA		58		
PUD's, condos, apartments, commercial businesses, industrial areas & & subdivisions < 50 acres	%impervious must be computed	Separate curve numbers shall be selected for pervious and impervious portions of the site		
For a more detailed and complete description of land use curve numbers refer to chapter two (2) of the Soil Conservation Service's Technical Release No. 55, (210-VI-TR-55, Second Ed., June 1986).				

Based on this curve number the potential for maximum natural detention is calculated using the equation (Ecology 2005):

S= (1000/CN)-10

Where: S = Potential maximum natural detention (inches/area)

CN = Curve number

This gives the upland area a potential maximum natural detention of 2.66 inches per area. Runoff depth can then be calculated using the equation (Ecology 2005):

$Q_d = (P-0.2S)^2 / (P+0.8S)$

Where: Q_d = Runoff depth (inches/area)

P = Precipitation depth (inches/area)

S = Potential maximum natural detention (inches/area)

The runoff depth for the 2, 10, and 100 year storms is 0.67, 1.37, and 2.38 inches/area respectively. Based on the upland area of 0.193 square miles or 5,380,500 square feet, the detention vault would need to be about 140,000 cubic feet for a six month storm event using the SMMWW guidelines. Results for the other design storms are shown in Table 4.8. These data will be further presented in a decision support tool in Chapter 7.

Table 4.8: Required vault size for each design storm for upland area

Design Storm	LEED (ft^3)	SMMWW (ft^3)	2 year (ft^3)	10 year (ft^3)	100 year (ft^3)
Vault Size (ft^3)	450,000	140,000	300,000	615,000	1,075,000

An interesting observation is the required vault size for the SMMWW guideline is much smaller than the vault size for the LEED guideline. When calculating the vault sizes for the trestle the LEED guideline indicated a smaller vault than the SMMWW guideline. The reason for this is the SMMWW calculations take into account the maximum natural detention and other hydrological processes upslope from the trestle for the landside contributions, while the LEED guideline is a uniform 0.75” of rainfall over the entire area regardless of what the surface detention or other processes might be. This is more apparent on the upland calculations due to the presence of forest land. When comparing these two guidelines for the trestle portion of the runoff, all of the area is impervious, causing the potential maximum natural detention to be quite small and therefore making the land surface impacts similar in the two approaches. The SMMWW estimate is larger for the trestle side since a greater rainfall depth of 1.49” is based specifically on rainfall patterns in the local area.

5. PERVIOUS CONCRETE-SWEEPING

This section covers an alternative LID design integrating a pervious concrete overlay for a portion or all of the paved trestle areas in combination with high efficiency sweeping and possibly special catch basin inserts. Background information is presented in Section 5.1 and three design options are presented in Section 5.2.

5.1 Background

The pervious concrete method would also be implemented during replacement, and consists of applying a pervious concrete overlay to the existing pavement which would allow for horizontal flow of stormwater through the medium to modified catch basins on the edge of the pavement prior to discharge into the Sound. The pervious concrete would undergo maintenance involving high efficiency sweeping. Catch basins are optional depending on the water quality improvement and the future water quality requirements imposed on WSF. Pervious concrete differs from traditional pavements in that it allows surface water to run through the pavement instead of on top of the pavement. As the water runs through the concrete, most pollutants remain on the surface of the pavement, which can later be removed by use of sweeping. It has been shown that a porous asphalt overlay is successful in removing total suspended solids, phosphorus, and heavy metals such as copper, lead, and zinc (Barrett 2008). Similar results can be expected with pervious concrete. Research has shown that pervious concrete in conjunction with pavement cleaning is successful in removing particulates from stormwater (Sansalone

2008). A study was recently performed in the Pacific Northwest comparing durability of permeable pavement to impermeable pavement. After six years of daily parking use, there were no major signs of wear. Nearly all of the stormwater infiltrated into the permeable pavement, reducing runoff to near zero (Rushton 2001; Battebo and Booth 2003; Bean et. al 2007). Motor oil was detected in 89% of the samples taken from the impervious pavement but was not found in any water that had been infiltrated through the permeable pavement (Brattebo and Booth, 2003).

As noted in the aforementioned studies, it is expected that a significant portion of the oil and grit pollutants from the pavements would be retained by the pervious concrete, although some oil and solids would still run through the concrete and therefore might be additionally treated using an oil/grit separator type of catch basin (EPA 2006). The pervious concrete method should also be combined with high efficiency sweeping, similar to what was concluded in the SR 520 study, to help with the reduction of dirt particles. Sweeping will also help to prevent the pervious concrete from clogging and losing effectiveness (Tennis et al. 2004).

Pervious concrete does not have as much strength and durability as traditional concrete for heavy vehicle loading. For this reason, it may be beneficial, and perhaps more economical, to strategically determine the most optimum places where a pervious concrete overlay can be used. In particular, it is important to limit usage in areas where trucks and heavy vehicles will be parked, or at those locations, specially design the pervious concrete to be able to withstand heavier than average vehicle loads. Pervious concrete can still be used in areas with heavy vehicle loads; it would just need to be designed for that purpose.

One advantage of using pervious concrete as a stormwater management technique is that it can work with all of the replacement staging strategies proposed by WSF. It is not necessary to replace the entire trestle to implement pervious concrete. Pervious concrete can simply be overlaid onto the existing structure on the trestle subject to appropriate loading validations or structural improvements. Three different overlay options will be examined in Section 5.2. These three look at an overlay for the entire trestle, the holding lanes only, and three of the four holding lanes, those expected to not have significant truck traffic.

5.2 Options

This section examines three different pervious concrete overlay options. The options are an overlay over the entire trestle, an overlay of just the holding lanes, and an overlay of three out of the four holding lanes.

