Exhibit 3-12. Identified Hazardous Material Sites Summary Table

					Regulatory Databases [1]																												
					Federal															State													
																				WASHINGTON							OREGON						
Site ID	Database Report ID	NAME	ADDRESS	STATE	RCRA-CESQG	RCRA-SQG	RCRA-LQG	RCRA-ND	RCRA-TSD	RCRA-CORRACTS	CERCLIS	CERCLIS-NFRAP	ENG-CONTROLS	INST-CONTROLS	NPL	TRIS	HMIRS	WATER	AIR	CSCSL	CSCSL NFA	SWF/LF	LUST	UST	CSCSL	DECISIONS	ECSI	UST-DECOM	LUST	UST	SW/LF	HAZMAT	BROWNFIELD
213	265	ROVALVE DIV. OF TECHNAFLOW INC	1945 N COLUMBIA BLVD	OR																							●		●				
214	266	ALLIED ROOFERS SUPPLY CORP	9111 N DENVER AVE	OR																								●	●				
215	267	WASTECH INC.	701 N HUNT ST	OR	●							●						●									●				●		
216	269	NICOLAI-MORGAN	1812 N COLUMBIA BLVD	OR																							●						
217	270	METROPOLITAN DISPOSAL & RECYCLING CORP	8520 N KERBY AVE	OR																							●						
218	271	PRECISION EQUIPMENT INC	8440 N KERBY AVE	OR		●						●						●	●								●						
219	272	NORSTAR BUSINESS CENTER	8501 N ALBINA AVE	OR																							●						
220	273	BLASEN FAMILY LLC	1601 N COLUMBIA BLVD	OR																							●						
221	274	WAYMIRE DRUM CO.	8443 N KERBY AVE	OR																							●						
222	275	EVERGREEN STAGES LINES	9038 N DENVER AVE	OR																							●						
223	277	QWEST - PORTLAND ARGYLE SOC (R00710)	2111 NE ARGYLE	OR																								●					
224	278	BRUNDAGE-BONE CONCRETE PUMPING, INC.	1627 NE ARGYLE ST.	OR																								●					
225	279	SPILL	2519 NW ARGYLE	OR																												●	
226	280	RB RECYCLING INC.	8501 N BORTHWICK AVE	OR														●									●				●		
227	281	P. C. DEVELOPMENT INC.	955 N COLUMBIA BLVD	OR																							●						
228	282	MACADAM ALUMINUM & BRONZE CO.	1255 N COLUMBIA BLVD	OR	●													●	●								●						
229	283	COLUMBIA ALUMINUM RECYCLING CORP	900 N COLUMBIA BLVD	OR				●																			●						
230	284/285	NELSON VIC PROPERTY/ CARL BUD HOFFMAN FACILITY	N DENVER AVE	OR				●																									
231	286	AMERICAN AUTO RECYCLING WRECKING	626 N COLUMBIA BLVD	OR																							●						
232	287	BRADFORD PROPERTY	511 N COLUMBIA BLVD	OR																							●						
233	288	LORD BROTHERS CONTRACTORS	437 N COLUMBIA BLVD	OR	●																						●	●	●				
234	289	FAIRMONT FINANCIAL PROPERTY	570 N COLUMBIA BLVD	OR																							●						
235	290	ALLIED PLATING, INC.	8135 NE UNION AV	OR				●			●				●												●						
236	291	RYDER TRANSPORTATION RESOURCES	310 N COLUMBIA BLVD	OR	●																						●		●	●			
237	292	CENTRAL MACHINE WORKS INC.	8009 N KERBY ST	OR																							●						
238	293	SPILL	7800 N DENVER & FARRAGAT	OR																												●	

Notes 1 = For detailed description of databse see Appendix B; for further information on identified sites see Appendix B

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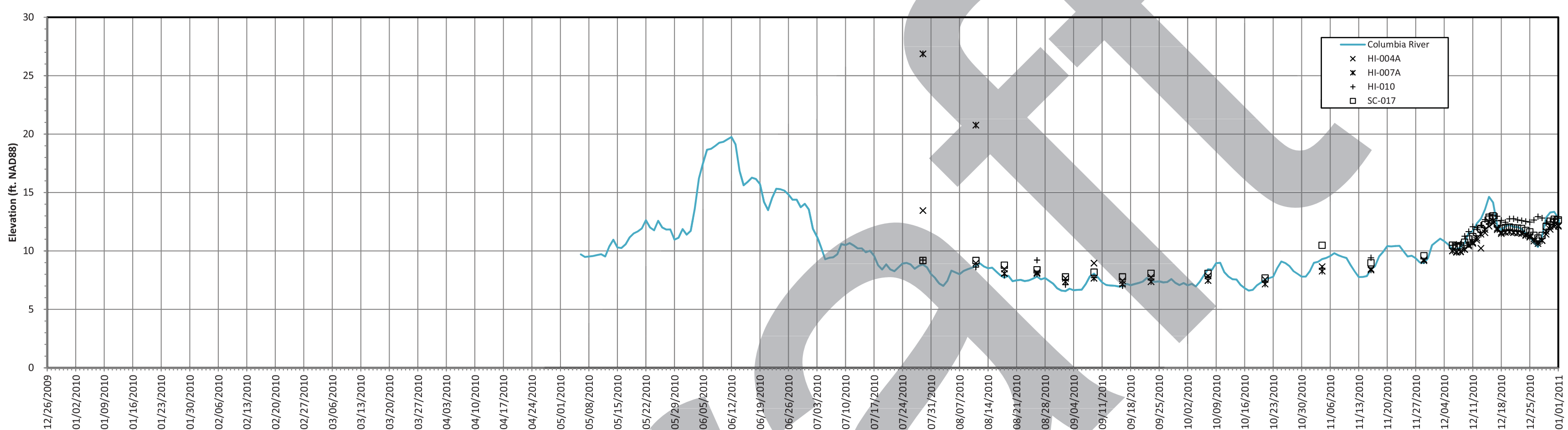
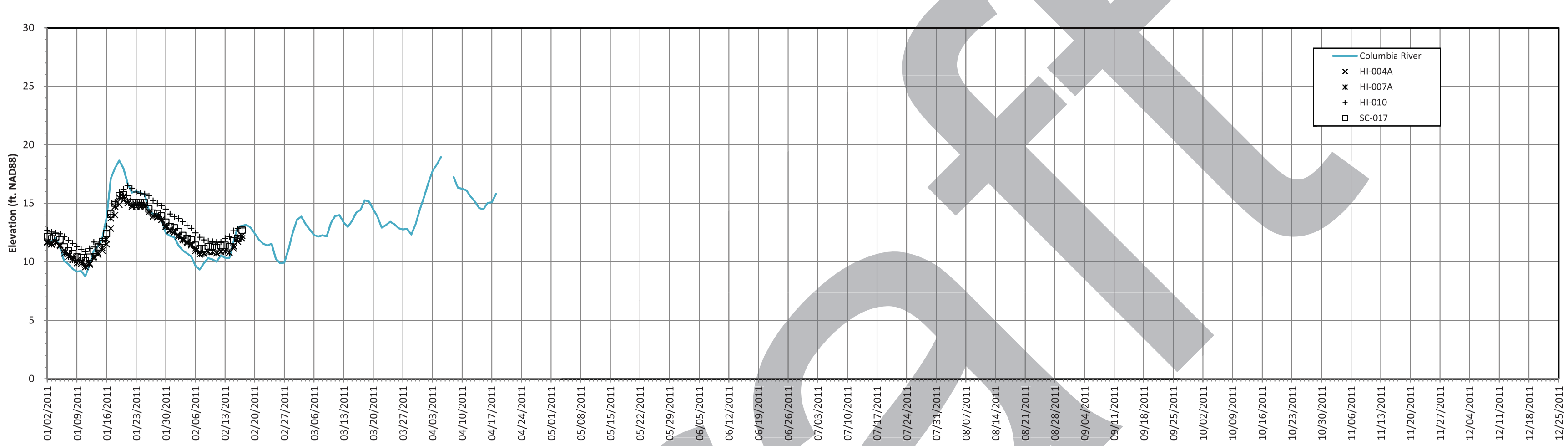
Groundwater Elevations at Hayden Island - 2010

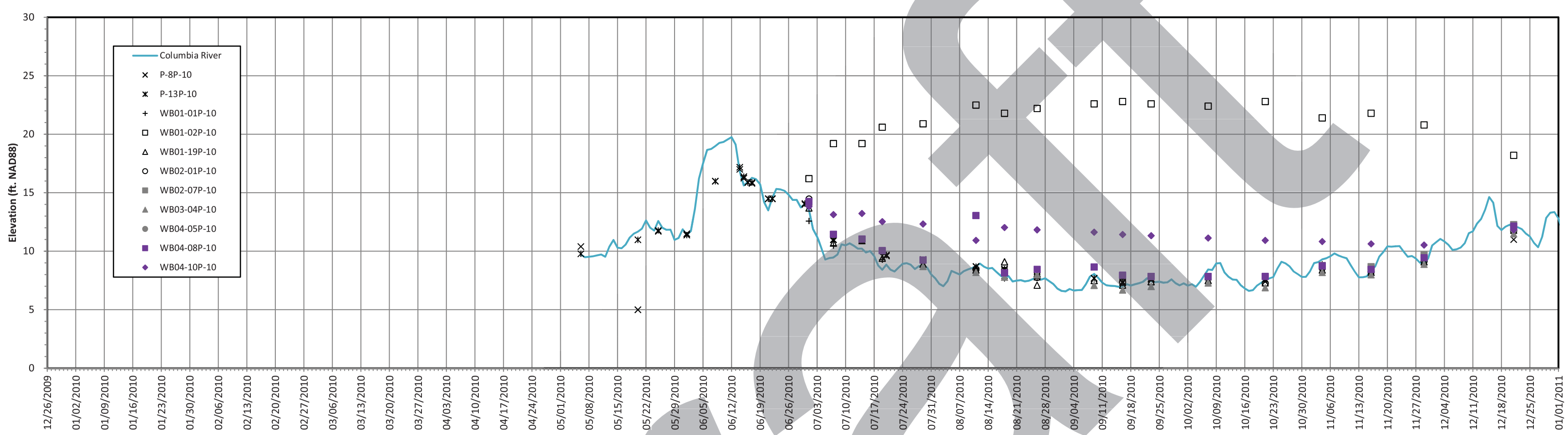


Draft

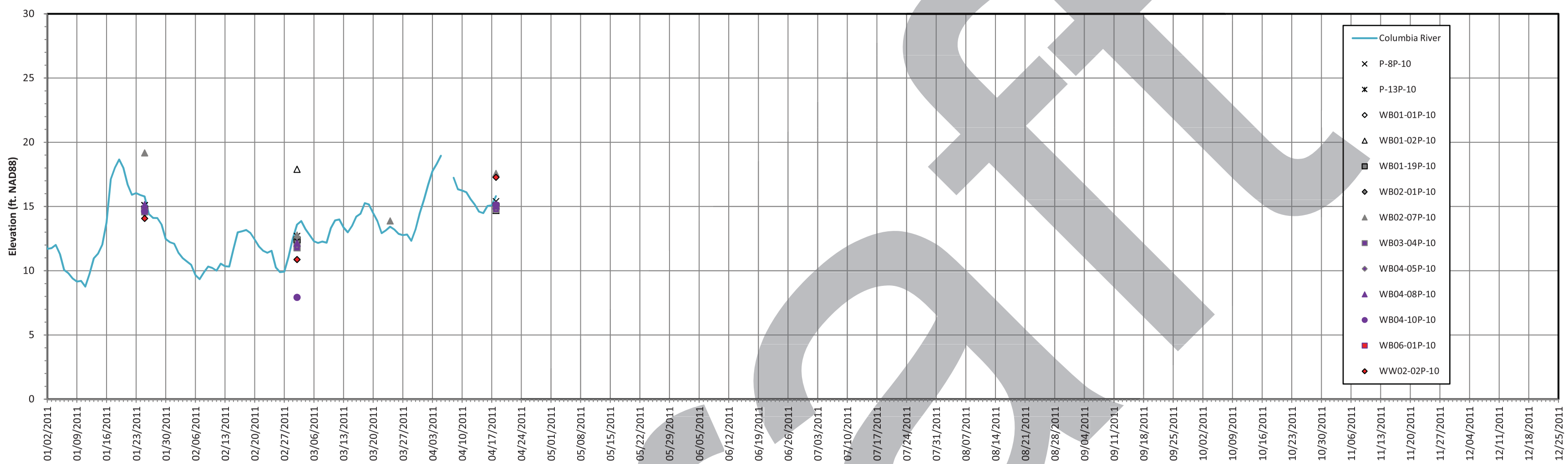
Groundwater Elevations at Hayden Island - 2011

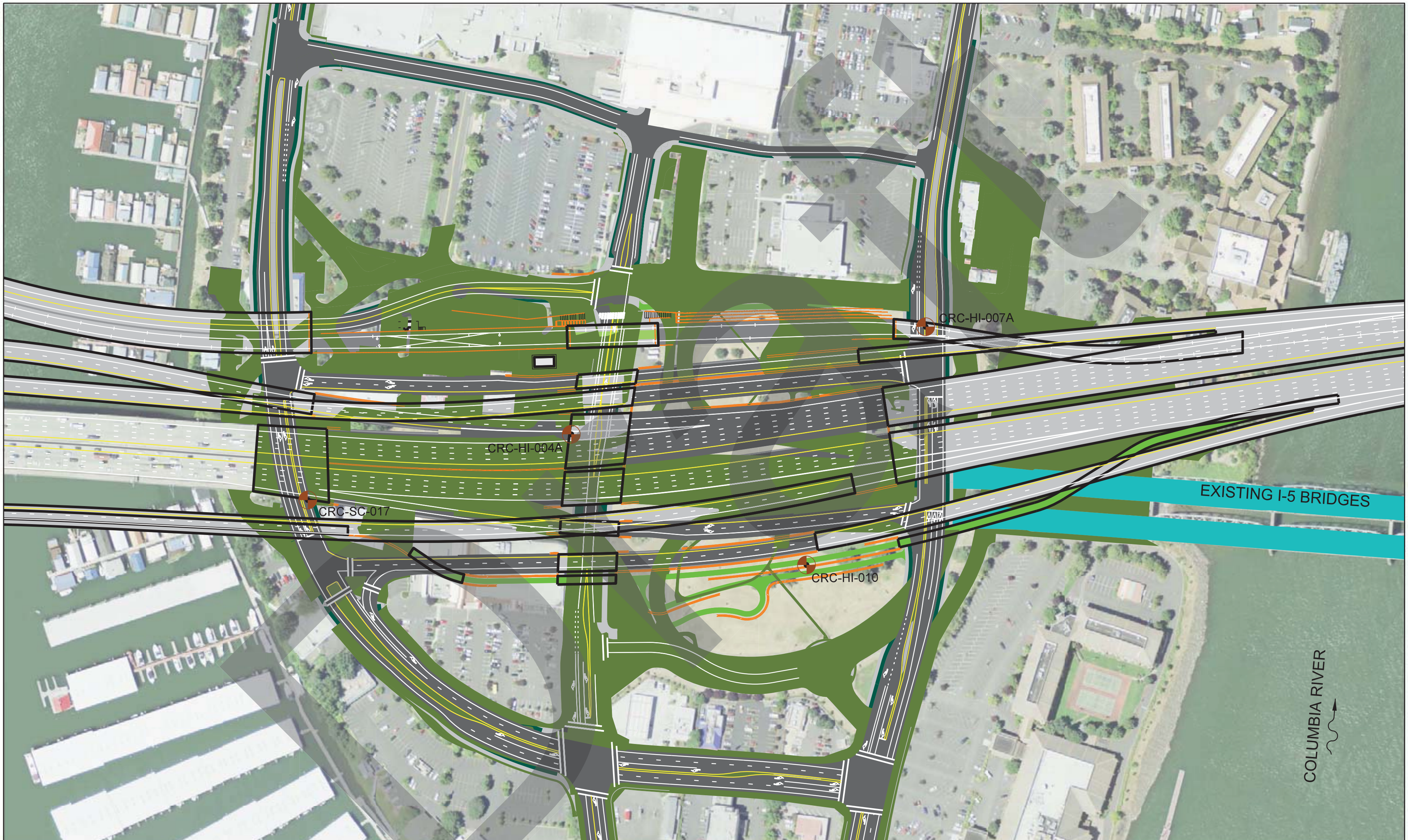


Groundwater Elevations at SR 14 - 2010



Groundwater Elevations at SR 14 - 2011





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PIEZOMETER ID

Piezometer Locations Hayden Island

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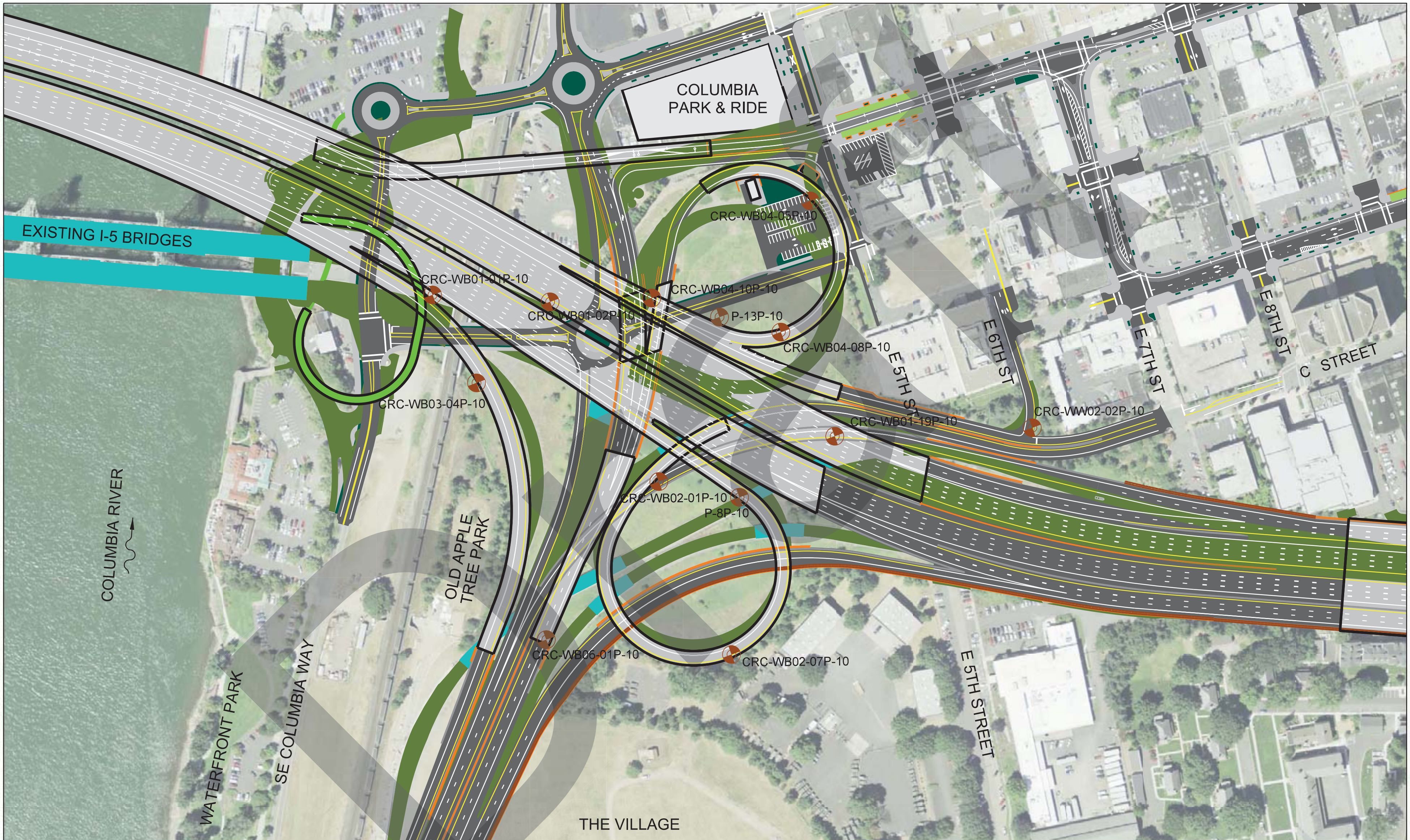
SCALE IN FEET

Columbia River CROSSING



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PIEZOMETER ID

Piezometer Locations SR 14

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SCALE IN FEET

Columbia River CROSSING

Permits Issued by ODOT for I-5 Right-of-Way

Permit No.	Year Issued	Utility Type	Applicant	Comments
4734	1955	Communications	Pacific Telephone & Telegraph Company	MP 6.24 (prior Mile Post system). Telephone cable crossing.
6142	1962	Communications	Pacific Northwest Bell	MP 307.45. U/G telephone cable.
5225	1964	Communications	Pacific Northwest Bell	MP 6.63 - 6.77 (prior Mile Post system). Telephone cable. Modified later.
11761	1967	Water	Hayden Island, Inc.	MP 308.02. 6" steel. Not shown on City of Portland data - could be abandoned.
11973	1967	Electricity	Portland General Electric	MP 307.69. U/G 11 kV crossing. Amended in Salem Permit Office.
12240	1968	Sewer	Hayden Island, Inc	MP 6.28 (prior Mile Post system). 8" welded steel pipe.
12259	1971	Communications	Pacific Northwest Bell	Location on attached map is not clear: it is likely at intersection of Hayden Island Drive and Center Avenue.
13509	1970	Water	Hayden Island, Inc.	MP 7.69 (prior Mile Post system). 12" pipe. Replaced - see Permit #30861.
13681	1970	Electricity	Portland General Electric	MP 6.59 - 6.60 (prior Mile Post system). 17kV buried cable and switch/transformer house. Current configuration not as shown on the permit.
14228	1971	Gas	Northwest Natural Gas Company	MP 307.69 - 307.99. 2" and 4" pipe.
15306	1972	Water	City of Portland	MP 307.06. 24" casing for 16" steel main.
15572	1972	Water	City of Portland	MP 307.05. 16" DIP crossing.
16216	1973	Communications	City of Portland	MP 307.48 - 307.70. Fire alarm cable suspended under Oregon Slough Bridge. Not shown for security reasons.
17675	1976	Communications	Pacific Northwest Bell	MP 308.14 - 308.16. Concrete parking area.
18599	1977	Sewer	City of Portland	MP 306.64 - 306.83. 6" DIP forcemain.
19107	1977	Gas	Northwest Natural Gas Company	MP 308.15 - 308.17. 2" steel.
20738	1979	Communications	Pacific Northwest Bell	MP 368.25. U/G cable. Mile Post is incorrect.
25437	1985	Communications	Pacific Northwest Bell	MP 307.45. U/G telephone cable and cable suspended under North Portland Harbor Bridge deck.
27148	1987	Communications	Roger's Cable Systems	MP 307.47 - 307.70. U/G TV cable and suspended cable under North Portland Harbor Bridge deck.
30693	1990	Water	City of Portland	MP 307.33 - 307.51. 16" DIP.
30861	1990	Water	City of Portland	MP 308.06 - 308.16. 12" DIP.
2BM35007	1990	Gas	Northwest Natural Gas Company	MP 307.32 - 307.47. 8" steel line.
2BM35178	1992	Sewer	City of Portland	MP 307.70. 10" PVC forcemain crossing.
2BM35338	1993	Communications	Red Lion Inn	MP 308.00. Record existing telephone cable.
2BM35356	1994	Communications	Columbia Cable of Washington	MP 307.99 - 308.38. 2" conduit with fiber-optic cable across Columbia River Bridge. Extends onto Washington side. Shown as a submarine crossing at lift span.
2BM35638	1996	Sewer	City of Portland	MP 307.16. 20" and 30" forcemain.
2BM35797	1997	Communications	TCI	MP 307.99 - 308.38. Temporary permit for installing fiber-optic cable on Columbia River Bridge. Extends onto Washington side.

Permit No.	Year Issued	Utility Type	Applicant	Comments
2BM35800	1997	Communications	All Phase Communications	MP 307.80 - 307.99. U/G fiber-optic cable.
2BM35801	1997	Communications	All Phase Communications	MP307.99 - 308.38. PVC conduits on Columbia River Bridge for fiber-optic cable. Extends onto Washington side, and includes vault and pull boxes.
2BM35831	1997	Communications	All Phase Communications	MP 307.46 - 307.70. Fiber-optic cable suspended under Oregon Slough Bridge.
2BM35873	1997	Communications	GST Telecom	MP 307.30. U/G fiber-optic cable. Mile Post is incorrect – cable located on Pier 99 Street.
2BM36005	1998	Water	City of Portland	MP 307.45. 8" DIP.
2BM36010	1998	Communications	Electric Lightwave	MP 307.48. O/H fiber-optic line on PP&L poles.
2BM36073	1999	Communications	Paragon Cable	MP 307.46 - 307.47. U/G fiber-optic & TV cable.
2BM36236	2000	Electricity	Portland General Electric	MP 308.00. U/G mainline backbone feeder.
2BM36242	2000	Electricity	Portland General Electric	MP 308.00. 4" & 6" U/G power conduit.
2BM36281	2000	Communications	Hayden Corner	MP 308.00. Replace traffic loop detector - loops not shown on drawings.
2BM36614	2002	Water	Doubletree Hotel	MP 308.00. Connection to ODOT water line. Insufficient information to verify location. Private connections not shown on the drawings.
2BM36829	2003	Communications	Qwest	MP 307.71. U/G 2" service conduit. Service connections not shown on drawings.
2BM37005	2005	Communications	Qwest	MP 307.71. U/G telephone cable.

Franchises and Permits Issued by WSDOT for I-5 Right-of-Way

Permit No.	Year Issued	Utility Type	Applicant	Comments
FRANCHISES				
	1994	Communications	Columbia Cable of Washington	MP 0.00 - 0.17. See ODOT Permit # 2BM35356.
	1997	Communications	All Phase Communications	See ODOT Permit # 2BM35801.
	1997	Communications	TCI	MP 0.00 - 0.23. See ODOT Permit # 2BM35797.
6423	1980	Electricity	Clark County PUD	MP 0.27. Existing 12.5kV O/H crossing. Franchise Agreement (expires 2005).
6423	1980	Electricity	Clark County PUD	MP O.53. Existing guy wire and neutral wire O/H crossing. Franchise Agreement (expires 2005). No longer there.
6423	1980	Electricity	Clark County PUD	MP 0.65. Existing 12.5kV O/H crossing. Franchise Agreement (expires 2005).
6423	1980	Electricity	Clark County PUD	MP 0.93. Existing 12.5kV O/H crossing. Franchise Agreement (expires 2005).
6423	1980	Electricity	Clark County PUD	MP 1.23. Existing 2 - 6" conduits without cable. Franchise Agreement (expires 2005).
6423	1980	Electricity	Clark County PUD	MP 1.82. Existing 12.5kV O/H crossing. Franchise Agreement (expires 2005).
6423	1980	Electricity	Clark County PUD	MP 2.02. Existing 69kV O/H crossing. Franchise Agreement (expires 2005).
6644	1984	Communications	Pacific Northwest Bell Telephone Co.	MP 0.54. O/H telephone cable crossing. Franchise Agreement (expires 2009). Crossing no longer exists.
6644	1984	Communications	Pacific Northwest Bell Telephone Co.	MP 0.84. O/H telephone cable crossing. Franchise Agreement (expires 2009). Crossing is on bridge.
6644	1984	Communications	Pacific Northwest Bell Telephone Co.	MP 1.55. U/G telephone cable crossing encased in a 30" steel pipe. Franchise Agreement (expires 2009.
6644	1984	Communications	Pacific Northwest Bell Telephone Co.	MP 1.56. U/G telephone cable crossing. Franchise Agreement (expires 2009).
6644	1984	Communications	Pacific Northwest Bell Telephone Co.	MP 1.98. O/H telephone cable crossing. Franchise Agreement (expires 2009). Crossing is actually at 33rd (MP 2.02).
6644	1984	Communications	Pacific Northwest Bell Telephone Co.	MP 0.29 - 0.32. U/G telephone cable crossing. Franchise Agreement (expires 2009).
6644	1991	Communications	Pacific Northwest Bell Telephone Co.	MP 1.55 - 1.62. U/G telephone cable crossing: within an existing duct. Franchise Agreement (expires 2009).
6644	1991	Communications	Pacific Northwest Bell Telephone Co.	MP 1.56 - 1.62. U/G telephone cable crossing: within existing ducts. Franchise Agreement (expires 2009).
40006	1985	Gas	Northwest Natural Gas Company	MP 0.25. 6" steel. Franchise Agreement (expires 2010).
40006	1985	Gas	Northwest Natural Gas Company	MP 1.28 - 1.29. 4" steel. Franchise Agreement (expires 2010).
40025	1987	Water	City of Vancouver	MP 0.25. 6" DIP. Franchise Agreement (expires 2012).
40025	1987	Water	City of Vancouver	MP 0.54 - 0.56. 12" DIP. Franchise Agreement (expires 2012).
40025	1987	Water	City of Vancouver	MP 0.58 - 0.60. 12" DIP. Franchise Agreement (expires 2012).

Permit No.	Year Issued	Utility Type	Applicant	Comments
40025	1987	Water	City of Vancouver	MP 1.00 - 1.04. 12" DIP. Franchise Agreement (expires 2012).
40025	1987	Water	City of Vancouver	MP 1.03 - 1.08. 8" pipe. Franchise Agreement (expires 2012). Partly abandoned.
40025	1987	Water	City of Vancouver	MP 1.03 - 1.04. 6" pipe. Franchise Agreement (expires 2012).
40025	1987	Water	City of Vancouver	MP 2.33 - 2.37. 8" DIP. Franchise Agreement (expires 2012).
40025	1987	Water	City of Vancouver	MP 2.36 - 2.38. 8" DIP with a 2" galvanized pipe. Franchise Agreement (expires 2012).
40025	1987	Water	City of Vancouver	MP 1.30. 20" DIP crossing not previously described. Franchise Agreement (expires 2012).
40025	1987	Water	City of Vancouver	MP 1.68. 6" pipe crossing in 36" culvert not previously described. Franchise Agreement (expires 2012). Abandoned.
40025	1987	Water	City of Vancouver	MP 1.83. 12" DIP crossing in 42" culvert not previously described. Franchise Agreement (expires 2012).
40025	1987	Water	City of Vancouver	MP 1.97. 10" DIP crossing in 42" culvert not previously described. Franchise Agreement (expires 2012).
40058	1988	Sewer	City of Vancouver	MP 0.26. Existing 8" CSP. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 0.43 - 0.44. Existing 8" CSP. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 0.44 - 0.45. Existing 8" CSP. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 0.56 - 0.58. Existing 33" pipe. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 1.03. Existing 8" pipe. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 1.08. Existing 8" pipe. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 1.19 - 1.26. Existing 10" pipe. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 1.30 - 1.37. Existing 8" pipe. Franchise Agreement (expires 2013). Abandoned.
40058	1988	Sewer	City of Vancouver	MP 1.68. Existing 14" pipe. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 1.68. Existing 12" pipe. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 2.25 - 2.29. Existing 8" pipe. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 2.29 - 2.34. Existing 8" pipe. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 2.34 - 2.35. Existing 27" pipe. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 2.31 - 2.37. Existing 8" pipe. Franchise Agreement (expires 2013).
40058	1988	Sewer	City of Vancouver	MP 2.41 - 2.44. Existing 12" pipe. Franchise Agreement (expires 2013).
40118	1994	Communications	Columbia Cable of Washington	MP 0.00 - 0.26. 2" duct with fiber-optic cable on Columbia River Bridge. Franchise Agreement (expires 2019).

