South Park Bridge Replacement

HYDRAULICS/STORM DRAINAGE DESIGN

TECHNICAL INFORMATION REPORT

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1 INTRODUCTION AND PROJECT OVERVIEW

This project is being directed by King County, administered and funded by King County, and has been designed according to the KCSWDM (2009) and meets or exceeds the Department of Ecology Stormwater Management Manual (SWMM 2007) water quality requirements. The project areas within the City of Seattle and City of Tukwila have also been designed according to the KCSWDM. This report is organized into ten sections per Section 2.3.1.1 of the KCSWDM and contains specific requirements and design parameters used for the design of the water quality treatment facilities and conveyance system.

1.1 Project Purpose

This project proposes to construct a new bascule bridge adjacent to the existing bridge, re-align the roadway, and remove the existing bridge. The existing bridge is structurally deficient and is functionally obsolete. The purpose of this bridge replacement project is to provide a safe facility for the public, maintain and improve the existing waterway, and minimize environmental impacts to the Duwamish Waterway. Several design alternatives were development and evaluated during preliminary engineering the main considerations that governed the design and alternative selection were safety, environmental impacts, function, aesthetics, and impacts to the South Park businesses and neighborhood. This report is based on the preferred alternative selected following the Draft Environmental Impact Statement (September 2005) and the Final Environmental Impact Statement (February 2009).

1.1.1 Proposed Bridge Configuration

The bridge will be constructed downstream of the existing bridge to allow for continued traffic operations while the new bridge is being constructed. The proposed bridge cross-section will have four 11-foot traffic lanes, 5-foot bike lanes, and 6-foot sidewalks on each side. The sidewalk will be separated by a traffic barrier preventing roadway debris from accumulating in the sidewalk area. The traffic barrier will contain roadway trash, winter sanding, and general pollutants to the roadway portion of the bridge allowing traditional street cleaning maintenance activities to be more effective. The barrier will prevent trash and sanding debris from accumulating on the sidewalk and pedestrian railing area where a street cleaning machine may not have access or ability to provide cleaning maintenance activities.

1.1.2 Proposed Drainage System

As part of this project, the existing storm drainage system will be reconstructed to provide water quality treatment facilities, low impact development treatment methods, and two new outfalls into the Duwamish Waterway.

Two water quality treatment rain gardens will be constructed in the south basin to treat pollution generating impervious surfaces. A conveyance system will drain the roadway surfaces, sidewalk areas, capture offsite water entering the project limits, and convey runoff to the water quality treatment rain gardens prior to discharge into the Duwamish Waterway.

The north basin includes property on both sides of the project and right-of-way for the roadway is minimized. Access easements will be developed for maintenance under the bridge and for the proposed conveyance and water quality treatment wet vault. Boeing parking and storage areas are on both sides of the new roadway. Boeing has access under the proposed bridge for vehicle movements to connect the eastern and western Boeing parcels for business activities. An underground water quality wet vault has been designed to provide as much surface area as possible for Boeing activities, and provide the level of water quality treatment required for the project improvements.

A conveyance system is designed to bypass Boeing stormwater and the roadway north of the project limits around the project site. The bypass interceptor will connect into the existing 18-inch outfall for discharge into the Duwamish Waterway.

The proposed roadway and bridge stormwater runoff will be captured in a conveyance system and conveyed to the underground water quality treatment wet vault prior to discharge into the Duwamish Waterway through a new 24-inch diameter outfall.

1.2 Project Location and Limits

The existing South Park Bridge No. 3179 is a 78-year old bridge built in 1931 and is located in an industrial area on the Duwamish Waterway, approximately 5 miles south of downtown Seattle, as shown in Figure 1. The project is located in Township 24N, Range 4E, Section 32 and encompasses the roadway corridor defined by 16th Avenue South (between East Marginal Way South and the South Park Bridge) and 14th Avenue South (between the bridge and South Cloverdale Street).

1.2.1 Existing Bridge Configuration

The existing bridge is approximately 1,045 feet long between abutments and the overall length of the project area is approximately 2,400 feet. The existing roadway consists of four 9.5-foot lanes and a total pavement width of approximately 38-feet not including sidewalks. The bridge is comprised of approach fills, abutment walls, approach spans supported on piers, bascule towers, and the bascule movable section over the Duwamish Waterway navigable channel.

1.2.2 Existing Jurisdictional Boundaries

The project area is governed by three local government jurisdictions. The area north of the Duwamish Waterway (between East Marginal Way S. and the waterway) lies within the city limits for both the City of Seattle (northern portion) and the City of Tukwila (southern portion). The area south of the Duwamish Waterway (between the waterway and S. Cloverdale Street) lies within unincorporated King County and the City of Seattle. The two-block area between the riverbank and Dallas Avenue S. is in King County, and the city blocks to the south are in the City of Seattle.

1.2.3 Existing Land Use and Zoning

Land uses in the project area are mixed residential, retail commercial, and industrial. The Boeing Company Plant 2 is located on the north side of the Duwamish Waterway. On the south side, retail commercial and light industrial land fronts 14th Avenue S. and the banks of river. Single family residences generally characterize the area south of the bridge.

1.3 Pre-developed Site Conditions

The project is located in the Duwamish Waterway floodplain bounded by upland areas to the east and west. Historically, the Puget Sound Region was shaped by the Vashon Stade Frasier Glaciation. The resulting Duwamish River meandered across the flood plain and formed freshwater wetlands and tidal marshes across a river delta discharging into Elliott Bay. According to the Geotechnical Report (August 2007), prior to 1910, an abandoned meander channel of the Duwamish existed south of the existing South Park Bridge between Dallas Avenue South and South Orr Street. According to the Hazardous Materials Data Summary Report (May 15, 2008), the channel was dredged and straightened by the U.S. Army Corps of Engineers between 1913 and 1920 and most of the meanders were filled.

1.3.1 Historic Site Development

Between 1920 and 1930 a wooden swing bridge (14th Avenue South Bridge) structure was in service. During the early 1900’s, the area shifted from mixed residential and farmlands to commercial and industrial uses. Between 1920 and 1935, a Standard Oil bulk fuel storage facility operated on a dock on the north shore. The north shore of the Duwamish Waterway became more industrialized during and following World War II. Commercial business activity in the project vicinity includes aviation manufacturing, oil transfer and storage, gasoline service stations, dry cleaners, boat storage yards, and light industrial warehouses.

1.3.2 Pre-developed Drainage Condition Assumption

This project is not required to provide detention or flow control due to the proximity of the project to the Duwamish Waterway. Project water from impervious surface areas will be routed through water quality treatment facilities and discharge directly into the Duwamish Waterway. Detention and discharge into the City of Seattle combined storm/sewer system is prohibited by the City of Seattle, the pre-developed drainage condition does not affect the design of the storm drainage or water quality facilities.

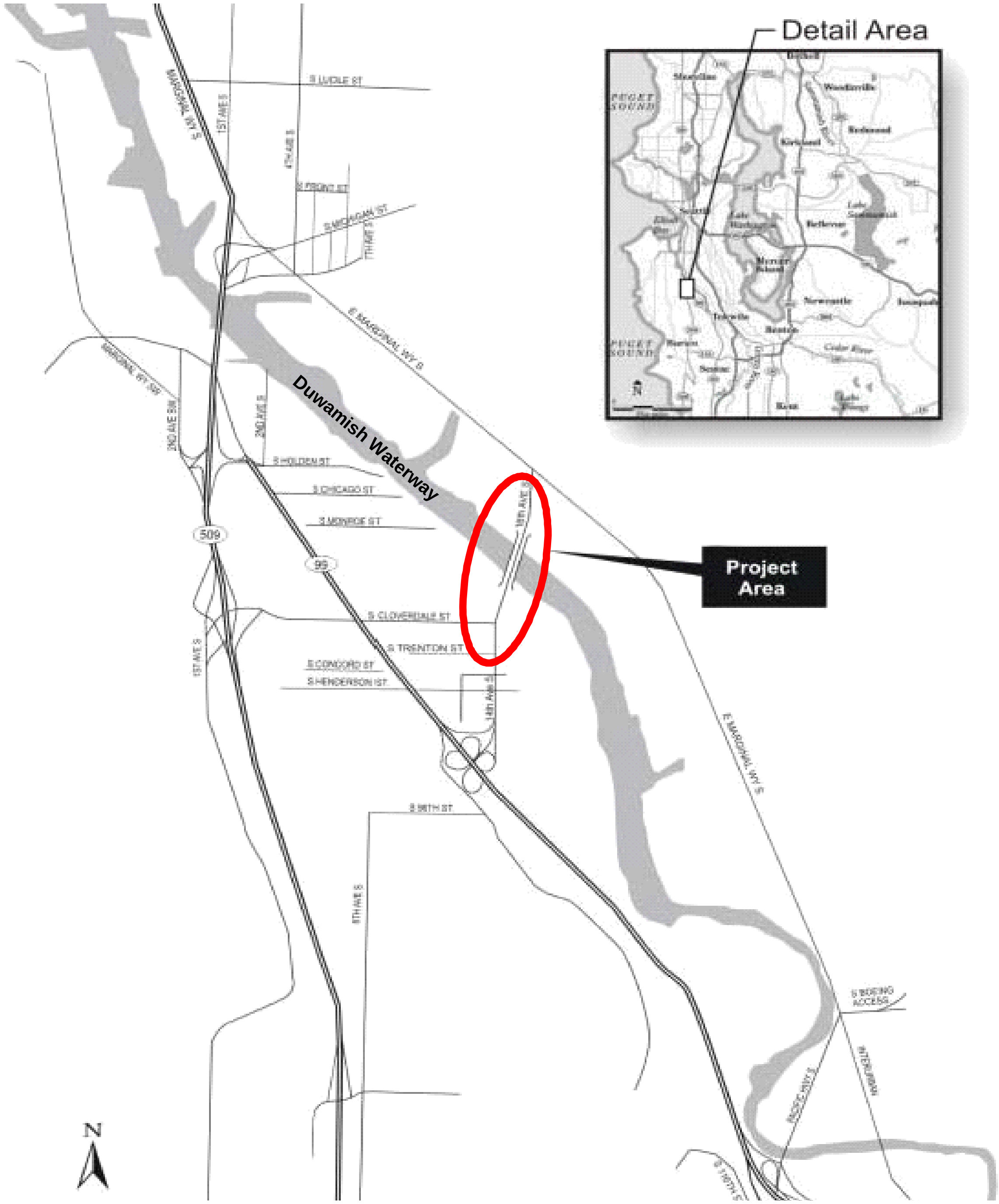

Figure 1 – Site Location

1.4 Existing Site Conditions

The existing soils are fill materials placed in the early 1900's. The existing fill material within the project limits are silty sand to gravelly sand with some sandy gravel. The existing site is comprised of impervious and pervious areas ranging from gravel to grass, and concrete to brick respectively. While brick surface may infiltrate stormwater, this design assumes the unsealed brick is impervious and cannot allow water to infiltrate. This approach is the most conservative for water quality treatment analysis (yielding the largest possible treatment facility).

Exhibit 1 (Appendix A) shows the entire project limits from E. Marginal Way south to S. Cloverdale Street. The project has been split into two basins, the North Basin (existing and proposed) as well as the South Basin (existing and proposed). Both north and south basins are considered part of one combined Threshold Discharge Area (TDA).

Each basin has been divided into sub-basins based on surface grades and surface drainage patterns. Each sub-basin has been evaluated for impervious and pervious areas for water quality treatment and conveyance design. Basins and sub-basins are within the limits of the federally designated floodway and must meet the requirements for flood hazard areas in the King County Sensitive Areas Ordinance and Chapter 16.52 of the Tukwila Floodplain Management Municipal Code. See Sections 3, and 5.8 and 5.9 for information regarding Special Requirement #2 (Flood Hazard Delineation) for more details regarding the flood plain. See Appendix A for basin limits and sub-basin area exhibits.

1.4.1 Existing North Basin (ENB)

The existing North Basin (ENB) is bordered by East Marginal Way South, Boeing on the east and west, and the Duwamish Waterway to the south. The existing North Basin is commercial/industrial and primarily impervious paved asphalt and concrete surfaces for the roadway, parking lots, and sidewalks.

The ENB contains both private and public conveyance systems collecting onsite and offsite stormwater runoff into the Duwamish Waterway. The roadway runoff is collected into a conveyance system that discharges into the Duwamish Waterway through an existing 18-inch outfall pipe fitted with a tide-flap gate. Much of the Boeing offsite runoff is collected and conveyed in a private conveyance system that also connects to the public stormwater system and discharges through the same 18-inch diameter public outfall pipe. Boeing has additional private outfalls connecting directly to the Duwamish Waterway at various locations along the waterfront within the project limits.

The west side of the roadway has several large buildings and a large fenced parking lot. The Boeing Plant 2 is a historic and working aircraft manufacturing facility supported by two smaller buildings. The Boeing Pier (formerly Standard Oil) is located adjacent to the Duwamish Waterway and South Park Bridge. Boeing also has four large buildings on the east side of 16th Avenue South. A sidewalk, ramp access, and tunnel provide pedestrian access from the west to east side of the street mid-block between East Marginal Way South and the existing South Park Bridge Number 3179.