5.2.1 Option 1: Entire trestle overlay

Pervious concrete could be overlaid over the entire existing pavement, totaling 58,580 ft^2. The concrete would need to have a greater strength (usually depth) in areas of moving traffic or where heavy vehicles may be parked for extended periods of time (Figure 5.1). This option has the advantage of treating stormwater for pollutants throughout the entire trestle but has the disadvantage of a higher cost. All three options are summarized in Table 5.1.

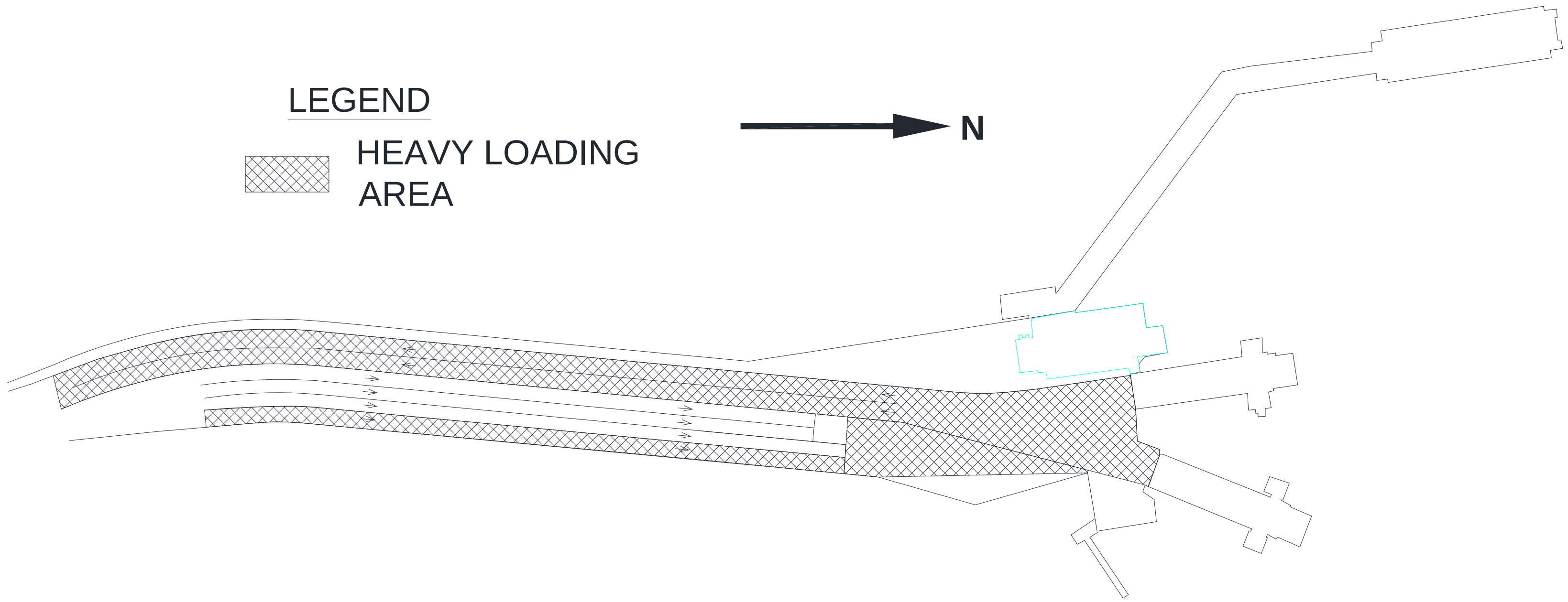

Figure 5.1: Pervious concrete overlay over the entire trestle

5.2.2 Option 2: Holding lanes only

As previously mentioned, the holding lanes are the source of the highest pollutant loads. These high pollutant loads are caused by vehicles being parked or idling at this location for extended periods of time. As a result, the holding area should be the highest priority when treating stormwater for pollutants. By overlaying pervious concrete on only the holding lanes, the efficiency of pollutants treated versus area is as high as possible (Figure 5.2). When overlaying pervious concrete on all four holding lanes, it may be necessary to specify one lane for heavy vehicles and use a thicker, stronger pervious concrete for that lane. Using Equation 4.4 in Section 4.4, this option treats 66% of the pollutants on the trestle (Table 5.1). Additionally, to provide insight into the amounts of pollutants treated due to varying ‘hotspot’ factors, Table 5.1 also includes final results from varying the factor from 4 to 10.