Permit No.	Year Issued	Utility Type	Applicant	Comments
40118	1998	Communications	TCI	MP 0.00 - 0.26. 2" duct with fiber-optic cable. High level crossing of bridge lift span. Franchise Agreement (expires 2019).
40118	1998	Communications	TCI	MP 2.02. O/H fiber-optic cable crossing. Franchise Agreement (expires 2019).
40151	1997	Communications	Electric Lightwave	MP 0.26 - 0.27. O/H fiber-optic cable crossing. Franchise Agreement (expires 2022).
40151	1997	Communications	Electric Lightwave	MP 2.02. O/H fiber-optic cable crossing. Franchise Agreement (expires 2022).
40161	1998	Communications	GTE	MP 1.82. O/H fiber-optic cable crossing. Franchise Agreement (expires 2023).
PERMITS				
8828	1983	Communications	Cox Cable	MP 0.94. O/H CATV cable crossing. See #11072.
8842	1984	Communications	Cox Cable	MP 1.84. Two CATV cables within 29th Street structure.
8868	1983	Electricity	Clark County PUD	MP 0.66 - 0.69. 4" PVC duct with 12.5kV cable.
9749	1984	Communications	City of Vancouver	MP 1.03 - 1.05. U/G cable in PVC duct.
9278	1985	Communications	Cox Cable	MP 0.79 - 0.84. U/G CATV cable parallel to I-5 in 2" PVC duct.
11013	1994	Communications	Clark Public Utilities	MP 0.94 - 0.95. O/H fiber-optics cable lashed to neutral wire authorized under Franchise #6423.
11072	1995	Communications	Columbia Cable of Washington	MP 0.94. O/H CATV cable crossing.
11466	1996	Communications	TCI	MP 1.27 - 1.28. 2 - 2" PVC ducts. One is empty and one has a CATV cable.
U1196	2001	Communications	City of Vancouver	MP 1.03 - 1.05. U/G 3" duct with fiber-optic cable.
U1271	2002	Communications	Clark County Dept. of Information Technology	MP 0.85. 3 - 1.25" fiber-optic cable ducts.
U1315	2002	Communications	Clark Public Utilities	MP 0.26 - 0.28. O/H fiber-optic cable crossing.
U1444	2004	Communications	City of Vancouver	MP 1.58. Fiber-optic cables.

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N W E S

0 275 550

Feet

ICP Project Footprint

ICP Stormwater Treatment Facilities

Vanport Wetlands Mitigation Area

Wetland Areas

Potentially Jurisdictional Water Area (PJWA)

Outfalls and Culverts

Dry Stormwater Feature

Figure 1.0. Wetlands and Stormwater Treatment Facilities - Oregon

Columbia River CROSSING

Source: Locally Identified Wetlands = Clark Co. and Metro; Project Delineated Wetlands = Columbia River Crossing (Parametrix)

Analysis by J. Koloszar; Analysis Date: 31 Oct 2012; File Name: Exhibit3_6_3_8_TF255.mxd

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ICP Project Footprint
ICP Stormwater Treatment Facilities
Vanport Wetlands Mitigation Area
Wetland Areas
Potentially Jurisdictional Water Area (PJWA)
Outfalls and Culverts
Dry Stormwater Feature

0 130 260
Feet

Figure 2.0. Wetlands and Stormwater Treatment Facilities - Oregon

Columbia River CROSSING

Source: Locally Identified Wetlands = Clark Co. and Metro; Project Delineated Wetlands = Columbia River Crossing (Parametrix)

Analysis by J. Koloszar; Analysis Date: 31 Oct 2012; File Name: Exhibit3_6_3_8_TF255.mxd

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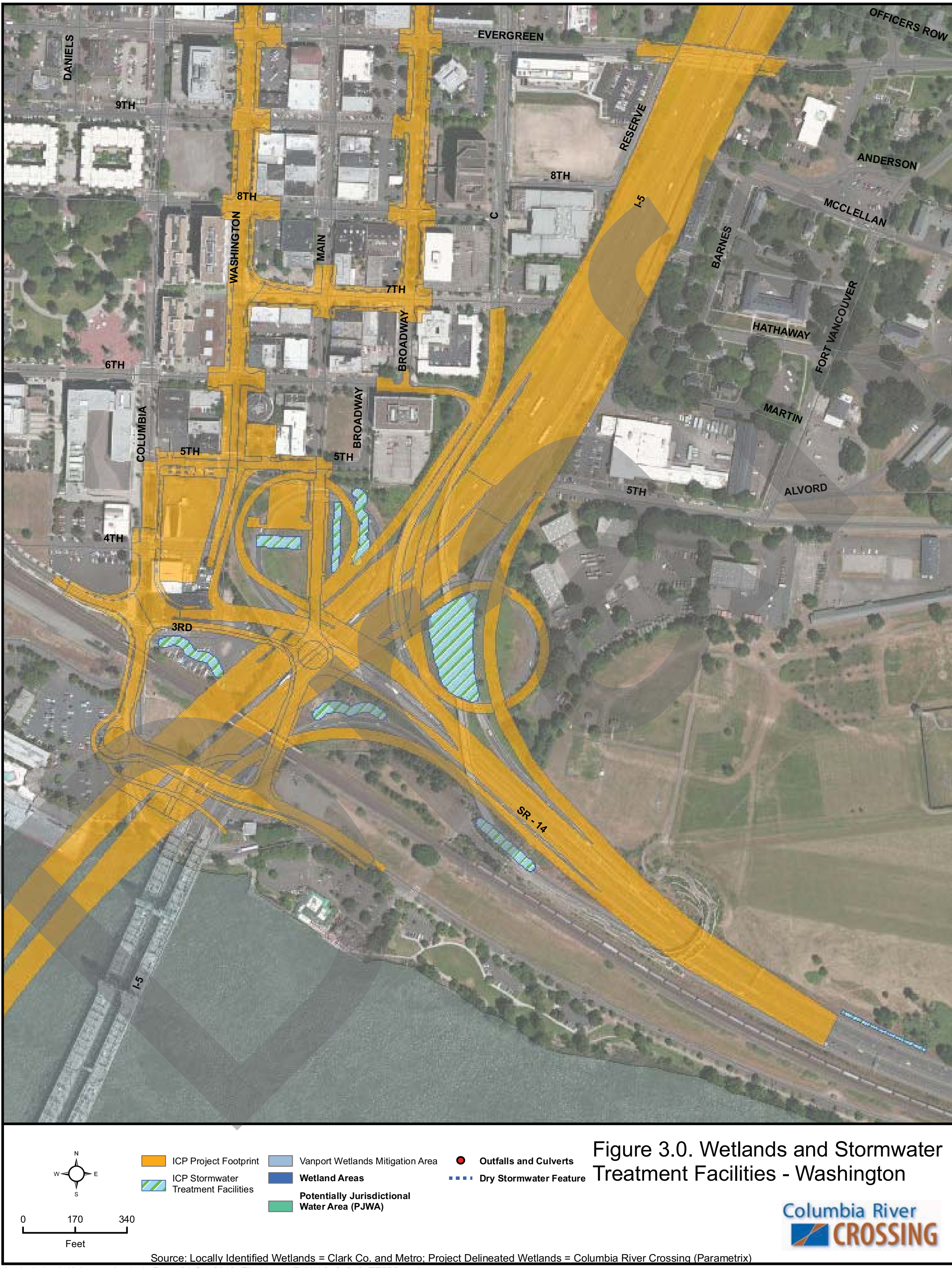

Figure 3.0. Wetlands and Stormwater Treatment Facilities - Washington

Columbia River CROSSING

Source: Locally Identified Wetlands = Clark Co. and Metro; Project Delineated Wetlands = Columbia River Crossing (Parametrix)

Analysis by J. Koloszar; Analysis Date: 31 Oct 2012; File Name: Exhibit3_6_3_8_TF255.mxd

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Figure 4.0. Wetlands and Stormwater Treatment Facilities - Washington

Columbia River CROSSING

Source: Locally Identified Wetlands = Clark Co. and Metro; Project Delineated Wetlands = Columbia River Crossing (Parametrix)

Analysis by J. Koloszar; Analysis Date: 31 Oct 2012; File Name: Exhibit3_6_3_8_TF255.mxd

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APPENDIX L

Project Description – Initial Construction Program

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1. Project Description – Initial Construction Program (ICP)

1.1 General

The Record of Decision for the Columbia River Crossing Program identifies the transportation improvements of the selected alternative for the 5-mile project corridor, including:

- A new river crossing over the Columbia River and I-5 highway improvements.
- Improvements to seven interchanges, from south to north: Victory Boulevard, Marine Drive, Hayden Island, SR-14, Mill Plain, Fourth Plain and SR 500. Related enhancements to the local street network.
- Three new structures over North Portland Harbor associated with I-5, and one new multi-modal bridge carrying light rail transit, local traffic, pedestrians and bicyclists.
- A variety of bicycle and pedestrian improvements throughout the project corridor. A multiuse path connecting to the existing system. The path would allow users to travel from north Portland, over Hayden Island and the Columbia River into downtown Vancouver.
- Extension of light rail transit from the Expo Center in Portland to Clark College in Vancouver and associated transit improvements. Transit stations would be built on Hayden Island, in downtown Vancouver, and a terminus near Clark College. Three park and rides are to be built, Columbia (near the SR 14 interchange), Mill (in uptown Vancouver) and Central (near Clark College). Improvements would be made to the tracks on the Steel Bridge. Also, bus route changes and the expansion of the Ruby Junction light rail transit maintenance facility.
- Transportation demand and system management measures to be implemented with the project, including the use of tolls, subject to the authority of the Washington and Oregon Transportation Commissions.

(A detailed description of the selected alternative is included in Chapter 2 of the Final Environmental Impact Statement.)

The construction of the selected alternative will be phased to match available funding while providing significant transportation benefits. The first construction phase is referred to as the Initial Construction Program (ICP). The ICP includes the following multi-modal elements:

- The new river crossing over the Columbia River and the I-5 highway improvements, including improvements to three interchanges, as well as associated enhancements to the local street network.
- Extension of light rail from the Expo Center in Portland to Clark College in Vancouver, and associated transit improvements, including transit stations, park and rides, bus route and station changes, and expansion of a light rail transit (LRT) maintenance facility.
- Upgrades and modifications to the Steel Bridge and transit command center.
- Purchase of 19 light rail vehicles (LRV), public art and other transit-related procurements.

- Bicycle and pedestrian improvements throughout the project corridor that connect to the transit system.
- Toll system for the river crossing.
- Transportation demand and system management measures to be implemented with the project.

The ICP will require multiple construction contract bundles or packages (see attached figure). The following narrative contains a description of each construction package.

1.2 ICP Construction Packages (see attached figure)

1.2.1 River Crossing (RC)

- Construct new northbound and southbound bridges over the Columbia River. The existing Interstate (I-5) Bridge structures will be replaced by two parallel bridges slightly downstream and to the west of the existing crossing. The proposed bridge type is a composite deck truss in which the diagonal steel members allow for an open-sided, covered passage for the light rail guideway and multi-use path. The southbound bridge will carry highway traffic on the upper bridge deck with a two-way light rail guideway on the lower bridge deck. The northbound bridge will carry highway traffic on the upper bridge deck and a bicycle and pedestrian path on the lower deck.
- Construct LRT approach structures to the Columbia River Bridge from Hayden Island and Vancouver.
- On the lower deck of the southbound bridge, the Oregon LRT approach structure, and the Washington LRT approach structure, construct and install all transit civil, track, and systems components. All track on the main river bridge and approach structures will be direct fixation. The maximum grade will be 6%, on the Washington LRT approach structure from the BNSF crossing to touchdown at 5th Street and Washington Street in Vancouver.
- Construct the I-5 mainline from Columbia River Bridge to North Portland Harbor Bridge.
- Reconstruct ramp connections on the east and west sides of I-5 on Hayden Island in a configuration similar to the existing ramp connections.
- Reconstruct various local roads on Hayden Island.
- Reconstruct SR-14 connections to and from I-5 and downtown Vancouver.
- Construct a C Street entrance ramp to I-5.
- Reconstruct the I-5 mainline from the Columbia River Bridge to Evergreen Boulevard.
- Construct retaining walls on the east and west sides of the I-5 mainline.
- Construct a replacement Evergreen Boulevard Bridge over I-5.
- Construct the community connector over I-5 near the Evergreen Boulevard Bridge.
- Construct a replacement McLoughlin Boulevard Bridge with transitions on I-5 to accommodate the LRT that passes beneath I-5 at this point.
- Reconstruct portions of the Mill Plain Boulevard entrance ramp to I-5 southbound.
- Reconstruct portions of the I-5 northbound exit ramp to Mill Plain Boulevard.
- Reconstruct portions of Columbia Street, Columbia Way, Main Street, and 5th Street.
- Construct a shared-use path from the Columbia River Bridge to Columbia Way.
- Reconstruct portions of the southbound off-ramp to Fourth Plain Boulevard.

- Reconstruct portions of Fourth Plain Boulevard and the ramp terminal intersections on the east side of I-5.
- Construct an off-ramp from I-5 northbound to Fourth Plain Boulevard.
- Construct shared-use path connections from the Columbia River Bridge to connect to new and existing bicycle and pedestrian facilities on Hayden Island.

1.2.2 Bridge Removal (BR)

- Demolish the existing Interstate (I-5) Bridge structures.

1.2.3 Mainland Connector (MC)

- Elevate, realign, and reconstruct Marine Drive and modify the Marine Drive ramp terminal intersection and connecting ramps. Elevating Marine Drive provides a grade separation of the LRT from the local road mainland connector bridge to Hayden Island.
- Construct a mainland connector bridge to Hayden Island over North Portland Harbor. The North Portland Harbor (NPH) multimodal bridge will accommodate local vehicle traffic, LRT, and bicycle and pedestrian facilities and will connect to a new local street on Hayden Island and to N. Expo Road on the mainland.
- Construct a new driveway on the extension of N. Expo Road as a replacement access point for Diversified Marine Inc. and Ross Island Sand and Gravel.
- Realign the shared-use path adjacent to North Portland Harbor to go over the LRT line and the connecting street between the mainland and Hayden Island, running parallel and adjacent to Marine Drive. On either side of the grade separation, the path will reconnect to the existing path.

1.2.4 Marine Drive (MD)

- Construct a new single point interchange at Marine Drive and I-5 and associated ramps. This will require demolition of the existing structure that crosses I-5 and construction of a new structure over I-5 to carry Marine Drive. The Marine Drive alignment constructed with the mainland connector bridge will be adjusted in grade and alignment to match the new single point interchange. (Note: The MC package will be constructed first. The alignment of Marine Drive in the vicinity of the LRT and the local road will be slightly adjusted in the MD package. The structures constructed in the MC for the LRT and the local road will remain, with no disruption to light rail or traffic operations.)
- Reconstruct the connections from Marine Drive to Union Court and from Vancouver Way to Marine Drive.
- Construct a road on the south end of the Expo Center between North Expo Road and Force Avenue and thus provide a local route between Hayden Island and Marine Drive.
- Widen I-5 southbound from the North Portland Harbor bridge to a point just south of the Victory Boulevard crossing to provide an additional lane.
- Widen I-5 northbound from the Victory Boulevard crossing to the North Portland Harbor Bridge to accommodate the northbound Denver Street entrance ramp as an auxiliary lane.
- Re-stripe I-5 and reallocate the width of the North Portland Harbor bridge to allow for an additional southbound lane.
- Relocate the function of the North Portland Harbor shared-used path to the sidewalk and bike lanes on the new mainland connector multimodal bridge.

1.2.5 Oregon Transit (OT)

- Construct a double-track LRT guideway to extend from the existing Expo Center MAX station to the new multimodal mainland connector bridge over the North Portland Harbor and across Hayden Island. There will be accommodation for an at-grade crossing at Vancouver Way, a new street that is part of the larger Columbia River Crossing Program. This signalized crossing will include a signal gate on both the eastbound and westbound intersection approaches. On Hayden Island, the LRT guideway will be partially on fill and partially on structure. The alignment will be roughly parallel to the I-5 alignment. On the north end of Hayden Island, the light rail alignment will rise in elevation on structure until it transitions onto the lower deck of the new westernmost bridge (southbound I-5) over the Columbia River. The total distance of the LRT guideway between the Expo MAX station and the Columbia River Bridge approach structure is just over a half-mile.
    - The grade of the track upon leaving the Expo MAX Station will be 6%. On the NPH bridge, the grade from the south abutment to the approximate midpoint will be 5%, and then the grade will be 2% as the alignment descends to Hayden Island, before flattening out through the station and ultimately transitioning to the lower deck of the main river crossing bridge (with a maximum grade of 1%).
    - The exclusive (LRV only) guideway is a mix of ballasted track and direct fixation (on structure) from the Expo MAX station to the lower deck of the main river crossing bridge. At Vancouver Way, ballasted track with modular grade crossing panels will be constructed.
- Construct a bridge over the A Street to I-5 South (A-5S) on-ramp and to accommodate the future Tomahawk Island Drive.
- Build the Hayden Island transit station on structure as a center platform station providing the following amenities:
    - Minimum platform length of 200 feet and platform width of ±20 feet
    - A covered ticket vending machine at each platform access
    - Wind shelter and canopy incorporated into the structure as well as standard amenities, signage, and public art
    - Elevator, ramps, and stairs for access to and from adjacent roadways

1.2.6 Washington Transit (WT)

- At the beginning of the LRT alignment in Washington, at the intersection of Washington Street and 5th Street, install a signal gate for both eastbound and westbound vehicle traffic. The double-track LRT guideway will be in the center of the street between 5th and 7th Streets. The intersections at 6th Street and Washington Street and 7th Street and Washington Street will be signalized (both traffic and LRT). At 7th Street, the light rail alignment will transition to a couplet, with the northbound guideway on the west side of Broadway Street and the southbound guideway on the east side of Washington Street. At 17th Street, the two guideways will join and turn east for approximately nine blocks. At G Street, the guideway on 17th Street will angle north one block to McLoughlin Boulevard. There will be a signal gate on McLoughlin Boulevard for eastbound traffic. The guideway will then cross under I-5 to run down the center of McLoughlin Boulevard to the Central Park terminus station and park-and-ride structure east of I-5.

- Convert 7th Street to one-way traffic eastbound between Washington and Broadway Streets, with traffic and interconnected LRT signals installed at Main Street and Broadway Street. The profile grades along 7th Street will vary from 0% to 5%.
- Convert Broadway Street to two-lane traffic northbound, with traffic and interconnected LRT signals installed at 8th, 9th, Evergreen, 11th, 12th, 13th, Mill Plain, 15th, 16th, and 17th Streets. The LRT guideway will be constructed on the west side of Broadway Street, with the profile grades along Broadway Street varying from 0% to 5%.
- On 17th Street, construct the double-track LRT guideway to run down the center of the street, with eastbound traffic on the south side of the street and westbound traffic on the north side of the street. Profile grades along 17th Street vary from 0% to 4%. Traffic and interconnected LRT signals will be installed at intersections with Washington, Main, C, D, E, and F Streets.
- On McLoughlin Boulevard, roughly in between the I-5 underpass and a new station to the east, construct the double-track LRT guideway to run down the center of the street, with eastbound traffic on the south side of the street and westbound traffic on the north side of the street. Profile grades on McLoughlin Boulevard will vary from 0% to 5%. There will be a traffic and interconnected LRT signal installed at the entrance to the Central Park and Ride.
- On Washington Street, construct the guideway on the west side of the street, with traffic and interconnected LRT signals installed at 16th, 15th, Mill Plain, 13th, 12th, 11th, Evergreen, 9th, 8th, and 7th Streets. The profile grades on Washington Street will vary from 1% to 5%.
- All track in Washington will be embedded t-rail.
- Construct LRT stations, designed not to preclude BRT, along the transit guideway at:
    - 6th and Washington Street Station – located within vacated Washington Street between 5th and 6th Streets, and servicing the Columbia Park and Ride (see section 1.2.6, below). This station shall have co-located side platforms with northbound and southbound rail between them. The platforms shall provide:
        - A minimum platform length of 190 feet and a minimum platform width of 12 feet.
        - A covered ticket vending machine at each platform access.
        - Two shelters per platform with standard amenities, signage, and public art.
    - Evergreen and Broadway Platform – located on the west side of Broadway Street between 9th Street and Evergreen Street
    - 16th and Broadway Platform – located on the west side of Broadway Street between 15th Street and 16th Street
    - 9th and Washington Platform – located on the east side of Washington Street between 9th Street and Evergreen Street
    - 15th and Washington Platform – located on the east side of Washington Street between 15th Street and 16th Street. This platform adjoins and provides access to the Mill Park and Ride.
    - These platforms shall provide:
        - A minimum platform length of 190 feet (200 feet at 15th Street and Washington Street) and a minimum platform width of 12 feet.
        - An adjacent sidewalk of 7.5 feet.
        - A covered ticket vending machine at each platform access.

        - Two shelters per platform with standard amenities, signage, and public art.

    - Central Station – located at the end of line on McLoughlin Boulevard. This station provides access to the Central Park and Ride and a major bus transfer location and has a center platform. The platform shall provide:
        - A minimum platform length of 200 feet and a minimum platform width of 17.5 feet.
        - A covered ticket vending machine at each platform entrance and accommodation for future covered vending machines at or near the park-and-ride structure.
        - Four shelters per platform with standard amenities, signage, and public art.

- Construct full-block bus stops along the LRT alignment or adjacent to significant developed improvements at the following locations:
    - 7th and Main Streets.
    - Broadway and 9th Streets.
    - Broadway and Evergreen Streets.
    - Broadway and 13th Streets.
    - Broadway and 16th Streets.
    - Main and 15th Streets.
    - Washington and 12th Streets.
    - Washington and 8th Streets.
    - Central Station.
- Construct two surface parking lots, at SR-14 and at 5th Street (Smith Tower). The SR-14 lot will be located within the perimeter of the SR-14 on-ramp to I-5 North and will contain approximately 50 stalls. The 5th Street lot will be located north of 5th Street and east of the 6th and Washington Street LRT station. This lot is a reconstruction of an existing parking lot at the same location and will contain a minimum of 17 stalls.

1.2.7 Park and Rides (PR)

- Construct three park-and-ride garages, distributing a minimum of 2,900 spaces, needed for the project based on ridership demand models, as follows:
    - Columbia Park and Ride – located between Columbia Street and Washington Street and between 4th Street and 5th Street, and includes retail/office space frontage facing Columbia Street. Primary ingress and egress is on 5th Street at the north end of the structure. This park and ride will provide approximately 570 auto parking spaces and 34 bicycle parking spaces, and will have five floors and an exposed height of 68.5 feet.

    - Mill Park and Ride – located between 15th and 16th Streets and between Washington Street and Main Street, and includes retail/office space frontage on both Main Street and Washington Street. Washington Street will also have a C-TRAN Customer Service Center and parking on 16th Street to accommodate paratransit vehicles. Vehicles can enter from 15th and 16th Streets, but can exit only onto 16th Street. This park and ride will provide approximately 420 auto parking spaces and 30 bicycle parking spaces, and will have five floors and an exposed height of approximately 60 feet.

- Central Park and Ride – located east of I-5, north of McLoughlin Boulevard, and across from the Marshall Community Center. One access is provided via a loop road, which provides direct access to and from Fourth Plain Boulevard and the I-5 access ramps at the interchange. The loop road wraps around the east side of the building and passes through the south end of the garage before returning north to Fourth Plain Boulevard. The garage can also be accessed via an entrance from McLoughlin Boulevard. This park and ride will provide approximately 1,910 auto parking spaces and 81 bicycle parking spaces, and will have five floors and an exposed height of 55.5 feet. A C-TRAN shared safety and security and Vancouver police mini-station will be included at this location as well as an operator break room located outside of the structure near the terminus station.

- Construct access roads and two bridges near the Central Park and Ride to grade-separate ingress and egress to the parking facility.

1.2.8 Transit Systems (TS)

- The Transit Systems package will provide power, signalization, and communications capability along the entire light rail alignment and will be composed of the following primary system elements:
  - 2.9 miles of light rail extension (power, signals, and communications infrastructure) of the existing MAX system.
  - Three new 1-megawatt substations and three new combined signals/communications buildings at the following locations:
    - Next to Hayden Island Station off Tomahawk Island Drive.
    - Southeast of 6th Street/Washington Avenue Station near the 5th Street parking lot.
    - Near the intersection of 17th and G Streets just south of McLoughlin Boulevard.
  - One communications room inside the Mill Park and Ride.
  - One signals room inside the Mill Park and Ride.

1.2.9 Transit Other (TO)

1.2.9.1 Ruby Junction Yard and Maintenance Facility Expansion

- To accommodate storage of the 19 additional light rail vehicles (LRVs) associated with the ICP, the Ruby Junction Yard and Maintenance Facility in Gresham, Oregon, will be expanded. This expansion will be in conjunction with an existing expansion project to accommodate additional LRVs as part of the Portland Milwaukie Light Rail (PMLR) project. Improvements include storage for the new LRVs and other maintenance material, expansion of LRV maintenance bays, and expanded parking for additional personnel.

1.2.9.2 Steel Bridge Modifications

- The Steel Bridge, located near the Rose Quarter in downtown Portland, carries all of the light rail transit lines within TriMet's system over the Willamette River. To accommodate the additional LRVs associated with the ICP, the Steel Bridge will be modified to increase throughput over the bridge by raising the maximum crossing speed of LRVs from 10 miles per hour to 15 miles per hour. Specifically, the modifications are as follows:

- Grind the transit rails within the track bed to remove the lift joint bumps, rail corrugation, and any rough field welds.
- Install a vibration pad under the existing signal case on the lift span to dissipate vibration.
- Stiffen the overhead catenary system brackets to allow for greater impact as the catenary transfers from the fixed span to the movable span.
- Adjust signals for light rail transit and traffic at NW Everett Street and N Interstate Avenue to accommodate higher speeds.

1.2.9.3 Light Rail Vehicle Procurement

- To accommodate the additional passengers that have been identified for the ICP, 19 new LRVs will be procured. This procurement is planned to use an option clause associated with the PMLR project.

1.2.9.4 Command Center Upgrades/Modifications

- The TriMet command center at SE Center Street in Portland will be upgraded and modified to account for the light rail extension to Vancouver. This will include a number of hardware and software upgrades to the existing train control system.

1.3 Tolling

- Tolling cars and trucks that use the I-5 river crossing will be used to help fund the ICP and to encourage the use of alternative modes of transportation. A variable toll will be applied on vehicles using the I-5 crossing. Tolls will vary by time of day, with higher rates during peak travel periods and lower rates during off-peak periods. Medium and heavy trucks will be charged a higher toll than passenger vehicles. Tolls will be collected using an electronic toll collection system, so that toll collection booths will not be required.

1.4 Transportation Demand Management and Transportation System Management

- Implement physical features and operational elements as part of the Columbia River Crossing Program that enhance opportunities for the region to achieve its Transportation Demand Management (TDM) goals by promoting other modes to fulfill more of the travel needs in the project corridor. These include:
    - A new light rail line with connections to express bus and feeder routes operated by C-TRAN and TriMet.
    - Modern bicycle and pedestrian facilities that accommodate more bicyclists and pedestrians, and that improve connectivity, safety, and travel time.
    - Park-and-ride facilities.
    - A variable toll on the highway crossing.

- Implement facilities and equipment that could help existing or expanded Transportation System Management (TSM) programs maximize the capacity and efficiency of the system. These could include:
    - Replacement or expanded variable message signs or other traveler information systems.
    - Continued incident response capabilities.
    - Expanded traveler information systems with additional traffic monitoring equipment and cameras.

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Initial Construction Program (ICP)

STORMWATER DESIGN REPORT

DRAFT REPORT

VOLUME II: COLUMBIA SLOUGH WATERSHED

Highway	State	Location
Interstate 5	Oregon	MP 306.5 to MP 308.4

October 2012

Columbia River CROSSING

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Signature Sheet

Stormwater Design Report

VOLUME II - COLUMBIA SLOUGH WATERSHED

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ACRONYMS

Acronym	Description
ADA	Americans with Disabilities Act
ADT	Average Daily Traffic
BMP	Best Management Practice
BNSF	Burlington Northern Santa Fe Railroad
BPA	Bonneville Power Administration
CFR	Code of Federal Regulations
CMP	Corrugated Metal Pipe
CIA	Contributing impervious area
CRC	Columbia River Crossing
COP	City of Portland
C-Tran	Clark County Public Transit Benefit Area Authority
COV	City of Vancouver
CWS	Clean Water Services
DEIS	Draft Environmental Impact Statement
DEQ	Oregon Department of Environmental Quality
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
Expo	Portland Metropolitan Exposition (Center)
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Maps
Ft	feet/foot
FTA	Federal Transit Administration
GIS	Geographic Information System
ICP	Initial Construction Program
InterCEP	Interstate Collaborative Environmental Process
LPA	Locally Preferred Alternative
LRT	Light Rail Transit
MAX	Metropolitan Area Express
Mi	mile
Min	minute
MP	Milepost

Acronym	**Description**
Mph	Miles per hour
NAVD	North American Vertical Datum
NB	Northbound
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Oceanic and Atmospheric Administration for Fisheries
NPDES	National Pollutant Discharge Elimination System
NPH	North Portland Harbor
NRCS	Natural Resources Conservation Service
OAR	Oregon Administrative Rule
ODFW	Oregon Department of Fish & Wildlife
ODOT	Oregon Department of Transportation
OHW	Ordinary High Water Line
ORS	Oregon Revised Statutes
PCBs	Polychlorinated Biphenyls
PEN	Peninsula Drainage District
PGIS	Pollutant generating impervious area
PIR	Portland International Raceway
PPM	Parts Per Million
RCW	Revised Code of Washington
ROD	Record of Decision
ROW	Right-of-Way
SB	Southbound
SEPA	State Environmental Policy Act
SMA	Shoreline Management Act
TMDL	Total Maximum Daily Load
TriMet	Tri-County Metropolitan Transportation District of Oregon
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish and Wildlife
WRD	Oregon Department of Water Resources

1. Introduction

1.1 Overview – Columbia River Crossing Project

This Stormwater Design Report, which comprises four volumes, describes the design of the stormwater collection and conveyance systems (inlets, pipes, and ditches), and water quality facilities developed to treat project runoff for the Initial Construction Program (ICP) portion of the Columbia River Crossing (CRC) project. It does not address the effect of proposed bridges on scour or on water surface elevations for the Columbia River, the primary watercourse traversed by the project, nor does it include any temporary erosion and sediment control that may be required during construction.