The Boeing Plant 2 Stormwater Drainage System areas were determined by Ecology and Environmental Inc., 02-16-07 and can be found in Appendix B (Figure 15).

1.4.2 Existing North Basin Onsite Conditions

The ENB drainage pattern in the project area is a combination of onsite and offsite surface runoff and conveyance systems collecting and conveying water to the Duwamish Waterway. The drainage basin for this project was determined based upon surface drainage patterns, contours, and the limits of project impacts including construction staging and areas requiring temporary erosion control measures. For the purpose of this design and report, onsite is considered the geographic surface area surrounding the project impact zone draining via sheet flow, ditch, or curb and gutter into a conveyance system. Exhibit 3 in Appendix A shows the north basin limits, drainage patterns, and conveyance systems.

The north basin has a relatively small and insignificant amount of pervious area comprised of two small planter strip areas, and the vegetated shoreline. The two small "planter strips" are located behind the curb and gutter or adjacent to fence lines and parking lots. The planters are not irrigated and seasonal wild flowers "weeds" are the only vegetation in the dense gravelly planter soil. Since the planters are not maintained, comprised of dense gravel, and drain into the roadway, they will be considered impervious surfaces for the purposes of this design.

There is a more significant portion of pervious area in the ENB along the Duwamish Waterway. The area is comprised of an earth and dense grassy slope with broken concrete blocks providing erosion control and channel slope protection. The area will be considered pervious for the purposes of this design and determination of threshold water quality treatment criteria.

1.4.3 Existing North Basin Offsite Conditions

The existing drainage patterns within the ENB will be preserved as part of this project. The existing stormwater runoff from East Marginal Way north of the project limits is offsite roadway stormwater runoff and will be conveyed to the existing 18-inch public outfall for discharge into the Duwamish Waterway.

The Boeing parcels drain through a combination of private and public conveyance systems. The stormwater runoff draining through the private conveyance systems and private outfalls will be preserved. On the west side of the ENB, offsite flows do not enter the basin boundary as surface runoff. The flows are collected in a private conveyance system, treated for water quality in a private (Boeing) water quality treatment vault/oil water separator, and conveyed to the private 24-inch diameter outfall (OF-I, 4-125) into the Duwamish Waterway. On the east side of the ENB, Boeing offsite flows are conveyed to the existing public conveyance system and discharge into the Duwamish Waterway via the 18-inch diameter public outfall. Existing offsite areas collected and conveyed to the public system are shown in Exhibit 4 and 6 (Appendix A).

The offsite flows are not included into the project limits or project basin areas because the contributing offsite areas and flows will not be used for determining the proposed water quality treatment facility. The proposed water quality treatment facility will be sized and designed according to the onsite project impacts. However, additional offsite areas (from the Boeing Plant 2 Stormwater Drainage System Figure 15, 02-16-07) will be used for determining the conveyance system requirements where the offsite flows are re-configured to bypass public and private systems.

1.4.4 Existing North Basin Outfalls and Shoreline Conditions

1.4.4.1 List of Outfalls

The following is a list of existing outfalls labeled according to Boeing record documents on the north side of the waterway. The outfalls are labeled according to Boeing record documents according to outfall (OF) and lettered in order of sequence from downstream to upstream along the shoreline. See Exhibit 3 (Onsite Existing North Basin Exhibit) in Appendix A.

- 6-inch diameter CMP (Boeing OF-H, not found) serves only offsite stormwater runoff.
- 24-inch diameter CMP (Boeing OF-I, No. 4-125) serves only offsite stormwater runoff.
- 12-inch diameter pipe (Boeing, OF-J, not found) serves only offsite stormwater runoff
- 18-inch diameter SP (public outfall serving onsite stormwater runoff.. The pipe material is different between survey records and Boeing records and has been assumed to be concrete according to project survey records.
- 4-inch diameter SP (Boeing OF-K, surveyed as 6-inch diameter) serves only offsite stormwater runoff.
- 12-inch diameter SP (Boeing OF-L, abandon) flows are diverted to the public stormwater 18-inch diameter outfall.

The 18-inch diameter Boeing pipe that was not found is shown in the survey files and may be (most likely) the same pipe as the public outfall. Additionally, the 12-inch diameter outfall recorded in Boeing records may actually be the 18-inch diameter outfall.

1.4.4.2 Survey Data and Historical Records

Survey data and historical records show differences between pipe outfalls and sizes observed in the field and those reported in the as-built data. The following is a description based on the best available survey data and interpretation of historical records. Within the roadway and project limits (from East Marginal Way S. to the Duwamish Waterway), the surface runoff is collected via catch basins and conveyed to an existing 18-inch diameter steel (or concrete) pipe public outfall that discharges into the Duwamish Waterway.

1.4.4.3 North Basin Public Outfall

The existing public outfall extends beyond a sheet pile wall and old Standard Oil dock system. The pipe extends out into the waterway and is supported on wooden "joists" between four wooden piles. The end of the pipe has an iron tide flap that does not close completely and may allow river/saltwater to enter the pipe. Access to the outfall is controlled with security and fencing from the land-side, so a close visual inspection of the pipe was not performed to determine the condition of the existing outfall.

1.4.5 Existing North Basin Water Quality Treatment

The extent of Boeing offsite stormwater water quality treatment facilities has not been determined as part of this project. A search for commercial stormwater facilities documented in the King County GIS and mapping system (iMAP) indicated the absence of stormwater facilities in the north basin and Boeing parcels. Survey data indicates the possibility of some underground vaults/oil water separators on the Boeing parcels and it is assumed that existing storm drainage system collecting roadway stormwater runoff does not provide any water quality treatment or flow control prior to discharge into the Duwamish Waterway. Based on a field visit performed December 31, 2008, the existing Boeing Parcels adjacent to the roadway seem to be well contained and surface runoff from Boeing is not draining into the roadway region. Existing catch basins in the Boeing parking lots have permanent liners installed to trap sediment.

1.4.6 Existing South Basin (ESB)

The Existing South Basin (ESB) limits are shown in Exhibit 2 of Appendix A. The limits extend from South Cloverdale Street north to the Duwamish Waterway and extend approximately 300-feet left and right of 14th Avenue South.

The ESB is a combination of mixed retail, residential, and commercial use with both impervious and pervious surfaces. The existing 14th Avenue South roadway is constructed of asphalt concrete pavement, cement concrete traffic curb and gutters, and cement concrete sidewalks between South Cloverdale Street and Dallas Avenue South. The 14th Avenue South roadway surface is an exposed brick roadway from Dallas Avenue South to the roadway terminus at the Duwamish Waterway. Small portions of the project have existing pervious grass "planter strips and/or exposed gravel surfaces."

The ESB limits were established based on the proposed project limits, limits of construction activity for temporary erosion control, construction staging, and physical surface grading for drainage areas. The basin limits were established to account for onsite surface runoff as well as offsite drainage impacts within the project limits. For the ESB, offsite flows (roof top collection, driveways, alleys, etc…) drain into the existing onsite drainage system. The proposed design will continue to accept and preserve the offsite flow patterns. However, only onsite flows will be used to determine the design criteria for the water quality facility requirements/threshold treatment criteria. Both on and offsite flows will be added together to design and size the conveyance system, and conveyance for the water quality treatment facilities.

1.4.7 Existing South Basin Onsite Conditions

The ESB has both public and private stormwater conveyance systems discharging into the Duwamish Waterway or Puget Sound. The south basin also includes part of the City of Seattle combined storm/sewer system conveying stormwater runoff to the West Point water quality treatment facility.

Onsite stormwater runoff currently sheet flows into the City of Seattle combined storm/sewer system and is conveyed to the West Point water quality treatment facility for discharge in Puget Sound. A smaller portion of onsite stormwater runoff sheet flows under the existing bridge, down Thistle and/or Orr Street, and down Boat Access Road for collection into a public conveyance system discharging directly into the Duwamish Waterway.

Properties adjacent to the Duwamish Waterway sheet flow runoff directly into the river, or have private conveyance systems collecting runoff and discharging directly into the river. Several parcels drain into inlets with down-turned elbows trapping oil, and discharge into a 3-inch diameter cast iron pipe at the Duwamish Waterway.

1.4.8 Existing South Basin Offsite Conditions

Appendix L illustrates parcels with drainage complaints within the project vicinity. The existing City of Seattle combined storm/sewer system does not have sufficient capacity to convey large storm events and treat the events at the West Point water quality treatment facility. The project will provide relief to the combined storm/sewer system and adjacent offsite properties by redirecting runoff that currently discharges into the City of Seattle combined storm/sewer system into a water quality treatment facility for discharge into the Duwamish Waterway.

1.4.8.1 Existing Marina and Boat Ramp

A private concrete boat launch ramp is located on the east side of the bridge and serves the Marina and Boat Service Business and is labeled as area 2 in Offsite Existing South Area Exhibit 5 (Appendix A). The shoreline is a combination of dense grass, brush, rock, and mud, and sheet flows into the Duwamish Waterway. The existing catch basin serving the existing public 12-inch diameter corrugated aluminum metal pipe outfall is a brick and mortar catch basin that will be replaced. The existing aluminum outfall pipe extends beyond the rock and concrete slope protection and does not have a tide flap to control backwater into the pipe system. Based on a visual inspection, the pipe is in good condition, sounds solid, and does not show any signs of corrosion or damage.

The Marina has a storm drainage system including catch basins with down-turned elbows for oil containment. Based on a field visit, the marina did not seem to drain into the existing outfall or public combined storm/sewer system. However, roof drains and downspouts were observed to surface discharge into the public right of way. Roof water discharging into the public right-of-way is considered offsite water for this report and design. The offsite water will be included in the calculations for conveyance, and bypass flows for sizing the public water quality treatment facilities.

1.4.8.2 Existing Retail and Residential

Exhibits 4 and 5 in Appendix A shows area 1 as an offsite retail/residential area draining into the project area. Several retail parcels within the project limits also have drainage issues that were observed during the December 31, 2008 field visit. Parcel 7883607566 showed significant drainage problems adjacent to the existing alley. A storm drain catch basin has been destroyed and water seems to be draining under the building. Parcel 7883607550 has significant drainage problems with the existing parking lot. The pavement is broken and potholed and potholes range anywhere from 5 to 50 feet long. While some are filled with asphalt or concrete chunks, a passenger car cannot navigate the deep holes without scraping the bottom of the car. Parking lots within the project limits are a combination of paved, and gravel surfaces draining to both public and private conveyance systems.

Residential lots within the project limits are generally lower than the existing roadway. Some of the private residential lots show signs of long term water drainage issues and resulting damage caused by constant water contact and poor drainage. During a field visit, December 31, 2008, several houses had rotting siding, corner posts, porches, and car garages caused by long term water damage. Some houses had visible downspouts connecting to footing drains that connect to the combined storm/sewer system or infiltration trenches. In one location, a yard drain was found connected to the public storm system. Another parcel that showed signs of long term drainage and standing water problems was parcel 2185600080 adjacent to the existing bridge. The existing brick roadway is higher than the properties adjacent to the roadway. In general, the water drains off of the brick roadway into the back of parcel 2185600080 and then under the existing bridge. Two catch basins drain the area under the bridge, but standing water near the abutment wall was observed.

1.4.9 Existing South Basin Outfalls and Shoreline Conditions

Exhibit 2 in Appendix A shows the south basin boundary, sub-basin areas, and basin discharge locations. The basin area is a combination of private and public land draining via surface runoff into private and public conveyance systems. The ESB has three discharge locations, the existing public 12-inch corrugated aluminum pipe outfall into the Duwamish Waterway, the combined storm/sewer system to the West Point Treatment Facility, and a 3-inch diameter iron pipe serving the private Marina parcels and draining into the Duwamish Waterway.

- Some of the south basin surface runoff is collected into a conveyance system and discharged into the Duwamish Waterway with the existing 12-inch diameter CMP public outfall. Appendix A contains exhibits illustrating limits, sizes, and flow patterns for the existing south basin conditions.
- The smaller 3-inch cast iron private outfall is located downstream of the public outfall and serves parcels operated and maintained by the Marina. Catch basins collect surface water runoff from the paved parcels and convey the water directly to the Duwamish Waterway without treatment. Down-turned elbows are used inside the catch basins to prevent oils from discharging through the outfall.
- The City of Seattle area within the south basin currently collects surface runoff and conveys flows through a combined storm/sewer system to the West Point Water Quality Treatment Facility.

1.4.10 Existing South Basin Water Quality Treatment

The stormwater runoff draining into the combined storm/sewer system receives water quality treatment at the West Point Water Treatment Plant. All other water currently draining into the Duwamish Waterway does not receive any water quality treatment. A small 3-inch diameter cast iron pipe also drains into the Duwamish Waterway and serves two private marina boat yard parcels. A down-turned elbow is the only treatment provided.

A search was performed using the King County GIS iMap data base for commercial stormwater facilities located within the project limits. The search results showing commercial facilities near the project are shown in Appendix L.