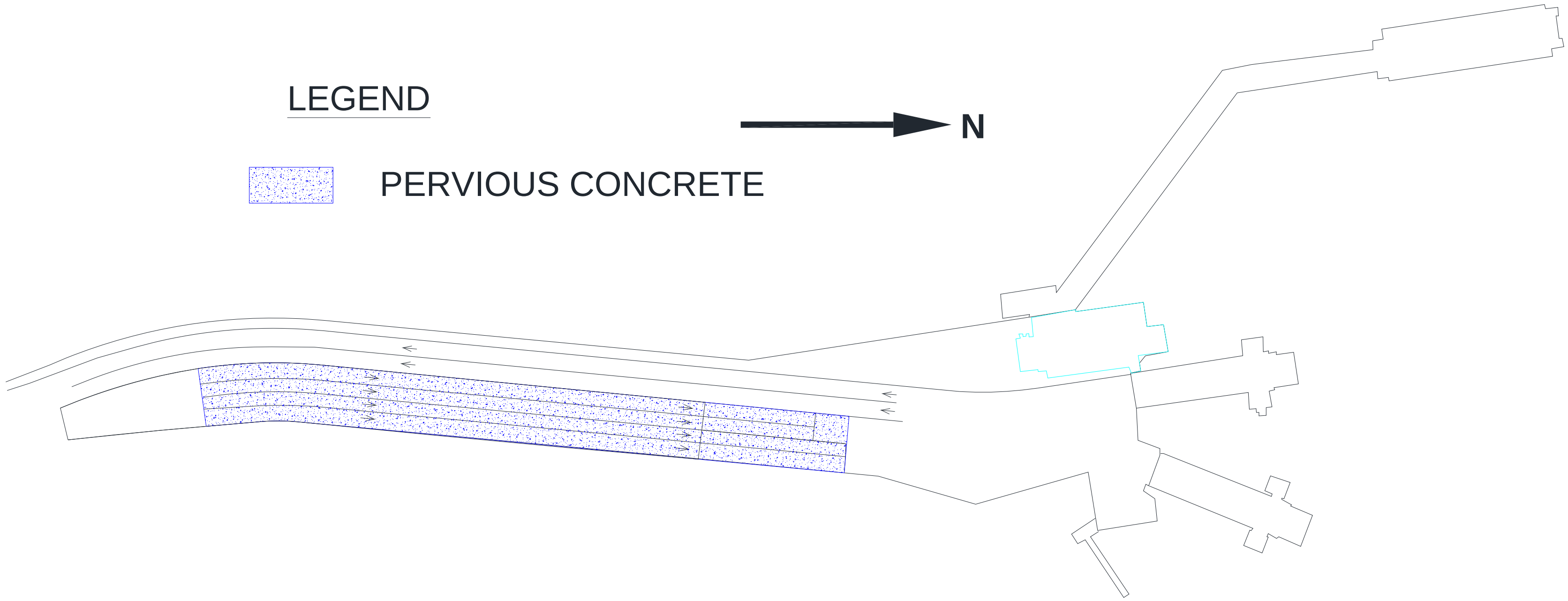

Figure 5.2: Pervious concrete overlay for the holding lanes only

5.2.3 Option 3: Three out of four holding lanes

A third option is applying a pervious concrete overlay to only three of the four holding lanes (Figure 5.3). The fourth holding lane would then be used for all heavy traffic. In this option, a majority of the heavy pollutant area is still treated and the pervious concrete will not have to be specially designed for a heavy traffic load and is therefore the least expensive option. It is assumed that heavy vehicles contribute the same amount of pollutants per area as the lighter vehicles. Using Equation 4.4 in Section 4.4, this option treats 49% of the pollutants on the trestle (Table 5.1).

Table 5.1: Summary of the three pervious concrete options presented

Options	**Total Pervious Concrete Area (ft^2)**	**Pervious Concrete Heavy Loading Area (ft^2)**	**P_x/P_T (%) if F_{HS} = 4**	**P_x/P_T (%) if F_{HS} = 5**	**P_x/P_T (%) if F_{HS} = 10**
Entire trestle overlay	58,580	28,190	100	100	100
Holding lanes only overlay	16,310	4,080	61	66	79
Three holding lanes overlay	12,230	0	46	49	60

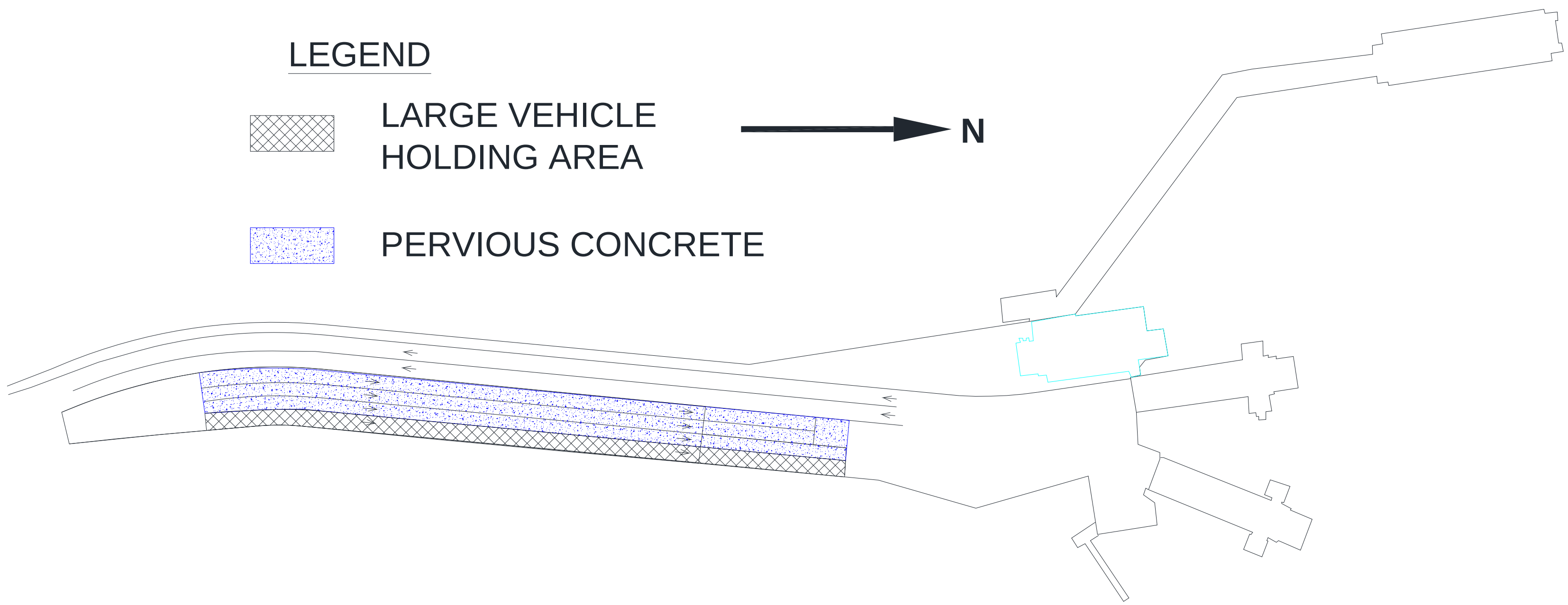

Figure 5.3: Pervious concrete overlay on three out of the four holding lanes

6. GREEN RATING SYSTEM POINTS

This section will make use of the Green Rating Integration Platform to identify which credits in each of the rating systems are met by the two designs discussed in Chapters 5 and 6. Both the reverse slope and the pervious concrete alternatives will be examined by each of the four land side rating systems (GreenLITES, LEED, SSI and PANYNJ) and the appropriate points and credits will be assigned in each rating system for the design. The reverse slope credits are summarized in Section 6.1 and Table 6.1 and the pervious concrete credits are summarized in Section 6.2 and Table 6.2.