The CRC project is a bi-state multimodal initiative which is being led by the Oregon Department of Transportation (ODOT) and Washington State Department of Transportation (WSDOT). The team also includes Metro, Southwest Washington Regional Transportation Council, Tri-County Metropolitan Transportation District of Oregon (TriMet), Clark County Public Transit Benefit Area Authority (C-TRAN), and the cities of Portland and Vancouver. Transportation modes addressed by the project include highway, light rail transit, bicycle, and pedestrian.

The project encompasses a five-mile length of the Interstate 5 (I-5) corridor within the cities of Portland (Oregon) and Vancouver (Washington State) as shown on Figure 1-1. The Columbia River is the only watercourse that the project crosses. Within the corridor, Hayden Island separates the river into two channels; the main channel to the north and North Portland Harbor to the south. The corridor, which extends from North Victory Boulevard in Portland to SR 500 in Vancouver, is located in Sections 3 and 4, Township 1N, Range 1E, WM., and Sections 14, 15, 22, 23, 26, 27, 33, and 34, Township 2N, Range 1E, WM.

The project corridor lies within the Columbia River valley. The Columbia River dominates the project area with Columbia Slough located at the project southern boundary. For the purpose of this report, the three watersheds crossing the project corridor are defined as the project drainage basins. These include, from south to north, Columbia Slough, Columbia River South, and Columbia River North.

The project includes improvements to interchanges with two state highways (SR 14 and SR 500), both are located in Washington State. The following major roads also cross the corridor:

- N Victory Boulevard (Portland)
- N Marine Drive (Portland)
- NE Martin Luther King Jr. Boulevard (Portland)
- E Mill Plain Boulevard (Vancouver)
- E McLoughlin Boulevard (Vancouver)
- E Fourth Plain Boulevard (Vancouver)

There are a number of federal, state, and local agencies with direct jurisdiction over or significant input to the stormwater aspects of the CRC project. These include:

- National Marine Fisheries Service (NMFS)
- U.S. Environmental Protection Agency (EPA)
- Oregon Department of Environmental Quality (DEQ)
- Washington State Department of Ecology (Ecology)
- City of Portland (COP)
- City of Vancouver (COV)

The state and federal agencies listed above are signatories of the Interstate Collaborative Environmental Process (InterCEP) agreement. The agreement defines a process for coordinating their involvement, and streamlining regulatory reviews and permits agencies and through this process, the team engages in an ongoing dialogue with the necessary state and federal agencies prior to making major decisions.

One result of this approach is the adoption of ODOT's technical memorandum on stormwater water quality (ODOT 2009) on a project-wide basis to provide a standard approach to determining types of water quality facilities that would provide adequate protection to listed species. The memorandum is the result of a venture by ODOT, Federal Highway Administration (FHWA), and natural resource agencies (NMFS, Oregon DEQ, U.S. Fish and Wildlife Service (USFWS), EPA, and the Oregon Department of Fish and Wildlife (ODFW)). The decision to use this approach on the CRC project has been endorsed by WSDOT and Ecology.

The general approach to stormwater water quality management is to treat runoff to reduce the following pollutants that are typically associated with transportation projects[1]:

- Debris and litter
- Suspended solids such as sand, silt and particulate metals
- Oil and grease
- Dissolved metals (dissolved copper is of particular concern due to its potential impact on the olfactory systems of listed fish)

The overriding requirements for stormwater management, which are defined in the Biological Opinion (NMFS 2011), can be summarized as follows:

- Provide pollution reduction and, where required, flow control for the entire Contributing Impervious Area (CIA) regardless of whether or not the impervious area would be considered pollutant-generating. The CIA comprises the impervious area within the project limits plus any impervious surfaces outside the project limits that would drain to the project via direct flow or discrete conveyance.

[1] *Stormwater Management Plan Submission Guidelines for Removal/Fill Permit Applications Which Involve Impervious Surfaces.* State of Oregon Department of Environmental Quality. July 2005, 2008, 2012.

- Treat stormwater runoff using a) bioretention, b) bioslope, c) porous pavement, d) constructed wetland, e) vegetated and soil amended swale designed for infiltration, or f) a treatment train described in "Stormwater Best Management Practices in an Ultra-Urban Setting" (FHWA 2002).

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Figure 1-1. Project Footprint & Vicinity Map

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1.2 Scope – Columbia River Slough Watershed

Volume II, this document, describes the design of the stormwater pipes and ditches comprising the stormwater conveyance system, and water quality facilities to handle and treat project runoff within the Columbia Slough watershed. Further information on the Columbia River Crossing Project can be found in Volume I – Stormwater Design Report Summary.

The CRC project, or Locally Preferred Alternative (LPA), was selected through the alternative analysis and development process. A detailed description of the selected alternative is included in Chapter 2 of the Final Environmental Impact Statement (FEIS). The construction of the selected alternative will be phased to match available funding while providing significant transportation benefits. The first construction phase is referred to as the Initial Construction Program (ICP). Project-related activities within the Columbia Slough watershed are shown in Figure 1-2.

The ICP generally includes the following multimodal elements:

- A new river crossing over the Columbia River and I-5 highway improvements, including major improvements to three interchanges, as well as associated enhancements to the local street networks in Vancouver and Portland. Minor improvements will also be done to I-5 outside of these interchanges.
- Extension of light rail from the Expo Center in Portland to Clark College in Vancouver, and associated transit improvements, including transit stations, park-and-rides, bus route and station changes, and expansion of a light rail transit (LRT) maintenance facility.
- Bicycle and pedestrian improvements throughout the project corridor that connect to the transit system.

The following construction elements describe improvements located specifically within the Columbia River Slough watershed. Construction elements describing improvements located within other watersheds within the CRC project footprint are located in Volumes I, III, and IV.

Highway construction will involve:

- Elevate, realign, and reconstruct Marine Drive and modify the Marine Drive ramp terminal intersection and connecting ramps. Elevating Marine Drive provides a grade separation of the LRT from the local road mainland connector bridge to Hayden Island.
- Construct a new single-point interchange at Marine Drive and I-5 and associated ramps. This will require demolition of the existing structure that crosses I-5 and construction of a new structure over I-5 to carry Marine Drive. The Marine Drive alignment constructed with the mainland connector bridge will be adjusted in grade and alignment to match the new single point interchange.
- Construct a new driveway on the extension of N Expo Road as a replacement access point for Diversified Marine Inc. and Ross Island Sand and Gravel.

- Reconstruct the connections from Marine Drive to Union Court and from Vancouver Way to Marine Drive.
- Construct a road on the south end of the Expo Center between N Expo Road and Force Avenue and thus provide a local route between Hayden Island and Marine Drive.
- Widen I-5 northbound from the Victory Boulevard crossing to the North Portland Harbor (NPH) Bridges to accommodate the northbound Denver Street entrance ramp as an auxiliary lane.

Bridge construction will involve:

- Re-stripe I-5 and reallocate the width of the North Portland Harbor (NPH) Bridges to allow for an additional southbound lane.
- Construct a mainland connector bridge to Hayden Island over NPH. The NPH Bridges are multimodal will accommodate local vehicle traffic, LRT, and bicycle and pedestrian facilities, and will connect to a new local street on Hayden Island and to N. Expo Road on the mainland.
- Widen I-5 southbound from the NPH Bridges to a point just south of the Victory Boulevard crossing to provide an additional lane.
- Relocate the function of the NPH shared-used path to the sidewalk and bike lanes on the new mainland connector multimodal bridge.

Transit-related improvements will involve:

- Construct a double-track LRT guideway to extend from the existing Expo Center MAX station to the new multimodal mainland connector bridge over the North Portland Harbor and across Hayden Island. There will be accommodation for an at-grade crossing at Vancouver Way, a new street that is part of the larger Columbia River Crossing Project. The total distance of the LRT guideway between the Expo MAX station and the Columbia River Bridge approach structure is just over a half-mile.
- The grade of the track upon leaving the Expo MAX Station will be 6%. On the NPH Bridge, the grade from the south abutment to the approximate midpoint will be 5%, and then the grade will be 2% as the alignment descends to Hayden Island, before flattening out through the station and ultimately transitioning to the lower deck of the main river crossing bridge (with a maximum grade of 1%).
- The exclusive (LRV only) guideway is a mix of ballasted track and direct fixation (on structure) from the Expo MAX station to the lower deck of the main river crossing bridge. At Vancouver Way, ballasted track with modular grade crossing panels will be constructed.

Drainage improvements include:

- Providing water quality treatment facilities, within project right-of-way (ROW), for the project surface area runoff.
- New conveyance stormsewer pipes and structures (inlets, manholes) for the interchange, I-5 mainline, and modified roadways.

- Water quality treatment will include four constructed wetlands and three biofiltration swales.
- Stormwater planter strips will be installed on the local streets to provide water quality treatment to roadway runoff.
- The drainage design will be developed in accordance with ODOT, COP, and WSDOT design criteria.

1.3 Datum

Elevations presented in this report are referenced to the North American Vertical Datum of 1988 (NAVD88). It is important to note that jurisdictions and other projects in the area may reference another vertical datum, the most commonly used being the National Geodetic Vertical Datum of 1929 (NGVD29). Add approximately 3.5 feet to a NGVD elevation to obtain an approximate elevation to NAVD88.

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Figure 1-2. Proposed Improvements

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2. Existing Conditions

2.1 Project Site

The project site addressed within this report is located within the Columbia Slough watershed. The watershed boundary is located at the southern end of the CRC project footprint, and discharges to the Willamette River. The watershed covers a 51-square-mile area that extends from Kelly Point to the west to Fairview Lake and Fairview Creek to the east, and now comprises the former Columbia River floodplain. Before the construction of a levee system and pump stations, the project area would have been subjected to frequent inundation from the surrounding water bodies.

The Marine Drive Interchange is located on the southern end of the CRC project and bounded by Victory Boulevard to the south and North Portland Harbor to the north. Land west of I-5 generally has an Industrial zoning designation while land to the east is generally designated as "open space." The latter area includes sports facilities such as baseball diamonds. In the vicinity of I-5, the original ground surface is below the Ordinary High Water Level for the Columbia River. (21.2 ft. NAVD88[2]) and groundwater levels are close to the surface.

2.2 Existing Drainage Systems

The existing drainage systems within and around the project site consist of a network of surface water bodies and enclosed conveyance systems. Runoff from the project area drains to a system of sloughs before being discharged to Columbia Slough. The drainage systems are mechanically controlled by four downstream pump stations operated by the Multnomah County Drainage district (MCDD). The pump stations are in place to regulate surface water discharges into the Columbia Slough by raising the water over the levee embankments system; which bounds the Columbia Slough, North Portland Harbor, and the Columbia River. As previously noted, the levee embankments are in place for the purpose of protecting the area from flooding. Figure 2-1.1 illustrates the existing drainage systems.

There are three drainage districts with jurisdiction over the project area as listed below with their respective pump stations. Figure 2-1.2 illustrates the existing surface water systems.

- **Multnomah County Drainage District (MCDD)**
- **Peninsula Drainage District No.1 (PEN 1)**
  Portland International Raceway (PIR) Pump Station
  Expo Pump Station
- **Peninsula Drainage District No. 2 (PEN 2)**
  Schmeer Road Pump Station
  PEN 2 – NE 13th Pump Station

[2] Memorandum from Kris Westersund (DEA) to Jim Burke (CRC) dated July 16, 2008. See Appendix C.

Peninsula Drainage District No. 1 and No. 2 own the four pump stations used by the project. However, the listed pump stations are operated and maintained by the MCDD.

The Peninsula Drainage Districts are separated by the I-5 mainline that was built over Denver Avenue, which was an interior cross levee. I-5, Marine Drive, and Martin Luther King, Jr. (MLK) Boulevard are elevated on an embankment that separates two drainage districts. The MCDD considers this embankment to be part of an internal levee system that protects the area from all but extreme flooding. Although the existing pump station operation provides regulation of discharges to Columbia Slough, there are no flow control measures for runoff within the project footprint.

There are no engineered water quality facilities except for a manhole sediment trap located at the Victory Boulevard interchange (see Figure 2-1.1) that treats runoff from approximately 6 acres of impervious surfaces at the interchange, but is not within the project footprint.

Surface runoff from I-5 and roads within the project footprint is generally confined to the roadway surface by continuous concrete barriers or curbs, and is collected almost entirely by closed gravity drainage systems with inlets and stormwater pipes. The one notable exception is MLK Boulevard east of I-5 where runoff is shed off the south shoulder is dispersed and infiltrated. The drainage systems that serve these roads do not handle runoff from outside the ROW.

2.3 Existing Drainage Basins

The limits of the existing drainage sub-basins within the Columbia River Slough are determined by the area draining to an outfall, whether on site or off site area is contributing. In this watershed outfalls are based on the existing pump stations located adjacent to the Columbia Slough channel and outfalls located along North Portland Harbor. The Expo Pump station is considered part of the PIR Pump station. Figure 2-2 shows the existing sub-basins, where delineated, and the general flow paths. Descriptions of each outfall and their drainage basins are provided below:

PIR Pump Station

The area west of I-5 corridor and south of Marine Drive, including Expo drains to the PIR pump station. The basin drains southwesterly to the existing pump station west of Expo, which releases into the natural watercourse that outflows to PIR pump station.

PIR pump station is located within Peninsula Drainage District No. 1. The PIR pump station receives flows from nearby natural watercourses and flows routed through the Expo pump station via a series of drainage ditches and culverts. The pump releases outflows into the Columbia Slough. The pump station is sized to handle runoff from the 100-year storm event (typically occurs on average once within 100 years), and has an installed capacity of 19,700 gallons per year.

NE 13th Pump Station

The area on the east side of MLK Boulevard and Vancouver Way drains to the northeast and outflows into an enclosed drainage system on Vancouver Way. The enclosed system releases into the downstream drainage ditch that outflows to the NE 13th pump station.

The NE 13th pump station is located within Peninsula Drainage District No. 2 (PEN 2). The NE 13th pump station receives flows from the upstream drainage ditch and releases outflows into the Columbia Slough. The pump station is sized to handle the 100-year runoff (events that typically occur on average once over 100 years), and has an installed capacity of 32,000 gallons per year.

Schmeer Road Pump Station

The area east of Marine Drive, including portions of MLK Boulevard, drains to the southeast through an enclosed drainage system and outflows into Walker Slough. The area surrounding Victory Blvd, including I-5 to the bridge over Denver Avenue entrance ramp drains to the southeast into an enclosed system to the eastern side of I-5.

Schmeer Road pump station is located within Peninsula Drainage District No. 2, which includes the area east of the I-5 corridor. The NE 13th pump station receives flows from the upstream drainage ditch. The pump releases outflows into the Columbia Slough. The Schmeer Road pump station is sized to handle the 100-year runoff (storm events that typically occur on average once over 100 years), and has an installed capacity of 40,000 gallons per year.

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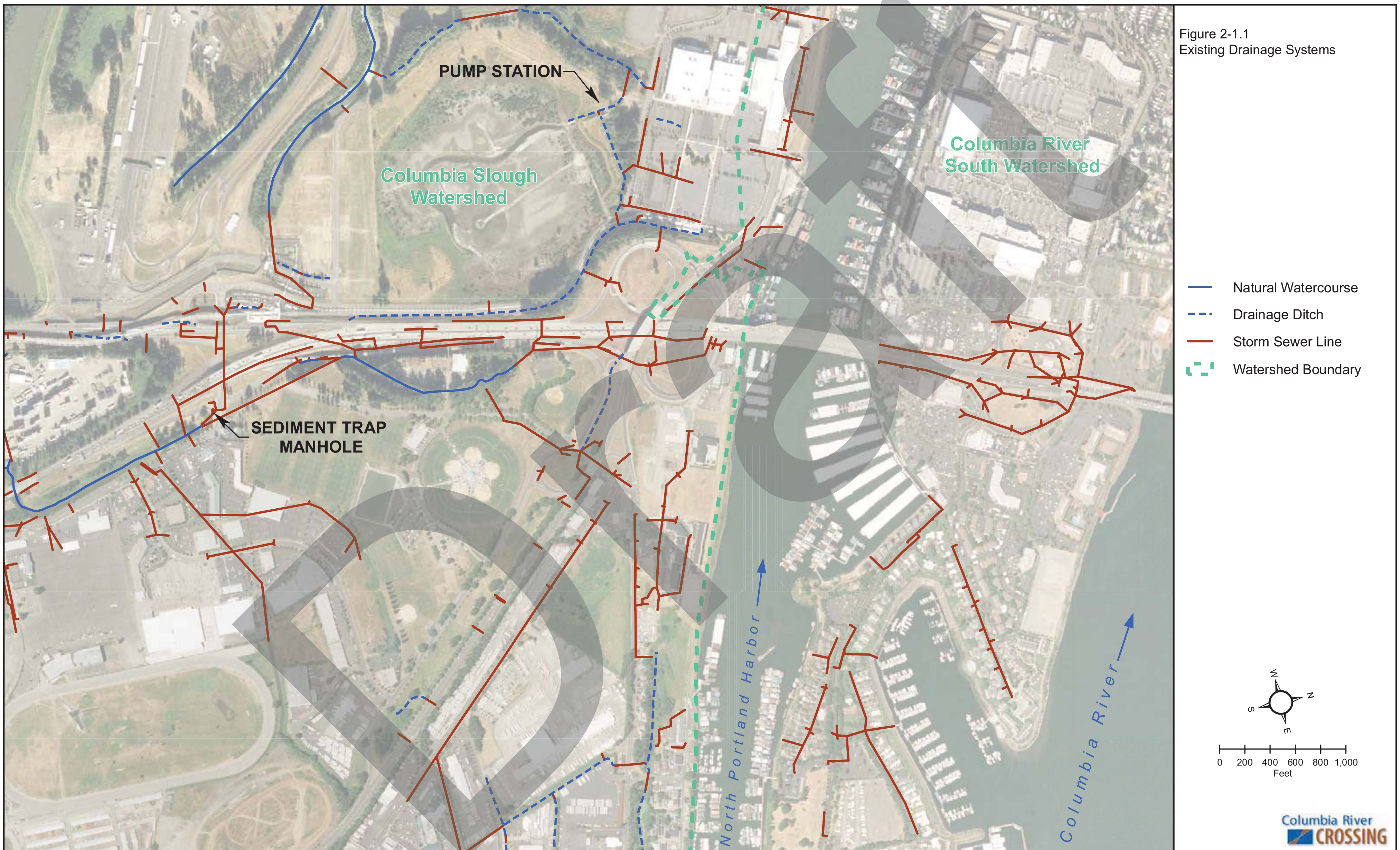
Figure 2-1.1
Existing Drainage Systems



Analysis by J. Koloszar; Analysis Date: Oct. 21, 2010; File Name: Ex3_13-1Stormwater_RK251.mxd

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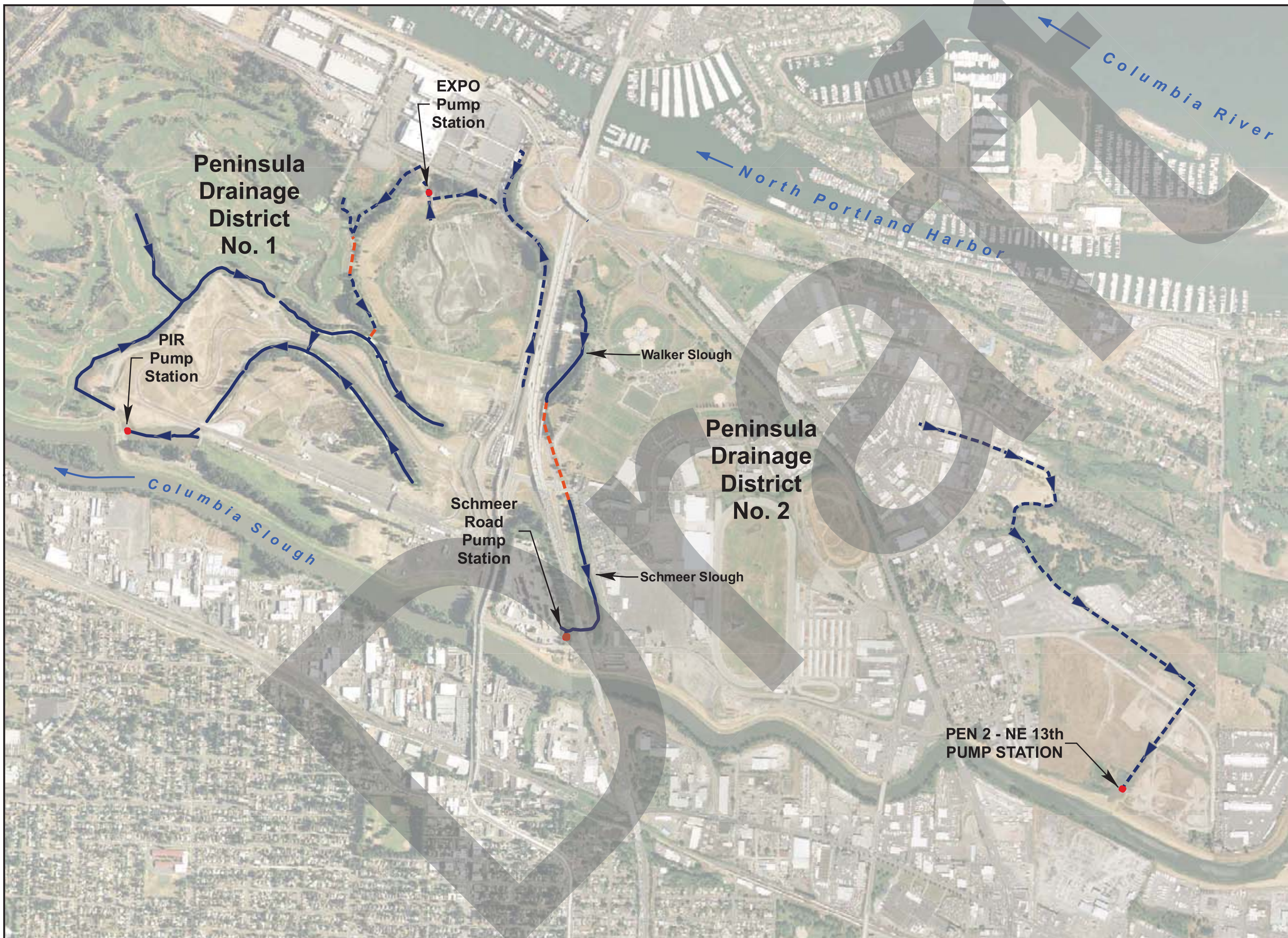

Figure 2-1.2
Existing Surface Water Systems

Columbia River CROSSING

Analysis by J. Koloszar; Analysis Date: Feb. 12, 2010; File Name: Ex3_13-5Stormwater_RK251.mxd

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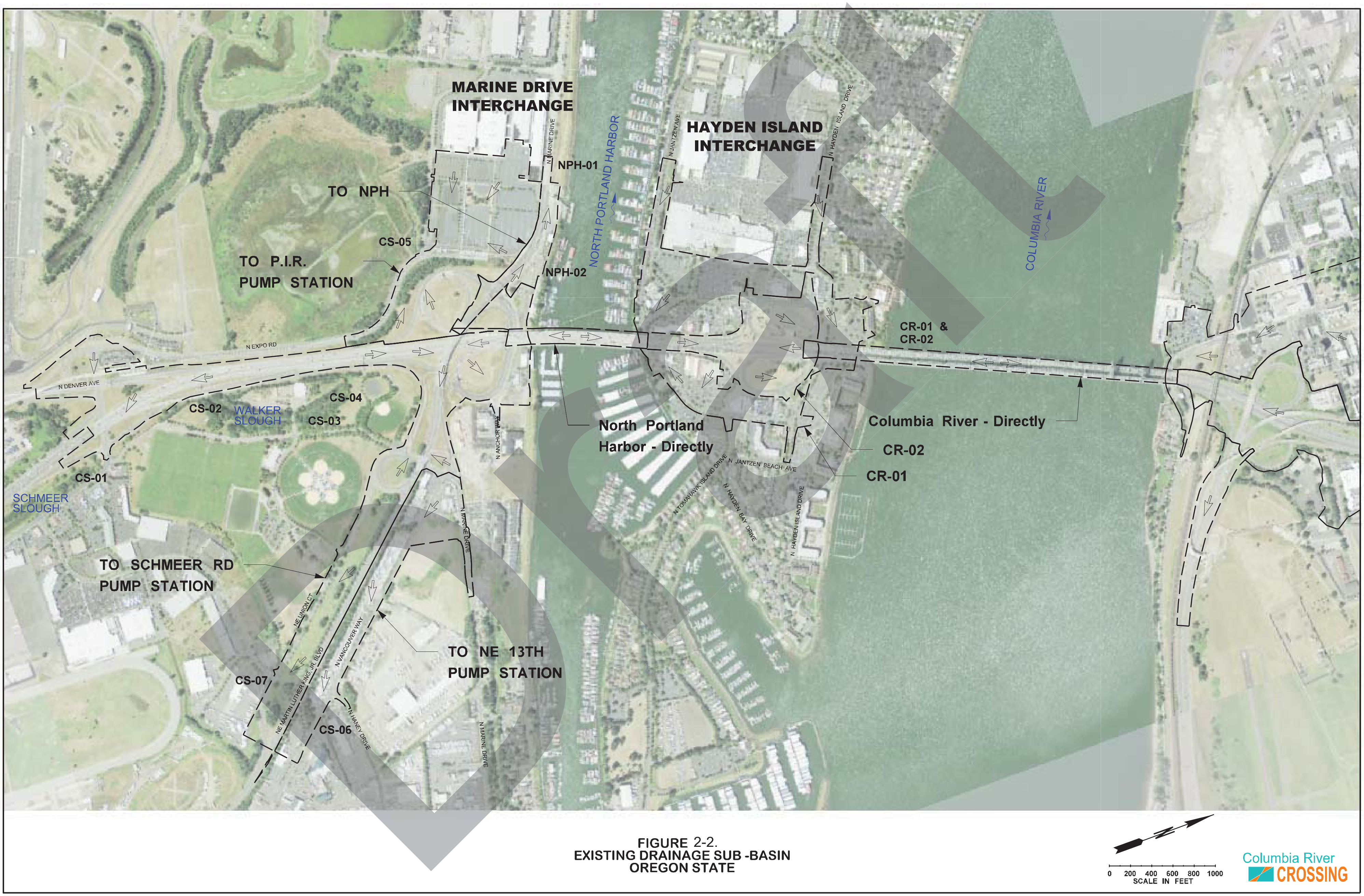

FIGURE 2-2.
EXISTING DRAINAGE SUB -BASIN
OREGON STATE

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2.4 Soils

Figure 2-3 shows the approximate aerial extent of the surficial soils in the vicinity of the entire project corridor. The descriptions below are derived from the National Resources Conservation Service (NRCS) website[3]. Site specific information to be provided in the discussion of water quality facilities will be based on geotechnical site exploration.

The Sauvie-Rafton-Urban land complex belongs to Hydrologic Soil Group D, the Pilchuck-Urban land complex belongs to Group A, and the Wind River and Lauren soils belong to Group B. A soil survey[4] indicates that water tables are at a depth of less than 1 foot for the Sauvie-Rafton-Urban land complex, and between two and four feet for the Pilchuck-Urban land complex. While the depths for the Sauvie-Rafton-Urban complex south of North Portland Harbor are confirmed by borehole logs available for the project area, they also indicate that the soils can be highly variable. For the Pilchuck-Urban soils on Hayden Island, available geotechnical data suggests that the water table is approximately 15 feet below ground level. It should also be noted that the phreatic surface is expected to respond to changes in river level given the highly permeable nature of these soils.

The hydrologic properties of the three Groups referenced above are:

- Group A soils have a high infiltration rate and consist mainly of deep, well drained to excessively drained sands or gravelly sands.
- Group B soils have a moderate infiltration rate and consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture.
- Group D soils have a low infiltration rate and high runoff potential. They consist primarily of clay soils that have high swelling potential, a permanent high water table, or a clay layer at or near the surface, and shallow soils over nearly impervious material.

Based on available data, there are no Group C soils within the project area.

Given the predominance of poorly drained soils and high groundwater table south of North Portland Harbor, infiltration (the preferred method for stormwater management) is not recommended for this area. As noted above, soils are variable and future site investigations may reveal locations where infiltration might be feasible.

Additional geotechnical investigations have been performed, resulting in technical documentation of the soil properties in and around the existing and proposed bridge locations. Upon further review of these technical documents additional definition of the onsite soils will be included in this report.

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3 http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

4 Soil Survey of Multnomah County, Oregon. United States Department of Agriculture, Soil Conservation Service, in cooperation with Oregon Agricultural Experiment. August 1983.