1.5 Developed Site Conditions

The proposed improvements include constructing a new bascule bridge crossing the Duwamish Waterway, revising the fender protection system for the new bridge, constructing shore/slope stabilization, re-aligning the roadway to meet the new bridge, and removing the existing bridge and roadway approaches. This work also includes modifying existing utilities, constructing new utilities, revising existing storm drainage systems to separate public and private systems, constructing a new storm drainage conveyance system, two 24-inch diameter outfalls to the Duwamish Waterway, low impact development water quality treatment rain gardens, and a water quality wet vault.

The redevelopment area consists of approximately 2,360 linear feet of roadway (including the bridge) on 16th Avenue South and 14th Avenue South. The proposed conveyance system consists of curb and gutter, catch basins, storm drain system to convey runoff to the proposed water quality treatment facilities, and two new outfalls. No inlets or storm pipes are proposed on the bascule sections of the bridge, conveyance on this portion of the bridge will be via curb and gutter sheet flow/channeled flow to the proposed conveyance system.

1.5.1 Developed North Basin (PNB)

The north basin onsite conditions will be very similar to the existing conditions. The proposed basin has slightly more impervious surface than the existing basin because the new bridge is slightly wider than the existing bridge and creates slightly more impervious surface crossing the waterway (see Section 2, Table 2 for a summary of pre and post-project area tabulations). All of the Boeing areas will remain the same and be graded and paved to drain stormwater runoff into the Boeing conveyance systems. Runoff outside of the project limits will be bypassed around the project and re-connected to the existing outfalls for discharge at their existing “natural location”.

The roadway and sidewalk will be concrete impervious surface graded to drain stormwater runoff into a new conveyance system conveying stormwater to the water quality wet vault. The water quality wet vault will provide stormwater treatment prior to discharge into the Duwamish Waterway.

1.5.2 Developed North Basin Onsite Conditions

All project roadway stormwater runoff will be collected into inlets and conveyed to the proposed water quality wet vault for treatment prior to discharge into the Duwamish Waterway. Water quality treatment will be provided for all new targeted treatment pollution generating impervious surfaces added as a result of the project and the proposed 24-inch diameter outfall will be fitted with a tide flex valve/flap gate to prevent river water from getting into the water quality wet vault or emergency bypass system. A high flow emergency bypass will be constructed to allow storm events larger than the design water quality storm to bypass the water quality wet vault and discharge into the Duwamish Waterway.

The following exhibits have been included in Appendix A to illustrate basin boundaries, limits, tributary areas, and flow patterns:

- Exhibit 7 in Appendix A shows the developed project basin boundaries.
- Exhibit 9 in Appendix A shows the proposed north basin limits as well as sub-basin tributary areas.
- Exhibits in Appendix K show the proposed catch basin areas supporting the conveyance calculations.
- Figure 10 in Appendix A shows the Boeing offsite areas on the west side of the north basin (Developed North Basin Outfalls and shoreline Conditions).

The developed north basin will also have a portion of the existing Standard Oil dock removed. The shoreline will be graded and stabilized to protect against erosion and slope stability. See Sections 1.5.4, for slope stability and shoreline protection, and Sections 5.8, and 5.9 for floodplain mitigation measures.

1.5.3 Developed North Basin Offsite Conditions

Offsite areas in the north basin are part of the Boeing facilities. The existing paved surfaces that are removed as part of the construction process will be re-graded and re-paved. Pavement destroyed as part of the construction activities will be restored. Drainage will continue to follow existing flow patterns and Boeing conveyance systems.

1.5.4 Developed North Basin Outfalls and Shoreline Conditions

The Developed (Proposed) North Basin (PNB) work will preserve the existing drainage patterns within the north basin (see also Section 2.2). The existing stormwater runoff from East Marginal Way (north of the project limits) will be re-routed to bypass the proposed project drainage system. The interceptor/bypass line will re-connect to the existing 18-inch diameter public outfall thereby preserving the existing flow path.

A portion of the existing offsite Boeing stormwater currently connects to the public storm drainage system and discharges through the 18-inch diameter public outfall. The proposed interceptor/bypass line will continue to preserve this flow pattern using lateral connections to the Boeing conveyance system and allowing continued stormwater discharge to the public outfall. All Boeing property that does not currently drain into the 18-inch diameter public outfall will continue to drain into private Boeing outfalls into the Duwamish Waterway.

The shoreline will be impacted by construction activities due to the removal of a portion of the existing dock, bridge, pile, and foundations. The shoreline will be re-graded and rock stabilized according King County rock protection at outfall criteria.

1.5.5 Developed North Basin Water Quality Treatment

Large Boeing parcels and facilities are directly adjacent to the right-of-way in the north basin. The existing bridge is in Right-of-Way, but Boeing has land ownership as well as access rights under the existing bridge to connect the eastern and western parcels for business activities. The new bridge configuration will create new right-of-way for the bridge but also preserve existing access under the bridge. The area adjacent to the bridge is used for parking, material storage, and access to existing building facilities. The project has been coordinated with Boeing representatives to account for safety, access, security, utilities, easements, property use, traffic circulation, and storm drainage improvements. Maintaining and maximizing flat open usable space is of great importance to the Boeing Company and the reason why an underground water quality wet vault was selected over other treatment options. The north basin will have a water quality wet vault constructed to treat all onsite roadway stormwater runoff prior to discharge into the Duwamish Waterway. For additional water quality vault information see Sections 4.2.3 and Appendix G of this report.

The project will create 0.73 acres of new impervious surface and 4.79 acres of replaced impervious surface with a total of 5.52 acres of proposed impervious surface. The proposed impervious surface is 0.19 acres of net added impervious surface larger than the existing 5.33 acres of impervious surface in the existing north basin. Therefore, 0.73 acres of new impervious surface is the required treatment goal and targeted treatment pollution generating impervious surface. The north basin will provide water quality treatment for the targeted treatment pollution generating impervious surfaces. See also Table 2 in Section 2 for a summary of pre and post-project area tabulations and Table 3 in Section 2 for a summary of project treatment thresholds.

1.5.6 Developed South Basin (PSB)

The proposed improvements within the south basin include constructing a new conveyance system, re-grading the existing shoreline, constructing shoreline mitigation and stabilization enhancements, constructing a new 24-inch diameter outfall to replace the existing 12-inch diameter outfall, and creating two new water quality treatment rain gardens. The proposed improvements also include re-directing all flows that currently drain into the City of Seattle combined storm/sewer system to the Duwamish Waterway. The improvements also involve constructing a new conveyance system to capture and convey the water quality targeted treatment pollution generating impervious surface areas into water quality treatment facilities prior to discharge into the Duwamish Waterway.

1.5.7 Developed South Basin Onsite Conditions

The City of Seattle's existing combined storm/sewer system drains the existing south basin. According to the City of Seattle, the existing combined storm/sewer system does not have capacity or the ability to accept any additional stormwater, and is not able to effectively treat flows at the West Point water quality treatment facility. The project has been coordinated with the City of Seattle Stormwater Department, and the City of Seattle (City) will not allow the project to directly discharge, nor detain and discharge stormwater into the combined storm/sewer system.

The project design team proposed to reduce the tributary area into the combined storm/sewer by increasing the pervious areas, and thereby reducing the flows to the combined storm/sewer system. However, the alternative was not acceptable for the City, and the design was modified according to City review, deviation approval, and direction to drain completely to the Duwamish Waterway.

The flow pattern for the south basin will be converted back to the original flow pattern that existed prior to the construction of the West Point water quality treatment facility in 1966. Prior to construction of the West Point facility, sewage and stormwater was discharged directly into the Duwamish Waterway and Elliot Bay. With the construction of the West Point facility, stormwater and sewage was diverted from the Duwamish waterway to the treatment plant for treatment and discharge into Puget Sound. The sewage flows will not be changed as part of this project, but the stormwater will be returned to the natural drainage path.

The proposed project south basin is slightly larger than the existing basin area because the new bridge is slightly larger than the existing bridge creating a slightly larger basin area. The project will significantly reduce the amount of impervious surface area within the basin, increase the pervious areas, and create opportunities for natural infiltration. The project will reduce the amount of impervious surface within the City of Seattle City limits as well as within the total basin boundary (see Table 1 in this Section). The developed south basin will have less impervious surface than the existing basin due to the removal of several buildings, a reduction in street width, increased pervious area including grass areas, planter strips, rain garden, and other natural landscape features (see Section 2, Table 2 for project treatment criteria, and Table 3 in Section 2 for basin treatment thresholds). See also Figure 8 in Appendix A showing the proposed south basin and sub-basin boundaries.

Table 1. Project Improvements within the City of Seattle

Description	Pervious Surface (acres)	Impervious Surface (acres)	Total Surface Area (acres)
Existing Surface Area in the City (Draining into the Combined Sewer System)	0.62	1.70	2.32
Proposed Surface in the City	0.84	1.38	2.22
Net Surface Area Reduction in the City of Seattle Sub-Basin	-	-0.10	-0.10
Net Area traded from Impervious to Pervious	0.22	-0.22	-
New and Replaced Impervious Surface		1.38	
Proposed Surface Area diverted away from the Combined Sewer System	0.84	1.38	2.22

1.5.8 Developed South Basin Offsite Conditions

An offsite analysis and field investigation has been performed for this project to identify existing drainage issues and potential impacts due to the proposed improvements. The existing residential and commercial drainage patterns will not be modified and existing drainage problems not associated with roadway stormwater will not be resolved as a part of this project.

Similar to the north basin, private stormwater runoff is not included in the design computations for the water quality treatment design, but private stormwater runoff is included for the design of the conveyance system. See Appendix C for the Technical Information Worksheet specific for this project. Each water quality treatment facility has been designed to treat 60% of the 2-year storm event for the targeted water quality treatment surfaces and the facilities have also been designed to pass all offsite flows during larger storm events.

1.5.9 Developed South Basin Outfalls and Shoreline Conditions

The existing 12-inch diameter CMP outfall will be removed and a 24-inch diameter outfall will be constructed in the same location to accommodate project drainage requirements. The outfall location is in a sheltered area adjacent to an upstream existing boat launch ramp. Outfall slope protection will be constructed to prevent slope erosion. The outfall will also be anchored with stainless steel straps and a concrete beam to prevent lateral force or uplift damage to the outfall.

1.5.10 Developed South Basin Water Quality Treatment

The Developed (Proposed) South Basin (PSB) consists of curbs and gutters, catch basin inlets and a storm drainage conveyance system connected to two water quality treatment rain gardens. Roadway stormwater runoff from both the City of Seattle and the new bridge is conveyed to the large Boat Access Road rain garden. An energy dissipation pit and level spreader will be constructed to reduce conveyance flows to slow sheet flow dispersion across the rain garden surface. The level spreader is designed to change the runoff from channeled flow into sheet flow across the rain garden surface. The rain garden will provide water quality treatment with a compost soil matrix and is designed as an on-line facility with an internal bypass for high flow discharge to the Duwamish Waterway. Outfall weir control structures and emergency outfall structures have been designed to control runoff storage and emergency bypass flows during storm events larger than 60% of the 2-year storm.

Orr Street stormwater surface runoff will sheet flow into a smaller “Orr Street” treatment rain garden for water quality treatment. The small rain garden will bypass large flows into the emergency outfall conveyance system shared with the larger “Boat Access Road” treatment rain garden. The emergency bypass flows with be conveyed to the new 24-inch diameter outfall near the boat launch ramp.

The large treatment rain garden (Boat Access Road) has been designed to treat 1.38 acres (from the City of Seattle) as well as 0.97 acres of pollution generating impervious surfaces from the proposed bridge totaling 2.35 acres of targeted treatment pollution generating impervious surfaces. The smaller rain garden is designed to treat 0.18 acres of pollution generating impervious surface area. Adding the area treated by the large and small rain garden yields a total of 2.53 acres for total treated area. This is consistent with the areas reported in the project

Biological Assessment and exceeds the minimum required targeted treatment pollution generating impervious surface threshold with the following exception:

- 1.38 acres will not be treated at the West Point water quality treatment facility. The area will be redirected and treated in the Boat Access Road rain garden.

1.6 Soils

The soils within the project limits have been investigated for strength, stability, quality of materials, suitability for the proposed improvements, and extent of contamination. A geotechnical report by Shannon and Wilson (2004) has been prepared documenting soils conditions and design criteria for the bridge, foundations, roadway, and other work elements associated with the project design.

Mechanically Stabilized Earth walls (MSE walls) are proposed for the approach grades leading up to the approach spans. The walls will vary from 2-feet high up to 17-feet high. As soon as the wall exceeds 10-feet high, earthquake drains will be installed under the walls and fill. The earthquake drains will extend a distance of 10-feet beyond the face of the wall according to geotechnical analysis of the fill, walls, existing soils, and soil saturation zone. The walls will be embedded 2-feet deep into the ground and be underlain with 2-feet of gravel drain layers providing void zones for water collection above the earthquake drains. See Appendix F for an exhibit showing general earthquake drain parameters. See also the South Park Bridge Project Geology and Soils Technical Report (February 2004) and addenda.