6.1 Reverse Slope

The reverse slope design meets the requirements for two credits in the GreenLITES system, W-1 and W-2. W-1 is the first water quality credit and focuses on both volume and quality of stormwater management. The reverse slope design is worth two points for this credit as long as it is accompanied by a model which demonstrates how the design will reduce the pollutant loading into Puget Sound. Credit W-2 of GreenLITES is focused on the use of BMPs. Reverse slope also earns two points in credit W-2 for the stormwater detention basin which the stormwater is diverted to.

The LEED retail system credit which can be met is Sustainable Sites credit 6.2. This credit focuses on quality control of stormwater and is worth one point. In order to meet this credit 90% of the average annual rainfall must be treated and 80% of the total suspended solids (TSS) must be removed from the stormwater. This can be proven if the detention system is designed according to state or local performance standards or if monitoring data is available. Unfortunately, none of the options outlined for reverse slope would precisely meet these requirements because less than 90% of the terminal is treated, but with a credit interpretation for the water quality criteria as meeting the intent of the credit, it might be met for the Option 1 (full replacement) without a crown or Option 3 (extended southern portion) without a crown. Also, LEED also has a credit for innovative design processes and the reverse slope technique may earn a point in that area.

Sustainable Sites Initiative's water credit 3.5 focuses on managing stormwater on site and is worth between five and ten points. To qualify for this credit the initial and final runoff rates as well as the target water storage volumes need to be documented. Also, it must be shown that the release of water from the detention basin will not harm the ecology or cause safety concerns. Finally, it must be documented that the design does not negatively affect the Puget Sound. The reverse slope design should meet all these requirements without a problem and therefore be eligible for the maximum number of points.

Implementing stormwater BMPs falls under credit IW-1 for the Port Authority of New York and New Jersey Sustainable Infrastructure Guidelines. This credit is currently worth one point in New Jersey and three points in New York. For sites large than ¼ of an acre, which the Vashon Island terminal is, the post-development flow of stormwater must be reduced and the quality improved. Also, the 2, 10, and 100 year storm events must be 50%, 75%, and 80% of pre-construction rates respectively. Similar to the LEED credit, the stormwater detention basin must reduce TSS by 80% and if the upland stormwater is included the TSS must be reduced by 50%. Finally, all catch basins must be marked to inform the public that they drain directly into the Sound. The reverse slope technique can be made to meet all of these requirements.

6.2 Pervious Concrete

Pervious pavement also meets both credits W-1 and W-2 in the GreenLITES rating system. The reduction in overall impervious area achieved by using pervious pavements is worth two points for credit W-1. All types of permeable pavement are also worth two points in credit W-2 as an appropriate BMP.

The LEED credit is also the same for both design methods. The sustainable site LEED credit 6.2 focuses on quality control of stormwater and is worth one point. In order to meet this credit 90% of the average annual rainfall must be treated and 80% of the total suspended solids (TSS) must be removed from the stormwater. This can be proven if monitoring data is available. This can be met only if the total overlay option is met.

For the Sustainable Sites Initiative green rating program, the pervious concrete design is eligible for two different credits. The water credit 3.5 focuses on managing stormwater on site and is worth between five and ten points. To quality for this credit the initial and final runoff rates need to be documented. Also, it must be shown that the water runoff will not harm the ecology or cause safety concerns. Finally, it must be documented that the design does not negatively affect the Puget Sound. Water credit 3.6 is worth between three and nine points and focuses on water quality. The first requirement for Wc3.6 is all exterior materials used in the construction must be chosen in order to minimize the amount of pollutants that stormwater will pick up. An example of this is coating railings which are a source of zinc. Second, a site maintenance plan must be enacted to ensure the pervious pavement continues to function correctly. This may involve sweeping. Finally, TSS must be reduced to 25 mg/L, which pervious concrete is expected to achieve. If 80% of stormwater on the site is treated 3 points are earned, 90% of the site gets 5 points, and 95% of the site earns eight points for credit Wc3.6. This credit will only be eligible for the pervious overlay of the total site, and should earn eight points for the credit.

Pervious concrete is eligible for two credits under the Sustainable Infrastructure Guidelines as well. Credit IS-7 is specifically awarded for the use of pervious pavement. One point is awarded if pervious pavement is used for 25% of the hardscape, two points for 50%, and three points for 75%. Pervious concrete may also achieve the requirements for credit IW-1. This credit is currently worth one point in New Jersey and three points in New York. For sites large than ¼ of an acre, which the Vashon Island terminal is, the post-development flow of stormwater must be reduced and the quality improved. Also, the 2, 10, and 100 year storm events must be 50%, 75%, and 80% of pre-construction rates respectively. The stormwater quantity issue may not apply to the trestle because it is an over-water structure and the rain which falls on it would normally enter the Puget Sound. This exempts the trestle from being subject to water quantity guidelines. Similar to the LEED credit, the TSS in the stormwater must be reduced by 80%. Finally, all catch basins must be marked to inform the public that they drain directly into the Sound. Due to the TSS requirements, this credit would only be achieved by the total overlay option.