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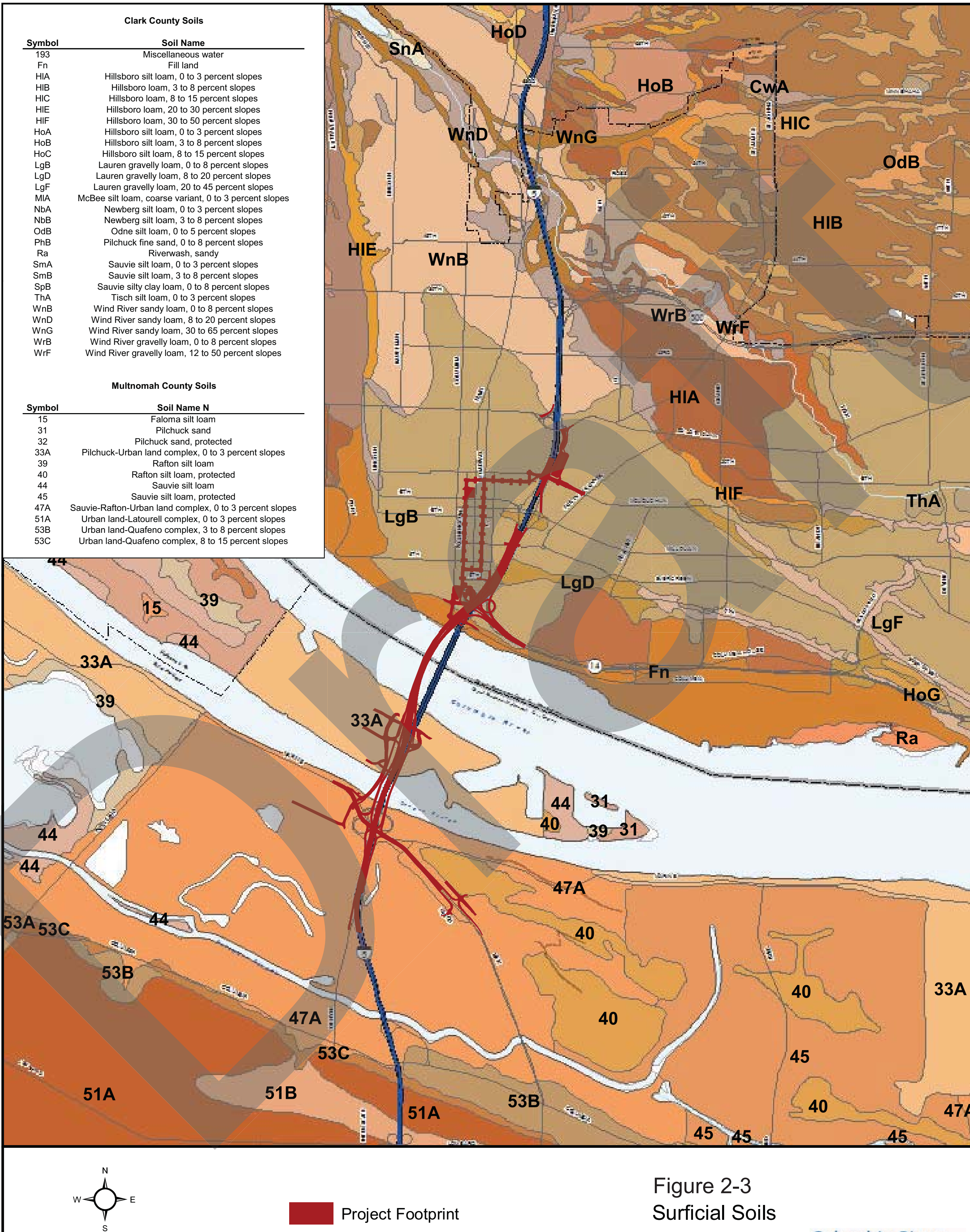
Clark County Soils

Symbol	Soil Name
193	Miscellaneous water
Fn	Fill land
HIA	Hillsboro silt loam, 0 to 3 percent slopes
HIB	Hillsboro loam, 3 to 8 percent slopes
HIC	Hillsboro loam, 8 to 15 percent slopes
HIE	Hillsboro loam, 20 to 30 percent slopes
HIF	Hillsboro loam, 30 to 50 percent slopes
HoA	Hillsboro silt loam, 0 to 3 percent slopes
HoB	Hillsboro silt loam, 3 to 8 percent slopes
HoC	Hillsboro silt loam, 8 to 15 percent slopes
LgB	Lauren gravelly loam, 0 to 8 percent slopes
LgD	Lauren gravelly loam, 8 to 20 percent slopes
LgF	Lauren gravelly loam, 20 to 45 percent slopes
MIA	McBee silt loam, coarse variant, 0 to 3 percent slopes
NbA	Newberg silt loam, 0 to 3 percent slopes
NbB	Newberg silt loam, 3 to 8 percent slopes
OdB	Odne silt loam, 0 to 5 percent slopes
PhB	Pilchuck fine sand, 0 to 8 percent slopes
Ra	Riverwash, sandy
SmA	Sauvie silt loam, 0 to 3 percent slopes
SmB	Sauvie silt loam, 3 to 8 percent slopes
SpB	Sauvie silty clay loam, 0 to 8 percent slopes
ThA	Tisch silt loam, 0 to 3 percent slopes
WnB	Wind River sandy loam, 0 to 8 percent slopes
WnD	Wind River sandy loam, 8 to 20 percent slopes
WnG	Wind River sandy loam, 30 to 65 percent slopes
WrB	Wind River gravelly loam, 0 to 8 percent slopes
WrF	Wind River gravelly loam, 12 to 50 percent slopes

Multnomah County Soils

Symbol	Soil Name N
15	Faloma silt loam
31	Pilchuck sand
32	Pilchuck sand, protected
33A	Pilchuck-Urban land complex, 0 to 3 percent slopes
39	Rafton silt loam
40	Rafton silt loam, protected
44	Sauvie silt loam
45	Sauvie silt loam, protected
47A	Sauvie-Rafton-Urban land complex, 0 to 3 percent slopes
51A	Urban land-Latourell complex, 0 to 3 percent slopes
53B	Urban land-Quafeno complex, 3 to 8 percent slopes
53C	Urban land-Quafeno complex, 8 to 15 percent slopes



Project Footprint

Figure 2-3
Surficial Soils

Columbia River CROSSING

Analysis by J. Koloszar; Analysis Date: 16 Oct 2012; File Name: Fig8_RK080_100510.mxd

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2.4.1 Infiltration

Infiltration is not currently proposed in the vicinity of the Marine Drive Interchange.

2.4.2 Groundwater

The groundwater elevations within the Marine Drive interchange are currently being evaluated.

2.4.3 Aquifers

Within the Portland Basin Aquifer System on the Oregon side of the project corridor, the project area is located on the unconsolidated sedimentary aquifer of the upper sedimentary subsystem (McFarland and Morgan 1996). This aquifer primarily comprises late Pleistocene catastrophic flood deposits and Columbia River alluvium. Recharge of the aquifer is primarily by direct infiltration of precipitation, though injection wells and wastewater from septic systems are locally important. Median hydraulic conductivity (the rate at which groundwater flows through soil and bedrock) of the aquifer is high, approximately 200 feet per day.

South of the Columbia River, several wells have been identified in the vicinity of the project and are likely screened within the unconsolidated sedimentary aquifer. These wells are used for a variety of industrial, irrigation, and municipal purposes. For further details on these wells, refer to the Section 4.6 of the FEIS Geology and Soils Technical Report. Figure 2-4 provides wellhead protection zones within the project corridor.

For details regarding the aquifer which affects the project corridor directly, refer to Volume I.

2.4.4 Wetlands

Existing field identified wetlands and wetland inventory areas for the project corridor are delineated in the Wetlands and Stormwater Treatment Facilities Figures 1 through 4 located in Appendix L.

2.5 Existing Outfalls

Within the Columbia Slough Watershed there are three existing outfalls. Outfalls are defined in this report as any location where runoff leaves the project footprint. In the Columbia River Slough watershed these all occur at the existing pump stations described below.

PIR Pump Station

The area west of I-5 and south of Marine Drive drains to a wetland regulated by the Expo pump station. The Expo pump station releases the water through a series of drainage ditches and culverts before outletting into the natural watercourse flowing to the PIR pump station. The PIR pump station routes the water over the levee embankment and into the Columbia Slough.

NE 13th Pump Station

The area north side of MLK Boulevard and Vancouver Way drains to an enclosed drainage system that outlets into a drainage ditch that flow to the NE 13th pump station. The NE 13th pump station routes the water over the levee embankment and into the Columbia Slough.

Schmeer Road Pump Station

The areas from the I-5 mainline, the eastern half of the Marine Drive interchange, and the southern half of MLK Boulevard drain through an enclosed drainage system which outflows into a large grassed lined channel located adjacent to the eastern side of I-5, known as Walker and Schmeer Slough. Walker Slough is connected to Schmeer Slough through an existing underground culvert pipe, several hundred feet long. Schmeer Slough outlets into Columbia Slough downstream.

2.6 Land Use

Exhibit 2-5 shows the general land use in the vicinity of the project corridor.

South of the Columbia River, land west of I-5 between Victory Boulevard and North Portland Harbor generally has an Industrial zoning designation while land to the east is generally designated as Open Space.

2.7 Utilities

Utility conflicts throughout the project corridor are currently being studied. Discussions at routine meetings with local agencies are ongoing to determine the extents of conflicts, disruptions to services, and relocations. Most of the Marine Drive interchange existing stormwater conveyance systems will be removed or abandoned in place. Existing outfalls will be maintained. Analysis of individual outfalls needs to be completed to determine their condition and suitability for use.

As the design progresses, conflicts with existing utilities will be further assessed and summarized in this section. Anticipated conflicts will be a result of structures passing through existing utilities, requiring relocation of the utility and its connections.

2.8 Climate

The climate within the project area is characterized by short, dry and warm summers, with a typically cool and wet spring, fall, and winter. The Coast Range offers limited shielding from the Pacific Ocean storms while the Cascades provide an orographic lift of moisture-laden westerly winds, resulting in moderate rainfall. Nearly 90% of the average annual rainfall of 36.3 inches occurs from October through May. The maximum 24-hour rainfall of 4.44 inches occurred in October 1994. Snowfall accumulations are rarely more than 2 inches, and usually melt within a couple of days.

Average monthly temperatures taken at Portland International Airport vary from 39.6 ºF in January to 68.6 ºF in August. The maximum and minimum recorded temperatures are 107 ºF and -3 ºF. These temperatures occurred in August 1981 and February 1950, respectively. Surface winds seldom exceed sustained wind speeds of 50 mph and have rarely exceeded 75 mph (NOAA 2009).

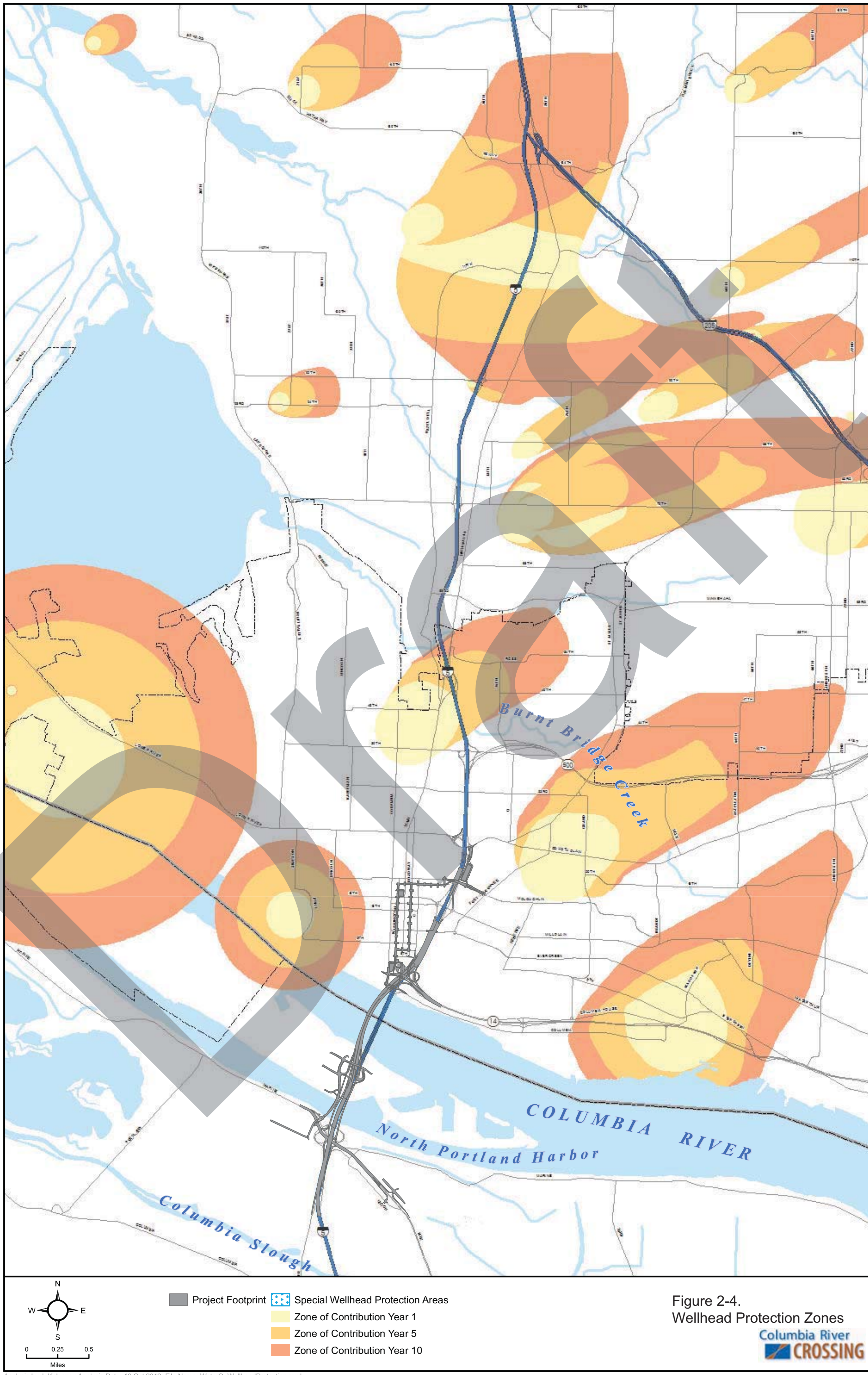

Figure 2-4.
Wellhead Protection Zones

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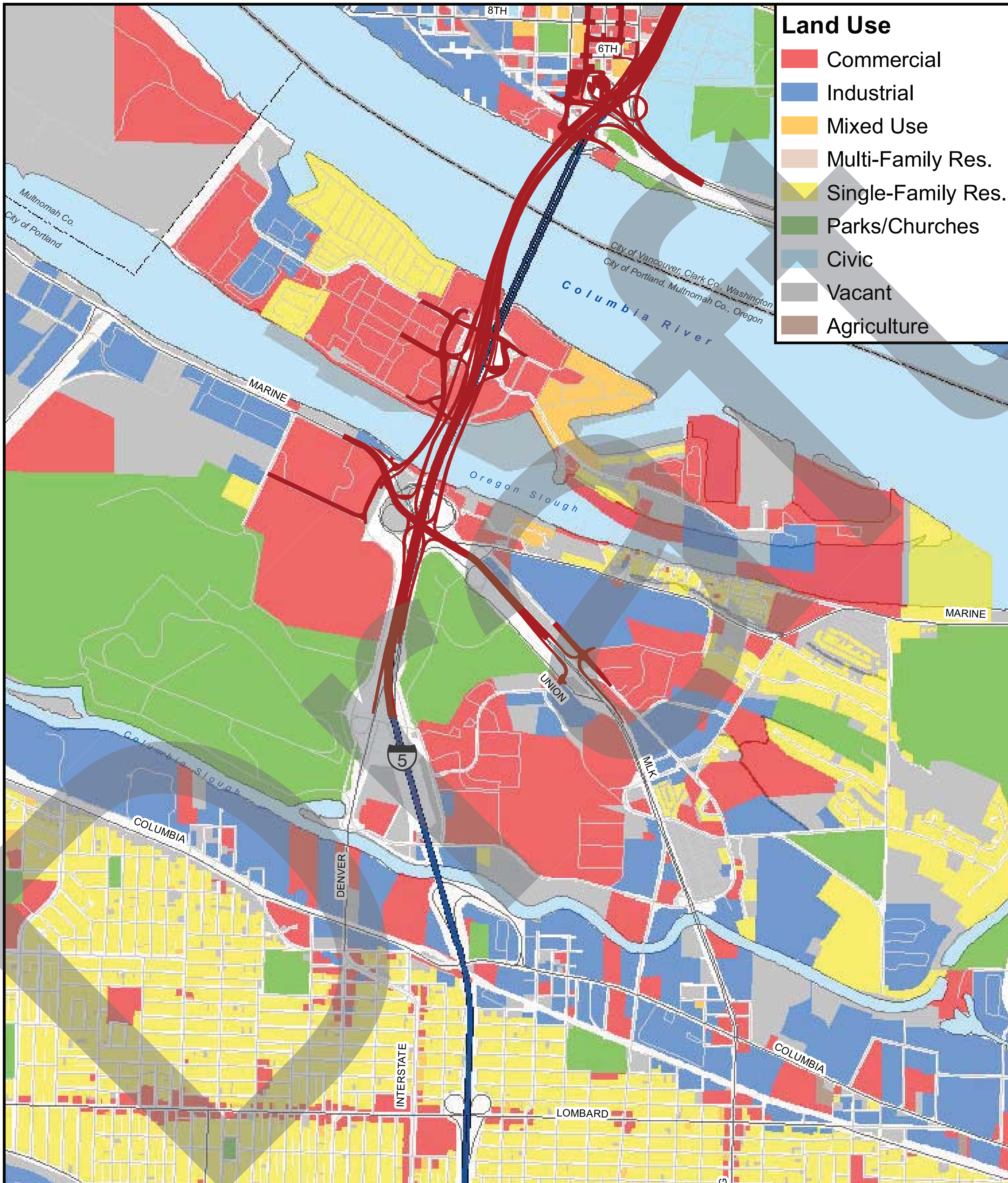

Figure 2-5
Land Use Designation - Oregon

Columbia River CROSSING

Analysis by J. Koloszar; Analysis Date: 16 Oct 2012; File Name: Figure 2_4_2_ExistingLandUses.mxd

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3. Design Standards

Following is a description of important considerations that affect stormwater design on a project-wide basis.

The key stormwater related issues include:

1. Regulatory agency concerns including:
    a. Protection of resources listed under the Endangered Species Act (ESA), notably the presence of salmonids in the Columbia River[5]. Specifically, NMFS has requested stormwater management focus on avoiding and minimizing impacts on their trust resources, and mitigation for unavoidable impacts. Dissolved metals are the primary pollutants of concern, especially dissolved copper. The agency requests that runoff from all contributing impervious surfaces within the project be treated. The agency also recommends single design standards be used for the Columbia River Bridges.
    b. The COP Bureau of Environmental Services (BES) also urged avoiding and minimizing impacts to natural resources[6]. The agency also expects the project to meet the requirements of the Portland Stormwater Management Manual.
    c. North of the Columbia River, the project corridor lies above the Troutdale Aquifer. The Environmental Protection Agency (EPA) recently designated this aquifer a Sole Source Aquifer, and stormwater facilities will need to be designed to eliminate the likelihood of contamination from polluted runoff.
2. Multi-agency jurisdiction and differing design standards and methodologies.
3. The need to collect and treat runoff from bridges across North Portland Harbor and Columbia River. Runoff from the existing bridges currently discharges, untreated, directly to the waterbody below.
4. The difficulty of incorporating stormwater treatment facilities within a confined, highly developed, urban environment.

3.1 Design Criteria

Snow was not considered at this level of design.

The precipitation values used for the project at this level of design are listed in Table 3-1. Values were populated from National Oceanic Atmospheric Administration (NOAA) Atlas 2 at 45.6387°N, 122.6615°W.

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[5] Letter from Kim Kratz (NMFS) to Heather Gunderson (CRC) dated August 6, 2008. See Appendix C.
[6] Letter from Dean Marriott (BES) to Heather Gunderson (CRC) dated February 28, 2007. See Appendix C.

Table 3-1. Design Precipitation

Storm Event	Precipitation (inches)	Precipitation Intensity (in/hr)
2-yr 6-hr	1.03	0.17
2-yr 24-hr	2.09	0.09
100-yr 6-hr	1.91	0.32
100-yr 24-hr	4.12	0.17

The design storm return periods used for the project at this level of design are listed in Table 3-2.

Table 3-2. Design Storms for Stormwater Conveyance

Stormwater System Element	Return Period (years)		
	ODOT[7,8]	City of Portland[9]	WSDOT[11]
Gutters & inlets	10	10	10
Laterals without trunk lines	-	-	10
Laterals and trunk lines	10	10	25
Inlets & conduits from sags	50	-	50
Ditches & channels	10	25	10
Culverts	50, 100 and 500	25	25 and 100
Energy Dissipators	50	-	-

In determining appropriate inlet spacing the Curb and Gutter Spreadsheet WSDOT Highway Runoff Manual (HRM Jan 2010; Page 5-15) was utilized. In determining appropriate pipe sizing the Storm Drain Design Spreadsheet (WSDOT HM Jan 2010; Page 6-7 Figure 6-4.1) was utilized. Input Parameters are listed in Table 3-3. The table provides values for both WSDOT and COV, where no value is presented for COV, the WSDOT values were used.

As design progresses it is expected that ODOT standards and design spreadsheets will be strictly adhered to.

7 *Hydraulics Manual.* Oregon Department of Transportation, Engineering and Asset Management Unit, Geo-Environmental Section. 2005.
8 For freeways.
9 *Sewer and Drainage Facilities Design Manual.* City of Portland, Bureau of Environmental Services. Public Review DRAFT, May 2006.

Table 3-3. Design Parameters for Inlet and Pipe Design

Design Parameter	WSDOT	ODOT	COP	COV
Runoff Time of Concentration, Tc	5 minutes	5 minutes	5 minutes	
Runoff Coefficient, C	0.90	0.90	0.92	
Allowable Spread, Zd	Shoulder Width OR Figure 5-4.1*	Shoulder Width or Table A**	Max Shoulder + 2 ft	
Inlet Grate Width & Length, GW & GL (ft)	1.67 or 3.89, 2.00 or 2.01	1'-1.5" or 2'-3.375", 2'-8" or 3'-4.25"	1'-1.5" or 2'-3.375", 2'-8" or 3'-4.25"	
Flow Bypass, Qbp	< 0.10 cfs to existing system or within hazardous areas	Per Method A		
Flow Velocity, v	<5.0 ft/s	> 3ft/s		
Inlet Spacing	Min.= 20 ft, Max.= 300 ft, or Inlet Spacing Spreadsheet	Min = 10ft, Max = 400ft, or Inlet Design Computation Sheet		Max.= 400ft
Pipe Length, L	Max.= 300 ft	Max = 400 ft		
Pipe Diameter, D	Min.= 12-inch	Min. = 45 inch	10 inch leads, 12 min.	Mainline: 12 inch Min. Lateral: 8 or 10 inch Only
Mean Rainfall Intensity, MRI	25 year (laterals and trunk lines) m= 6.06, n= 0.515	10 year, For zone 7	10 year	
Pipe: Time of Concentration, Tc	5 minutes	5 minutes	5 minutes	
Manning Roughness Coefficient, n	0.013	0.015	0.013	0.013
Pipe Velocity, v	10 ft/s Max, 3 ft/s Min.	3ft/s Min.	15 ft/s Max; 2.5 ft/s Min	

*WSDOT Hydraulics Manual 2010; Page 5-5
**ODOT Hydraulics Manual 2011; Page 13-D-1

Biofiltration Swales

Design and assumptions were developed into a template spreadsheet with explicit design instructions found and followed in WSDOT HRM (WSDOT HRM Jan 2010; RT.04 – Biofiltration Swale; Pages 5-44 through 5-49: Method 1) Input Parameters are listed in Table 3-4.

Table 3-4. Design Parameters for Biofiltration Swale Design

Design Parameter	
Longitudinal Slope, s	Min. 1.5%, Max. 5.0%
Manning's Roughness Coefficient, n	0.22 (grass-legume mix on lightly compacted compost-amended soil) 0.35 (with surface roughening features if site constrained)
Residence Time, t	9 minutes

3.2 Stormwater Management Guidelines

The following demonstrates the design approach and methods of treatment within the following management parameters:

1. Treatment capacity design will meet standards and specifications found in HRM (WSDOT 2010a), and thus exceed 50% of the 2-year, 24 hour storm; or 91% of the average annual runoff, as determined by continuous flow model.

2. Stormwater quality treatment will consist of one or more of the following methods:
    a. Bioretention ponds are infiltration ponds that use an engineered (amended) soil mix to remove pollutants as runoff infiltrates through this zone to the underlying soils. The primary mechanisms for pollutant reduction are filtration, sorption, biological uptake, and microbial activity. While this best management practice (BMP) is best suited to sites with Hydrologic Group A and B soils, it may be used for Group C and D Hydrologic Group soils with the addition of an underdrain system to collect infiltration runoff and direct it to a stormwater conveyance system. An infiltration rate of 1 inch per hour was assumed when estimating the size of these facilities. If the soils cannot sustain this rate and there is insufficient space to increase the pond size to accommodate a lower value, underdrains will be installed.
    b. Constructed treatment wetlands are shallow, permanent, vegetated ponds that function like natural wetlands. They remove pollutants through sedimentation, sorption, biological uptake, and microbial activity.
    c. Soil-amended biofiltration swales are trapezoidal channels with mild slopes and shallow depths of flow. The channels are dry between storm events and are typically vegetated. They treat runoff by filtration and sorption as runoff flows through the grass surface and amended soils. Amended soils, especially compost amended, constitute an excellent filtration medium. Compost-amended soils have a high cation exchange capacity that will bind and trap dissolved metals. Similar to bioretention ponds, an underdrain system is recommended for sites with Group C and D Hydrologic Group soils.
    d. Soil-amended filter strips treat sheet runoff from an adjacent roadway surface. Similar to grass swales, filter strips treat runoff by filtration and sorption as runoff flows through the vegetated surface and amended soils. In a confined urban setting such as the project corridor, opportunities to use this BMP are limited. Bioslopes, like filter strips, treat sheet runoff from an adjacent roadway surface. They comprise a vegetated filter strip, infiltration trench, and underdrain, and reduce pollutants through sorption and filtration. The percolating runoff flows through a special mixture of materials, including dolomite and gypsum, which promotes the adsorption of pollutants. Bioslopes are also known as media filter drains and ecology embankments.

Other water quality BMPs, including dispersal, drywells, and proprietary systems, such as cartridge filters, may be used when limiting factors prevent the use of these BMPs are prevented by lack of suitable space, soils non-conducive to infiltration, polluted soils, and protection of historic building foundations. Pre-treatment facilities including baffle type oil-water separators and coalescing plate oil-water are likely also. Their use is common in high average daily trip areas to protect the treatment facilities and to prevent overwhelming of the treatment technology. Accidents and spills are expected to occur on interstate freeways.

All treatment facilities will be designed and engineered to use the preceding techniques singly, or in combination, to achieve treatment. Engineering criteria including facility dimensions, depth, area, slopes, and materials (abiotic and biotic); and design parameters from the WSDOT Runoff Manual (WSDOT 2010a) will be used and met when designing these facilities.

All treatment facilities will be designed and engineered to use the preceding techniques singly, or in combination, to achieve treatment. Engineering criteria including facility dimensions, depth, area, slopes, and materials (abiotic and biotic); and design parameters from the WSDOT Runoff Manual (WSDOT 2010a) will be used and met when designing these facilities.

The project has agreed to adopt BMPs which are effective in reducing sediments, and particulate and dissolved metals. These agreements will be met. Specific locations of these facilities are described in additional volumes of this report and specific plan sheets for these facilities are located in Appendix C.

The following water quality BMPs used at Marine Drive Interchange are effective in reducing sediments, particulates, and dissolved metals; pollutants of concern for ESA-listed species observed in the waterbodies to which stormwater will be discharged. These BMPs would be constructed for the sole purpose of improving stormwater runoff quality. The location of such facilities in the proximity of well-travelled roads and transit systems combined with ongoing maintenance would discourage their use as habitat by wildlife.

- **Constructed Treatment Wetlands**
- **Biofiltration Swales**
- **Filter Strips**
- **Bioslopes**

Other water quality approaches, including **Dispersal**, and **Proprietary Systems** (such as cartridge filters), have been considered on a case-by-case basis where the BMPs listed above would not be practical or feasible.

Oil control pretreatment may be required at high-traffic intersections and park-and-ride facilities where high concentrations of oil and grease are expected in stormwater runoff. **Baffle Type Oil-Water Separators** and **Coalescing Plate Oil-Water Separators** are considered to be suitable types of treatment facility.

As the project design progresses, the team will continue to assess new technologies and whether they should be added to the suite of acceptable BMPs. For example, the Washington State Department of Ecology recently approved (Ecology 2009c) Americast's Filterra® system for reducing, among other pollutants, dissolved metals. This system uses engineered bioretention filtration incorporated into a planter box to treat runoff.

The waterbodies to which runoff would be discharged are Columbia Slough (via the Peninsula Drainage District No.1 and No.2 surface water systems and associated pump stations), and North Portland Harbor (a side channel of the Columbia River). Columbia Slough and North Portland Harbor contain species listed under the ESA, and all receiving watercourses are 303(d) listed. Note that although a watercourse may be 303(d) listed, the parameters listed may not necessarily have EPA-approved Total Maximum Daily Loads (TMDLs).

To address ESA and TMDL issues, the overall approach to stormwater management from a water quality perspective is to treat runoff to reduce the following pollutants that are typically associated with transportation projects[10]:

- Debris and litter
- Suspended solids such as sand, silt and particulate metals
- Oil and grease
- Dissolved metals

The last criterion, especially dissolved copper, is of particular concern to NMFS. Dissolved copper is known to have a detrimental effect on the olfactory senses of young salmonids.

Table 3-5 summarizes 303(d)-listed parameters and TMDLs for each receiving waterbody and the paragraphs following the table provide a brief description of existing water quality issues. Additional information may be found in the FEIS (CRC 2011).

Table 3-5. Listed Pollutants and TMDLs

Waterbody	303(d) Listed Pollutants	Established TMDLs
Columbia Slough Oregon DEQ	Toxics (lead, iron, manganese) Temperature	Toxics (lead, PCBs, DDE/DDT, dieldrin, dioxin) Eutrophication (pH, dissolved oxygen, phosphorus and chlorophyll *a*) Bacteria

Columbia Slough is 303(d) listed for lead, iron, manganese, and temperature. TMDLs have been established for pH, dissolved oxygen, phosphorous, chlorophyll *a*, bacteria, lead, PCBs, DDE/DDT, dieldrin, and dioxin (DEQ 1998) and the Lower Slough (to which project runoff would be discharged) consistently exceeds the upper pH limit of the water quality standard in the spring and summer and the chlorophyll *a* standards in the spring, summer, and fall (City of Portland 2009). In addition, 50 percent of BES sampling in the Lower Slough immediately downstream of the project met the target of 25 mg/L for total suspended solids (TSS).

3.3 Other Requirements

3.3.1 Oil Control

Oil control BMPs will be evaluated for Marine Drive interchange. At this time ODOT has not identified requirements for oil control at high use intersections.

3.4 Pipe Alternatives

Design calculations assume concrete pipe with a Mannings n of 0.013. Pipe diameters range from 12-inch to 24-inch. In some cases, pi alternative pipe materials will be selected according to available cover and the expected traffic loading.

[10] *Stormwater Management Plan Submission Guidelines for Removal/Fill Permit Applications Which Involve Impervious Surfaces.* State of Oregon Department of Environmental Quality. July 2005, 2008, 2012.

3.5 Downstream Analysis

Downstream analysis of the existing systems to determine capacity for use by upstream conveyance systems has not been performed physically or hydraulically modeled. The following provides a list of assumptions that identify the project's impact on the existing system:

- Stormwater runoff draining to Schmeer Road pump station outfall is less than the existing condition. The majority of the runoff from I-5, between Marine Drive and Victory Boulevard, will be routed to PIR pump station outfall via the Expo pump station.
- The existing ditch and culvert that drains to Expo pump station will be evaluated for capacity to drain the upstream water quality facility's high bypass flows.
- Stormwater runoff from the north side of Marine Drive and the areas I-5 west will outflow to outfall NPH-2 through a new enclosed drainage system. Resulting in less surface area draining into the Columbia Slough watershed.