1.6.1 Onsite Soil Conditions

According to the National Resource Conservation Service historical data, the soils in the project vicinity are Vashon Till type material. Geotechnical investigations conducted by Shannon and Wilson and documented in the 2004 Geotechnical Report indicate that subsurface conditions under the project area consist of man-made fill and marsh deposits in the upper regions of the soils profile. This is underlain by loose to medium dense alluvial deposits consisting primarily of sand and very soft to medium stiff clayey and silty estuarine deposits. These normally consolidated non-glacial soils are underlain by over consolidated glacial soils (glaciomarine drift) that consist of stiff to hard, clayey silt to silty clay with some sand and gravel. The elevation (NAVD88) of the glacial soils ranges from approximately 95 feet under the proposed north bascule abutment to approximately 60 feet under the south bascule abutment. See Appendix F for geotechnical borings and soils mapping.

1.6.2 Offsite Soil Conditions

In the south basin, sewer service is a combination of septic and City combined storm/sewer system. A small portion of private residential home owners have septic systems. See Appendix F, Figure 15 for the septic treatment areas.

1.6.3 Contaminated Soil Conditions

A Focused Corrective Measure Study has been performed by Boeing (March, 2002) for the Southwest Bank Corrective Measure. The study was performed to determine the appropriate actions for the Southwest Bank Corrective Measure and determine the horizontal and vertical extent of soil that contained elevated levels of constituents of concern within the saturated zone (approximately 6-feet below ground surface). The soils above the saturated zone will also be managed for cleanup activities. Soil borings were performed, and groundwater sampling wells were installed and have been monitored for corrective action. Soils were tested and contamination parameters were identified for cadmium, copper, lead, and zinc. The stormwater and temporary erosion control measures have been designed to accommodate for contaminated soils, high ground water, dewatering, stockpiling, and transportation of materials. During construction, areas will be established to stockpile soil. The areas will be contained with berms, and all stockpiles will be covered with plastic. The soil will be tested and determined if it is clean or contaminated prior to transport and disposal. Contaminated soils will be transported to a facility capable of treating the contaminated soils. For additional site specific hazardous materials documentation refer to the South Park Bridge Project Hazardous Materials Technical Report (February 2004).

1.6.4 Rain Garden Soils

The soils near the rain gardens are thought to be contaminated and plumes are spread by the groundwater towards the river. The rain gardens are not full infiltrating rain gardens because infiltration would most likely increase the potential for plume growth and movement toward the river. A percolation test has been performed for the soils within the rain garden areas to determine if the soils percolate well and if a construction geotextile for separation is warranted to prevent treated runoff from infiltrating and spreading contamination plumes toward the river. The test results report between 0.4 and 1.3 inches per hour infiltration rates of the existing soils. The long term infiltration rates are anticipated to be between 0.1 and 0.3 inches per hour (assuming a value of 4 for the factor of safety). These infiltration rates are well below the thresholds that would require installation of a liner, but the liner is proposed as a conservative judgment for addressing potential contamination issues.

The rain garden soil treatment bed will be composed of a well blended mixture of mineral aggregate and compost to produce a homogenous soil matrix. Low pH compost will be used to reduce pH impacts in the river. The City of Seattle has provided specifications and performance data on rain gardens throughout the City to be used as guidelines for this project.

2 CONDITIONS AND REQUIREMENTS SUMMARY

The proposed South Park Bridge Replacement Project and approach roadway work consists of redeveloping portions of public land. The project proposes to reduce the amount of pollution generating impervious surface and increasing the pervious area within the project limits. The following Table summarizes the comprehensive pre and post project impervious surfaces for the project and the targeted treatment surface areas:

Table 2. Pre- and Post-Project Impervious Surface Areas within the South Park Bridge Replacement Project Site

Parameter	Southern Portion of TDA[a] (acres)	Northern Portion of TDA[a] (acres)	Project Totals (acres)
Existing Impervious Surface	4.25	5.33	9.58
Proposed Impervious Surface[b] (New and Replaced = Proposed PGIS)	3.55	5.52	9.07
Net Added Impervious Surface	*-0.70*	*0.19*	*-0.51*
New Impervious Surface	*1.15*	*0.73*	*1.88*
Replaced Impervious Surface (Equals Replaced PGIS)	*2.40*	*4.79*	*7.19*
Existing PGIS	3.87	5.33	9.20
Proposed PGIS	3.55	5.52	9.07
Net Added PGIS	-0.32	0.19	-0.13
Replaced PGIS	2.40	4.79	7.19
Targeted Treatment PGIS	1.15	0.73	1.88
Area Diverted from West Point Combined Storm/Sewer System to the Treatment Rain Garden	1.38	0.00	1.38
Total Area Treated	2.53	0.73	3.26

[a] The project is located in a single TDA which drains to the Duwamish Waterway. For consistency with the original BA, impervious surface numbers for the TDA are given for two portions of the TDA, on either side of the Duwamish Waterway.

[b] Existing impervious area that is removed to sub-grade and then replaced.

TDA = threshold discharge area

PGIS = pollution-generating impervious surface

The following table shows the minimum required treatment areas and the amount of tributary area treated with each new water quality treatment facility:

Table 3. Targeted Water Quality Treatment Thresholds

Facility	Location	Minimum Treatment Area Required for PGIS[1] (acres)	Project PGIS[1] Treated (acres)
Water Quality Wet Vault	North Basin	0.73	0.73
Boat Access Rain Garden	South Basin	1.15	2.35
Orr Street Rain Garden	South Basin	0.00	0.18
Total PGIS Treatment	North and South Basins	1.88	3.26

[1] Pollution Generating Impervious Surface

A portion of the proposed improvements lie within the Lower Duwamish Waterway Superfund Site and the Boeing's Plant 2 RCRA Corrective Action Site spanning 5 river miles of the lower Duwamish River. Since the project is a redevelopment project on a combination of parcels in which the total of new plus replaced impervious surface is greater than 5,000 square feet, this project requires a Full Drainage Review per Figure 1.1.2A of the 2005 King County Surface Water Design Manual (KCSWDM). The following section addresses the applicable reports developed for additional conditions and requirements pertaining to the site, and Core Requirement #1.

2.1 Conditions/Permits Associated with Development Requirements

- Army Corps of Engineers Section 10 Permit.
- Army Corps of Engineers Section 404 Individual Permit.
- U.S. Coast Guard Section 9 Bridge Permit.
- U.S. Fish and Wildlife Service ESA Section 7 Consultation.
- Department of Ecology Water Quality 401 Certification.
- Department of Ecology NPDES General Permit for Stormwater Discharge.
- Department of Ecology NPDES Permit for Construction Activities.
- Department of Ecology Coastal Zone Management Certification.
- Washington department of Fish and Wildlife Hydraulic Project Approval.
- WA Office of Archaeology and Historic Preservation Section 106 Review Consultation.
- King County Landmarks and Heritage Certification.
- Puget Sound Clean Air Agency Demolition Notification for Structures Containing Asbestos.
- King County Easements.
- King County Clearing and Grading Permit.
- King County Demolition Permit.
- King County Haul Road Agreement.
- King County Noise Variance for Nighttime Construction.
- King County Critical Areas Ordinance.
- King County Shoreline Substantial Development Permit.
- King County Street Use Permit.
- King County Flood Plain Development Permit.
- Required Federal Emergency Management Agency (CFR 44).
- Port of Seattle Easement to Construct over Duwamish Waterway Bedlands.
- City of Seattle Public Agency and Utility Exception.
- City of Seattle Drainage Approval Permit.
- City of Seattle Clearing and Grading Permit.
- City of Seattle Demolition Permit.
- City of Seattle Haul Road Agreement Permit.
- City of Seattle Street Use Permit.
- City of Seattle Noise Variance for Nighttime Construction.
- City of Tukwila Shoreline Substantial Development Permit.
- City of Tukwila Sensitive Areas Review.
- City of Tukwila Public Agency and Utility Exception.
- City of Tukwila Clearing and Grading Permit.
- City of Tukwila Haul Road Agreement.

- City of Tukwila Street Use Permit.
- City of Tukwila Noise Variance for Nighttime Construction.

2.2 Core Requirement Summary List

The following is a summary list of the core requirements and special requirements according to King County SWDM 2009 and brief description how the requirements are addressed:

Core Requirement #1 (Discharge at the Natural Location): This project will preserve existing drainage paths. The project also proposes to restore the natural drainage paths for the south basin and reduce the flows to the City of Seattle combined storm/sewer system. See Sections 1.5.1, 1.5.5, and 1.5.6 for additional supporting information.

Core Requirement #2 (Offsite Analysis): The existing drainage conditions were evaluated considering impacts of the project improvements. A river survey, scour analysis, net-rise analysis, shoreline mitigation study, as well as conveyance analysis, backwater analysis, gutter flow evaluation, and upstream/downstream survey were performed to thoroughly evaluate drainage conditions and impacts within the project vicinity. See Sections 3 and 5 for additional related topics.

Core Requirement #3 (Flow Control): This project is flow control exempt but has been designed with context sensitive solutions to improve drainage within the project limits and not cause negative impacts to existing drainage systems. See Section 4 for a more in depth discussion.

Core Requirement #4 (Conveyance System): The pipe network, and outfall system has been designed according to King County criteria. However, within the City limits, the system has also been modified to meet City design standards and criteria. See Section 5 for inlet, pipe, outfall, groundwater, critical areas, and backwater discussions.

Core Requirement #5 (Erosion and Sediment Control): See Section 8 of this report and separate Stormwater Pollution Prevention Plan Report.

Core Requirement #6 (Maintenance and Operations): General maintenance and operation criteria for stormwater facilities has been included in Section 10 and Appendix M of this report.

Core Requirement #7 (Financial Guarantees and Liability): A general discussion of responsibilities for involved parties has been included in Section 9 of this report.

Core Requirement #8 (Water Quality): This project proposes to treat the new and replaced impervious surfaces. The project reduces the amount of impervious surface within the project limits. The new impervious surface is less than 50% of the existing impervious surface, and the area to which stormwater treatment BMPs will be applied is limited to the new impervious surface per the 2009 King County Surface Water Design Manual. The project exceeds the minimum targeted treatment areas as well as the thresholds identified in the Biological Assessment. Tables 1, 2, and 3 provide a summary of targeted treatment areas and Section 4.5 provides additional water quality discussion.

3 OFFSITE ANALYSIS

A Level 1 offsite analysis has been performed for this project. The goal of the offsite analysis is to identify potential changes or impacts to downstream or upstream areas as well as groundwater levels/quality, and Duwamish Waterway impacts. The analysis consisted of the following tasks:

1. **Field Investigation**: Task 1 is repeated in the Offsite Analysis Field Inspection report in Appendix E.

2. **Assessment of existing and proposed drainage patterns:** Task 2 consisted of qualitative analysis of any changed drainage patterns and backwater conditions.

3. **Evaluation of proposed changes to the existing drainage patterns**: Task 3 includes qualitative analysis of the proposed drainage for the Duwamish waterway, shoreline protection, zero-net rise backwater analysis, and scour analysis.

3.1 Field Investigation

A field visit was performed to visually inspect the existing drainage patterns for the onsite and offsite areas. Field notes and photographs can be found in Appendix E. The project Threshold Discharge Areas have been determined with basin boundaries, sub-basin boundaries, and areas of impervious and pervious surfaces for existing and proposed conditions. Appendix A contains exhibits depicting the project limits, basin boundaries, sub-basins, and tributary on and offsite areas.

3.2 Assessment of Existing and Proposed Drainage Patterns (Core Requirement #2)

The criteria established in the KCSWDM have been followed for a Level 1 analysis. The design approach is to maintain the existing drainage patterns to the maximum extent possible. Existing private outfalls will be maintained where feasible, and replaced in kind as necessary. Areas that convey water to private outfalls have been identified. While many of the areas within the project limits will be re-graded as part of the project, the tributary areas and general grades will be returned to the existing condition to the greatest extent possible. Area within the City of Seattle will be diverted from the combined storm/sewer system and drain toward the Duwamish Waterway. Full hydraulic analysis of the outfall capacity, energy dissipation, and discharge characteristics are included in this report.

All tributary areas outside of the project impact zone are considered offsite. Areas within the project limits have been identified and quantified for existing and proposed pervious and impervious surfaces. The areas contributing offsite water will be used to determine the offsite flows draining into the project and accounted for in the design of the conveyance system. Offsite areas will not be included for determining the targeted treatment pollution generating surface requirements for water quality treatment facilities. However, the offsite flows will be included in the design for sizing water quality treatment facilities for flow through or bypass capacity.

3.2.1 Onsite Surface Runoff

3.2.1.1 Existing Onsite Runoff

The existing north basin is primarily impervious surface and does not show signs of drainage problems. The Boeing parking lot areas are very flat and show signs of localized ponding, however observed ponding was not deep and did not show any signs of pavement pumping, potholing, or other distress. Boeing tributary areas are in Appendix B of this report. The existing outfall seemed to be functioning adequately, and signs of erosion, were not observed.

Additional existing basin, sub-basin, and tributary area Exhibits 1,2, and 3 can be found in Appendix A. The north basin existing onsite runoff drains into a stormwater conveyance system and is conveyed to the Duwamish Waterway. There is not any existing water quality treatment detention prior to discharge into the waterway. The conveyance system also accepts offsite stormwater from the Boeing conveyance systems.

Within the southern basin, the existing surface is a mixture of asphalt, concrete, brick, grass, and gravel. The asphalt, concrete, brick, and rooftops have been quantified as impervious surfaces. The asphalt, concrete, brick, and concrete sidewalk have been quantified and reported as existing pollution generating impervious surfaces. The pervious surfaces within the Southern Basin are grass lawns, or brushy vegetated vacant lots.