Table 6.1: Possible credits for reverse slope option

Upland GreenLITES	Land Side LEED retail	Land Side Sustainable Sites Initiative	Intermodal Port Authority
☐ **W-1: Stormwater Management - 2 points**	☐ **SSc6.2-Stormwater Quality Control - 1 point**	☐ **Wc3.5-Manage Stormwater on Site - 5 to 10 points**	☐ **IW-1: Implement Stormwater BMPs - 1 to 3 points**
Eligible for all three options	Possible credit for meeting intent:	Eligible for all three options	Eligible for all three options
☐ Demonstrate a reduction in pollutants	Full trestle without crown	☐ Calculate storage capacities	☐ Implement SW management plan
☐ **W-2:BMPSs - 2 points**	Extended southern portion without crown	☐ Don't harm ecology or safety	☐ Lower peak runoff rates
Eligible for all three options	☐ **IDc1-Innovation in Design - 1 point**	☐ Cannot negatively effect Puget Sound	☐ Lower TSS by 80%
☐ Use a structural BMP (detention basin)	Eligible for all three options		☐ Mark storm drains
	☐ Achieve measurable environmental performance		

Table 6.2: Possible credits for pervious concrete overlay option

Upland GreenLITES	Land Side LEED retail	Land Side Sustainable Sites Initiative	Intermodal Port Authority
☐ **W-1: Stormwater Management - 2 points**	☐ **SSc6.2-Stormwater Quality Control - 1 point**	☐ **Wc3.5-Manage Stormwater on Site - 5 to 10 points**	☐ **IS-7: Utilize Pervious Pavement - 1 to 3 points**
Eligible for all three options	Eligible for full trestle option	Eligible for all three options	One point for holding lanes option
☐ Reduce overall impervious area	☐ Treat 90% of stormwater	☐ Calculate storage capacities	Three points for full trestle option
☐ **W-2:BMPSs - 2 points**	☐ Remove 80% of TSS	☐ Don't harm ecology or safety	☐ Utilize pervious pavement
Eligible for all three options	☐ **IDc1-Innovation in Design - 1 point**	☐ Cannot negatively affect Puget Sound	☐ **IW-1: Implement Stormwater BMPs - 1 to 3 points**
☐ Inclusion of permeable pavement	Eligible for all three options	☐ **Wc3.6-Receiving water quality - 8 points**	Eligible for full trestle option
	☐ Achieve measurable environmental performance	Eligible for full trestle option	☐ Implement SW management plan
		☐ Choose materials which minimize pollutants	☐ Lower peak runoff rates
		☐ Maintain site to reduce pollutants	☐ Lower TSS by 80%
		☐ Discharge less than 25mg/L TSS	☐ Mark storm drains

7. SUMMARY AND RECOMMENDATIONS

A recap of how each objective was completed is provided in Section 7.1 followed by a summary of the findings in Section 7.2.

7.1 Objectives

Objective 1:

A literature review was performed on several common green rating systems. Background information was provided on 13 green rating systems which outline different low impact development practices in Section 1.4.1.

Objective 2:

Five rating systems (GreenLITES, LEED retail, Sustainable Sites Initiative, Port Authority of NY/NJ Sustainable Infrastructure Guidelines, and MVeP) were determined applicable for some portion of a ferry terminal in Section 2.1. Combined, these five rating systems addressed the upland, landside, intermodal, and waterside areas. These five rating systems were organized into seven categories set up using previous work done by WSU. A matrix, titled Green Rating Integration Platform (GRIP), was created integrating the LID practices of all five rating systems and previous WSU research, illustrating how credits relate across rating systems as found in Section 2.2.

Objective 3:

Since the detailed focus of this thesis is stormwater treatment, each of the rating systems stormwater credits was more thoroughly examined in Section 2.3. The WSU Ferry Guidelines section was expanded to include current research and new BMP techniques recommended by WSU for WSF specifically in the area of stormwater treatment in Section 2.4. The WSF safety management system was examined and activities which related to stormwater were reorganized to fit into the previously developed GRIP matrix. The GRIP was then further expanded to include stormwater credits from all five rating systems, expanded WSU Ferry Guidelines, and the current WSF safety management system procedures in Section 2.5 (Table 2.7).

Objective 4:

This thesis then goes on to examine the Vashon Island terminal as a case study with respect to stormwater challenges and sustainability in Chapter 3. Two different LID strategies used to reduce stormwater pollutant levels were examined. The reverse slope method was explained and three different implementation options were presented in Chapter 4. Each of the options resulted in different required vault sizes and different levels of pollutants which are treated. The reverse slope also presented the possibility of treating stormwater running onto the terminal from Vashon Island as well as treating stormwater runoff from the terminal itself. The pervious concrete method was then explained. It also has three different design options presented which resulted in different construction areas and levels of treated pollutants, as is presented in Chapter 5. Both of these strategies are further summarized in decision support tools later in this Chapter 7.

Objective 5:

In Chapter 6, these two LID techniques are analyzed using the Green Rating Integration Platform in order to relate them to sustainability tools. The GRIP shows which credits each strategy may be eligible for and what points can be earned.

7.2 Findings

Stormwater runoff contains pollutants which may need to be treated before being discharged into a water body. Due to the close proximity of ferry terminals to the Puget Sound, most common treatment techniques cannot be easily implemented. Two possible stormwater treatment techniques for use at the Vashon Island ferry terminal have been investigated. The first of these techniques are a reverse slope of a portion of the paved trestle area, directing stormwater back towards the land where it is collected in a stormwater detention vault and appropriately treated. The second technique uses a pervious concrete overlay on certain portions of the paved areas of the trestle. The overlay would trap and treat many of the pollutants at the source and might be used in combination with specialized catch basins for additional treatment.