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4. Developed Conditions

4.1 Proposed Drainage Sub-Basins

The limits of the drainage sub-basins are determined by the area draining to the outfall, whether on site or off site area is contributing. The outfalls are defined as the existing pump stations located adjacent to the Columbia Slough channel. Note the Expo Pump station is considered to be part of the PIR Pump station. Within the sub-basins, contributing impervious areas (CIAs) are delineated according to water quality facility to which the stormwater runoff flows. Multiple water quality facilities may outflow to a common outfall, their cumulative areas comprising a single sub-basin, named for this outfall. The description of each outfall and their drainage basins are provided below.

Within the Columbia Slough watershed there are three sub-basins impacted by the project. The outfalls to which these sub-basins flow are pump stations PIR, PEN 2, and Schmeer Road. Figure 4-1 shows the proposed sub-basins and their associated general flow paths.

Table 4-1 summarizes the proposed CIA receiving runoff treatment within The Columbia Slough watershed. A discussion of each sub-basin and the water quality treatment facilities for each basin's CIA follows. The locations of these facilities are shown in Appendix A. Note the areas listed in the table below do not include potential staging areas.

Table 4-1. Proposed Drainage Sub-Basins

Sub-Basin	Total Area (acres)	Proposed Impervious Surfaces (acres)	Proposed Pervious Surfaces (acres)
PIR	11.6	11.6	
Schmeer Rd	15.0	15.0	
PEN 2	1.5	1.5	

Notes: Numbers may change with project design progression. Pervious surfaces will be included in the next phase of design.

PIR Pump Station

Within this Sub-Basin the project will collect and treat stormwater runoff from the I-5 highpoint near Victory Blvd to the lowpoint at Marine Drive, as well as, the new Marine Drive west to I-5 south on ramp. The stormwater will be collected through an enclosed drainage system and constructed wetland. The stormsewer pipes will drain to the roadway lowpoint and continue westerly to the constructed wetland. The pond water quality outflows and high bypass flows will be conveyed to through an existing culvert pipe which outlets into an existing ditch adjacent to the LRT tracks. The existing ditch outflows into a grassed lined channel located on the southern side of Expo Road. The grassed lined channel outflows into a wetland that is regulated by the existing Pump Station west of Expo which drains to the PIR Pump Station Outfall to the Columbia Slough.

NE 13th Pump Station

Within this Sub-Basin the project will collect and treat stormwater runoff from the MLK Boulevard to Vancouver Way off ramp and the Vancouver Way to MLK Boulevard on ramp, as well as Vancouver Way. The stormwater will be collected via an enclosed drainage system and receive water quality treatment through a biofiltration swale with stormwater planters along the local roads. The stormsewer pipes will drain to the roadway lowpoint and continue southeasterly to the biofiltration swale. The water quality outflows and high bypass flows will be conveyed to an existing stormsewer manhole that is part of the existing enclosed drainage system on Vancouver Way. The enclosed drainage system outlets downstream into an open channel that flows to NE 13th pump station outfall to the Columbia Slough.

Schmeer Road Pump Station

There are five proposed water quality facilities upstream of the Schmeer Road Pump Station outfall to the Columbia Slough. A summary of each CIA is included below:

- Within the CS-D facility CIA, the project will collect and treat project stormwater runoff draining from the highpoint at Marine Drive east to the I-5 North entrance ramp via an enclosed drainage system and constructed wetland. The stormsewer pipes will drain to the roadway lowpoint and continue southwesterly to the constructed wetland. The pond water quality outflows and high bypass flows will be conveyed to through an existing pipe that outflows into a grassed lined channel located adjacent to the eastern side of I-5, which is known as Walker Slough. Walker Slough flows south and is connected to Schmeer Slough through an existing underground culvert pipe, several hundred feet long.
- Within the CS-B facility CIA the project will collect and treat project stormwater runoff draining from the highpoints at MLK Boulevard via an enclosed drainage system and constructed wetland. The new stormsewer pipe on MLK Boulevard will included a trunkline off the roadway centerline and inlets along the edge of shoulder with lateral connection to the trunkline. The stormsewer pipe will drain to the roadway lowpoint and continue south to the constructed wetland. The pond water quality outflows and high bypass flows will be conveyed to through an existing pipe that outflows into a grassed lined channel located adjacent to the eastern side of I-5, which is known as Walker Slough.

- Within the CS-C facility CIA the project will collect and treat project stormwater runoff draining from Denver Avenue to I-5 north on-ramp and the I-5 north to Marine Drive west off-ramp, via an enclosed drainage system and biofiltration swale. The new stormsewer pipe will continue south along the existing ramp towards Victory Blvd. to the proposed swale location. Treated water and high bypass flows will be conveyed into a grassed lined channel known was Walker Slough and is located adjacent to the eastern side of I-5 near the of Denver Avenue underpass.
- Within the CS-H facility CIA the project will collect and treat project stormwater runoff draining from the highpoint of I-5 South off ramp to Denver Avenue via an enclosed drainage system and biofiltration swale. The swale outflows into the existing stormsewer pipe, which conveys the treated water and high bypass flows downstream to a large grassed lined channel located adjacent to the eastern side of I-5, known as Schmeer Slough.
- Within the CS-G facility CIA the project will collect and treat stormwater runoff from the highpoint at MLK Boulevard, the off ramp to N. Hayden Meadows Drive and NE Union Court via an enclosed drainage system and constructed wetland with stormwater planters along the local roads. The stormsewer pipes will drain to the roadway lowpoint and continue westerly to the constructed wetland. The pond water quality outflows and high bypass flows will be conveyed to an existing stormsewer manhole that is part of the existing enclosed drainage system adjacent to N. Hayden Meadows Drive. The enclosed drainage system drains southwesterly and outlets downstream into the large grassed lined channel known as Schmeer Slough.

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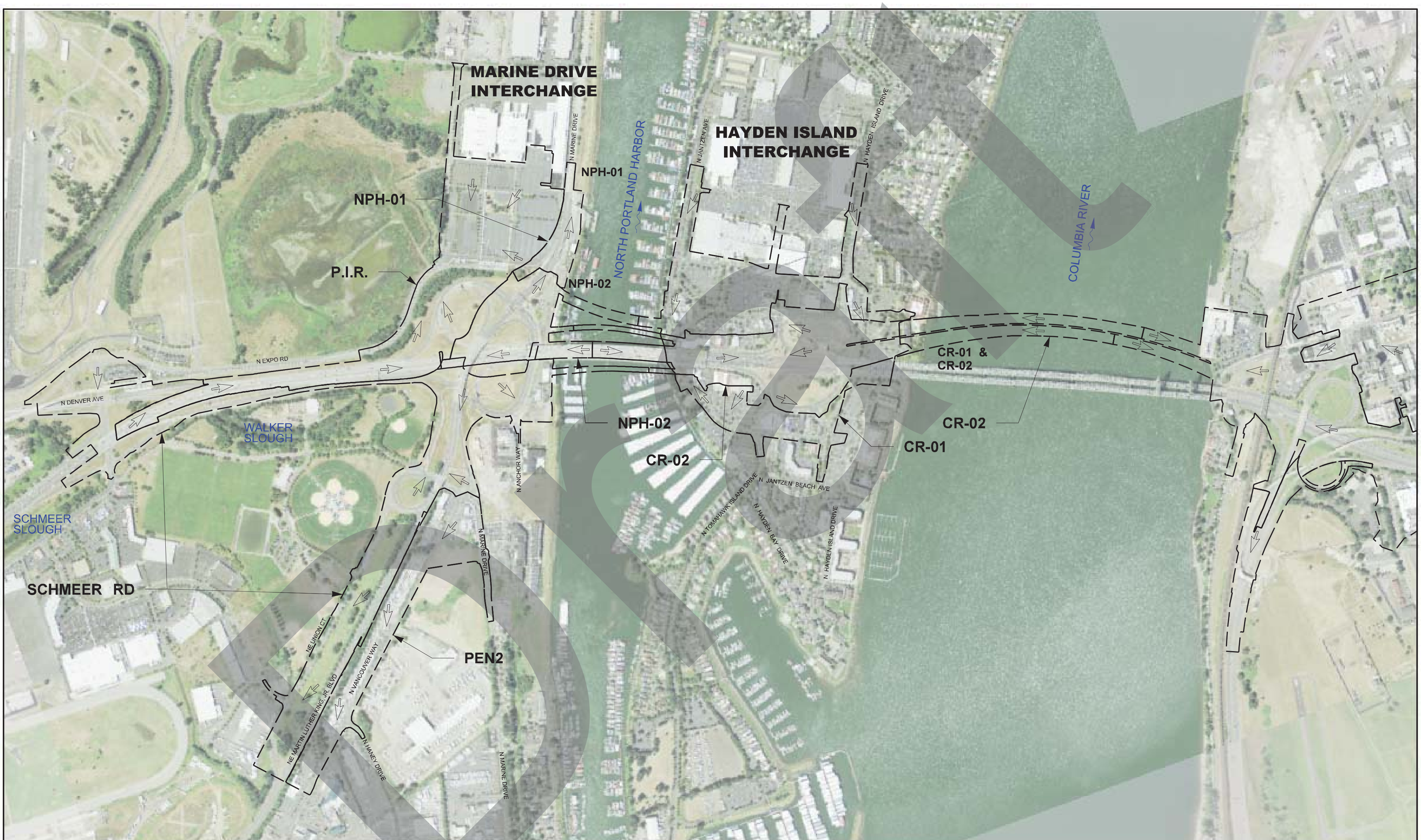

FIGURE 4-1.
PROPOSED DRAINAGE SUB BASIN
OREGON STATE - ICP

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5. Hydrologic and Hydraulic Design

5.1 Flow Control

Flow control is not required for runoff discharged into Columbia Slough.

5.2 Runoff Treatment Design

The primary proposed BMP for water quality facilities in this watershed is the constructed treatment wetland. Constructed wetlands provide the surface area necessary to treat larger volumes of concentrated flows draining from the highways and interchanges. The constructed wetland design is based on Clean Water Services (CWS) guidelines for sizing wetlands. ODOT and COP currently do not have design guidelines available for constructed wetlands.

The water quality treatment facilities volumes and flows were obtained using the guidelines outlined in Chapter 5 of the WSDOT HRM and the COP Stormwater Management Manual.

On a project and sub-basin level all contributing impervious surfaces will receive water quality treatment as defined in Section 3.2. The WSDOT software program, MGSFlood, was used to calculate the required water quality volume necessary to treat the upstream CIA. The CIA was obtained from quantity takeoffs via CAD Microstation design files.

Because no flow control is required for facilities draining into the Columbia Slough, a flow splitter will be installed upstream of each facility. The splitter will convey the water quality flow (from the 2yr-24hr design storm) to the facility while bypassing the high flows to the outfall. The bypass and outlet pipes are assumed to be 12 inch diameter at this stage in design. Following are general assumptions used in the preliminary water quality facility design:

Biofiltration swale:

- MGSFlood Modeling used to calculate Runoff Treatment Design Flow Rate (Qwq)
    - Predeveloped condition = Grass Till for the entire Impervious Area
    - Postdeveloped condition = Impervious Area delineation
    - Water Quality 15-minute Design Discharge for Link Inflow – off-line facility from Water Quality Data
    - Swales considered “offline”
- Swale depth
    - 0.33 ft (HRM Table RT.04.2)
    - infrequent mowing
- Assume trapezoidal channel
    - 4:1 side slopes
- Residence time, t

  - 9 min (HRM pg 5-49)
- Flow spreaders
  - If b > 6ft than 1 every 50ft and 1 at inlet (HRM pg 5-56)
- Swale length, L
  - Min 100 ft
- Freeboard
  - 1 ft (HRM Table TR.04.2)
- When swales are in parallel there is a 2ft wide divider which runs between

Constructed Wetlands:

- Post developed Cover Type
  - Impervious
- Computational Time step
  - 1 Hour
- Water Quality Treatment Volume
  - Computed Basic Wet Pond Volume
- Compost Amended Soil Depth
  - 12 inches

Maintenance Access Roads: (HRM pgs 5-24 thru 5-25)

  - Width = 12 ft straight segments, 15 ft on curves
  - Outside turning radius = 40 ft

5.3 Water Quality Treatment BMPs

Water quality facility dimensions and contributing impervious areas are summarized in Table 5-1. Appendix B contains facility sizing calculations and design data for these stormwater facilities. Contributing impervious area for each facility is delineated in Appendix A.

Table 5-1. Water Quality Treatment Facility Summary

Sub-Basin	Facility Type/ Number	Impervious Area Collected (acres)	Pervious Area Collected (acres)	Surface Area (sq-ft)	Bottom Length/ Width (ft/ft)	Volume (cu-ft)	Depth (ft)	Bottom Elev. (ft)
SchmeerRd	Swale/CS-H	0.8			110/5		1.5	20.5
	Swale/CS-C	2.0			120/10		1.5	12.5
	Constructed Wetland/CS-B	4.7		18000		25500	2.5	21.0
	Constructed Wetland/CS-D	2.3		10000		12000	2.5	33.0
	Constructed Wetland/CS-G	5.2		19800		28000	2.5	23.5
PIR	Constructed Wetland/CS-ICP-E	11.6		38000		58000	2.5	23.0
PEN 2	Swale/CS-F	1.5			116/8		1.5	23.5

Notes: Numbers may change with project design progression. Pervious surfaces will be included in the next phase of design.

5.3.1 Water Quality Facility CS-B

CS-B is designed as a constructed wetland. MGSFlood modeling provided the water quality volume of 25,500 cubic feet. This volume was used with the CWS guidelines for sizing wetlands. This facility has a proposed top elevation of 24.5 ft and bottom elevation range of 20.0 to 21.0 ft. It is approximately 200 feet long and 90 feet wide, on average. It has 5:1 side slopes to the water quality surface level and 3:1 side slopes to the top of freeboard, which is in addition to the ponds capacity for the 25-year storm event. It is anticipated a pond liner will be included in the pond design.

Runoff from approximately 4.7 acres of impervious surface from the most eastern highpoint of MLK Boulevard to the Marine Drive interchange highpoint at I-5 will be conveyed to this constructed wetland located within the existing loop ramp from MLK Boulevard to Union Court. The existing ramp will be removed as part of the project. The conveyance consists of a new stormwater trunk main located near the roadway centerline and inlet lateral connections. The existing conveyance system within the roadway section will be removed.

A flowsplitter will be installed upstream of the facility to route water quality flows to the facility, while diverting high bypass flows downstream. Outflows from the facility and the flowsplitter will be released into the existing 24-inch COP stormwater pipe which outlets into Walker Slough, and ultimately Columbia Slough, through outfall Schmeer Rd. The design assumes that the outflows from the wetland will flow through existing stormwater pipes. It should be noted that survey of the existing stormwater pipe draining to the outfall is not complete. Additional survey will be needed to confirm use of the existing downstream conveyance system.

The maintenance access to this pond is not yet confirmed. The wetland is located at the bottom of the MLK Boulevard embankment with limited options for access. It is understood that the existing Union Court road will no longer connect to the existing ramp area. The wetland is also located adjacent to a new pedestrian-bike path that connects users to the COP park area. The new path could provide suitable access to the pond. Discussions with ODOT maintenance have been initiated regarding this option.

The pond location has been maintained throughout the design process. Changes in the pond design have been minimal and related to roadway refinements resulting in changes in CIA and roadway geometry.

5.3.2 Water Quality Facility CS-C

CS-C is designed as a biofiltration swale. MGSFlood modeling provided the water quality flow of 0.18 cfs. This facility has a proposed top elevation of 14.0 ft and bottom elevation 12.5 ft. It is approximately 120 feet long and 10 feet wide, on average. It has 4:1 side slopes to the top of freeboard.

Approximately 2.0 acres of impervious surface from the northbound I-5 to westbound Marine Drive and from Denver Avenue to northbound I-5 ramps will be conveyed to the CS-C biofiltration swale. The grades for the ramps are such that it would be difficult to convey the runoff with the I-5 runoff to the water quality facility CS-ICP-E. As a result, the runoff is conveyed south towards Victory Boulevard to the nearest suitable location for the swale. A flowsplitter located upstream of the swale will divert high bypass flows to the swale's outflow manhole and a new stormwater pipe will be installed to route the runoff for release into Walker Slough and into Outfall Schmeer Rd. The existing stormsewer system will be removed as it no longer functions with the new ramp alignments.

The location of this swale moved several hundred feet south when the original low point for Marine Drive to Denver Avenue off ramp moved further south. As a result, the runoff is routed south along the existing ramp until the open area where the swale is now located. The outlet pipe travels adjacent to an existing shallow depression for a few hundred feet before it reaches the outfall location. Other outfall connection options may be considered with addition survey.

The maintenance access will be from the existing Denver to northbound I-5 shoulder.

5.3.3 Water Quality Facility CS-D

CS-D is designed as a constructed wetland. MGSFlood modeling provided the water quality volume of 12,000 cubic feet. This volume was used with the CWS guidelines for sizing wetlands. This facility has a proposed top elevation of 36.5 ft and bottom elevation range of 32.0 to 33.0 ft. It is approximately 200 feet long and 50 feet wide, on average. It has 5:1 side slopes to the water quality surface level and 3:1 side slopes to the top of freeboard which is in addition to the ponds capacity for the 25-year storm event. It is anticipated a pond liner will be included in the pond design. At this time the facility is over-sized.

Runoff from approximately 2.3 acres of impervious surface from the Marine Drive to northbound I-5 ramp, located between Marine Drive and the northern highpoint, will be conveyed to constructed treatment wetland CS-D. The new ramp will include stormwater conveyance with inlets. A flowsplitter will be installed upstream of the facility to route water quality flows to the facility while diverting high bypass flows downstream. A new stormwater pipe will be installed to route the runoff downstream to an existing manhole that drains into an existing 21-inch stormsewer pipe which ultimately releases into Walker Slough, and subsequently Columbia Slough, via Outfall Schmeer Rd.

The wetland is currently located between I-5 northbound and the new ramp northbound I-5 with a retaining wall along the eastern side of the facility. The maintenance access road crosses under the ramp bridge section and connects to Vancouver Way. The location of this facility has remained throughout the design process, however other treatment options have been considered. Due to the smaller CIA, a biofiltration swale has been considered, but not adopted. It may be adopted as the design progresses and the potential for dispersion is utilized. At this time the facility is over-sized.

5.3.4 Water Quality Facility CS-ICP-E

MGSFlood modeling provided the water quality volume of 58,000 cubic feet. This volume was used with the CWS guidelines for sizing wetlands. This facility has a proposed top elevation of 26.5 ft and bottom elevation range of 22.0 to 23.0 ft. It is approximately 290 feet long and 130 feet wide, on average. It has 5:1 side slopes to the water quality surface level and 3:1 side slopes to the top of freeboard which is in addition to the ponds capacity for the 25-year storm event. It is anticipated a pond liner will be included in the pond design.

Approximately 11.6 acres of impervious surface from southbound and northbound I-5 between the Victory Boulevard Bridge and the low point located under the Marine Drive interchange, including the impervious area from the Marine Drive to southbound I-5 ramp, will be conveyed to constructed treatment wetland CS-ICP-E. I-5 will be widened and, as a result, new stormwater pipe and inlets will be installed along the edge of shoulder. The existing drainage conveyance system will be removed as its current arrangement will no longer function in the proposed condition. At the low point flanking inlets route runoff west to a drop manhole that outlets into a flowsplitter installed upstream of the facility to route water quality flows to the facility while diverting high bypass flows downstream. The constructed treatment wetland outflow along with the flowsplitter bypass flows will drain into an existing 18-inch stormwater pipe.

Further survey and analysis will be required to verify downstream connections flowing into the drainage channel, located immediately south of Expo. Current as-builts indicate that the 18-inch stormwater pipe outlets into a ditch adjacent to the existing MAX LRT guideway, which conveys flows to the Expo pump station. The Expo pump station outflows into outfall PIR. Both are located within PEN No. 1. Flows draining to the Expo pump station will need to be analyzed for their impact on the channel and associated pump station, which may need to be enlarged to handle the additional concentrated high bypass flows.

A maintenance access road is proposed to provide connection between Marine Drive and the facility. Other options for access are limited due to the existing levee system and LRT. The location of the wetland has remained throughout the design process as it sits in the area of the existing ramp that will be removed. The size of the facility has increased due to an increase in CIA from the southern end of the project at Victory Boulevard. Changes in the roadway design made it possible for areas from the bridge to drain north to the I-5 low point.

The CS-ICP-E wetland currently sits at the bottom of the Marine Drive embankment, a location that has been maintained throughout the design process. However, the CS-ICP-E is designed as a modified version of the facility required for the LPA, the CS-E constructed wetland. Though both facilities are very similar in size and shape, the ICP version, CS-ICP-E, will be located further north than the LPA version, CS-E. In the LPA design the Marine Drive alignment is located further south and the loop ramp is removed. For the ICP the loop ramp is maintained and the Marine Drive alignment is located further north. This creates a small and specific area for the CS-ICP-E facility to be located. The modification will be maintained with LPA construction.

5.3.5 Water Quality Facility CS-F

CS-F is designed as a biofiltration swale. MGSFlood modeling provided the water quality flow of 0.12 cfs. This facility has a proposed top elevation of 25.0 ft and bottom elevation 23.5 ft. It is approximately 116 feet long and 8 feet wide, on average. It has 4:1 side slopes to the top of freeboard.

The project will construct new connections between MLK Boulevard and Vancouver Way. Runoff from approximately 1.5 acres of new and resurfaced impervious surface from the westbound MLK Boulevard off ramp to Vancouver Way, and Vancouver Way to westbound MLK Boulevard on ramp will receive treatment from the CS-F biofiltration swale, located adjacent to the connection between MLK Boulevard and Vancouver Way. The new ramps will require new stormsewer pipe and inlets. A flowsplitter will be installed upstream of the facility to route water quality flows to the facility while diverting high bypass flows downstream. Outflows from the swale will drain to an existing manhole identified as outfall PEN2 and located within the existing COP stormwater conveyance system under Vancouver Way. The existing conveyance system continues northeasterly and outlets downstream into an open channel that flows to Pen No. 2 pump station at NE 13th. Additional water quality improvements may be expected as runoff flows through over 7,000 feet of open channel before being pumped to Columbia Slough via the Pen No. 2 Pump Station (see Figure 2-1.2). The location of the swale has remained throughout the design process. There have been a few adjustments to facility size based on changes in roadway and CIA.

5.3.6 Water Quality Facility CS-G

CS-G is designed as a constructed wetland. MGSFlood modeling provided the water quality volume of 25,300 cubic feet. This volume will be used with the CWS guidelines for sizing wetlands. It will have 5:1 side slopes to the water quality surface level and 3:1 side slopes to the top of freeboard which is in addition to the ponds capacity for the 25-year storm event. It is anticipated a pond liner will be included in the pond design. At this time the facility design is in progress.

Runoff from 5.2 acres of impervious surface from MLK Boulevard eastern highpoint to the eastern end of construction and the eastbound MLK Boulevard off ramp to Union Court will be conveyed to the constructed treatment wetland CS-G located between the two roadways. Changes in MLK Boulevard geometry and the addition of the new off ramp will require installation of new stormsewer pipe and inlets to collect runoff. A flowsplitter will be installed upstream of the facility to route water quality flows to the facility while diverting high bypass flows downstream. Flows from the constructed wetland will be released to an existing COP conveyance system adjacent to Union Court at outlet Schmeer Rd. And will ultimately be pumped to Columbia Slough via the Schmeer Road pump station.

The location of this wetland has remained throughout the design process. Maintenance access to the facility will be off of Union Court. The project will consider reducing the facility size by dispersing sheet flow runoff from the MLK Boulevard to Union Court off ramp shoulder, which would maintain the current drainage while encouraging infiltration and evaporation. Part of the option would be to also implement a shallow biofiltration swale for the areas that cannot be dispersed.

5.3.7 Water Quality Facility CS-H

CS-H is designed as a biofiltration swale. MGSFlood modeling provided the water quality flow of 0.07 cfs. This facility has a proposed top elevation of 22.0 ft and bottom elevation 20.5 ft. It is approximately 110 feet long and 5 feet wide, on average. It has 4:1 side slopes to the top of freeboard.

Approximately 0.8 acres of impervious surface from the southbound I-5 to Denver Avenue off-ramp high point will be conveyed to the CS-H biofiltration swale. The runoff will be conveyed south from the ramp lowpoint to Victory Boulevard, where the new swale will be located adjacent to the northern back of sidewalk. A flowsplitter located upstream of the swale will divert high bypass flows to the swale’s outflow manhole and a new stormwater pipe will be installed to route the runoff for release into the existing downstream conveyance system. The existing stormwater pipe outflows into Schmeer Slough, which outflows into outfall Schmeer Road. The maintenance access will be from the existing shoulder along Victory Boulevard.

The location of this swale was moved from the south side of the Victory Boulevard to accommodate runoff from the new I-5 southbound to Denver Avenue off-ramp that does not drain to the I-5 mainline drainage system.

5.3.8 Other Water Quality Facilities

Following is a summary of other proposed water quality facilities used in the stormwater design:

- Runoff from the new merge lane south of Victory Boulevard (about 0.3 acres) for the ramp from Marine Drive to southbound I-5 would be conveyed to a water quality swale constructed as part of the I-5 Delta Park project. This swale has adequate capacity to handle the additional runoff. In addition there is approximately 3.7 acres of existing impervious surface which will also be conveyed to, and treated by, this existing swale.
- Runoff from approximately 3.9 acres of proposed new, rebuilt, and existing local streets and contiguous sidewalks within the CIA would be treated using a mix of stormwater planter strips and proprietary systems such as cartridge filters.
- Runoff from about 1.1 acres of the bike-pedestrian pathway that is physically separated from the street network will likely be shed to adjacent landscaped areas where it will infiltrate and/or evaporate.

As described earlier, soils in this area are generally poorly drained. However, boreholes in the area show that the soils can be quite variable and, as the project design advances, site-specific geotechnical investigations may prove that one or more of the locations proposed for water quality facilities may be suitable for infiltration.

5.4 Gutter Design

The inlet spacing has been designed according to ODOT's Hydraulic Manual, Appendix D. The maximum spacing between inlets was 400 feet. Inlet spacing calculation spreadsheets provided by WSDOT were used calculate spread and bypass flows. The rational method with a 5-minute time of concentration and 10-year rainfall intensity was used to calculate upstream flows for inlet catchment areas. Runoff spread was restricted to the highway shoulder area. Bypass flows and spread width where also considered at superelevation transitions and ramp ends.

The maximum spacing between stormwater manholes for city streets is 500 feet per the COP Sewer and Drainage Facilities Design Manual. Inlets are installed with lateral connections to the trunkline.

The inlet spacing spreadsheets are presented in Appendix B-3.

5.5 Sag Design

The inlet spacing design does not include Sag design for this submittal. However, inlets at sag locations will be designed according to ODOT's Hydraulic Manual, Appendix D Section 6.0.

5.6 Enclosed Drainage Design

The enclosed drainage systems for Marine Drive interchange have been designed according to the ODOT's Hydraulic Manual, Appendix F to convey the 25-year event flows. City streets will be designed according to the COP Sewer and Drainage Facilities Design Manual. Several of the streets include stormwater planters for water quality treatment. The planters drain into the existing trunk lines where practical, otherwise, new trunk lines have been detailed.

The current design was developed through the WSDOT Storm Sewer Design calculation spreadsheets, which use the rational method to calculate contributing area flows and the manning's equation to determine pipe parameters. Drainage plans showing the storm sewer pipe locations, drainage structures, water quality facilities, and outfalls area included in Appendix C. The storm sewer design spreadsheets are presented in Appendix B-5.

The following list contains assumptions used in the conveyance system design:

- A ballasted LRT track proposed between the existing Expo station and south end of the combined LRT-arterial bridge across North Portland Harbor. Perforated underdrains serving existing ballasted track at the Expo station will be extended to collect runoff from the new guideway: the existing track underdrain system discharges to the channel located immediately south of the Expo (outfall PIR).
- The new conveyance system, constructed as part of the CRC project, will enable some of the runoff that currently flows to the outfall Schmeer Rd. (PEN 2) to be re-routed to PIR

(PEN 1). The runoff being re-routed would be from the I-5 mainline between Victory Boulevard and Marine Drive and will be treated by CS-ICP-E constructed treatment wetland. The primary reasons for this strategy are:

1. The west side of the proposed interchange provides the largest uninterrupted open area for water quality facilities.

2. MCDD has requested that CRC minimize runoff from the project to the Pen No. 2 surface water system to provide greater flexibility for handling increased runoff from potential redevelopment of the Hayden Meadows race track.

5.7 Culvert Design

No new, replaced, or modified culverts are proposed at this time. Any culvert design would be designed according to ODOT's Hydraulic Manual.

5.8 Ditch Design

No new, replaced, or modified ditches are proposed at this time. Any ditch design would be designed according to ODOT's Hydraulic Manual.

5.9 Downstream Analysis

See Section 4.5.

5.10 Level of Retrofit

No retrofits of existing systems are proposed at this time. Any retrofit design would be designed according to ODOT's Hydraulic Manual. Note: the existing drainage basins have been modified in the proposed condition to route stormwater from Schmeer Rd. Pump Station to the PIR pump station, as discussed in Section 5.6.

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6. Permits and Associated Reports

Detailed environmental analysis can be found in the Biological Assessment, available upon request. The Biological Opinion can be found in Appendix H.

6.1 Permits and Approvals

A list of specific permits issued by WSDOT and ODOT for the I-5 ROW can be found in Appendix L.

6.2 Easements

At the current stage of design no additional easements to accommodate drainage or slopes are required. Though it is not currently anticipated, additional ROW may be required for construction or maintenance at the next phase of design.

6.3 Additional Reports or Studies

Additional reports and studies can be found in the appendices of the Biological Assessment.

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7. Inspection and Maintenance Summary

Continued inspection and maintenance of the permanent water quality and flow control facilities is vital to the long-term protection of receiving water bodies. While detailed procedures will be developed as part of final design and associated design reports, Appendix L contains general inspection and maintenance requirements contained in the ODOT Hydraulics Manual[11] and WSDOT HRM[12].

It is assumed that a vactor trunk will be required to provide maintenance for the water quality facilities described in this report. An access road, 12 feet wide on tangents and 15 feet wide on curves, has been placed in such a way that facility access is feasible. Biofiltration swales will be mowed to maintain the depth of grass necessary for them to provide treatment.