The south basin existing runoff is split into three discharge locations, the City of Seattle combined storm/sewer system, the Marina 3-inch diameter iron pipe outfall, and a 12-inch outfall near the Marina boat ramp. A stormwater runoff problem was observed along the brick road adjacent to the existing bridge approach span walls. The stormwater seemed to drain under the existing bridge, pond, and slowly discharge into a catch basin for discharge into the Duwamish Waterway. No other onsite drainage deficiencies were observed during the field visit.

3.2.1.2 Developed Onsite Runoff

The project limits and basin boundaries have been identified and are shown in Exhibits 7, 8, and 9 of Appendix A. Portions of Boeing are considered onsite and portions are considered offsite. For distinctions between the Boeing on and offsite areas, refer to Exhibits in Appendix A. The developed onsite areas are designed and graded for positive drainage. Inlet spacing and conveyance calculations have been performed to evaluate stormwater surface runoff and are included in Appendix I.

For this design, all pervious areas are considered non-pollution generating. The gravel parking lots are considered pollution generating even though natural infiltration or flow dispersion provides some measure of natural treatment. Most, if not all, of the gravel parking lots drain into the existing street which is treated as a pollution generating surface.

The runoff flows have been modeled assuming 100% pollution generating impervious surface area draining from the Boeing property into the public conveyance system. Since the existing roadway contains very little pervious surface, the area from right-of-way to right-of-way is assumed to also be 100% pollution generating impervious surface. The only non-pollution generating pervious surface in the North Basin is a small section of waterway bank that is a composite of grassy, brushy, muddy, concrete, and rocky slope stabilization constructed with fill material. Since the rock and concrete slope stabilization is not dense, the area is considered grass till.

3.2.2 Onsite Backwater Analysis

A backwater analysis has been performed for each basin. The analysis evaluates the affects of high tide (mean higher high water surface elevation) of the Duwamish Waterway. Tideflex valves are proposed for the outfalls preventing the river water from entering into the conveyance system. The backwater analysis for this occurrence has been performed and both basins are designed to drain during high water events. See Section 5 for additional backwater analysis and Appendix D for the backwater calculations.

3.2.3 Offsite Surface Runoff

In the Existing North Basin, Boeing property contains a significant offsite area that is surface-drained into a private conveyance system that is either conveyed to private outfalls or connects to the public conveyance system, both which discharge into the Duwamish Waterway. The offsite Boeing areas have been evaluated and included in the analysis for the design of the intercepting conveyance system bypassing the offsite Boeing stormwater around the project water quality facility.

In the existing South Basin, the offsite stormwater runoff has been included into the inlet spacing calculations and conveyance system calculations shown in Appendix I.

3.3 Duwamish Waterway Analysis

The Duwamish Waterway flow characteristics were evaluated during the alternative analysis and preliminary design phases. The study included evaluating the existing site conditions as well as the proposed project conditions and resulting impacts to the waterway system. See the Water Resources Technical Report for the South Park Bridge (2004) for additional calculations and summaries.

3.3.1 Shoreline Protection

Shoreline protection is proposed as part of the project improvements. Duwamish Waterway channel velocities and average soil shear stresses have been determined at the bridge for the 100-year peak flow rate and are reported in the Water Resources Technical Report for the South Park Bridge (2004). The channel velocities and shear stresses were used to evaluate upstream and downstream scour conditions and shoreline protection impacts.

3.3.2 Zero-Net Rise Backwater Analysis

The Duwamish Waterway was evaluated for net rise and impacts associated with the proposed project improvements. See Section 5.8 (Floodplain Analysis) and the Water Resources Technical Report for the South Park Bridge (2004) for additional information. The shoreline will be graded to increase the channel capacity at the bridge location. The grading mitigates for the stormwater runoff and river water displacement due to the underwater bridge elements. See the

3.3.3 Scour Analysis

A scour analysis was performed for channel and channel bank stability. Soil shear stress properties, thresholds for particulate movement, and river bed deformation were evaluated. See Section 5.9 of this report and the Analysis of Hydraulic Effects and Riverbed Scour report for the South Park Bridge Replacement Project (2007).

4 FLOW CONTROL AND WATER QUALITY FACILITY ANALYSIS AND DESIGN

The project reduces the amount of impervious surface within the project limits and the new impervious surface is less than 50% of the existing impervious surface. The area to which stormwater treatment BMPs will be applied is limited to the new impervious surface per the 2009 King County Surface Water Design Manual. Table 2 lists project areas and minimum treatment goals for the design. The water quality treatment design approach involves meeting and/or exceeding the targeted treatment goals also outlined in Table 2. To summarize water quality treatment goals and thresholds for each basin, see Table 3 in Section 2

The stormwater treatment area will include the targeted "new pollution" generating impervious surface (PGIS) which is 0.73 acres for the northern portion of the Threshold Discharge Area (TDA) and 2.53 acres for the southern portion of the TDA. For the south basin, this includes 1.38 acres diverted from the City of Seattle, 0.97 acres of bridge area, and 0.18 acres from Orr Street. The required treatment area from target surfaces does not include replaced PGIS because the new or added impervious surface totals less than 50 percent of existing impervious surface. The total area proposed for stormwater treatment in the project is 3.26 acres.

4.1 Existing Site Hydrology (Part A)

Both the existing North and South Basins project limits fall within the urban shoreline management area and Duwamish Waterway floodways. Appendix L contains maps of the designated floodways and 100-year floodplain. For additional flood and river analysis see Section 5.2 of this report.

4.1.1 Existing North Basin Drainage Description and Areas

The existing project site contains a mixture of commercial/industrial, residential, and retail zones. The North Basin is bordered by the Boeing Company property and used for commercial airplane manufacturing. The onsite and offsite areas are comprised of mainly paved impervious surfaces. The roadway is graded to drain into a stormwater conveyance system on each side of the roadway. Near the existing bridge approach, the roadway and Boeing conveyance systems connect and drain to the existing 18-inch outfall. See Section 1.4 of this report for additional existing basin conditions and description. See Appendix A, Exhibits 1, and 3 for existing basin boundaries and surface characteristics.

4.1.2 Existing North Basin Flow Control Facilities and Locations

The existing north basin does not have any flow control facilities within the project limits.

4.1.3 Existing North Basin Overflow Route

A defined overflow route is not apparent in the north basin. If the existing conveyance system is not sufficient to convey the full storm event, runoff most likely surface drains off the existing dock and into the Duwamish Waterway.

4.1.4 Existing South Basin Drainage Description and Areas

In the South Basin, the areas include commercial/industrial, retail, and residential land uses. Within the project limits, stormwater surface drains to conveyance systems discharging into the Duwamish Waterway or the City of Seattle combined storm/sewer system. The existing South Basin lies within a groundwater management area and aquifer recharge area monitored by wells located within the project limits (see Appendix L for a map of the groundwater management area and aquifer recharge area). For additional south basin conditions and descriptions, see Section 1.4 of this report.

4.1.5 Existing South Basin Flow Control Facilities and Locations

Upstream of the South Basin are industrial areas that have an impervious asphalt “cap” over a contaminated Port of Seattle site. Permanent drainage control measures have been installed to provide containment. Appendix L contains a map of commercial stormwater facilities in the project vicinity.

4.1.6 Existing South Basin Overflow Routes

The overflow route for the south basin is to surface drain under the existing bridge and toward the existing 12-inch diameter outfall. The existing overflow route will be maintained with the new design.

4.2 Developed Site Hydrology (Part B)

The proposed storm drainage improvements for this project include an underground water quality vault, a bypass interceptor line, two rain gardens, conveyance systems, one new outfall and one replaced outfall to the Duwamish Waterway.

The Stormwater modeling has been performed using KCRTS methods and software for sizing the underground vault, the rain gardens, and temporary erosion control water treatment tanks, sumps, and pump systems trap. The project is modeled using the Sea-Tac location for the time series development. Pervious areas are modeled as till grass because the existing site is primarily fill material according to the geotechnical boring logs (Appendix F). Exposed soils will be hydroseeded for permanent erosion control and is best modeled and classified as till grass conditions. The biofiltration swale and rain garden were designed using the 15-minute time step analysis. The wet vault was sized using the rainfall intensity according to Figure 6.4.1.A (page 6-

71) of the KCSWDM. Facility sizing worksheets can be found in Appendix G. Additional water quality design parameters can be found in section 4.5 of this report.

4.2.1 Developed North Basin Description and Areas

A stormwater bypass interceptor conveyance system will be constructed to intercept the Boeing offsite tributary areas. The goal is to bypass stormwater areas from Boeing and the roadway north of the project. The interceptor will connect to the existing 18-inch diameter outfall and remain a public outfall. A new conveyance system will be constructed for the bridge and roadway with a new water quality treatment wet vault and new discharge through a 24-inch diameter outfall. Additional information regarding the vault and interceptor line can be found in sections 4.2.3 and 5.0 of this report.

4.2.2 Developed North Basin Flow Control Facilities

No flow control facilities are required or proposed for this project (see Section 4.4 of this report).

4.2.3 Developed North Basin Water Quality Facilities

Stormwater runoff from the new bridge and impervious areas will be collected via a series of catch basins and conveyed to the water quality treatment wet vault. Basic water quality treatment will be performed in the wet vault to remove suspended solids and upstream down-turned elbows will be used to trap floatable greases and oils preventing/minimizing oil substance discharge into the waterway. The wet vault has been designed as an off-line system with an emergency bypass to the outfall.

The water quality vault has been designed according to Wet Vault Sizing Worksheet in the KCSWDM. The mean annual storm rainfall was determined and used to calculate the runoff from the mean annual storm. The wet pool volume was determined to be 3,435 cubic feet. The water quality vault was designed to meet the criteria for Water Quality Design Flows in Section 6.2.1 for the KCSWDM.

The vault will have four manhole lids rather than four 12-inch diameter air vents sticking up out of the ground. The vault exceeds a length to width ratio of 5:1 allowing the vault to have only one cell. Air exchange grates will be installed in the lid to provide aerobic exchange and meet DOE and King County design criteria.

4.2.4 Developed North Basin Overflow Route

The Boeing paved surface will not be modified significantly and the existing surface overflow route to the Duwamish Waterway will be maintained. A backwater analysis has been performed for the 100-year storm event with mean higher high water (Appendix G). According to the backwater analysis, the 100-year storm event should not cause the emergency overflow route to engage.

4.2.5 Developed South Basin Description and Areas

In the developed south basin, several buildings will be removed as well as the existing brick road and paved marina boat service yards. The replaced pervious surfaces will be graded to drain using natural drainage paths and stabilized with vegetation. A rain garden and biofiltration swale will be constructed to treat the pollution generating impervious surfaces.

Two parcels are currently paved and used by the boat marina as storage and work areas. The parcels drain into private catch basins and 3-inch diameter ductile iron pipe conveyance system and discharge untreated into the Duwamish Waterway. As part of this project, the existing pollution generating impervious surface will be removed, and the site will be re-graded. The two parcels will have permanent erosion control measures constructed to maintain the current drainage patterns. The permanent erosion control measures will use natural methods such as grasses, rock check dams, wattles, and other more natural mechanisms to prevent erosion control on the parcels rather than permanent sediment traps and silt fences.

4.2.6 Developed South Basin Flow Control Facilities

No flow control facilities are required or proposed for this project (see Section 4.4 of this report).

4.2.7 Developed South Basin Water Quality Facilities

The proposed South Basin will utilize low impact development methods to perform water quality treatment for the targeted pollution generating surfaces. Two rain gardens will be constructed to treat stormwater from the bridge and roadway surfaces. Rain garden facilities are not a King County listed water quality treatment option and an adjustment will be processed to allow for their use. The 2007 Department of Ecology Stormwater Management Manual and 2005 Low Impact Development Manual for Puget Sound were used for design of the rain garden facilities.

4.2.7.1 Boat Access Road Treatment Rain Garden

The Boat Access Road Rain Garden is designed to accept all of the City of Seattle stormwater within the project limits. City water will be redirected from the combined storm/sewer system and diverted into the rain garden and treated prior to discharge to the Duwamish Waterway.

The proposed rain garden is designed for 2.35 acres of tributary area assuming 100% of the tributary area is pollution generating impervious surface. The rain garden is sized to treat more than 60% of the 2-year peak flow exceeding the required treatment threshold criteria. The rain garden is designed as an on-line facility and to bypass flows above the water quality treatment volume.

A gravel recollection bed under the soil matrix is designed to recapture the treated runoff. Perforated pipes will collect and convey the treated stormwater to the outfall at the Duwamish Waterway. A geotextile liner is also included to provide separation between the gravel recollection bed and the existing soil and groundwater stratum to prevent potentially contaminated groundwater from contaminating the rain garden water quality treatment facility. Calculations supporting the rain garden design can be found in appendix H of this report.