A summary of the size of the treatment facilities, the percent of pollutants treated based on the trestle side pavement loadings for water quality volumes as related to the LEED and the SMMWW standards for the reverse slope method are listed in Table 7.1. Also listed is the additional critical criterion for the change in elevation of the trestle at the edge of the land (lowered distance), which may or may not be feasible depending on water levels, etc. Also, the additional waters that the vault would need to handle if landside runoff is also directed are included in the additional landside row in Table 7.1. (Note that the LEED requirement does not address the hydrological processes upslope on the land and therefore the SMMWW volume is more realistic.)

Table 7.1: Reverse slope decision support tool (assuming a hotspot factor of 5)

Scenario	**LEED Vault Size (ft^3)**	**SMMWW Vault Size (ft^3)**	**Pollutants Treated (%)**	**Lowered Distance***
Option 1 (full replacement) – Without Crown	2250	4470	82	0
Option 1 (full replacement) – With Crown	1250	2480	69	0
Option 2 (southern portion) – Without Crown	1800	3600	65	2’-1.5”
Option 2 (southern portion) – With Crown	1000	1990	55	2’-1.5”
Option 3 (extended southern portion) – Without Crown	2250	4470	82	2’-7.5”
Option 3 (extended southern portion) – With Crown	1250	2480	69	2’-7.5”
Additional Landside	450,000**	140,000	-	-

* If feasible.

** Does not address typical hydrological process modeling upslope on the land usually performed for these larger land areas.

A summary of the square footage of trestle area treated with a pervious concrete overlay, the heavy vehicle loading portions of the total overlay treated with an enhanced pervious concrete overlay, and the percent of pollutants treated for the pervious concrete methods is shown in Table 7.2. (The heavy vehicle loading area will require a specially designed pervious concrete. This specially designed concrete will most likely be thicker and more expensive.)

Table 7.2: Pervious concrete decision support tool (assuming a hotspot factor of 5)

Options	Total Pervious Concrete Area (ft^2)	Pervious Concrete Heavy Loading Area (ft^2)	Trestle Pavement Pollutants Treated (%)
Entire trestle overlay	58,580	28,190	100
Holding lanes only overlay	16,310	4080	66
Three holding lanes overlay	12,230	0	49

WSF can make preliminary decisions as to which approaches to use based on these decision support tools, especially in conjunction with other project goals, phasing and economic constraints. Table 6.1 or Table 6.2 may then be consulted to see which points and credits for which the choices are eligible, in order to facilitate the decision process based on environmental priorities.

Once a decision has been made, the Green Rating Integration Platform (Figure 2.7) can be addressed to determine which criteria or credits of the various guidelines the choice will meet and also how it fits in with current SMS procedures.

It is recommended that either of the alternatives be implemented. The choice of which alternative and option to use should be based on cost, project phasing, and pollutant reduction goals. The tables in Chapter 6 and the Green Rating Integration Platform can be used to compare the alternatives when analyzing the green building and pollutant reduction goals of WSF.

Using this approach for the Vashon Island decision process will aid in the validation of the decision model. It will also provide information as to how the two proposed low impact development schemes might be approached economically when implemented at future sites. It is also recommended that water quality data be collected from the Vashon Island site implementation. This can provide a basis for further refinement of the decision support tools when future water quality requirements are implemented, and can help with decisions for future site designs.

7.3 Future Development of the GRIP

The GRIP presented in the thesis currently integrates five rating systems relevant to intermodal facilities as well as a set of guidelines for ferry terminals previously developed by WSU. Ideally, future work could be done to expand this integration beyond simply green rating systems and guidelines to include regulations and standards as well.

Green rating systems are tools which are used to confirm a building is being designed and built sustainably. They provide a metric which measures how sustainable a building or project is by assigning a representative value which increases the more sustainable practices are used. This value is typically assigned based on how many credits or criteria the project meets. These credits often fall into a wide range of categories including site selection, water conservation, energy use, materials selection, and operations and maintenance. Each credit that is achieved earns points towards the value which is representative of how sustainable the project is.

Guidelines differ from green rating systems in that there is no value established which relates to the sustainability of the project. Guidelines are simply in place to help set a principle and suggest courses of action for the purpose of meeting the goal of building more sustainably. The WSU Ferry Guidelines used in the GRIP provide a framework of sustainability practices which are specifically tailored for passenger ferry terminals. These guidelines will assist in allowing WSF to achieve their sustainability goals by identifying preventative or corrective measures in areas where sustainability can be improved.

Regulations are laws established by the government which must be followed under penalty of a fine. In the case of WSF, the overriding regulations which must be abided by are set by WSDOT permitting. Other sources of regulations may come from the King County Surface Water Design Manual and the Stormwater Management Manual for Western Washington. Another source which must be followed is design standards. For WSF, these are set by the Washington State Public Building Requirements, the International Building Code, and the International Green Building Code.

Additional standards which are not building standards include those set by other agencies such as ASTM or ISO. These standards are sometimes used by green rating systems such as LEED to see if credits have been successfully earned. Standards can be procedures used for measuring sustainability and can be used to ensure the same methods are being used universally. The ISO 14000 level standards specifically apply to environmental management and were actually incorporated into the WSF SMS.

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APPENDIX

9. APPENDIX

9.1 Appendix A: Table 2 from WSF

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**	SMS covers this source.