Manufacturers[13,14] of some proprietary facilities recommend one inspection per year and maintenance every 1-3 years for each facility. Historically, each facility would require approximately 30 minutes to remove debris and accumulated sediments, and replace necessary components. Facilities located within the LRT guideway, will require maintenance activities to be performed within a limited time period, generally during the early AM hours to avoid adversely affecting transit operations.

The project has participated in preliminary meetings with WSDOT, ODOT, and C-TRAN maintenance staff regarding maintenance of the stormwater facilities in terms of access and anticipated obstacles to meeting maintenance requirements due to site grading and access constraints. There has also been some discussion of using pedestrian bike path facilities for maintenance access for areas with few options for access from the highway.

[11] Hydraulics Manual, Chapter 14 (Draft). Prepared by the Oregon Department of Transportation, Highway Division. 2007.

[12] Highway Runoff Manual. Prepared by Washington State Department of Transportation. Publication M31-16.01. June 2008.

[13] Contech Engineered Solutions LLC. Stormwater Management StormFilter: Product Description. (2012) Retrieved from http://www.conteches.com/Products/Stormwater-Management/Treatment/Stormwater-Management-StormFilter.aspx.

[14] Filterra Bioretention Systems. AmeriCast. Frequently Asked Questions: Maintenance. Retrieved from http://www.filterra.com/index.php/faq/category/C7/.

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APPENDIX A

Drainage Basin Maps and Area Calculations

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INITIAL CONSTRUCTION PROGRAM (ICP)

PROPOSED STORMWATER MANAGEMENT FACILITIES - OREGON

CONTRIBUTING IMPERVIOUS AREAS DRAINING TO WATER QUALITY TREATMENT FACILITIES

- CR-A
- CR-B
- CR-C
- CS-B
- CS-C
- CS-D
- CS-E
- CS-F
- CS-G
- CS-H
- NPH-A
- NPH-B
- LRT BALLAST TRACK
- DELTA PARK SWALE
- OTHER (PLANTER STRIPS OR PROPRIETARY SYSTEM)

STORMWATER FACILITY

- WATER QUALITY TREATMENT FACILITY
- OUTFALL

DRAFT

11/ 1/ 2012

Columbia River CROSSING

INITIAL CONSTRUCTION PROGRAM (ICP)

PROPOSED STORMWATER MANAGEMENT FACILITIES - WASHINGTON STATE (1 OF 2)

CONTRIBUTING IMPERVIOUS AREAS DRAINING TO WATER QUALITY TREATMENT FACILITIES

- CR-Ca
- CR-Cc
- CR-CdCe
- CR-D
- CR-E
- CR-F
- CR-P
- OTHER (PLANTER STRIPS OR PROPRIETARY SYSTEM)

STORMWATER FACILITY

- WATER QUALITY TREATMENT FACILITY
- OUTFALL

0 200 400 600 800 1000
SCALE IN FEET

Columbia River CROSSING

DRAFT
10/ 23/ 2012

CRC_BP_DR_ShapesForExhibits_ICP.dgn 10/23/2012 5:46:22 PM

INITIAL CONSTRUCTION PROGRAM (ICP)

PROPOSED STORMWATER MANAGEMENT FACILITIES - WASHINGTON STATE (2 OF 2)

CONTRIBUTING IMPERVIOUS AREAS DRAINING TO WATER QUALITY TREATMENT FACILITIES

- CR-G
- CR-H
- CR-Lb
- CR-J
- OTHER (PLANTER STRIPS OR PROPRIETARY SYSTEM)

STORMWATER FACILITY

- WATER QUALITY TREATMENT FACILITY
- OUTFALL

Columbia River CROSSING

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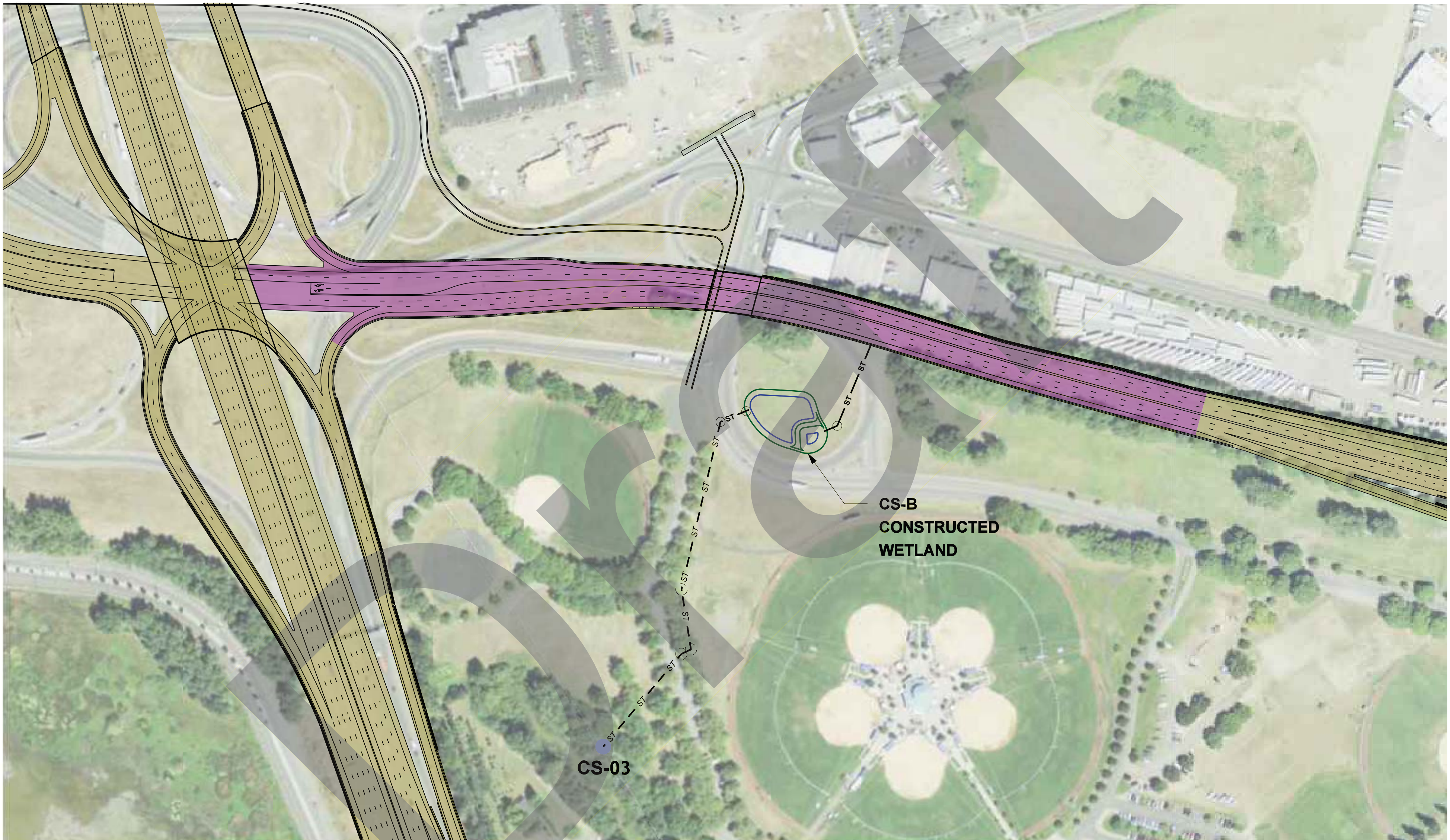


LEGEND

- CONTRIBUTING IMPERVIOUS AREA
- PROPOSED IMPERVIOUS AREA
- OUTFALL
- ST —— ST — NEW CONVEYANCE SYSTEM
- ST — — ST — EXISTING CONVEYANCE SYSTEM

PROPOSED WATER QUALITY FACILITY CS-B

0 50 100 150 200
SCALE IN FEET

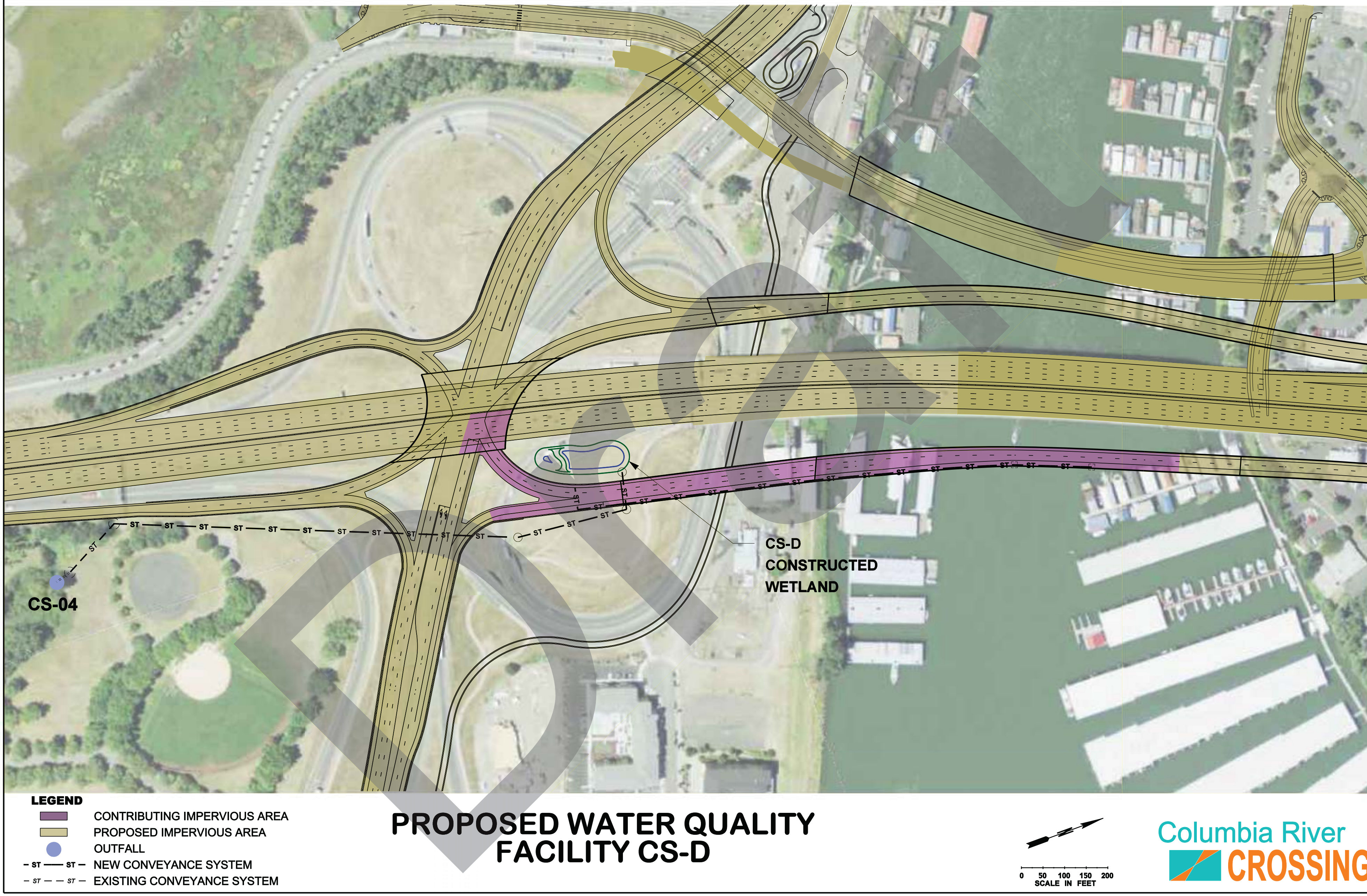
Columbia River CROSSING

LEGEND
- CONTRIBUTING IMPERVIOUS AREA
- PROPOSED IMPERVIOUS AREA
- OUTFALL
- ST —— ST NEW CONVEYANCE SYSTEM
- ST — — ST EXISTING CONVEYANCE SYSTEM

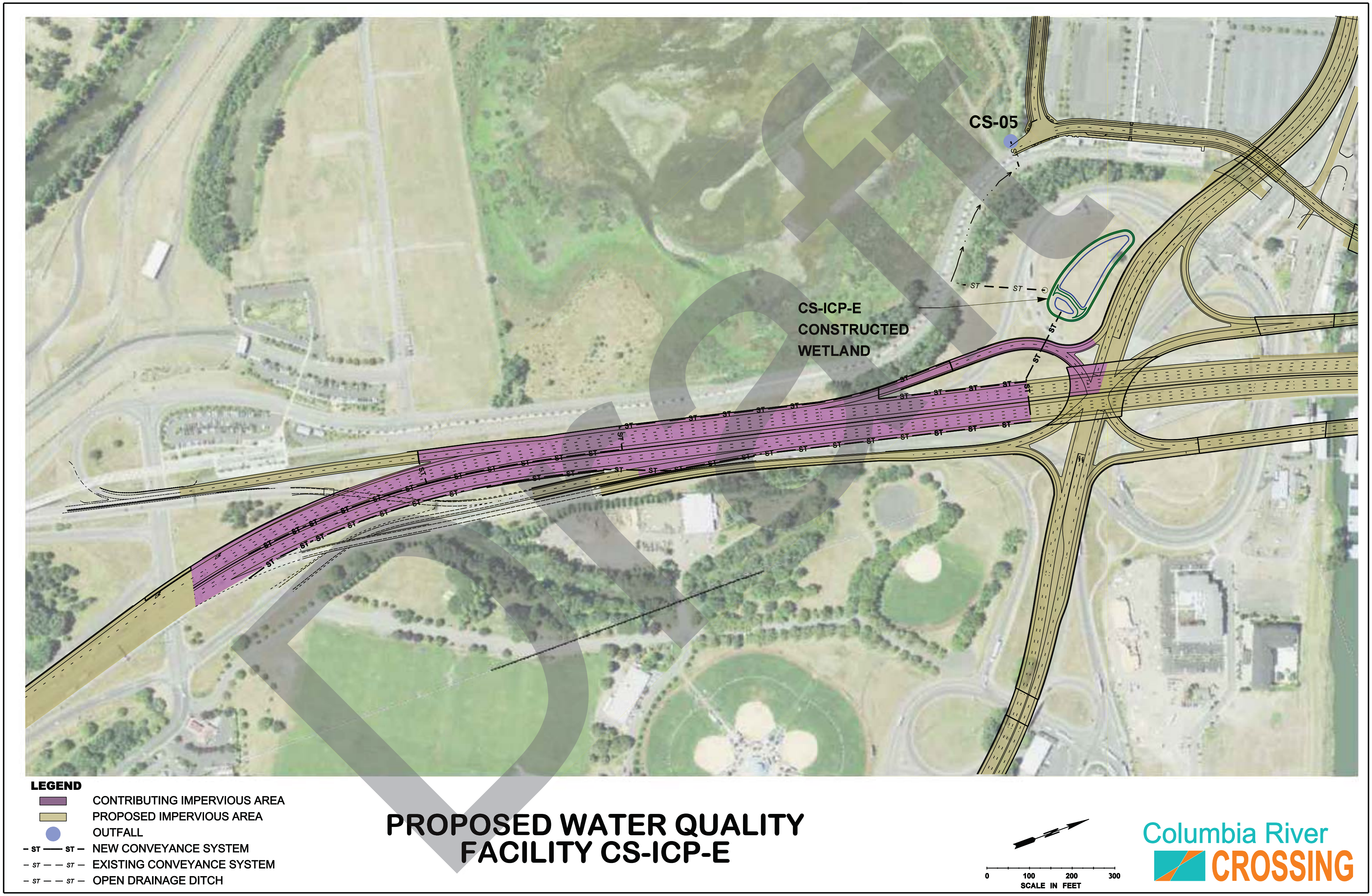
PROPOSED WATER QUALITY FACILITY CS-C

0 50 100 150 200
SCALE IN FEET

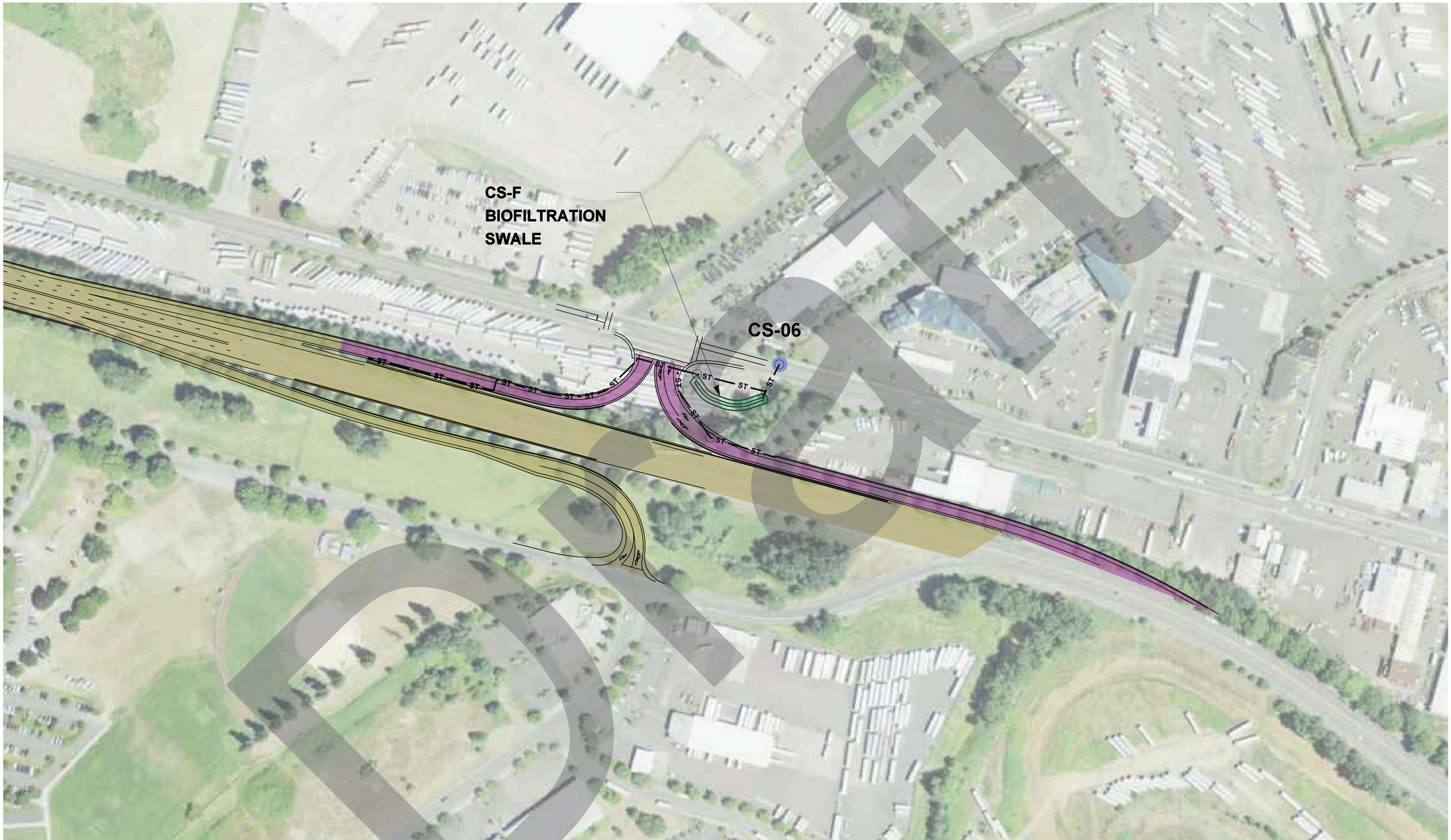
Columbia River CROSSING



PROPOSED WATER QUALITY FACILITY CS-D



PROPOSED WATER QUALITY FACILITY CS-ICP-E

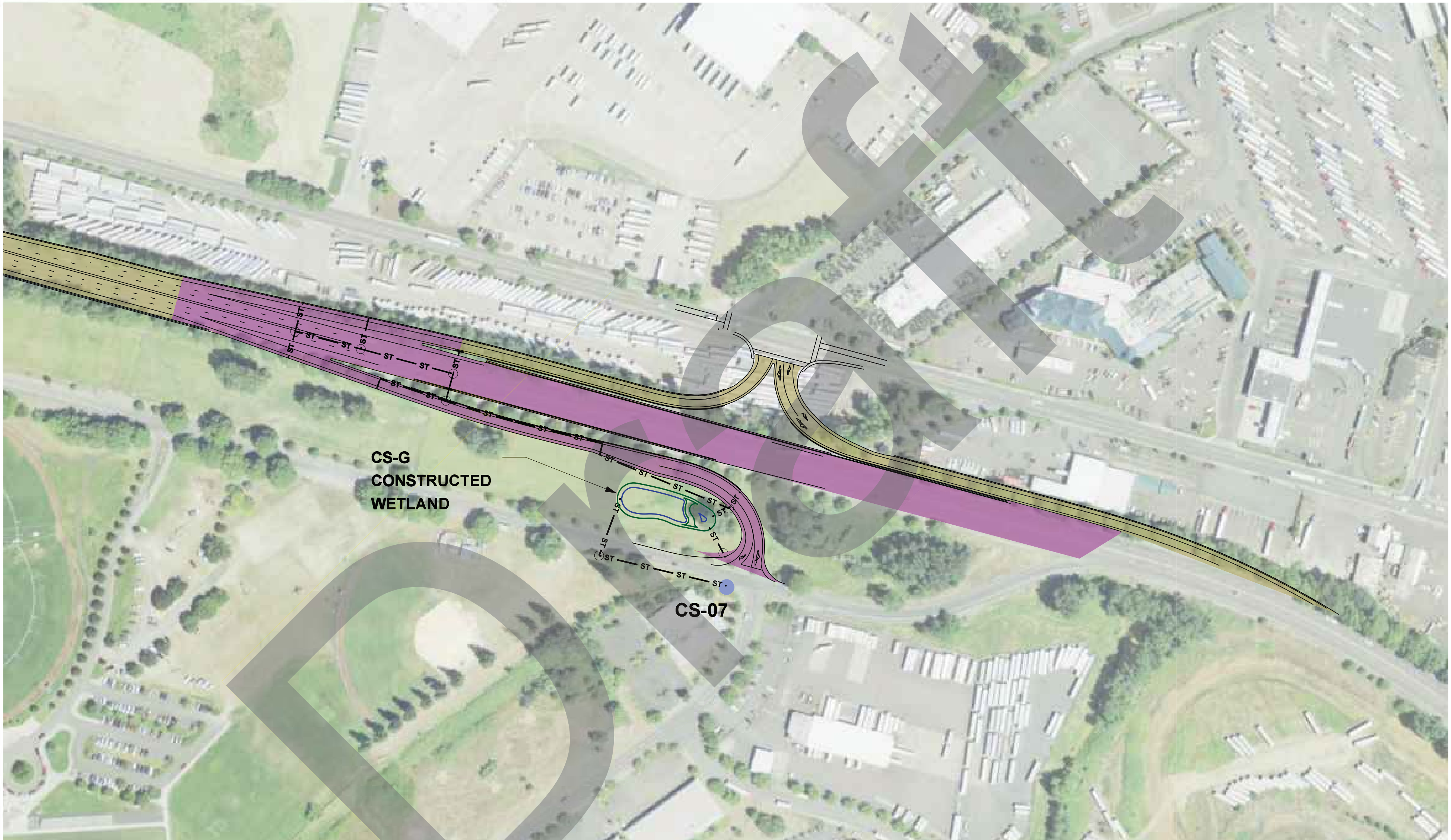


LEGEND

- CONTRIBUTING IMPERVIOUS AREA
- PROPOSED IMPERVIOUS AREA
- OUTFALL
- ST —— ST NEW CONVEYANCE SYSTEM
- ST — — ST EXISTING CONVEYANCE SYSTEM

PROPOSED WATER QUALITY FACILITY CS-F

Columbia River CROSSING



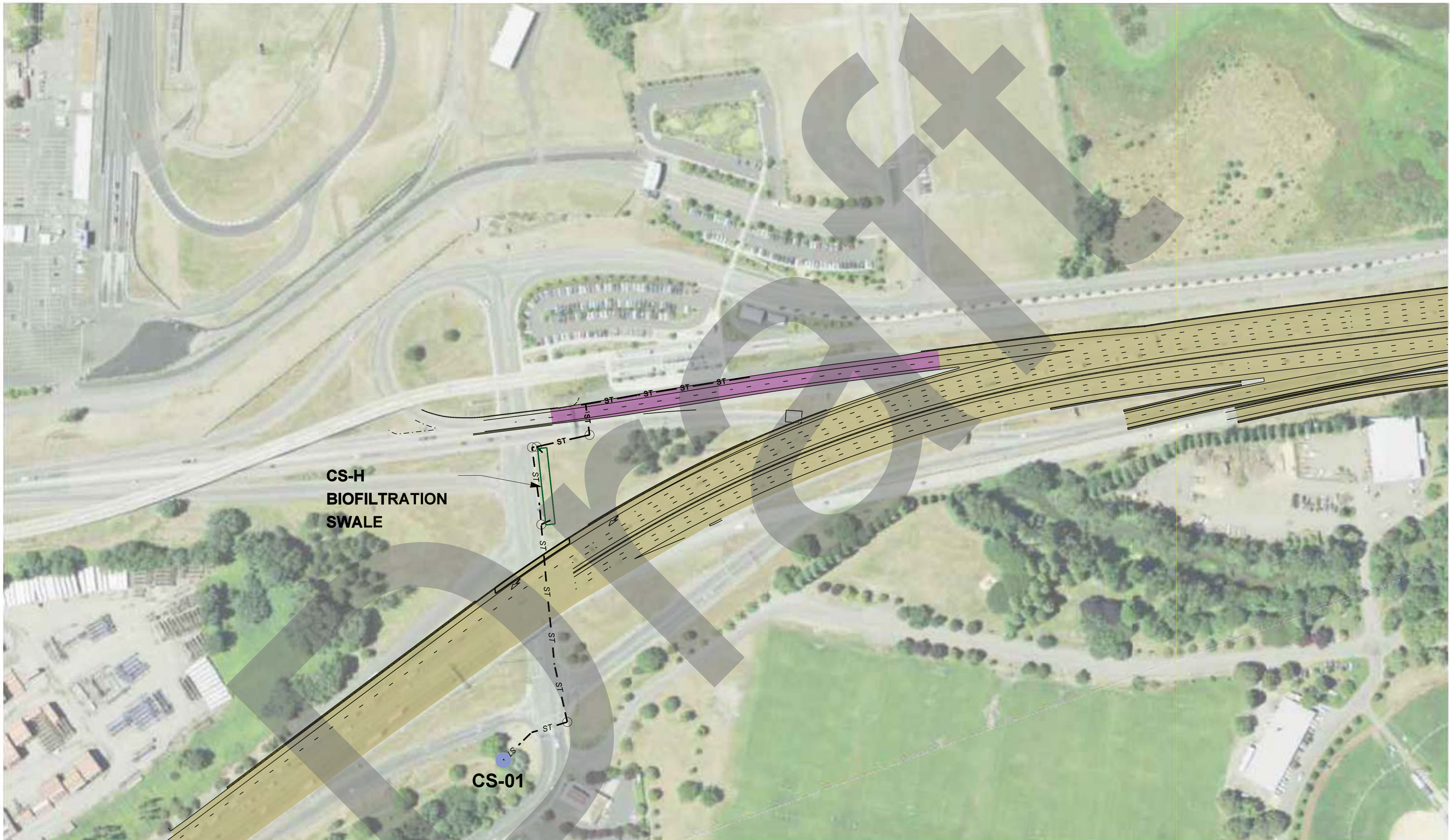
PROPOSED WATER QUALITY FACILITY CS-G

LEGEND

- CONTRIBUTING IMPERVIOUS AREA
- PROPOSED IMPERVIOUS AREA
- OUTFALL
- – ST —— ST – NEW CONVEYANCE SYSTEM
- – ST — — ST – EXISTING CONVEYANCE SYSTEM

0 50 100 150 200
SCALE IN FEET

Columbia River CROSSING



LEGEND

- CONTRIBUTING IMPERVIOUS AREA
- PROPOSED IMPERVIOUS AREA
- OUTFALL
- ST —— ST NEW CONVEYANCE SYSTEM
- ST — — ST EXISTING CONVEYANCE SYSTEM

PROPOSED WATER QUALITY FACILITY CS-H

Columbia River CROSSING

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APPENDIX B

Calculations and Program Output

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APPENDIX B-1

MGSFlood Output

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MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.09
Program License Number: 200210003
Run Date: 10/29/2012 1:20 PM

Input File Name: CS-B Wetland_ICP.fld
Project Name: Constructed Wetland CS-B
Analysis Title: ICP Design
Comments: Marine Drive I/C 30% Design. CS-03 Outfall, Columbia Slough Watershed

PRECIPITATION INPUT

Computational Time Step (Minutes): 60

Extended Precipitation Timeseries Selected
Climatic Region Number: 19

Full Period of Record Available used for Routing
Precipitation Station : 97004005 Vancouver 40 in_5min 10/01/1939-10/01/2060
Evaporation Station : 971040 Vancouver 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********************** WATERSHED DEFINITION ***********************

---------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 2

---------- Subbasin : Predeveloped Target Condition ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	4.700
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	4.700

---------- Subbasin : Facility Location SA ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.370
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	0.370

---------------------SCENARIO: POSTDEVELOPED

Number of Subbasins: 2

---------- Subbasin : Post Target ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	4.700
Subbasin Total	4.700

---------- Subbasin : CS-B Wetland SA ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.370
Subbasin Total	0.370

************************ **LINK DATA** *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 1

Link Name: Facility Location
Link Type: Copy
Downstream Link: None

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

Link Name: CS-B Constructed Wetland
Link Type: Copy
Downstream Link: None

*************************FLOOD FREQUENCY AND DURATION STATISTICS*******************

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 2
Number of Links: 1

----------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2
Number of Links: 1

***********Water Quality Facility Data *************

----------------------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: Facility Location **********

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 802.58
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------------------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: CS-B Constructed Wetland **********

Basic Wet Pond Volume (91% Exceedance): 22840. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 34261. cu-ft

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 1721.07
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

***********Compliance Point Results *************

Scenario Predeveloped Compliance Link: Facility Location
Scenario Postdeveloped Compliance Link: CS-B Constructed Wetland

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.292	2-Year	1.330
5-Year	0.513	5-Year	1.797
10-Year	0.731	10-Year	2.158
25-Year	1.022	25-Year	2.371
50-Year	1.268	50-Year	2.779
100-Year	1.288	100-Year	2.918
200-Year	1.293	200-Year	3.036

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	1164.4%	FAIL
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	6457.8%	FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	99999.0%	FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):	100.0% FAIL	

POND FAILS ONE OR MORE DURATION DESIGN CRITERIA: FAIL

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.09
Program License Number: 200210003
Run Date: 10/29/2012 11:45 AM

Input File Name: CS-C Swale_ICP.fld
Project Name: CS-C Swale
Analysis Title: ICP Design
Comments: Marine Drive I/C 30% Design. CS-02 Outfall, Columbia Slough Watershed

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Timeseries Selected
Climatic Region Number: 19

Full Period of Record Available used for Routing
Precipitation Station : 97004005 Vancouver 40 in_5min 10/01/1939-10/01/2060
Evaporation Station : 971040 Vancouver 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ***********************

---------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Predeveloped Target Condition ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	2.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	2.000

---------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Post Target ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	2.000
Subbasin Total	2.000

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 1

--
Link Name: Facility Location
Link Type: Copy
Downstream Link: None

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

--
Link Name: CS-C Biofiltration Swale
Link Type: Copy
Downstream Link: None

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

---------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 1

---------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1
Number of Links: 1

***********Water Quality Facility Data *************

--------------------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: Facility Location **********

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 318.06
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

--------------------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: CS-C Biofiltration Swale **********

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.28 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.16 cfs

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 688.13
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

***********Compliance Point Results *************

Scenario Predeveloped Compliance Link: Facility Location
Scenario Postdeveloped Compliance Link: CS-C Biofiltration Swale

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.153	2-Year	0.731
5-Year	0.325	5-Year	0.971
10-Year	0.447	10-Year	1.164
25-Year	0.643	25-Year	1.472
50-Year	0.884	50-Year	1.732
100-Year	1.000	100-Year	2.072
200-Year	1.087	200-Year	2.209

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	2404.5%	FAIL
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	11969.2%	FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	99999.0%	FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):	100.0% FAIL	

POND FAILS ONE OR MORE DURATION DESIGN CRITERIA: FAIL

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.09
Program License Number: 200210003
Run Date: 10/29/2012 1:14 PM

Input File Name: CS-D Wetland_ICP.fld
Project Name: Constructed Wetland CS-D
Analysis Title: ICP Design
Comments: Marine Drive I/C 30% Design. CS-04 Outfall, Columbia Slough Watershed

PRECIPITATION INPUT

Computational Time Step (Minutes): 60

Extended Precipitation Timeseries Selected
Climatic Region Number: 19

Full Period of Record Available used for Routing
Precipitation Station : 97004005 Vancouver 40 in_5min 10/01/1939-10/01/2060
Evaporation Station : 971040 Vancouver 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

*********************** WATERSHED DEFINITION ***********************

---------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 2

---------- Subbasin : Predeveloped Target Condition ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	2.300
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	2.300

---------- Subbasin : Facility Location SA ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.200
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	0.200

---------------------SCENARIO: POSTDEVELOPED

Number of Subbasins: 2

---------- Subbasin : Post Target ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	2.300
Subbasin Total	2.300

---------- Subbasin : CS-D Wetland SA ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.200
Subbasin Total	0.200

**************************** LINK DATA *********************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 1

--
Link Name: Facility Location
Link Type: Copy
Downstream Link: None

**************************** LINK DATA ********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

--
Link Name: CS-D Constructed Wetland
Link Type: Copy
Downstream Link: None

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 2
Number of Links: 1

----------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2
Number of Links: 1

***********Water Quality Facility Data *************

----------------------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: Facility Location **********

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 395.75
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------------------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: CS-D Constructed Wetland **********

Basic Wet Pond Volume (91% Exceedance): 11263. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 16894. cu-ft

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 848.65
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

***********Compliance Point Results *************

Scenario Predeveloped Compliance Link: Facility Location
Scenario Postdeveloped Compliance Link: CS-D Constructed Wetland

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.144	2-Year	0.656
5-Year	0.253	5-Year	0.886
10-Year	0.361	10-Year	1.064
25-Year	0.504	25-Year	1.169
50-Year	0.625	50-Year	1.370
100-Year	0.635	100-Year	1.439
200-Year	0.638	200-Year	1.497

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	1164.4%	FAIL
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	6457.8%	FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	99999.0%	FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):	100.0% FAIL	

POND FAILS ONE OR MORE DURATION DESIGN CRITERIA: FAIL

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.09
Program License Number: 200210003
Run Date: 10/29/2012 12:55 PM

Input File Name: CS-E Wetland_ICP.fld
Project Name: Constructed Wetland CS-ICP-E
Analysis Title: ICP Design
Comments: Marine Drive I/C 30% Design. Outfall CS-05, Columbia Slough Watershed.