4.2.7.2 Orr Street Rain Garden

The Orr Street Rain Garden is designed to accept 0.61 acres of pervious and impervious tributary areas from around and under the bridge. The rain garden will accept sheet flow from Orr Street and treat 0.18 acres of pollution generating impervious surface area. The rain garden is sized to treat more than 60% of the 2-year peak flow exceeding the required treatment threshold criteria. The rain garden is designed as an on-line facility and will bypass flows above the water quality treatment volume to the conveyance system/emergency outfall.

This rain garden will have the gravel recollection bed, soil matrix, perforated pipes, and geotextile liner. Calculations supporting the rain garden design can be found in appendix H of this report.

4.2.8 Developed Overflow Route

The existing overflow route will be modified due to project impacts. However, the same flow path will be maintained. The basin emergency overflow route will be down South Orr Street and surface discharge into the Duwamish Waterway near the boat launch ramp, or down Boat Access Road with surface discharge into the Duwamish Waterway. A backwater analysis has been performed for the 100-year storm event with mean higher high water. According to the backwater analysis, the 100-year storm event would not cause the emergency overflow route to engage.

4.3 Performance Standards (Part C)

4.3.1 Flow Control Standards

This project lies within basic water quality treatment area that is flow control exempt due to the proximity of the project to the Duwamish River, the discharge location below river mile 6, and the natural threshold discharge area. Additional information regarding exemptions, targeted treatment thresholds, and treatment menu options can be found in Sections 2.2 and 4.4 of this report.

4.3.2 Conveyance Capacity Standards

The applicable conveyance capacity standards have been developed for this project according to KCSWDM Section 1.2.4 and Core Requirement #4 (Conveyance System). The conveyance system has been designed for system gradient, velocity, and capacity. The new pipe conveyance system is designed with sufficient capacity to convey and contain the 25-year peak flow assuming developed conditions for onsite tributary areas and existing conditions for offsite tributary areas. The conveyance design was evaluated according to the 100-year storm event to determine if overtopping, overflow conditions would create erosion control problems, or hazards in the roadway. Additional conveyance design criteria can be found in Section 5 of this report. The design has been evaluated and documented herein to provide some protection against overtopping, flooding, and erosion for new systems, existing systems, and implementation requirements.

4.3.3 Water Quality Treatment Standards

The water quality treatment method was determined from the applicable water quality treatment menu and eco-charrette (08/06/2008). According to the King County Water Quality Applications Map, the project lies within the basic water quality treatment area. The project does not contain wetlands, sphagnum bogs, or any other feature that may require enhanced treatment. The eco-charrette and preliminary alternative analysis was performed to identify potential opportunities to incorporate Low Impact Development methods into the design. Alternative analysis used for selecting the preferred alternatives can be found in Appendix H.

4.4 Flow Control System (Part D)

This project is classified as a King County transportation redevelopment project for the replacement of the existing South Park Bridge. According to the KCSWDM 2009 and the following Core Requirement #3, this project is flow control exempt.

4.4.1 Core Requirement #3 (Flow Control)

All redevelopment projects are required to provide onsite flow control facilities or flow control best management practices to mitigate the impacts of storm and surface runoff generated by new impervious surface, new pervious surface, and replaced impervious surfaces targeted for flow mitigation. However, any onsite area is exempt from the flow control facility requirement if the area drains into a major receiving water listed in Table 1.2.3.B of the KCSWDM, and meets the direct discharge exemption requirements listed on Page 1-30 of the KCSWDM. This project is flow control exempt because it meets the following direct discharge exemption criteria:

This project lies within the Duwamish Waterway below river mile 6 and drains into the Duwamish River (classified as a major receiving water in Table 1.2.3B of the KCSWDM). This is consistent with the King County Flow Control Applications Map (2005 KCSWDM). The project also fulfills the requirements a through e listed below:

a) The flow path from the project site discharge location to the edge of the 100-year floodplain of the Duwamish Waterway is no longer than a quarter mile.

b) The conveyance system between the project site and the major receiving water will extend to one foot above the ordinary high water mark, and will be a man-made conveyance system. The conveyance system will be within public right-of-way or private drainage easement.

c) The conveyance system will be designed according to Core Requirement #4 and have adequate capacity for the entire contributing drainage area, assuming build-out conditions.

d) The conveyance system will be adequately stabilized to prevent erosion. A scour analysis will be performed and slope mitigation will be performed as part of this project.

e) The direct discharge proposal will not divert flows from, or increase flows to an existing wetland or stream sufficient to cause a significant adverse impact. A flood zone analysis will be performed to determine the impacts of the project within the flood regulation area, and mitigation will be performed to achieve the zero net rise criteria.

4.5 Water Quality System (Part E)

4.5.1 Core Requirement #8 (Water Quality)

According to Section 1.2.8 of the KCSWDM and Core Requirement #8, all proposed projects, including redevelopment projects must provide water quality facilities to treat runoff from new and replaced pollution generating impervious surfaces and new pollution generating pervious surfaces.

4.5.2 Area Specific Water Quality Facility Requirements

According to Section 1.2.8.1 (Area-Specific Water Quality Facility Requirements) in the KCSWDM and the King County Water Quality Drainage Area Map the project lies with the zone for basic treatment. The project has been designed according to the requirements for basic treatment even though "50% or more of the runoff that drains to any proposed treatment facility is from a road with an expected ADT count of 2,000 or more vehicles or expected to serve 200 or more homes." The reason is because the water quality treatment menu may be reduced to basic water quality for treatment of any runoff that is discharged, via a non-fish bearing conveyance system, all the way to the ordinary high water mark of a stream with a mean annual flow of 1,000 cfs or more. The project utilizes full conveyance systems that are non-fish bearing and the Duwamish Waterway meets and/or exceeds the 1,000 cfs flow criteria.

The project exceeds treatment for the targeted new pollution generating impervious surfaces. The metal roofs on the new bridge control towers will be treated for leaching and are not included in the pollution generating impervious surface area. The project does not contain pollution generating pervious surface areas and is not a targeted treatment. Since no impervious surface has been added within the project limits since January 8, 2001 the existing impervious surface is not a targeted treatment area. The replaced pollution generating impervious surface is not a targeted treatment surface either, because the new impervious surface is less than 50% of the existing impervious surface. See Table 2 in this report and Appendix A for project area exhibits.

5 CONVEYANCE SYSTEM ANALYSIS AND DESIGN

The conveyance system for this project will be designed according to the requirements outlined in Section 1.2.4 of the KCSWDM. The conveyance system has also been designed to conform with Core Requirement #4 (Conveyance System) spill control provisions, and groundwater protection. The process for designing the entire storm drainage system included providing inlet spacing, conveyance, capacity, and velocity calculations, as well as a backwater analysis for discharge into water quality facilities or the Duwamish Waterway.

5.1 Conveyance Requirements for New Systems

Since this project is flow control exempt and detention is not required, the pre-developed condition does not need to be modeled to establish pre-developed flows. Post developed flows will be determined and will not be matched to pre-developed flows. Existing offsite flows have been evaluated for conveyance capacity to determine 25-year and 100-year flow conditions. The 25-year and 100-year flow events have also been used to evaluate the existing offsite conveyance systems discharging into the proposed conveyance system. The proposed conveyance system was sized and designed to accept the offsite 25-year storm event and checked for flooding conditions during the 100-year event to avoid causing severe flooding problems.

5.1.1 Inlets

Roadway Inlets

The 10-year storm event was used for the inlet spacing calculations. Inlet capacity calculations have been performed according to the KCSWDM to provide appropriate spacing and conveyance system distribution. The inlets were calculated using 95% free capacity for vaned grates and 80% free capacity for non-vaned grates or special fixture bridge grates. No credit was included in the design to account for the curb face opening.

The roadway does not have profile sag conditions, but some inlets are in localized low points and were designed to be combination inlets. Combination inlets are allowed to have 0% blocking in “sag conditions” so the 0% blockage was used for the localized drainage depressions even though full sag calculations do not apply. See Appendix I for the inlet spacing and spread calculations.

Sidewalk Inlets

On the approach spans, the sidewalk does not drain into the roadway because the traffic barrier separates the roadway from the walkway. Special sidewalk drains were evaluated using the spread calculations to determine the appropriate collection treatment and spacing on the approach spans and MSE wall section. Sidewalk spread was evaluated for the 10-year storm event and stormwater bypass was determined to make sure water was not channeled down the sidewalk and onto the street at the bottom of the approach grade on the Boeing side or intersection on the south side of the project. See Appendix I for roadway and sidewalk inlet spacing calculations.

Bridge Inlets

Special bridge inlets are necessary to provide drainage on the bridge and fit within the constraints of the bridge span flanges, traffic barrier, and diaphragms. The following inlet data was used for the inlet spacing calculations:

- City of Seattle Bridge Drain Frame Grate was used to drain the roadway on the approach spans with a vaned grate and 1.25-foot grate width. The ability of the inlet to capture stormwater is based on the assumption that the grate is 20% plugged and has an 80% free inlet capacity (grated area on slopes). 1.25 times 80% equates to using a 1.00-foot grate width for inlet spacing calculations.

- Neenah R-3927 Bridge Drain Frame Bolted Grate was used to drain the sidewalk behind the traffic barrier within the MSE wall area. The inlet has a slotted grate type "B" and 1.25-foot opening. Using the same assumption as the bridge inlets, an 80% free capacity yields an opening equating to a 1.00-foot grate width for inlet spacing calculations.

All other inlets spacing calculations were based on a vaned grate or combination inlet with vaned grate and grate width of 1.67-feet. Using a 95% free capacity equates to using a 1.59-foot grate width for inlet spacing calculations. The combination grate does not require and reduction according to the WSDOT Hydraulics manual. However, 95% free capacity was applied as a conservative estimate.

5.1.2 Pipes

The drainage pipe material on the approach span structures is a 6-inch diameter Victaulic pipe and a 0.25-inch thick coated steel casing under the approach slab. The pipe shall have mechanically restrained joint connections and flexible expansion joint connections for earthquake and settlement protection at the abutment wall penetration locations. Within the mechanically stabilized earth walls, and all other areas of the project, the pipes are designed to be concrete class III or ductile iron class 50 meeting cover requirements in Table 4.2.1.C of the KCSWDM.

The pipe system has been designed to connect from structure to structure without bends or deflections. Breaks in grade occur at manhole or catch basin locations and were determined according to KCSWDM guidelines for changes in pipe sizes. Structures have been evaluated for cover, pipe entrance/exit angles, and internal clearance between pipes, inlet location, rim elevations, and spacing. Pipes have been designed to either clear existing utilities or clear relocated utilities according to the minimum 6-inch vertical and 3-foot horizontal criteria in the KCSWDM. Pipes were designed to convey runoff within a minimum velocity of 3-feet per second and maximum velocity of 10-feet per second. Trench backfill criteria conform to the KCSWDM and WSDOT 2008 Standard Specifications. A special trench has been recommended in the geotechnical report and a detail has been added to the design addressing specific trench requirements adjacent to existing structures.

The pipe outlet from the Orr Street rain garden has been designed to be fitted with a debris barrier according to Figure 4.2.1.E of the KCSWDM to prevent blockage of the discharge flows. The Boat Access Road rain garden has also been designed with pipe discharge protection according to Figure 4.2.2.M of the KCSWDM and acts as an energy dissipater for the rain garden.

North Basin Onsite Pipe System

In the north basin, the new roadway conveyance system will discharge through the new 24-inch diameter outfall into the Duwamish Waterway. The system will contain an emergency bypass pipe system for high flow events. The system meets requirements according to 25 and 100-year storm event conveyance and backwater analysis.

The "interceptor" line bypassing areas north of the project and the Boeing storm drains was evaluated using both the 25 and 100-year storm events. The existing outfall meets requirements during the 25-year storm event, but does not have enough capacity at the outfall for the 100-year event. Due to the capacity issue during the 100-year storm event, a backwater analysis was also performed to evaluate drainage conditions during the 25 and 100-year storm events. The analysis shows that overtopping will not occur during either event, but is very close to over-topping during the 100-year storm event. Rather than replace the existing outfall to provide for greater capacity, the surface is graded to drain to the waterfront, pond slightly, and sheet flow over the bank into the river providing a surface path for emergency runoff flows.

South Basin Onsite Pipe System

The South Basin, conveyance system is designed to the same standards, storm events, and backwater as the north basin. The south basin does not have capacity, velocity, or conveyance issues during either the 25 or 100-year storm events. However, the conveyance system does have a "special manhole structure" designed to allow the storm system to cross the combined sewer and discharge runoff from the City into the rain garden. The special structure was coordinated with the City of Seattle and allowed because it was the best of several alternatives (not included) to convey stormwater from the City areas into the rain garden.

The City conveyance system discharges into an energy dissipater/dispersion pit in the rain garden and will have a semi-permanent tailwater on the system. The rain garden water will infiltrate into the rain garden and is not designed to be a permanent condition. The backwater analysis and conveyance design was used to evaluate conveyance performance from the rain garden to the end of the proposed conveyance system in the City limits assuming the rain garden is staged at maximum pool depth.

Since the rain gardens are on-line, the emergency outfall pipes were designed to convey the 100-year storm event. An emergency overflow route was created to sheet flow down Orr Street and Boat Access Road to the river should the rain gardens or conveyance system over-top or become overwhelmed.