		ERM SAFE 0150 Ordering/Using Chemical Products **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	◆ Investigate if inspection is adequate and whether or not procedure needs to include charging hose with potable water before pumping

		ENGR ENVN 0050 Spill Response	

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	◆ Address in Terminal Stormwater Procedure

	Transporting Livestock TERM OPER 0030 Unique Loading and Off-Loading Situations	
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
	  - Fuel in designated areas or offsite
	  - Spill kits in vehicles and fueling area
	  - Daily Inspect ion of equipment
	  - Maintain equipment off site
	  - 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 - 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

9.2 Appendix B: Detailed management practices for each of the rating systems in the Green Rating Integration Platform

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

Sustainable Sites Initiative

1. Traffic and Parking
2. Integration in the Community

☐ **SSp1.2: Protect floodplain functions**

- ☐ Design so as not to disturb floodplain
- ☐ Re-establish areas of vegetated floodplain on greyfield or brownfield sites
- ☐ Manage invasive plants species

☐ **SSp1.3: Preserve wetlands**

- ☐ Give preference to sites that do not include wetlands
- ☐ Design to minimize disruption to existing wetlands

☐ **SSp1.4: Preserve threatened or endangered species and their habitats**

- ☐ Develop sites that do not include habitat for threatened or endangered plants and animal species
- ☐ Design to minimize disruption of habitats
- ☐ Allow species connectivity through the site

☐ **SSc1.6: Select sites within existing communities**

- ☐ Design within existing areas that have pedestrian access
- ☐ Include pedestrian access as part of the project

☐ **SSc1.7: Select sites that encourage non-motorized transportation and use of public transit**

- ☐ Select site near mass transit, sidewalks, and bicycle networks

☐ **SVp4.1: Control and manage known invasive plants found on site**

- ☐ Contract local agencies or consultants for most effective management techniques of invasive species

☐ **SVp4.2: Use appropriate, non-invasive plants**

- ☐ Select native plants that play a role in the local ecosystem
- ☐ Use ANSI A300 BMP for guide when planting trees
- ☐ Plant a diverse amount of plants

☐ **SVp4.3: Create a soil management plan**

- ☐ Use compost blankets, berms, or socks for erosion and sediment control
- ☐ Reuse compost for amendment in soil restoration

☐ **SVc4.5: Preserve all vegetation designated as special status**

- ☐ Minimize harm to special status trees and plants

☐ **SVc4.6: Preserve or restore appropriate plant biomass on site**

- ☐ Design to minimize disruption of existing vegetation
- ☐ Use trees, green roofs, or vegetated structures to cover non-vegetated areas

- ☐ **SVc4.7: Use native plants**
- ☐ **SVc4.8: Preserve plant communities native to the ecoregion**
- ☐ **SVc4.9: Restore plant communities native to the ecoregion**
- ☐ **SVc4.12: Reduce urban heat island effects**
    - ☐ Use shade from plants
    - ☐ Install light-colored surfaces where possible
- ☐ **SVc4.13: Reduce the risk of catastrophic wildfire**
    - ☐ Use fire resistant plants appropriately spaced
    - ☐ Adopt fuel management practices
- ☐ **HHc6.1: Promote equitable site development**
    - ☐ Develop the site to benefit a wide range of residents, beyond primary users
- ☐ **HHc6.2: Promote equitable site use**
    - ☐ Use the site to benefit a wide range of residents, beyond primary users
- ☐ **HHc6.3: Promote sustainability awareness and education**
    - ☐ Design educational and interpretive elements
- ☐ **HHc6.4: Protect and maintain unique cultural and historical places**
- ☐ **HHc6.5: Provide for optimum site accessibility, safety, and wayfinding**
    - ☐ Identify techniques to address safety and accessibility concerns
    - ☐ Improve legibility and understanding of site's layout and uses
- ☐ **HHc6.6: Provide opportunities for outdoor physical activity**
    - ☐ Creatively design meandering pathways
- ☐ **HHc6.7: Provide views of vegetation and quiet outdoor spaces for mental restoration**
    - ☐ Design a variety of small spaces instead of one large space
    - ☐ Design outdoor spaces away from distractions

- ☐ Minimize noise levels
- ☐ Create a sense of enclosure with low walls, fences, vegetation, or topography

☐ **HHc6.8: Provide outdoor spaces for social interaction**

- ☐ Look for areas that could accommodate moderate and large groups

☐ **HHc6.9: Reduce light pollution**

- ☐ Avoid off-site lighting and night sky pollution

3. Energy Management

☐ **SVc4.10: Use vegetation to minimize building heating requirements**

☐ **SVc4.11: Use vegetation to minimize building cooling requirements**

- ☐ Use plants to increase shading

☐ **OMc8.4: Reduce outdoor energy consumption for all landscape and exterior operations**

- ☐ Use energy efficient outdoor appliances
- ☐ Look for solar powered alternatives

☐ **OMc8.5: Use renewable sources for landscape electricity needs**

- ☐ Use renewable energy

4. Water Management

☐ **Wp3.1: Reduce potable water use for landscape irrigation by 50 percent from established baseline**

- ☐ Use low-water-demand vegetation
- ☐ Use high-efficiency equipment and/or climate based controllers for irrigation systems
- ☐ Reuse graywater and captured rainwater

☐ **Wc3.2: Reduce potable water use for landscape irrigation by 75 percent or more from established baseline**

- ☐ Use low-water-demand vegetation

- ☐ Use high-efficiency equipment and/or climate based controllers for irrigation systems
- ☐ Reuse graywater and captured rainwater

☐ **Wc3.3: Protect and restore riparian, wetland, and shoreline buffers**

- ☐ Design to avoid disturbance of riparian, wetland, and shoreline buffers
- ☐ Re-establish areas of vegetated floodplain
- ☐ Manage invasive plant species

☐ **Wc3.4: Rehabilitate lost streams, wetlands, and shorelines**

- ☐ Remove physical modifications to stream, wetlands, and shorelines
- ☐ Replace road crossings/dams which disrupt sediment transport