PRECIPITATION INPUT

Computational Time Step (Minutes): 60

Extended Precipitation Timeseries Selected
Climatic Region Number: 19

Full Period of Record Available used for Routing
Precipitation Station : 97004005 Vancouver 40 in_5min 10/01/1939-10/01/2060
Evaporation Station : 971040 Vancouver 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********************** WATERSHED DEFINITION ***********************

---------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 2

---------- Subbasin : Predeveloped Target Condition ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	11.600
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	11.600

---------- Subbasin : CS-ICP-E Facility SA ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.810
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	0.810

---------------------SCENARIO: POSTDEVELOPED

Number of Subbasins: 2

---------- Subbasin : Post Target ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	11.600
Subbasin Total	11.600

---------- Subbasin : CS-ICP-E Wetland SA ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.810
Subbasin Total	0.810

************************* **LINK DATA** *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 1

Link Name: Facility Location
Link Type: Copy
Downstream Link: None

**************************** LINK DATA ********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

Link Name: CS-ICP-E Constructed Wetland
Link Type: Copy
Downstream Link: None

**************************FLOOD FREQUENCY AND DURATION STATISTICS*******************

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 2
Number of Links: 1

----------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2
Number of Links: 1

*************Water Quality Facility Data **************

----------------------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: Facility Location **********

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 1964.51
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------------------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: CS-ICP-E Constructed Wetland **********

Basic Wet Pond Volume (91% Exceedance): 55907. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 83861. cu-ft

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 4212.71
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

***********Compliance Point Results *************

Scenario Predeveloped Compliance Link: Facility Location
Scenario Postdeveloped Compliance Link: CS-ICP-E Constructed Wetland

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.715	2-Year	3.256
5-Year	1.256	5-Year	4.399
10-Year	1.790	10-Year	5.283
25-Year	2.501	25-Year	5.805
50-Year	3.103	50-Year	6.803
100-Year	3.153	100-Year	7.144
200-Year	3.165	200-Year	7.432

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance According to Dept. of Ecology Criteria ****
Excursion at Predeveloped ½Q2 (Must be Less Than 0%): 1164.4% FAIL
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%): 6457.8% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 100.0% FAIL

POND FAILS ONE OR MORE DURATION DESIGN CRITERIA: FAIL

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.09
Program License Number: 200210003
Run Date: 10/29/2012 11:46 AM

Input File Name: CS-F Swale_ICP.fld
Project Name: CS-F Swale
Analysis Title: ICP Design
Comments: Marine Drive I/C 30% Design. CS-06 Outfall, Columbia Slough Watershed

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Timeseries Selected
Climatic Region Number: 19

Full Period of Record Available used for Routing
Precipitation Station : 97004005 Vancouver 40 in_5min 10/01/1939-10/01/2060
Evaporation Station : 971040 Vancouver 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********************** WATERSHED DEFINITION ***********************

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Predeveloped Target Condition ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	1.500
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	1.500

---------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Post Target ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	1.500
Subbasin Total	1.500

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 1

--
Link Name: Facility Location
Link Type: Copy
Downstream Link: None

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

--
Link Name: CS-F Biofiltration Swale
Link Type: Copy
Downstream Link: None

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

---------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 1

---------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1
Number of Links: 1

***********Water Quality Facility Data *************

---------------------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: Facility Location **********

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 238.54
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

---------------------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: CS-F Biofiltration Swale **********

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.21 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.12 cfs

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 516.10
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

***********Compliance Point Results *************

Scenario Predeveloped Compliance Link: Facility Location
Scenario Postdeveloped Compliance Link: CS-F Biofiltration Swale

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff Tr (Years)	Discharge (cfs)	Postdevelopment Runoff Tr (Years)	Discharge (cfs)
2-Year	0.115	2-Year	0.549
5-Year	0.244	5-Year	0.728
10-Year	0.335	10-Year	0.873
25-Year	0.482	25-Year	1.104
50-Year	0.663	50-Year	1.299
100-Year	0.750	100-Year	1.554
200-Year	0.815	200-Year	1.657

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	2404.5%	FAIL
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	11969.2%	FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	99999.0%	FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):	100.0%	FAIL

POND FAILS ONE OR MORE DURATION DESIGN CRITERIA: FAIL

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.09
Program License Number: 200210003
Run Date: 10/29/2012 2:31 PM

Input File Name: CS-G Wetland_ICP.fld
Project Name: Constructed Wetland CS-G
Analysis Title: ICP Design
Comments: Marine Drive I/C 30% Design. CS-07 Outfall, Columbia Slough Watershed.

PRECIPITATION INPUT

Computational Time Step (Minutes): 60

Extended Precipitation Timeseries Selected
Climatic Region Number: 19

Full Period of Record Available used for Routing
Precipitation Station : 97004005 Vancouver 40 in_5min 10/01/1939-10/01/2060
Evaporation Station : 971040 Vancouver 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********************** WATERSHED DEFINITION ***********************

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 2

---------- Subbasin : Predeveloped Target Condition ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	5.200
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	5.200

---------- Subbasin : Facility Location SA ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.410
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	0.410

---------------------SCENARIO: POSTDEVELOPED

Number of Subbasins: 2

---------- Subbasin : Post Target ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	5.200
Subbasin Total	5.200

---------- Subbasin : CS-G Wetland SA ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.410
Subbasin Total	0.410

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 1

--
Link Name: Facility Location
Link Type: Copy
Downstream Link: None

**************************** LINK DATA ***********************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

--
Link Name: CS-G Constructed Wetland
Link Type: Copy
Downstream Link: None

**************************FLOOD FREQUENCY AND DURATION STATISTICS*********************

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 2
Number of Links: 1

----------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 2
Number of Links: 1

*************Water Quality Facility Data ***************

----------------------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: Facility Location **********

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 888.07
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

----------------------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: CS-G Constructed Wetland **********

Basic Wet Pond Volume (91% Exceedance): 25273. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 37910. cu-ft

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 1904.38
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

***********Compliance Point Results *************

Scenario Predeveloped Compliance Link: Facility Location
Scenario Postdeveloped Compliance Link: CS-G Constructed Wetland

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.323	2-Year	1.472
5-Year	0.568	5-Year	1.989
10-Year	0.809	10-Year	2.388
25-Year	1.131	25-Year	2.624
50-Year	1.403	50-Year	3.075
100-Year	1.426	100-Year	3.229
200-Year	1.431	200-Year	3.360

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%): 1164.4% FAIL
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%): 6457.8% FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 99999.0% FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%): 100.0% FAIL

POND FAILS ONE OR MORE DURATION DESIGN CRITERIA: FAIL

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.09
Program License Number: 200210003
Run Date: 10/29/2012 11:46 AM

Input File Name: CS-H Swale_ICP.FLD
Project Name: CS-H Swale
Analysis Title: ICP Design
Comments: Marine Drive I/C 30% Design. CS-01 Outfall, Columbia Slough Watershed

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Timeseries Selected
Climatic Region Number: 19

Full Period of Record Available used for Routing
Precipitation Station : 97004005 Vancouver 40 in_5min 10/01/1939-10/01/2060
Evaporation Station : 971040 Vancouver 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********************** WATERSHED DEFINITION ***********************

----------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Predeveloped Target Condition ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.800
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.000
Subbasin Total	0.800

---------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Post Target ----------

	-------Area(Acres) --------
Till Forest	0.000
Till Pasture	0.000
Till Grass	0.000
Outwash Forest	0.000
Outwash Pasture	0.000
Outwash Grass	0.000
Wetland	0.000
Green Roof	0.000
User 2	0.000
Impervious	0.800
Subbasin Total	0.800

**************************** LINK DATA *******************************

----------------------SCENARIO: PREDEVELOPED
Number of Links: 1

--
Link Name: Facility Location
Link Type: Copy
Downstream Link: None

**************************** LINK DATA *******************************

----------------------SCENARIO: POSTDEVELOPED
Number of Links: 1

--
Link Name: CS-H Biofiltration Swale
Link Type: Copy
Downstream Link: None

**********************FLOOD FREQUENCY AND DURATION STATISTICS*******************

---------------------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 1

---------------------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1
Number of Links: 1

***********Water Quality Facility Data *************

---------------------SCENARIO: PREDEVELOPED

Number of Links: 1

********** Link: Facility Location **********

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 127.22
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

---------------------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: CS-H Biofiltration Swale **********

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.11 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.06 cfs

Infiltration/Filtration Statistics--------------------
Total Runoff Volume (ac-ft): 275.25
Total Runoff Infiltrated (ac-ft): 0.00, 0.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Percent Treated (Infiltrated+Filtered)/Total Volume: 0.00%

***********Compliance Point Results *************

Scenario Predeveloped Compliance Link: Facility Location
Scenario Postdeveloped Compliance Link: CS-H Biofiltration Swale

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	0.061	2-Year	0.293
5-Year	0.130	5-Year	0.388
10-Year	0.179	10-Year	0.465
25-Year	0.257	25-Year	0.589
50-Year	0.354	50-Year	0.693
100-Year	0.400	100-Year	0.829
200-Year	0.435	200-Year	0.884

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance According to Dept. of Ecology Criteria ******

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	2404.5%	FAIL
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	11969.1%	FAIL
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	99999.0%	FAIL
Percent Excursion from Q2 to Q50 (Must be less than 50%):	100.0%	FAIL

POND FAILS ONE OR MORE DURATION DESIGN CRITERIA: FAIL

APPENDIX B-2

BMPs Design

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Oregon

ICP Design
CS-B (Outfall XX)

DESIGN WORKSHEET FOR CONSTRUCTED WETLANDS

PROJECT:	Columbia River Crossing
BASIN:	Columbia Slough
OUTFALL:	
LOCATION\JURISDICTION:	ODOT
TREATMENT FACILITY:	Constructed Wetland
FACILITY NAME:	CS-B
ORIGINAL DESIGN DATE:	7/1/2012 apprx
UPDATED:	10/29/2012
DESIGNED BY:	C. Sourek
CHECKED BY:	L. Line

Parameter		Units	Comments
Preliminary Data Collection			
Contributing Impervious Area, CIA	4.70	acres	
	204732	sq-ft	Delineated with CAD software, 10/2012
Water Quality Volume, WQV	22840	cu-ft	Calculated in MGSFlood with a 1-hour timestep (basic wet pond volume, 91% exceedance), includes facility surface area
Total Water Volume, VT	25465	cu-ft	VT = V1 + V2 + V3; should meet or exceed WQV
Uppermost Layer of Facility Dimensions			
Top of Facility			
Total Top Width, W	90	ft	Primary input
Total Top Length, L	200	ft	Primary input
Total Top Surface Area, B	18000	sq-ft	= Total Top Length * Total Top Width
Top Elevation	24.5	ft	From contours/proposed surfaces
At Water Surface			
Upland/Dry Side Slope, Z1	3	:1	maximum 3:1 *[LIDA Handbook; pg. 51]*
Freeboard Depth	1.0	ft	80% of WQV *[Low Impact Development Approaches (LIDA) Handbook; pg. 51]*
Total Water Surface Width, W1	84	ft	= Total Top Width - (2 * Upland Side Slope * Freeboard Depth)
Total Water Surface Length, L1	194	ft	= Total Top Length - (2 * Upland Side Slope * Freeboard Depth)
Total Water Surface Area, B1	16296	sq-ft	= W1 * L1
Total Water Surface Area	0.37	acres	
Water Surface Elevation	23.5	ft	= Top Elevation - Freeboard Depth
At Berm			
Wet Side Slope, Z3	5	:1	maximum 5:1 *[LIDA Handbook; pg. 51]*
Berm Width	12	ft	per requirements????
Water Depth Above Berm, h1	1	ft	per requirements????
Width (approx), W2	74	ft	= W1 - (2 * Z3 * h1)
Length (approx), L2	184	ft	= L1 - (2 * Z3 * h1)
Surface Area, B2	13616	sq-ft	= L1 * W1
Berm Elevation	23	ft	= Top Elevation - Freeboard Depth
Overall			
Volume of Water Above the Berm, V1	14936	cu-ft	frustum volume = (h/3) * (B1 + B2 + √B2*B1) *[ODOT Hydraulics Manual; Equation 12-16]*
Amended Soils Depth	1	ft	12 inch minimum *[LIDA Handbook; pg. 53]*
Forebay Design			
Ideal Forebay Volume	4568	cu-ft	20% of WQV [Low Impact Development Approaches (LIDA) Handbook; pg. 51]
Actual Forebay Volume, VF	6213	cu-ft	= V2 + % of V1 as determine by (L2f + 1/2 of berm width) / L2; Should meet or exceed Ideal Forebay Volume
Calculated Volume, V2	3128	cu-ft	frustum volume = (h2/3) * (B2f + B3f + √B2fB3f); does not include volume above the berm *[ODOT Hydraulics Manual; Equation 12-16]*
At Water Surface			
Forebay Water Surface Width, W1f	84	ft	= W1
Forebay Water Surface Length, L1f	40	ft	=Whatever makes L3f min of 4 ft OR {= 0.1 * L1}; Use goal seek to determine by setting L3f to 4; Adjust to obtain desired relative volumes
Forebay Water Surface Area, B1f	1630	sq-ft	10% of Total Surface Area *[LIDA Handbook; pg. 51]*
At Berm			
Width (approx), W2f	74	ft	= W2
Length (approx), L2f	29	ft	= L2 - (Z1 * h1) - (0.5 * Berm Width)
Surface Area at Berm, B2f	2146	sq-ft	= W2f * L2f
Pond Bottom			
Depth Below Berm, h2	3	ft	
Forebay Side Slope, Z2	4	:1	H:V
Berm Side Slope, Zbf	4	:1	H:V
Elevation	20	ft	= Berm Elevation - h2
Width (approx), W3f	50	ft	= W2 - (2 * Z3 * h2)
Length (approx), L3f	5	ft	= L2f - (Z3 * h2) - (Z2f * h2); Min 4 ft; Use Goal Seek to determine by changing L1f
Bottom Area, B3f	250	sq-ft	= W3f * L3f
Permenant Pool Design			
Calculated Volume, V3	7400	cu-ft	V3 = 2Va + Vb + Vc + 2Vd (see notes)
At Water Surface			
Pool Water Surface Width, W1p	84	ft	= W1
Pool Water Surface Length, L1p	154	ft	= L1 - L1f OR {= 0.9 * L1}
At Berm			
Width (approx), W2p	74	ft	= W2
Length (approx), L2p	143	ft	= L1p - (Z1 * h1) - (0.5 * Berm Width)
Surface Area at Berm, B2p	10582	sq-ft	= W2p * L2p
Pond Bottom			
Max Depth Below Berm, h3	1.5	ft	maximum 2.5 ft *[LIDA Handbook; pg. 52]*
Pool Side Slope, Z3	5	:1	maximum 5:1 *[LIDA Handbook; pg. 51]*
Berm Side Slope, Zbp	5	:1	H:V
Elevation	21.0	ft	= Berm Elevation - h3
Width (approx), W3p	59	ft	= W2p - (2 * Z3 * h3)
Length (approx), L3p	128	ft	= L2p - (Z3 * h3) - (Zbp * h3)
Bottom Area, B3	7552	sq-ft	= W3p * L3p
Volumes - Permenant Pool volumes were calculated assuming a sloped bottom (from the berm top to the pool bottom). The volume was modeled and calculated by slicing the pool into 6 simpler shapes. The volumes for those shapes were calculated and combined to determine overall volume. This is an assumption. Actual pool volume will depend on contours and pooling areas within the main pool.			
Va	508	cu-ft	Pyramid, V = {(1/3) * Z3 * $h3^2$} * (L2p - Z3*h3)
Vb	5996	cu-ft	Prism, V = (1/2) * h3 * (L2p - Z3*h3) * (W2p - 2*Z3*h3)
Vc	332	cu-ft	Prism, V = Z3 * $h3^2$ * {(1/2)*W2p - Z3*h3}
Vd	28	cu-ft	Pyramid, V = {(1/3) * $Z3^2$ * $h3^3$}

Notes:

(yellow)	Denotes input required
(blue)	Goal Seek to Determine Values
(green)	Match equations to Forebay WS Length, L1f, if necessary

Geometry per Cleanwater Services recommendations
Sizing parameters per ???? ODOT???? CRC ???

DESIGN WORKSHEET FOR BIOFILTRATION SWALES

PROJECT:	Columbia River Crossing	29-Oct	Prepared by: C. Sourek
BASIN:	Columbia Slough		Checked by: L.Line
OUTFALL:			
LOCATION\JURISDICTION:	ODOT		
TREATMENT FACILITY:	Biofiltration Swale(s)		
FACILITY NAME:	CS-C		

Parameter		Units	Comments
Preliminary Steps (P) from WSDOT HRM November 2011, pg 5-41			
Impervious Area A	87,120	sq ft	
	2.00	acre	Delineated in Cad dgn file
Water Quality Design Storm Depth, P	2.09	in	2yr-24hr (45.6387° N, 122.6615° W) *[NOAA Atlas 2, Precipitation Frequency Data Output]*
Runoff Treatment Design Flow Rate, Q_{wq}	0.16	cfs	Cont. Model in MGSFlood; P-1; includes swale surface area
$P_{(72\%\text{-}2yr)}$	1.50	in	72% of the 2yr-24hr precipitation depth (6month-24hr precip can be used instead) *[HRM pg. 5-44]*
k	3.71		= $2.5*P_{(72\%\text{-}2yr)}$ - 0.052 (for off-line bioswales in western WA) *[HRM pg 5-44]*
Biofiltration Design Flow Rate, Q_{biofil}	0.60	cfs	= $k*Q_{wq}$; P-2
Longitudinal Slope, s	1.5	%	Recommended 1.5-5.0%; P-3 *[HRM Table RT.04.2]*
	0.015	ft/ft	
Manning "n"	0.35		Assuming surface roughening features, n=0.35; P-4 *[HRM Table RT.04.1]*
Design Steps (D) from WSDOT HRM November 2011, pg 5-44 thru 5-48			
Design Depth, y	4	in	Assuming infrequent mowing; D-1 *[HRM Table RT.04.2]*
	0.33	ft	
Treatment Area side slope, z	4	:1	per WSDOT maintenance request 25Nov08, Trapezoidal channel; D-2
Cross-Sectional Area, A	2.68	sq ft	= (b + zy)*y; D-4 *[HRM Table RT.04.5]*
Wetted Perimeter, P	9.45	ft	= $b + 2y*(1+z^2)^{0.5}$ *[HRM Table RT.04.5]*
Hydraulic Radius, R	0.28		= A / P *[HRM Table RT.04.5]*
= $(Q_{biofil}*n) / (1.49s^{0.5})$	1.15		Goal Seek to = $AR^{0.67}$ by changing Q_{wq}; *[HRM Equation RT.04-1]*
= $AR^{0.67}$	1.15		Goal Seek to = $(Q_{biofil}*n) / (1.49s^{0.5})$ by changing b; D-3, Method 1 *[HRM Equation RT.04-1]*
Bottom Width, b	6.7	ft	
Actual Bottom Width, b	7.0	ft	2-10 ft *[HRM Table RT.04.2]*
Residence Time, t	9.00	min	For basic biofiltration swales *[HRM pg 5-49]*
Velocity, V_{biofil}	0.22	fps	= Q_{biofil} / A, Max 1.0fps; D-5 *[HRM Equation RT.04-2]*
Swale Length , L	120.5	ft	= V_{biofil} * t * 60(sec/min); D-6
Actual Swale Length, L	121.0	ft	Min 100ft [*HRM Table RT.04.2]*
Top Width, T	9.36	ft	= B + 2yz *[HRM Table.04.5]*
Number of Flow Spreaders	4		If b > 6ft recommended flow spreader every 50 ft plus one at inlet *[HRM pg 5-56]*
Freeboard	1.0	ft	Min 1.0ft *[HRM Table RT.04.2]*
Total Swale Depth	1.33	ft	Freeboard plus Design Depth, y
Actual Top Width	17	ft	includes Freeboard
Actual Top Length	132	ft	includes Freeboard
Minimum Area Required	2,101	sq ft	
	0.05	acre	
Access Road Width	12.0	ft	*[Figure RT.04.1]*
Total Area Required	3,553	sq ft	Access Road Width added to Actual Top Width - access road running parallel to swale length
	0.08	acre	
NRCS Hydrologic Soil Group	B		
Underdrain Required	NO		*[Figure RT.04.3]*
Energy Dissipater Required	NO		*[HRM-Design Site Elements, pg. 5-56]*
Parallel Swales Required	NO		*[Table RT.04.2; comment 2]*
If parallel swales are required			
Swale Width	n/a	ft	
Swale Length	n/a	ft	
Water Surface Width	n/a	ft	
Water Surface Length	n/a	ft	
Actual Top Width	n/a	ft	both swales and assuming 2ft divider width
Actual Top Length	n/a	ft	
Total Area Required	n/a	ac	

Oregon

ICP Design
CS-D (Outfall XX)

DESIGN WORKSHEET FOR CONSTRUCTED WETLANDS

PROJECT:	Columbia River Crossing
BASIN:	Columbia Slough
OUTFALL:	
LOCATION\JURISDICTION:	ODOT
TREATMENT FACILITY:	Constructed Wetland
FACILITY NAME:	CS-D
ORIGINAL DESIGN DATE:	7/1/2012 apprx
UPDATED:	10/29/2012
DESIGNED BY:	C. Sourek
CHECKED BY:	L. Line

Parameter		Units	Comments
Preliminary Data Collection			
Contributing Impervious Area, CIA	2.30	acres	
	100188	sq-ft	Delineated with CAD software, 10/2012
Water Quality Volume, WQV	11263	cu-ft	Calculated in MGSFlood with a 1-hour timestep (basic wet pond volume, 91% exceedance), includes facility surface area
Total Water Volume, VT	11735	cu-ft	VT = V1 + V2 + V3; should meet or exceed WQV
Uppermost Layer of Facility Dimensions			
Top of Facility			
Total Top Width, W	50	ft	Primary input
Total Top Length, L	200	ft	Primary input
Total Top Surface Area, B	10000	sq-ft	= Total Top Length * Total Top Width
Top Elevation	36.5	ft	From contours/proposed surfaces
At Water Surface			
Upland/Dry Side Slope, Z1	3	:1	maximum 3:1 *[LIDA Handbook; pg. 51]*
Freeboard Depth	1.0	ft	80% of WQV *[Low Impact Development Approaches (LIDA) Handbook; pg. 51]*
Total Water Surface Width, W1	44	ft	= Total Top Width - (2 * Upland Side Slope * Freeboard Depth)
Total Water Surface Length, L1	194	ft	= Total Top Length - (2 * Upland Side Slope * Freeboard Depth)
Total Water Surface Area, B1	8536	sq-ft	= W1 * L1
Total Water Surface Area	0.20	acres	
Water Surface Elevation	35.5	ft	= Top Elevation - Freeboard Depth
At Berm			
Wet Side Slope, Z3	5	:1	maximum 5:1 *[LIDA Handbook; pg. 51]*
Berm Width	12	ft	per requirements????
Water Depth Above Berm, h1	1	ft	per requirements????
Width (approx), W2	34	ft	= W1 - (2 * Z3 * h1)
Length (approx), L2	184	ft	= L1 - (2 * Z3 * h1)
Surface Area, B2	6256	sq-ft	= L1 * W1
Berm Elevation	35	ft	= Top Elevation - Freeboard Depth
Overall			
Volume of Water Above the Berm, V1	7367	cu-ft	frustum volume = (h/3) * (B1 + B2 + vB2*B1) *[ODOT Hydraulics Manual; Equation 12-16]*
Amended Soils Depth	1	ft	12 inch minimum *[LIDA Handbook; pg. 53]*
Forebay Design			
Ideal Forebay Volume	2253	cu-ft	20% of WQV [Low Impact Development Approaches (LIDA) Handbook; pg. 51]
Actual Forebay Volume, VF	2779	cu-ft	= V2 + % of V1 as determine by (L2f + 1/2 of berm width) / L2; Should meet or exceed Ideal Forebay Volume
Calculated Volume, V2	1258	cu-ft	frustum volume = (h2/3) * (B2f + B3f + vB2fB3f); does not include volume above the berm *[ODOT Hydraulics Manual; Equation 12-16]*
At Water Surface			
Forebay Water Surface Width, W1f	44	ft	= W1
Forebay Water Surface Length, L1f	40	ft	=Whatever makes L3f min of 4 ft OR {= 0.1 * L1}; Use goal seek to determine by setting L3f to 4; Adjust to obtain desired relative volumes
Forebay Water Surface Area, B1f	854	sq-ft	10% of Total Surface Area *[LIDA Handbook; pg. 51]*
At Berm			
Width (approx), W2f	34	ft	= W2
Length (approx), L2f	29	ft	= L2 - (Z1 * h1) - (0.5 * Berm Width)
Surface Area at Berm, B2f	986	sq-ft	= W2f * L2f
Pond Bottom			
Depth Below Berm, h2	3	ft	
Forebay Side Slope, Z2	4	:1	H:V
Berm Side Slope, Zbf	4	:1	H:V
Elevation	32	ft	= Berm Elevation - h2
Width (approx), W3f	10	ft	= W2 - (2 * Z3 * h2)
Length (approx), L3f	5	ft	= L2f - (Z3 * h2) - (Z2f * h2); Min 4 ft; Use Goal Seek to determine by changing L1f
Bottom Area, B3f	50	sq-ft	= W3f * L3f
Permenant Pool Design			
Calculated Volume, V3	3110	cu-ft	V3 = 2Va + Vb + Vc + 2Vd (see notes)
At Water Surface			
Pool Water Surface Width, W1p	44	ft	= W1
Pool Water Surface Length, L1p	154	ft	= L1 - L1f OR {= 0.9 * L1}
At Berm			
Width (approx), W2p	34	ft	= W2
Length (approx), L2p	143	ft	= L1p - (Z1 * h1) - (0.5 * Berm Width)
Surface Area at Berm, B2p	4862	sq-ft	= W2p * L2p
Pond Bottom			
Max Depth Below Berm, h3	1.5	ft	maximum 2.5 ft *[LIDA Handbook; pg. 52]*
Pool Side Slope, Z3	5	:1	maximum 5:1 *[LIDA Handbook; pg. 51]*
Berm Side Slope, Zbp	5	:1	H:V
Elevation	33.0	ft	= Berm Elevation - h3
Width (approx), W3p	19	ft	= W2p - (2 * Z3 * h3)
Length (approx), L3p	128	ft	= L2p - (Z3 * h3) - (Zbp * h3)
Bottom Area, B3	2432	sq-ft	= W3p * L3p
Volumes - Permenant Pool volumes were calculated assuming a sloped bottom (from the berm top to the pool bottom). The volume was modeled and calculated by slicing the pool into 6 simpler shapes. The volumes for those shapes were calculated and combined to determine overall volume. This is an assumption. Actual pool volume will depend on contours and pooling areas within the main pool.			
Va	508	cu-ft	Pyramid, $V = \{(1/3) * Z3 * h3^2\} * (L2p - Z3*h3)$
Vb	1931	cu-ft	Prism, V = (1/2) * h3 * (L2p - Z3*h3) * (W2p - 2*Z3*h3)
Vc	107	cu-ft	Prism, $V = Z3 * h3^2 * \{(1/2)*W2p - Z3*h3\}$
Vd	28	cu-ft	Pyramid, $V = \{(1/3) * Z3^2 * h3^3\}$

Notes:

(yellow)	Denotes input required
(blue)	Goal Seek to Determine Values
(green)	Match equations to Forebay WS Length, L1f, if necessary

Geometry per Cleanwater Services recommendations
Sizing parameters per ???? ODOT???? CRC ???