Offsite Pipe System

Some offsite water will be conveyed into the proposed project improvements. The offsite tributary areas have been established and checked against the design 25-year event for capacity of the existing system. The proposed system has been evaluated to insure the proposed system will not negatively impact the existing system. Existing offsite conveyance systems proposed for direct discharge to the Duwamish Waterway will be designed according to the core requirement #3 and Section 1.2.4.1 of the KCSWDM. See Appendix I for 25-year and 100-year analysis calculations.

Bridge Pipe System

The new bridge is designed to accommodate the 100-year peak flow and flood plain development standards in the Duwamish Waterway. The bridge conveyance system has been evaluated for the 25-year storm event. The 100-year storm event was used to check for potential flooding problems at the outfalls. See Appendix I for the 25 and 100-year conveyance calculations.

Table 4.2.1.D of the KCSWDM was used to establish the appropriate mannings "n" value for the pipes. A value of 0.014 was used for Victaulic pipes assuming uniform flow.

The storm drainage pipes under the approach spans are designed to use Victaulic flange couplings under the approach spans and be hung between the precast pre-stressed concrete girders. In the abutment under the approach slab, an 18-inch diameter 0.25 inch thick coated steel casing will be installed to encase the Victaulic pipe to the first catch basin connection. Reinforcement and routing details are designed for the diaphragm penetrations under the approach spans to provide clearance for the pipes. Flexible expansion joints will be installed prior to penetration into the abutment wall. The flexible expansion joints are designed to prevent damaging shear and bending forces from breaking the pipe due to settlement, expansion or contraction, or earthquake activity.

Pipe hangers are designed following the Uniform Building Code and calculations have been checked according to data and methods established by the Ductile Iron Pipe Research Association (DIPRA) and supporting calculations can be found in Appendix G.

5.2 Backwater Analysis

The Duwamish Waterway was evaluated with the proposed project conditions to determine what impacts the project might have to water surface elevation, scour, and channel characteristics. The Hydraulic Engineering Center-River Analysis System modeling program was used to evaluate tidal affects and determined the highest water elevation during the 100-year storm event with the bascule bridge is elevation 11.84 (NAVD88). However an independent review by King County (July 2009) determined that 12.31 should be used as the design value for the 100-year high floodwater elevation. Mean high water is elevation 7.64, mean higher high water elevation is 8.93, and the City of Seattle highest observed water level is 12.14 (all NAVD88). The 100-year floodwater elevation 12.31 will be used for this design because it exceeds the 12.14 City of Seattle highest observed water elevation.

Design flows were determined using the Rational method found in Section 3.0 of the KCSWDM. The conveyance was evaluated for pipe slope, capacity, and velocities using an “n” value of 0.14. However, for the backwater calculations, the “n” value was adjusted to 0.12 according to Table 4.2.1.D of the KCSWDM. Figures 4.2.1.H, and I were used as templates for the calculations. Bend head losses were accounted for according to Table 4.2.1.K, and junction head losses were evaluated according to Figure 4.2.1.L of the KCSWDM.

The backwater analysis was evaluated for the low areas of the project and not for the system that is higher in the abutment walls or approach spans up to the bridge. During a mean higher high water event and heavy rains, the inlet will be fully submerged, so all pipes conveying water to the outfall were evaluated under inlet control fully submerged conditions.

5.2.1 North Basin Backwater Analysis

The backwater analysis was evaluated using the analysis method in Section 6 of the KCSWDM. All rims are above the backwater elevation during the 25-year storm event and 12.31 tail-water elevation during the 100-year floodwater condition. The designed conveyance system provides a minimum 1-foot of freeboard above the backwater surface elevation.

The 100-year storm event was also checked using the 12.31 100-year floodwater elevation. The analysis showed that all backwater remained within the inlet structures below the rim elevations but do not provide for 1-foot of freeboard.

The underground water quality wet vault on the north side of the project discharges directly to the new 24-inch diameter outfall. The outfall elevation is also set at 8.64, one-foot above the mean high elevation. The vault discharge elevation and wet pool elevation is 9.3 and is controlled with a flow restrictor tee apparatus. The internal top of the vault is at elevation 12.19 and 2.89-feet above the water quality surface elevation. The backflow analysis determined that stormwater will rise within the vault structure but not enough to fill the risers or over-top. The backwater analysis using elevation 12.31 is included in Appendix D.

5.2.2 South Basin Backwater Analysis

The storm drainage design was evaluated for the 1-foot freeboard criteria to check the minimum height of the backwater elevation and the overtopping rim elevation for each structure during the 25-year storm event and 100-year floodwater elevation (12.31). During this event, the emergency overflow structure in the rain garden has a freeboard clearance of 0.96-feet, slightly less than 1-foot, (but within survey and construction tolerances to be acceptable). During the 100-year storm event and 100-year floodwater elevation, the structures do not over-top. See Appendix D for additional calculations.

A tideflex valve has been added to the outfall pipes to prevent salt water from entering the conveyance system. The bottom of the rain garden is set at elevation 13.00, and the bottom of the soil matrix is at elevation 11.5 and the bottom of the recollection gravel bed and perforated pipe is at elevation 9. Ground water has been reported as high as elevation 7.3 and mean high water has been reported as elevation 7.64 at the river outfall location. The outfall discharge pipes have been designed with inverts at elevation 8.64 (one-foot above the mean high water mark). According to the design elevations, mean high water should not cause any head or backwater against the designed outfall and treatment facility.

The tidal influence is approximately 12 hours and may cause some water to stage within the rain garden and pipes during extreme events. Since the bottom of the rain garden is at elevation 13 and can potentially stage water to elevation 14.00 before engaging the emergency outfall structures. The emergency outfall structures have been modeled using KCRTS to stage water as high as 14.13 during full flow emergency discharge conditions and is well below the top of berm at elevation 15.25 for the rain gardens.

An additional backwater analysis was performed for the City of Seattle conveyance system that drains into the rain garden assuming the 14.13 tailwater elevation. The system exceeds the minimum 1-foot freeboard for both inlets and rain gardens during the 25-year storm event and 14.13 tailwater elevation condition. Overtopping does not occur during the 100-year storm event either.

5.3 Conveyance Requirements for Existing Systems

Existing onsite drainage systems that are modified as part of this project are designed to convey the 25-year peak flow event and exceed the minimum 10-year event design requirement. The existing conveyance system was also evaluated using the proposed 100-year storm event and checked for conveyance capacities and possible flooding or system overtopping conditions.

The analysis showed the existing outfall does not have adequate capacity during the 100-year storm event. The project reduces the tributary flows to the existing outfall, thereby improving the performance and adequacy of the existing system.

5.4 Outfalls

Two new 24-inch diameter outfalls will be constructed as part of this project. See Exhibits 8 and 9 in Appendix A for location of outfalls and tributary areas. The outfalls are designed according to the requirements in Section 1.2.4.3.E of the KCSWDM. A rock splash pad has been designed according to table 4.2.2.A and the velocities determined according to the 100-year conveyance calculations at the outfalls. Velocities are greater than 5 feet per second and less than 10 feet per second for both outfalls.

For both new outfalls, an anchoring system and restraint strapping have been designed to anchor the pipe in place and protect it from harm due to floating debris, boats, and currents. The concrete anchor is one-foot wide by one-foot high by 10.0-feet long weighing 1,500 pounds. The anchor is intended to counteract any buoyant forces on the end of the pipe protruding into the water. Without applying soil shear stresses, soil friction resistance, and other restraint factors, the resultant pounds per square inch on the concrete block due to hydraulic activity to overcome 500 pounds of side force is approximately 3.7 pounds per square inch and well within soil shear resistant parameters. See Appendix G for supporting calculations.

5.5 Spill Control and Source Control

Down-turned elbows or tees will be used to detain oils, greases, or other floatable pollutants prior to discharging into water quality facilities. A down-turned elbow has been designed for the stormwater structure upstream of the rain garden as well as the upstream catch basins preventing and/or reducing the potential for oil contamination into the rain garden. In the north basin, the same approach is used to trap oils.

5.5.1 Special Requirement #5: Oil Control

The project is exempt from this requirement because the average daily traffic (ADT) is well below the 25,000 ADT threshold per Section 1.3.5 of the KCSWDM (2005). Down-turned elbows and tee restrictors are proposed to trap/prevent potential oil from offsite sources. The tee restrictors are designed with flap gates for cleaning the pipe.

5.5.2 Special Requirement #4: Source Control

The mechanical room, operating systems, and bridge component source control measures shall be shown on the architectural and site improvement plans. Garbage collection areas shall be contained and located in an accessible area for service. Chemicals stored onsite shall be stored in a room with containment capacity. Fire safety systems shall be provided for life safety. Sewer connections shall be designed according to applicable design criteria.

5.6 Groundwater Protection

Appendix L contains critical areas mapping found in the King County iMap system. Critical areas include a groundwater management area documenting areas thought to be highly susceptible to groundwater contamination as well as a category 2 critical aquifer recharge area. The project meets the conditions of development within the parameters established by the category 2 critical aquifer recharge area classification.

The rain gardens have been designed with a special soil matrix to provide water quality treatment by plant filtration and infiltration through the matrix. The soil matrix is separated from a recollection gravel zone with a geotextile fabric for underground drainage. The recollection gravel zone contains perforated pipes to re-collect the treated stormwater and convey it for discharge into the Duwamish Waterway. A permanent liner for gravel zone separation will prevent further infiltration from the rain garden into the groundwater. The groundwater in the project vicinity is monitored with monitoring wells for contamination and groundwater levels. During construction, the groundwater elevation will also be monitored. Upstream of the project contamination has been found in the groundwater and soils.

5.7 Pump Systems

The new bridge will feature a solid bridge deck on the movable span, rather than open steel grating which currently exists, to better facilitate collection of roadway runoff and improve water quality at the site. Minor stormwater runoff leaking between the bascule bridge and the approach spans will go into the bascule pier counterweight pits and be pumped out into the sanitary sewer facility several times each year during non-storm events. The anticipated annual flows are very small. On the north side, the stormwater is pumped into the Boeing sewer system for conveyance to the public combined storm/sewer system. On the south side, the stormwater is pumped directly to the City of Seattle combined storm/sewer system.

King County Runoff Time Series software was used to establish flows for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year flows. The flows will be used to determine the pump system curve for pump sizing and design. Using the peak flows, a peak volume was evaluated using the software resulting in a 2-foot deep pool in the bottom of the bascule pier counterweight pits. The pits will be sloped to drain into sumps for the pumps and will not have standing pools of water over 2-feet deep. See Appendix I for KCRTS storm runoff data.

5.8 Floodplain Analysis

The proposed project impacts have been evaluated and mitigated for impacts to the existing waterway and floodplain. According to Special Requirements #2 and #3, the 100-year floodplain limits shall be shown in the improvement plans and profiles. The project shall also demonstrate conformance with FEMA regulations according to Section 4.4.2, Table 4.4.2A, and Army Corps of Engineers permit CFR 44. The FEMA 100-year floodplain map can be found in Appendix F, and floodways maps have been included in Appendix L. The following criteria and analysis have been evaluated and performed for this project:

5.8.1 Local and Federal Flood Protection Requirements

5.8.1.1 Local Protection and Design Requirements

The bridge and storm drainage was designed according to section 4.3.3 (Bridges) and meets the requirements of the King County Road Standards, Chapter 6, the critical areas code (KCC 21A.24), Shoreline Management (KCC Title 25), and the Clearing and Grading Code (KCC 16.82) as well as the requirements of other agencies such as the Washington State Department of Fish and Wildlife.

5.8.1.2 Local Biological Protection and Design Requirements

According to the Water Resources Technical Report (February 2004), the Duwamish Waterway in the project vicinity is a federally designated and locally regulated floodway and is classified as a Class B Freshwater Waterway and must meet the requirements for freshwater fish bearing habitat. Slope/channel restoration and erosion protection will be implemented as part of this project to fulfill requirements for enhancing and restoring fish bearing habitat. A work window requirement restricting construction activities between February 15 and July 15 will be implemented in the design to protect salmon species. For additional information regarding fish habitat, waterway characteristics, and alternative analysis, please see the Fish, Wildlife, and Vegetational Technical Report (February 2004).

5.8.1.3 Federal Bridge Design Requirements

The vertical clearance at the center of the navigation channel will remain at 34 feet above the Mean High Water level as per the 1998 revision to the U.S. Coast Guard permit drawings and reconfirmed by a letter from the U.S. Coast Guard on August 16, 2002. The proposed 125 foot horizontal clearance of between the fenders was accepted by the U.S. Coast Guard in a letter dated November 21, 2006.

5.8.2 Floodplain Hazard and Delineation

In accordance with the KCSWDM Special Requirement #2, the FEMA flood maps have been reviewed for historic flood criteria.

5.8.2.1 Duwamish Waterway Characteristics

According to the Water Resources Technical Report (February 2004), constructed levees line portions of the waterway along the project site. The floodway is approximately 450 wide feet between the constructed levees. The area on the land side of the levees is not within the regulated floodplain. The 100-year peak discharge at the bridge is 12,000 cfs and the 100-year flood plain elevation is 8.0 per datum NGVD 29 (Figure 16, FEMA Floodplain Map, September 06, 2002) and elevation 11.58 for NAVD 88. King County has provided independent review and a 100-year flood elevation of 12.31 for design purposes.