☐ **Wc3.5: Manage stormwater on site**

- ☐ Consider all components of the hydrologic cycle in design
- ☐ Minimize impervious cover
- ☐ Where infiltration is not desirable use other techniques to reduce runoff

☐ **Wc3.6: Protect and enhance on-site water resources and receiving water quality**

- ☐ Reduce impervious cover
- ☐ Disconnect impervious cover
- ☐ Provide depression storage in the landscape
- ☐ Convey stormwater in swales to promote infiltration
- ☐ Use biofiltration to provide vegetated and soil filtering
- ☐ Exapotranspire
- ☐ Infiltrate stormwater
- ☐ Minimize materials that can be a source of pollutants

- ☐ Plan and implement maintenance activities that reduce the exposure of pollutants to stormwater

☐ **Wc3.7:Design rainwater/stormwater features to provide a landscape amenity**

☐ **Wc3.8: Maintain water features to conserve water and other resources**

- ☐ Design water features that match or mimic water in the natural environment
- ☐ Avoid water features that are incompatible with the local ecological context
- ☐ Estimate volumes of rainwater available for use in water features
- ☐ Collect and reuse non-potable water
- ☐ Design and maintain water features as natural ecosystems
- ☐ Water quality can be enhanced with biologically-based water treatment

☐ **OMp8.1: Plan for sustainable site maintenance**

5. Materials Management

☐ **MSp5.1: Eliminate the use of wood from threatened tree species**

- ☐ Identify suppliers who provide wood products from sustainably managed forests
- ☐ Use recycled plastic or composite lumber instead of wood

☐ **MSc5.2: Maintain on-site structures, hardscape, and landscape amenities**

- ☐ Identify opportunities to incorporate existing site materials into site design

☐ **MSc5.3: Design for deconstruction and disassembly**

☐ **MSc5.4: Reuse salvaged materials and plants**

☐ **MSc5.5: Use recycled content materials**

- ☐ Specify plastic lumber made from recycled content
- ☐ Remove on-site concrete pavement and crushing it for aggregate
- ☐ Utilize spent iron and foundry sand as fine aggregate in concrete

☐ **MSc5.6: Use certified wood**

- ☐ **MSc5.7: Use regional materials**
- ☐ **MSc5.8: Use adhesives, sealants, paints, and coatings with reduced VOC emissions**
- ☐ **MSc5.9: Support sustainable practices in plant production**
    - ☐ Use plants from nurseries that reduce damage to the environment and conserve resources
- ☐ **MSc5.10: Support sustainable practices in materials manufacturing**
- ☐ **OMp8.2: Provide for storage and collection of recyclables**
    - ☐ Coordinate the size and function of the recycling areas with anticipated collection rates
- ☐ **OMc8.3: Recycle organic matter generated during site operations and maintenance**
    - ☐ Collect excess vegetation and divert to a compost facility

6. Air Quality

- ☐ **OMc8.6: Minimize exposure to environmental tobacco smoke**
    - ☐ Take into account prevailing winds when establishing smoking areas
    - ☐ Use filters near air intakes and outdoor smoke rooms
- ☐ **OMc8.7: Minimize generation of greenhouse gases and exposure to localized air pollutants during landscape maintenance activities**
    - ☐ Design to minimize gasoline-powered maintenance equipment
    - ☐ Select plants that require minimum maintenance
    - ☐ Select equipment with low emissions
- ☐ **OMc8.8: Reduce emissions and promote the use of fuel-efficient vehicles**
    - ☐ Provide alternative fuel refueling stations
    - ☐ Consider sharing costs and benefits of refueling station with neighbors

7. Construction Phase

- ☐ **SSp1.1: Limit development of soils designated as prime farmland, unique farmland, and farmland of statewide importance**
- ☐ **SSc1.5: Select brownfields or greyfields for redevelopment**
- ☐ **PDp2.1: Conduct a pre-design site assessment and explore opportunities for site sustainability**
  - ☐ Evaluate the impact the design may have on sustainability during construction, operations, and maintenance
- ☐ **PDp2.2: Use an integrated site development process**
  - ☐ Ensure multiple meeting with the project team for optimal interaction and communication
- ☐ **SVp4.4: Minimize soil disturbance in design and construction**
  - ☐ Limit grading for planting mounds or other topological forms
  - ☐ Establish clear construction boundaries
- ☐ **Cp7.1: Control and retain construction pollutants**
  - ☐ Temporary and permanent seeding
  - ☐ Mulching
  - ☐ Earth dikes
  - ☐ Sediment traps
  - ☐ Sediment basins
  - ☐ Filter socks
  - ☐ Compost berms and blankets
  - ☐ Secondary containment
  - ☐ Spill control equipment
  - ☐ Hazardous waste manifests
  - ☐ Overfill alarms

- ☐ Implement post-construction stormwater management
- ☐ Account for weather conditions

☐ **Cp7.2: Restore soils disturbed during construction**

- ☐ Stockpile and reuse existing site topsoils
- ☐ Amend soils in place
- ☐ Import a topsoil

☐ **Cc7.3: Restore soils disturbed by previous development**

- ☐ Stockpile and reuse existing site topsoils
- ☐ Amend soils in place
- ☐ Import a topsoil

☐ **Cp7.4: Divert construction and demolition materials from disposal**

- ☐ Reuse existing materials on site or recycle for on-site use when possible
- ☐ Develop a construction waste management plan

☐ **Cp7.5: Reuse or recycle vegetation, rocks, and soil generated during construction**

- ☐ Balance cut and fill

☐ **Cp7.6: Minimize generation of greenhouse gas emissions and exposure to localized air pollutants during construction**

- ☐ Select contractors with reduced diesel emissions

Port Authority of NY/NJ Sustainable Infrastructure Guidelines

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