Oregon

ICP Design
CS-ICP-E (Outfall XX)

DESIGN WORKSHEET FOR CONSTRUCTED WETLANDS

PROJECT:	Columbia River Crossing
BASIN:	Columbia Slough
OUTFALL:	
LOCATION\JURISDICTION:	ODOT
TREATMENT FACILITY:	Constructed Wetland
FACILITY NAME:	CS-ICP-E
ORIGINAL DESIGN DATE:	7/1/2012 apprx
UPDATED:	10/29/2012
DESIGNED BY:	C. Sourek
CHECKED BY:	L. Line

Parameter		Units	Comments
Preliminary Data Collection			
Contributing Impervious Area, CIA	11.60	acres	
	505296	sq-ft	Delineated with CAD software, 10/2012
Water Quality Volume, WQV	55907	cu-ft	Calculated in MGSFlood with a 1-hour timestep (basic wet pond volume, 91% exceedance), includes facility surface area
Total Water Volume, VT	58489	cu-ft	VT = V1 + V2 + V3; should meet or exceed WQV
Uppermost Layer of Facility Dimensions			
Top of Facility			
Total Top Width, W	130	ft	Primary input
Total Top Length, L	290	ft	Primary input
Total Top Surface Area, B	37700	sq-ft	= Total Top Length * Total Top Width
Top Elevation	26.5	ft	From contours/proposed surfaces
At Water Surface			
Upland/Dry Side Slope, Z1	3	:1	maximum 3:1 *[LIDA Handbook; pg. 51]*
Freeboard Depth	1.0	ft	80% of WQV *[Low Impact Development Approaches (LIDA) Handbook; pg. 51]*
Total Water Surface Width, W1	124	ft	= Total Top Width - (2 * Upland Side Slope * Freeboard Depth)
Total Water Surface Length, L1	284	ft	= Total Top Length - (2 * Upland Side Slope * Freeboard Depth)
Total Water Surface Area, B1	35216	sq-ft	= W1 * L1
Total Water Surface Area	0.81	acres	
Water Surface Elevation	25.5	ft	= Top Elevation - Freeboard Depth
At Berm			
Wet Side Slope, Z3	5	:1	maximum 5:1 *[LIDA Handbook; pg. 51]*
Berm Width	12	ft	per requirements????
Water Depth Above Berm, h1	1	ft	per requirements????
Width (approx), W2	114	ft	= W1 - (2 * Z3 * h1)
Length (approx), L2	274	ft	= L1 - (2 * Z3 * h1)
Surface Area, B2	31236	sq-ft	= L1 * W1
Berm Elevation	25	ft	= Top Elevation - Freeboard Depth
Overall			
Volume of Water Above the Berm, V1	33206	cu-ft	frustum volume = (h/3) * (B1 + B2 + √B2*B1) *[ODOT Hydraulics Manual; Equation 12-16]*
Amended Soils Depth	1	ft	12 inch minimum *[LIDA Handbook; pg. 53]*
Forebay Design			
Ideal Forebay Volume	11181	cu-ft	20% of WQV [Low Impact Development Approaches (LIDA) Handbook; pg. 51]
Actual Forebay Volume, VF	11855	cu-ft	= V2 + % of V1 as determine by (L2f + 1/2 of berm width) / L2; Should meet or exceed Ideal Forebay Volume
Calculated Volume, V2	6644	cu-ft	frustum volume = (h2/3) * (B2f + B3f + √B2fB3f); does not include volume above the berm *[ODOT Hydraulics Manual; Equation 12-16]*
At Water Surface			
Forebay Water Surface Width, W1f	124	ft	= W1
Forebay Water Surface Length, L1f	45	ft	=Whatever makes L3f min of 4 ft OR {= 0.1 * L1}; Use goal seek to determine by setting L3f to 4; Adjust to obtain desired relative volumes
Forebay Water Surface Area, B1f	3522	sq-ft	10% of Total Surface Area *[LIDA Handbook; pg. 51]*
At Berm			
Width (approx), W2f	114	ft	= W2
Length (approx), L2f	34	ft	= L2 - (Z1 * h1) - (0.5 * Berm Width)
Surface Area at Berm, B2f	3876	sq-ft	= W2f * L2f
Pond Bottom			
Depth Below Berm, h2	3	ft	
Forebay Side Slope, Z2	4	:1	H:V
Berm Side Slope, Zbf	4	:1	H:V
Elevation	22	ft	= Berm Elevation - h2
Width (approx), W3f	90	ft	= W2 - (2 * Z3 * h2)
Length (approx), L3f	10	ft	= L2f - (Z3 * h2) - (Z2f * h2); Min 4 ft; Use Goal Seek to determine by changing L1f
Bottom Area, B3f	900	sq-ft	= W3f * L3f
Permenant Pool Design			
Calculated Volume, V3	18639	cu-ft	V3 = 2Va + Vb + Vc + 2Vd (see notes)
At Water Surface			
Pool Water Surface Width, W1p	124	ft	= W1
Pool Water Surface Length, L1p	239	ft	= L1 - L1f OR {= 0.9 * L1}
At Berm			
Width (approx), W2p	114	ft	= W2
Length (approx), L2p	228	ft	= L1p - (Z1 * h1) - (0.5 * Berm Width)
Surface Area at Berm, B2p	25992	sq-ft	= W2p * L2p
Pond Bottom			
Max Depth Below Berm, h3	1.5	ft	maximum 2.5 ft *[LIDA Handbook; pg. 52]*
Pool Side Slope, Z3	5	:1	maximum 5:1 *[LIDA Handbook; pg. 51]*
Berm Side Slope, Zbp	5	:1	H:V
Elevation	23.0	ft	= Berm Elevation - h3
Width (approx), W3p	99	ft	= W2p - (2 * Z3 * h3)
Length (approx), L3p	213	ft	= L2p - (Z3 * h3) - (Zbp * h3)
Bottom Area, B3	21087	sq-ft	= W3p * L3p
Volumes - Permenant Pool volumes were calculated assuming a sloped bottom (from the berm top to the pool bottom). The volume was modeled and calculated by slicing the pool into 6 simpler shapes. The volumes for those shapes were calculated and combined to determine overall volume. This is an assumption. Actual pool volume will depend on contours and pooling areas within the main pool.			
Va	827	cu-ft	Pyramid, V = {(1/3) * Z3 * $h3^2$} * (L2p - Z3*h3)
Vb	16372	cu-ft	Prism, V = (1/2) * h3 * (L2p - Z3*h3) * (W2p - 2*Z3*h3)
Vc	557	cu-ft	Prism, V = Z3 * $h3^2$ * {(1/2)*W2p - Z3*h3}
Vd	28	cu-ft	Pyramid, V = {(1/3) * $Z3^2$ * $h3^3$}

Notes:

(yellow)	Denotes input required
(blue)	Goal Seek to Determine Values
(green)	Match equations to Forebay WS Length, L1f, if necessary

Geometry per Cleanwater Services recommendations
Sizing parameters per ???? ODOT???? CRC ???

DESIGN WORKSHEET FOR BIOFILTRATION SWALES

PROJECT: Columbia River Crossing — 29-Oct — Prepared by: C. Sourek
BASIN: Columbia Slough — Checked by: L.Line
OUTFALL:
LOCATION\JURISDICTION: ODOT
TREATMENT FACILITY: Biofiltration Swale(s)
FACILITY NAME: CS-F

Parameter		Units	Comments
Preliminary Steps (P) from WSDOT HRM November 2011, pg 5-41			
Impervious Area A	65,340	sq ft	
	1.50	acre	Delineated in Cad dgn file
Water Quality Design Storm Depth, P	2.09	in	2yr-24hr (45.6387° N, 122.6615° W) *[NOAA Atlas 2, Precipitation Frequency Data Output]*
Runoff Treatment Design Flow Rate, Q_{wq}	0.12	cfs	Cont. Model in MGSFlood; P-1; includes swale surface area
$P_{(72\%-2yr)}$	1.50	in	72% of the 2yr-24hr precipitation depth (6month-24hr precip can be used instead) *[HRM pg. 5-44]*
k	3.71		= 2.5*$P_{(72\%-2yr)}$ - 0.052 (for off-line bioswales in western WA) *[HRM pg 5-44]*
Biofiltration Design Flow Rate, Q_{biofil}	0.45	cfs	= k*Q_{wq}; P-2
Longitudinal Slope, s	1.5	%	Recommended 1.5-5.0%; P-3 *[HRM Table RT.04.2]*
	0.015	ft/ft	
Manning "n"	0.35		Assuming surface roughening features, n=0.35; P-4 *[HRM Table RT.04.1]*
Design Steps (D) from WSDOT HRM November 2011, pg 5-44 thru 5-48			
Design Depth, y	4	in	Assuming infrequent mowing; D-1 *[HRM Table RT.04.2]*
	0.33	ft	
Treatment Area side slope, z	4	:1	per WSDOT maintenance request 25Nov08, Trapezoidal channel; D-2
Cross-Sectional Area, A	2.04	sq ft	= (b + zy)*y; D-4 *[HRM Table RT.04.5]*
Wetted Perimeter, P	7.54	ft	= b + 2y*$(1+z^2)^{0.5}$ *[HRM Table RT.04.5]*
Hydraulic Radius, R	0.27		= A / P *[HRM Table RT.04.5]*
= $(Q_{biofil}*n) / (1.49s^{0.5})$	0.85		Goal Seek to = $AR^{0.67}$ by changing Q_{wq}; *[HRM Equation RT.04-1]*
= $AR^{0.67}$	0.85		Goal Seek to = $(Q_{biofil}*n) / (1.49s^{0.5})$ by changing b; D-3, Method 1 *[HRM Equation RT.04-1]*
Bottom Width, b	4.8	ft	
Actual Bottom Width, b	5.0	ft	2-10 ft *[HRM Table RT.04.2]*
Residence Time, t	9.00	min	For basic biofiltration swales *[HRM pg 5-49]*
Velocity, V_{biofil}	0.22	fps	= Q_{biofil} / A, Max 1.0fps; D-5 *[HRM Equation RT.04-2]*
Swale Length , L	117.8	ft	= V_{biofil} * t * 60(sec/min); D-6
Actual Swale Length, L	118.0	ft	Min 100ft [*HRM Table RT.04.2]*
Top Width, T	7.45	ft	= B + 2yz *[HRM Table.04.5]*
Number of Flow Spreaders	0		If b > 6ft recommended flow spreader every 50 ft plus one at inlet *[HRM pg 5-56]*
Freeboard	1.0	ft	Min 1.0ft *[HRM Table RT.04.2]*
Total Swale Depth	1.33	ft	Freeboard plus Design Depth, y
Actual Top Width	15	ft	includes Freeboard
Actual Top Length	129	ft	includes Freeboard
Minimum Area Required	1,824	sq ft	
	0.04	acre	
Access Road Width	12.0	ft	*[Figure RT.04.1]*
Total Area Required	3,240	sq ft	Access Road Width added to Actual Top Width - access road running parallel to swale length
	0.07	acre	
NRCS Hydrologic Soil Group	B		
Underdrain Required	NO		*[Figure RT.04.3]*
Energy Dissipater Required	NO		*[HRM-Design Site Elements, pg. 5-56]*
Parallel Swales Required	NO		*[Table RT.04.2; comment 2]*
If parallel swales are required			
Swale Width	n/a	ft	
Swale Length	n/a	ft	
Water Surface Width	n/a	ft	
Water Surface Length	n/a	ft	
Actual Top Width	n/a	ft	both swales and assuming 2ft divider width
Actual Top Length	n/a	ft	
Total Area Required	n/a	ac	

Oregon

ICP Design
CS-G (Outfall XX)

DESIGN WORKSHEET FOR CONSTRUCTED WETLANDS

PROJECT:	Columbia River Crossing	
BASIN:	Columbia Slough	
OUTFALL:		
LOCATION\JURISDICTION:	ODOT	
TREATMENT FACILITY:	Constructed Wetland	
FACILITY NAME:	CS-G	
ORIGINAL DESIGN DATE:	7/1/2012	apprx
UPDATED:	10/29/2012	
DESIGNED BY:	C. Sourek	
CHECKED BY:	L. Line	

Parameter		Units	Comments
Preliminary Data Collection			
Contributing Impervious Area, CIA	5.20	acres	
	226512	sq-ft	Delineated with CAD software, 10/2012
Water Quality Volume, WQV	25273	cu-ft	Calculated in MGSFlood with a 1-hour timestep (basic wet pond volume, 91% exceedance), includes facility surface area
Total Water Volume, VT	28079	cu-ft	VT = V1 + V2 + V3; should meet or exceed WQV
Uppermost Layer of Facility Dimensions			
Top of Facility			
Total Top Width, W	90	ft	Primary input
Total Top Length, L	220	ft	Primary input
Total Top Surface Area, B	19800	sq-ft	= Total Top Length * Total Top Width
Top Elevation	27.0	ft	From contours/proposed surfaces
At Water Surface			
Upland/Dry Side Slope, Z1	3	:1	maximum 3:1 *[LIDA Handbook; pg. 51]*
Freeboard Depth	1.0	ft	80% of WQV *[Low Impact Development Approaches (LIDA) Handbook; pg. 51]*
Total Water Surface Width, W1	84	ft	= Total Top Width - (2 * Upland Side Slope * Freeboard Depth)
Total Water Surface Length, L1	214	ft	= Total Top Length - (2 * Upland Side Slope * Freeboard Depth)
Total Water Surface Area, B1	17976	sq-ft	= W1 * L1
Total Water Surface Area	0.41	acres	
Water Surface Elevation	26.0	ft	= Top Elevation - Freeboard Depth
At Berm			
Wet Side Slope, Z3	5	:1	maximum 5:1 *[LIDA Handbook; pg. 51]*
Berm Width	12	ft	per requirements????
Water Depth Above Berm, h1	1	ft	per requirements????
Width (approx), W2	74	ft	= W1 - (2 * Z3 * h1)
Length (approx), L2	204	ft	= L1 - (2 * Z3 * h1)
Surface Area, B2	15096	sq-ft	= L1 * W1
Berm Elevation	25	ft	= Top Elevation - Freeboard Depth
Overall			
Volume of Water Above the Berm, V1	16515	cu-ft	frustum volume = (h/3) * (B1 + B2 + vB2*B1) *[ODOT Hydraulics Manual; Equation 12-16]*
Amended Soils Depth	1	ft	12 inch minimum *[LIDA Handbook; pg. 53]*
Forebay Design			
Ideal Forebay Volume	5055	cu-ft	20% of WQV [Low Impact Development Approaches (LIDA) Handbook; pg. 51]
Actual Forebay Volume, VF	6205	cu-ft	= V2 + % of V1 as determine by (L2f + 1/2 of berm width) / L2; Should meet or exceed Ideal Forebay Volume
Calculated Volume, V2	3128	cu-ft	frustum volume = (h2/3) * (B2f + B3f + vB2fB3f); does not include volume above the berm *[ODOT Hydraulics Manual; Equation 12-16]*
At Water Surface			
Forebay Water Surface Width, W1f	84	ft	= W1
Forebay Water Surface Length, L1f	40	ft	=Whatever makes L3f min of 4 ft OR {= 0.1 * L1}; Use goal seek to determine by setting L3f to 4; Adjust to obtain desired relative volumes
Forebay Water Surface Area, B1f	1798	sq-ft	10% of Total Surface Area *[LIDA Handbook; pg. 51]*
At Berm			
Width (approx), W2f	74	ft	= W2
Length (approx), L2f	29	ft	= L2 - (Z1 * h1) - (0.5 * Berm Width)
Surface Area at Berm, B2f	2146	sq-ft	= W2f * L2f
Pond Bottom			
Depth Below Berm, h2	3	ft	
Forebay Side Slope, Z2	4	:1	H:V
Berm Side Slope, Zbf	4	:1	H:V
Elevation	22	ft	= Berm Elevation - h2
Width (approx), W3f	50	ft	= W2 - (2 * Z3 * h2)
Length (approx), L3f	5	ft	= L2f - (Z3 * h2) - (Z2f * h2); Min 4 ft; Use Goal Seek to determine by changing L1f
Bottom Area, B3f	250	sq-ft	= W3f * L3f
Permenant Pool Design			
Calculated Volume, V3	8435	cu-ft	V3 = 2Va + Vb + Vc + 2Vd (see notes)
At Water Surface			
Pool Water Surface Width, W1p	84	ft	= W1
Pool Water Surface Length, L1p	174	ft	= L1 - L1f OR {= 0.9 * L1}
At Berm			
Width (approx), W2p	74	ft	= W2
Length (approx), L2p	163	ft	= L1p - (Z1 * h1) - (0.5 * Berm Width)
Surface Area at Berm, B2p	12062	sq-ft	= W2p * L2p
Pond Bottom			
Max Depth Below Berm, h3	1.5	ft	maximum 2.5 ft *[LIDA Handbook; pg. 52]*
Pool Side Slope, Z3	5	:1	maximum 5:1 *[LIDA Handbook; pg. 51]*
Berm Side Slope, Zbp	5	:1	H:V
Elevation	23.5	ft	= Berm Elevation - h3
Width (approx), W3p	59	ft	= W2p - (2 * Z3 * h3)
Length (approx), L3p	148	ft	= L2p - (Z3 * h3) - (Zbp * h3)
Bottom Area, B3	8732	sq-ft	= W3p * L3p
Volumes - Permenant Pool volumes were calculated assuming a sloped bottom (from the berm top to the pool bottom). The volume was modeled and calculated by slicing the pool into 6 simpler shapes. The volumes for those shapes were calculated and combined to determine overall volume. This is an assumption. Actual pool volume will depend on contours and pooling areas within the main pool.			
Va	583	cu-ft	Pyramid, V = {(1/3) * Z3 * $h3^2$} * (L2p - Z3*h3)
Vb	6881	cu-ft	Prism, V = (1/2) * h3 * (L2p - Z3*h3) * (W2p - 2*Z3*h3)
Vc	332	cu-ft	Prism, V = Z3 * $h3^2$ * {(1/2)*W2p - Z3*h3}
Vd	28	cu-ft	Pyramid, V = {(1/3) * $Z3^2$ * $h3^3$}

Notes:

(yellow)	Denotes input required
(blue)	Goal Seek to Determine Values
(green)	Match equations to Forebay WS Length, L1f, if necessary

Geometry per Cleanwater Services recommendations
Sizing parameters per ???? ODOT???? CRC ???

DESIGN WORKSHEET FOR BIOFILTRATION SWALES

PROJECT:	Columbia River Crossing	29-Oct	Prepared by: C. Sourek
BASIN:	Columbia Slough		Checked by: L.Line
OUTFALL:			
LOCATION\JURISDICTION:	ODOT		
TREATMENT FACILITY:	Biofiltration Swale(s)		
FACILITY NAME:	CS-H		

Parameter		Units	Comments
Preliminary teps P from D o ember pg			
Impervious Area A	34,848	sq ft	
	0.80	acre	Delineated in Cad dgn file
Water Quality Design Storm Depth, P	2.09	in	2yr-24hr (45.6387° N, 122.6615° W) *[OAA Atlas 2 recipitation requency Data Output]*
Runoff Treatment Design Flow Rate, Q_{wq}	0.06	cfs	Cont. Model in MGSFlood; P-1; includes swale surface area
$P_{(72\%-2yr)}$	1.50	in	72% of the 2yr-24hr precipitation depth (6month-24hr precip can be used instead) *[H M pg. 5-]*
k	3.71		= 2.5*$P_{(72\%-2yr)}$ - 0.052 (for off-line bioswales in western WA) *[H M pg 5-]*
Biofiltration Design Flow Rate, Q_{biofil}	0.24	cfs	= k*Q_{wq}; P-2
Longitudinal Slope, s	1.5	%	Recommended 1.5-5.0%; P-3 *[H M Table T. .2]*
	0.015	ft/ft	
Manning "n"	0.35		Assuming surface roughening features, n=0.35; P-4 *[H M Table T. .1]*
Design teps D from D o ember pg t r			
Design Depth, y	4	in	Assuming infrequent mowing; D-1 *[H M Table T. .2]*
	0.33	ft	
Treatment Area side slope, z	4	:1	per WSDOT maintenance request 25Nov08, Trapezoidal channel; D-2
Cross-Sectional Area, A	1.20	sq ft	= (b + zy)*y; D-4 *[H M Table T. .5]*
Wetted Perimeter, P	5.01	ft	= b + 2y*$(1+z^2)^{0.5}$ *[H M Table T. .5]*
Hydraulic Radius, R	0.24		= A / P *[H M Table T. .5]*
= (Q_{biofil}*n) / ($1.49s^{0.5}$)	0.46		Goal Seek to = $AR^{0.67}$ by changing Q_{wq}; *[H M Equation T. -1]*
= $AR^{0.67}$	0.46		Goal Seek to = (Q_{biofil}*n) / ($1.49s^{0.5}$) by changing b; D-3, Method 1 *[H M Equation T. -1]*
Bottom Width, b	2.3	ft	
Actual Bottom Width, b	3.0	ft	2-10 ft *[H M Table T. .2]*
Residence Time, t	9.00	min	For basic biofiltration swales *[H M pg 5-]*
Velocity, V_{biofil}	0.20	fps	= Q_{biofil} / A, Max 1.0fps; D-5 *[H M Equation T. -2]*
Swale Length , L	106.9	ft	= V_{biofil} * t * 60(sec/min); D-6
Actual Swale Length, L	107.0	ft	Min 100ft *[H M Table T. .2]*
Top Width, T	4.93	ft	= B + 2yz *[H M Table. .5]*
Number of Flow Spreaders	0		If b > 6ft recommended flow spreader every 50 ft plus one at inlet *[H M pg 5-56]*
Freeboard	1.0	ft	Min 1.0ft *[H M Table T. .2]*
Total Swale Depth	1.33	ft	Freeboard plus Design Depth, y
Actual Top Width	13	ft	includes Freeboard
Actual Top Length	118	ft	includes Freeboard
Minimum Area Required	1,384	sq ft	
	0.03	acre	
Access Road Width	12.0	ft	*[igure T. .1]*
Total Area Required	2,668	sq ft	Access Road Width added to Actual Top Width - access road running parallel to swale length
	0.06	acre	
NRCS Hydrologic Soil Group	B		
Underdrain Required	NO		*[igure T. .3]*
Energy Dissipater Required	NO		*[H M-Design ite Elements pg. 5-56]*
Parallel Swales Required	NO		*[Table T. .2; comment 2]*
f parallel s ales are re ire			
Swale Width	n/a	ft	
Swale Length	n/a	ft	
Water Surface Width	n/a	ft	
Water Surface Length	n/a	ft	
Actual Top Width	n/a	ft	both swales and assuming 2ft divider width
Actual Top Length	n/a	ft	
Total Area Required	n/a	ac	

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APPENDIX B-3

Inlet Spreadsheets

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INLET SPACING - CURB AND GUTTER SPREADSHEET (ENGLISH UNITS)

Areas Draining to Stormwater Facility:
CS-C

(Located at NE quadrant of VC I/C)

Tc =	5.00	Design Storm	Inlets	10-year
C =	0.90		Low points	50-year
I =	2.18			
m=	4.92	Zd Allowable	>45mph & sag	Shldr+2ft
n=	0.506		<45	Shldr
Allowable Zd=	Shldr Width		Local	1/2 Lane+shldr
Mannings n		0.015	Max d @ Trvl	0.12 inches

Project Name:	CRC
Project #:	
S.R.:	5
Designed By:	L.Line
Date:	18-Aug-11
Updated:	

CS-C

Station	Rim Elev	Distance		Shldr Width	Area	Δ Q	Σ Q	Slope L	Super T	G.W.	G.L.	d	Z_d	Q_{bp}**	Vcontinuous**	Vside**
De-5N																
101+46.35	37.97	-------------		-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	
100+04.21	37.13	142.14		4.00	0.1178	0.230	0.230	0.006	0.035	1.67	0.78	0.11	3.14	0.03	1.48	1.30
97+67.99	33.01	236.22		4.00	0.2040	0.400	0.428	0.017	0.020	1.67	0.78	0.09	4.50	0.12	2.48	1.95

****FOR LAST GRATE ON RUN OF GUTTER, IF SPREADSHEET SHOWS A VALUE FOR Vside, CHECK Vside AND Qbp (COLUMN S) FOR COMPLIANCE. OTHERWISE, CHECK Vcontinuous AND Qbp (COLUMN L) FOR COMPLIAN**

PLEASE REPORT ANY PROBLEMS TO WSDOT HQ HYDRAULICS OFFICE. SPREADSHEET IS PROTECTED BUT DOES NOT REQUIRE A PASSWORD TO UNPROTECT.

E_o	R_s	E	Q_i	Q_{bp**}	Z_d Check	Velocity Check	Q_{bp} Check	Comments (L/R)
-------------	-------------	-------------	-------------		-------------	-------------	-------------	
0.87	0.08	0.88	0.20	0.03	Zd ALLOWABLE > Zd DESIGN	VELOCITY < 5 FT/SEC	Qbp < 0.1 CFS	
0.71	0.02	0.72	0.31	0.12	NEED TO DECREASE Zd	VELOCITY < 5 FT/SEC	NEED TO REDUCE Qbp	

CE.

INLET SPACING - CURB AND GUTTER SPREADSHEET (ENGLISH UNITS)

Areas Draining to Stormwater Facility:
CS-C

(Located at NE quadrant of VC I/C)

Tc =	5.00	Design Storm	Inlets	10-year
C =	0.90		Low points	50-year
I =	2.18			
m=	4.92	Zd Allowable	>45mph & sag	Shldr+2ft
n=	0.506		<45	Shldr
Allowable Zd=	Shldr Width		Local	1/2 Lane+shldr
Mannings n		0.015	Max d @ Trvl	0.12 inches

Project Name: CRC
Project #:
S.R.: 5
Designed By: L.Line
Date: 18-Aug-11
Updated:

CS-C

Station	Rim Elev	Distance		Shldr Width	Area	Δ Q	Σ Q	Slope L	Super T	G.W.	G.L.	d	Z_d	Q_{bp}**	Vcontinuous**	Vside**
5N-MDw																
113+67.78	59.23	-------------		-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	
113+14.52	57.47	53.26		8.00	0.0677	0.130	0.130	0.033	0.020	1.67	0.78	0.05	2.50	0.01	2.21	
113+14.52	56.32	58.00		4.00	0.3143	0.620	0.627	0.020	0.020	1.67	0.78	0.10	5.00	0.21	2.98	2.23
111+02.66	48.83	211.86		4.00	0.2091	0.410	0.618	0.015	0.001	1.67	0.78	0.03	60.00	0.57	0.91	0.86
111+02.66	48.83	32.50		8.00	0.0000	0.000	0.572	0.025	0.000	1.67	0.78	0.02	50.00	0.52	1.51	
109+02.66	41.24	200.00		8.00	0.1509	0.300	0.822	0.038	0.020	1.67	0.78	0.10	5.00	0.28	3.91	
106+17.11	36.40	285.55		8.00	0.1885	0.370	0.648	0.017	0.020	1.67	0.78	0.11	5.50	0.25	2.58	2.20
105+17.06	35.54	100.05		8.00	0.1697	0.330	0.572	0.009	0.040	1.67	0.78	0.15	3.75	0.12	2.33	1.92
102+99.76	34.73	217.30		8.00	0.1469	0.290	0.550	0.004	0.040	3.34	1.78	0.18	4.50	0.01	1.41	1.43
97+71.26	37.40	-------------		-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	
99+62.84	35.65	191.58		8.00	0.1207	0.240	0.240	0.009	0.020	1.67	0.78	0.08	4.00	0.06	1.73	1.30
102+99.76	34.73	336.92		8.00	0.2279	0.450	0.504	0.003	0.040	1.67	0.78	0.18	4.50	0.15	1.46	1.23

****FOR LAST GRATE ON RUN OF GUTTER, IF SPREADSHEET SHOWS A VALUE FOR Vside, CHECK Vside AND Qbp (COLUMN S) FOR COMPLIANCE. OTHERWISE, CHECK Vcontinuous AND Qbp (COLUMN L) FOR COMPLIAN**

PLEASE REPORT ANY PROBLEMS TO WSDOT HQ HYDRAULICS OFFICE. SPREADSHEET IS PROTECTED BUT DOES NOT REQUIRE A PASSWORD TO UNPROTECT.

E_o	R_s	E	Q_i	Q_{bp}**	Z_d Check	Velocity Check	Q_{bp} Check	Comments (L/R)
-------------	-------------	-------------	-------------		-------------	-------------	-------------	
					Zd ALLOWABLE > Zd DESIGN	VELOCITY < 5 FT/SEC		
0.66	0.02	0.67	0.42	0.21	NEED TO DECREASE Zd	VELOCITY < 5 FT/SEC		
0.07	0.00	0.07	0.05	0.57	NEED TO DECREASE Zd	VELOCITY < 5 FT/SEC		
					NEED TO DECREASE Zd	VELOCITY < 5 FT/SEC		
					Zd ALLOWABLE > Zd DESIGN	VELOCITY < 5 FT/SEC		
0.62	0.02	0.63	0.41	0.24	Zd ALLOWABLE > Zd DESIGN	VELOCITY < 5 FT/SEC		
0.79	0.04	0.80	0.46	0.11	Zd ALLOWABLE > Zd DESIGN	VELOCITY < 5 FT/SEC		
0.97	0.34	0.98	0.54	0.01	Zd ALLOWABLE > Zd DESIGN	VELOCITY < 5 FT/SEC		
-------------	-------------	-------------	-------------		-------------	-------------	-------------	
0.76	0.04	0.77	0.19	0.05	Zd ALLOWABLE > Zd DESIGN	VELOCITY < 5 FT/SEC	Qbp < 0.1 CFS	
0.71	0.09	0.74	0.37	0.13	Zd ALLOWABLE > Zd DESIGN	VELOCITY < 5 FT/SEC	NEED TO REDUCE Qbp	

CE.