5.8.2.2 Historic Flooding

The project lies within a regulated flood plain and is controlled by the Howard Hanson Dam. According to the Water Resources Technical Report (February 2004), the Duwamish Waterway has overtopped the Boeing parking lot approximately 1,500 feet upstream of the bridge. The parking lot is at approximately elevation 16 (NGVD 88). While undocumented, a major storm event with high river flows coupled with a high tide may be responsible for causing upstream flooding. See Appendix F, FEMA Flood Plain Map Figure 16 for additional information.

5.8.2.3 Analysis and Mitigation

In accordance with KCSWDM Special Requirement #3, a floodplain zero rise river analysis and riverbed scour analysis was performed using Hydrologic Engineering Center – River Analysis System Version 3.0 to evaluate floodway conveyance impacts and mitigation associated with the proposed project.

5.8.2.4 Floodway Water Surface Elevation (Backwater Analysis)

According to the zero net rise analysis performed by Herrera Environmental (An Analysis of Hydraulic Effects and Riverbed Scour for the South Park Bridge Replacement Project, 2007), the 100-year flood water surface will rise 0.02 feet immediately upstream of the new bascule bridge. The water surface elevation rise coincides with a high tide of 11.78 feet and high river flows.

The south bank of the channel will be re-graded to mitigate for the water surface elevation rise. The mitigation involves removing a volume of soil equal to the water displaced by the project, and stabilizing the slopes with natural protection and vegetation. The analysis demonstrates the floodplain up and downstream of the project will not be impacted as a result of the project.

5.8.2.5 Scour Analysis

The river scour was evaluated for existing and proposed bridge conditions. The only significant hydraulic modification to the channel is the change in location of the bascule piers. The increased size of the piers will have a proportional effect on the scour depth in the river as compared to the existing bridge. The pier scour for the proposed bridge is anticipated to form the same bathymetric features as the existing bridge with respect to scour adjacent to the pier, scour between the pier and river bank, and deposition downstream of the of the pier.

5.8.2.6 River Survey and Mean Higher High Water Analysis

The South Park Bridge Hydrographic Survey (July, 2006) and analysis has been performed for this project. Sidescan sonar technology was used to map the bottom of the existing channel, identify debris, buried piles, and any other underwater items. According to the report, the data reprocessed for the South Park Bridge Project was in the higher section of the 2003 survey area and the value established from the United States Army Corps of Engineers web site for station 92 “Duwamish Waterway” of -2.42 feet was used for data processing. To go from MLLW (1960-1978 epoch) to NAVD88, 2.42-feet would need to be subtracted from the MLLW elevations.

5.9 Critical Areas Analysis and Delineation

This project satisfies Special Requirement #1 (Other Adopted Area-Specific Requirements) by complying with the KCSWDM (2005). Appendix L contains exhibits for the aquifer recharge area, shoreline management classification, floodplain analysis, and channel scour analysis.

5.9.1 Critical Areas Delineation

Critical area delineation maps were generated with the King County iMap system. The shoreline within the project limits is classified as an urban shoreline with no channel migration hazard areas and low river reach quality areas. The basin condition is also low for both the north and south basin areas. The banks of the Duwamish Waterway will be re-graded to maintain a zero net water surface elevation rise within the floodway. See Section 5.2 the floodplain analysis discussion.

5.9.2 Critical Areas Analysis (Slope Protection/Stability)

The Duwamish Waterway channel slopes are soil and armored banks. The banks consist of two zones, a rock, or concrete block armored zone, and a vegetated zone. The vegetated zone is well established and does not show significant signs of erosion, soil deposition, sloughing, or other signs of failure. The armored zone contains large broken blocks of concrete with small to large voids of exposed mud earth. Based on field observations, the muddy armored area seemed to be stable and did not show signs of sediment travel. See Section 5.5 and Appendix G of this report for slope protection verification/check calculations.

An independent review of the scour analysis was performed and a shoreline protection analysis was performed. Four cross-sections developed by the geotechnical review and hydrographic survey were used to determine the average area of the channel. The high flow value of 12,000 cubic feet per second (cfs) was reported in the Water Resources Technical Report (February 2004). For the analysis, the river was assumed to be in full laminar flow with the velocities in the middle of the river equaling the velocities on the rivers edge. Typical stream velocities during high flow events have the middle of the river flowing more quickly than the water at the rivers edge. Estimating the velocity as laminar flow results in the highest scour potential at the waters edge and yields the most conservative estimate. Based on the resulting water velocity, the KCSWDM Table 4.2.2.A (Rock Protection at Outfalls) was used to size the rock for slope protection. The slope protection approach was to use natural material as opposed to engineered, manmade, or other fabricated slope protection methods. Since the calculated river velocities while flowing full were between 0.0 and 5.0-feet per second, rock lining is adequate for the slope protection. However, the rock lining gradation allows 100% passing the 8-inch square sieve and up to 10% passing the ¾-inch square sieve. Fines lower than observed field conditions are not recommended because fines lower than field observed fines would likely be washed downstream. An average size piece of the existing shoreline concrete/rock armor was measured and an approximate weight of the armor piece was determined. Using the specific gravity of stone as 2.67, the weight of rock was calculated for the Riprap gradation and determined to be closer to the field observed conditions. Therefore, the minimum rock armor size for slope protection shall be Riprap according to the gradation in the KCSWDM Table 4.2.2.A and support calculations in Appendix G.

5.10 Groundwater Monitoring

A Focused Corrective Measure Study Report was created for the Southwest Bank Corrective Measures (March 2002) report to mitigate the net water surface rise. The report documents test locations, found contamination, concentrations, types of contaminants, and recommendations. The study investigated bank and surface sediments, upland soil data, and groundwater monitoring. According to the study, groundwater first occurs at approximately elevation 6.3 (NAVD88) and surface water intrusion into the bank varies with river stage and tidal cycle. The conclusions drawn from the sampling, testing and study, suggested that if debris filled within the saturated zone were removed, a major source of recontamination potential would be reduced/eliminated. Additional groundwater monitoring has been performed on the south side of the project. Based on the tabulated data (see Appendix F for boring and monitoring well data), contaminated soils will be encountered during excavation and will be accommodated in the SWPPP and TESC plans.

Groundwater elevations have been monitored for this project and ranges between elevation 6.5 and 7.3-feet. The prevailing elevation of the project is approximately elevation 16 placing the water approximately 9-feet below ground surface. Demolition of groundwater monitoring wells will be a part of this project and will be performed by a driller certified for decommissioning groundwater monitoring wells.

5.11 Anadromous Fisheries Impact

Fish and fisheries may be impacted as a part of this project. Site design, erosion control measures, construction phasing, construction scheduling, and mitigation measures have been studied and are being implemented for this project to minimize impacts to the waterway. According to studies and data from the Washington State Department of Fish and Wildlife, an evaluation for rare and endangered plant species has been performed for the project and the information provided indicated no reported rare plants or high quality native ecosystems within the project area. Additional information can be found in the Addendum to the Geotechnical and Hazardous Materials Investigations for the South Park Bridge (Shannon and Wilson, 2004).

6 SPECIAL REPORTS AND STUDIES

The following is a list of additional reports that have been prepared for this project:

6.1 Reports Associated with Development Requirements

- Final Biological Assessment - South Park Bridge Replacement (March 2009).
- South Park Bridge ESA Technical Memorandum (September 3, 2007).
- Analysis of Hydraulic Effects and Riverbed Scour (November 2007).
- Final Cultural Resources Section 106 Technical Report (June 2007).
- South Park Bridge Replacement Transportation Technical Report (April 2004).
- South Park Bridge Project Geology and Soils Technical Report (February 2004).
- South Park Bridge Project Water Resources Technical Report (February 2004).
- South Park Bridge Project Fish, Wildlife, and Vegetation Technical Report (Feb. 2004).

- South Park Bridge Project Hazardous Materials Technical Report (February 2004).
- South Park Bridge Project Relocations Technical Report (February 2004).
- South Park Bridge Project Land Use Technical Report (February 2004).
- South Park Bridge Project Economics Technical Report (February 2004).
- South Park Bridge Rehabilitation Feasibility Study Technical Report (May 2003).

7 OTHER PERMITS

See Section 2.1 of this report.

8 CSWPPP ANALYSIS AND DESIGN

The construction stormwater pollution prevention plan (CSWPPP) is applicable to the proposed construction activities and the time of year construction is to take place. For additional reporting, design, and calculations see the South Park Stormwater Pollution Prevention Plan Report.

9 BOND QUANTITIES, FACILITY SUMMARIES, AND DECLARATION OF COVENANT

9.1 Core Requirement #7: Financial Guarantees and Liability

The project is a public improvement project within King County right-of-way lead by King County and for King County. Quantities shall be prepared for the work elements pertaining to the project. An engineer's estimate shall be provided to establish an opinion of cost for the project. Since this is a public works project, bonding worksheets usually prepared for private developer projects have not been developed.

10 OPERATIONS AND MAINTENANCE MANUAL

See Appendix M for the general operation and maintenance manual. Please note special requirements included below:

10.1 Core Requirement #6: Maintenance and Operations

The water quality wet vault should be checked at least once every 6-months. The outlet flow restrictor tee should be checked to make sure it is free of debris and capable of passing water. The vault should be dipped to check for sediment accumulation. Should sediment build up any higher than one-foot deep, it should be removed. The vault may be drained for cleaning, but should not be drained after a major storm event or while the groundwater elevation is high.

The rain gardens have been designed to recollect the stormwater under the soil amended matrix. Perforated pipes are lined with permeable geosynthetic fabric to prevent soils or silts from plugging the pipes. A gravel bed 2.5-feet deep surrounds the perforated pipes allowing water to travel through the gravel bed into the pipes efficiently. Sewer cleanouts have been designed to allow maintenance access to flush the pipes, back flush the gravel bed, and make sure silts do not accumulate in the system. The emergency outfall structure must be checked for debris because the Orr Street rain garden discharges into the emergency outfall structure under normal operation. The primary outfall should be checked frequently to insure proper discharge capacity.

The outfalls should be checked to make sure the Tideflex valves are seated securely, free of damage, and in good operation. Manholes have been provided directly up-stream of the outfall to allow maintenance to flush the system and visually inspect the discharge stream for dirt and debris. Rock and plantings should be visually inspected for damage and repaired as necessary.

11 DESIGN REFERENCES

King County Surface Water Design Manual, 2005

King County Road Design and Construction Standards, 2007

Dept. Of Ecology Stormwater Management Manual for Western Washington, 2007

Low Impact Development Manual for Puget Sound, 2005

APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D

APPENDIX E

Level 1 Offsite Analysis Field Inspection 44 Pages

APPENDIX F

Existing South Park Bridge (Figure 2)	1 Page
Combined and Separated Sewer System General Areas (Figure 15)	1 Page
FEMA Floodplain Map (Figure 16)	1 Page
Duwamish Waterway Sections	2 Pages
Site and Exploration Plan	1 Page
Generalized Subsurface Profile A-A (Figure 16)	1 Page
Critical Areas Map (Figure 17)	1 Page
Fault Location Map (Figure 18)	1 Page
South Basin Soil Boring Logs	1 Page
Typical Detail for Earthquake Drain Installation (Figure 19)	1 Page

APPENDIX G

Rain Garden Design Data	9 Pages
Underground Wet Vault	5 Pages
Underground Vault Orifice Design	1 Page
Vault Buoyancy Calculation	3 Pages
Jail House Weir (2-Year Analysis)	1 Page
Emergency Outfall/Weir (100-Year Analysis)	1 Page
Overflow Weir Between Rain Gardens	1 Page
Bascule Pier Pump Flows	2 Pages
Scupper Design Option (Proof of Impracticality)	7 Pages
Pipe Support Calculations	10 Pages
Shoreline Slope Stabilization	3 Pages
Anchor Restraint Calculations	6 Pages
Outfall Valve Calculation	2 Pages

APPENDIX H

Low Impact Development Technical Memo (Alternatives Analysis) 28 Pages

APPENDIX I

North Basin Sidewalk Inlet Spacing Calculations (10-Year Storm Event)	1 Page
South Basin Sidewalk Inlet Spacing Calculations (10-Year Storm Event)	1 Page
North Basin Roadway Inlet Spacing Calculations (10-Year Storm Event)	1 Page
South Basin Roadway Inlet Spacing Calculations (10-Year Storm Event)	1 Page
Conveyance Calculations (25-Year Storm Event)	2 Pages
Conveyance Calculations (100-Year Storm Event)	2 Pages

APPENDIX J

APPENDIX K

Inlet Catchment Area Exhibits 6 Pages

APPENDIX L

SPB Groundwater Management Area	2 Pages
SPB Shoreline Management Designation	2 Pages
SPB Critical Aquifer Recharge Area	2 Pages
SPB Drainage Complaints	1 Page
SPB Shoreline Jurisdiction	1 Page
SPB Floodways	1 Page
SPB 100-Year Floodplain	2 Pages
SPB Flow Control and Water Quality	2 Pages
SPB Commercial Stormwater Facilities	1 Page
River Reach Quality Area	1 Page

APPENDIX M

Maintenance Manual 33 Pages