Maximum/Minimum Soil Forces

Max Axial Soil Force	0.1141E+04	Kip	1	0	2
Min Axial Soil Force	-0.1793E+03	Kip	1	0	3
Max Lateral Force in X dir	0.2537E+03	Kip	1	0	4
Min Lateral Force in X dir	-0.5825E+02	Kip	1	0	4
Max Lateral Force in Y dir	0.4012E+03	Kip	1	0	2
Min Lateral Force in Y dir	-0.5953E+02	Kip	1	0	4
Max Torsional Soil Force	0.1049E+04	Kip-ft	1	0	2

Maximum/Minimum Pile Displacements

Max Axial Displacement	0.3590E+00	in	1	0	2
Min Axial Displacement	-0.8189E-01	in	1	0	3
Max Displacement in X	0.4654E+00	in	1	0	3
Min Displacement in X	-0.1215E-01	in	1	0	1
Max Displacement in Y	0.2461E+00	in	1	0	2
Min Displacement in Y	-0.9171E-02	in	1	0	4

Maximum/Minimum Column Forces

	Value		Load	Comb.	Column
Max Axial Force	0.0000E+00	Kip	0	0	0
Min Axial Force	0.0000E+00	Kip	0	0	0
Max Shear in 2 Direction	0.0000E+00	Kip	0	0	0
Min Shear in 2 Direction	0.0000E+00	Kip	0	0	0
Max Shear in 3 Direction	0.0000E+00	Kip	0	0	0
Min Shear in 3 Direction	0.0000E+00	Kip	0	0	0
Max Moment about 2 Axis	0.0000E+00	Kip-ft	0	0	0
Min Moment about 2 Axis	0.0000E+00	Kip-ft	0	0	0
Max Moment about 3 Axis	0.0000E+00	Kip-ft	0	0	1
Min Moment about 3 Axis	0.0000E+00	Kip-ft	0	0	0
Absolute Max Torque	0.1000E+06	Kip-ft	1	0	0

Maximum/Minimum Pier Cap Forces

Max Axial Force	0.0000E+00	Kip	0	0
Min Axial Force	0.0000E+00	Kip	0	0
Max Shear in 2 Direction	0.0000E+00	Kip	0	0
Min Shear in 2 Direction	0.0000E+00	Kip	0	0
Max Shear in 3 Direction	0.0000E+00	Kip	0	0
Min Shear in 3 Direction	0.0000E+00	Kip	0	0
Max Torque	-0.1000E+06	Kip-ft	1	0
Min Torque	0.0000E+00	Kip-ft	0	0
Max Moment about 2 Axis	0.0000E+00	Kip-ft	0	0
Min Moment about 2 Axis	0.0000E+00	Kip-ft	0	0
Max Moment about 3 Axis	0.0000E+00	Kip-ft	0	0
Min Moment about 3 Axis	0.0000E+00	Kip-ft	0	0

****
Foundation Flexibilty for given loads
****

Averaged flexiblity

	Fx	Fy	Fz	Mx	My	Mz
DeltaX	0.9880E-04	0.9227E-06	-0.1928E-05	0.4201E-08	-0.7257E-07	0.6737E-08
DeltaY	0.9227E-06	0.4456E-04	-0.6233E-06	0.3549E-08	-0.3665E-08	-0.1699E-09
DeltaZ	-0.1928E-05	-0.6233E-06	0.1561E-04	-0.3011E-08	0.7096E-08	-0.5843E-09
ThetaX	0.4201E-08	0.3549E-08	-0.3011E-08	0.1036E-09	-0.1608E-10	0.3564E-11
ThetaY	-0.7257E-07	-0.3665E-08	0.7096E-08	-0.1608E-10	0.5268E-09	-0.1531E-11
ThetaZ	0.6737E-08	-0.1699E-09	-0.5843E-09	0.3564E-11	-0.1531E-11	0.3602E-09

****
Foundation Stiffness for given loads
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STIFFNESS

	DeltaX	DeltaY	DeltaZ	ThetaX	ThetaY	ThetaZ
Fx	0.1129E+05	-0.8368E+02	0.6469E+03	-0.1902E+06	0.1539E+07	-0.2016E+06
Fy	-0.8368E+02	0.2252E+05	0.6969E+03	-0.7311E+06	0.1135E+06	0.2103E+05
Fz	0.6469E+03	0.6969E+03	0.6482E+05	0.1719E+07	-0.7264E+06	0.7327E+05
Mx	-0.1902E+06	-0.7311E+06	0.1719E+07	0.9779E+10	0.2437E+09	-0.8972E+08
My	0.1539E+07	0.1135E+06	-0.7264E+06	0.2437E+09	0.2128E+10	-0.2328E+08
Mz	-0.2016E+06	0.2103E+05	0.7327E+05	-0.8972E+08	-0.2328E+08	0.2781E+10

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Foundation Stiffness in STANDARD X-Y-Z directions

BSI FB-MultiPier - File: P8-LCS.out
(FB-Pier->Stardard, X->X, Y->Z & -Z->Y)
Translations: kips/in   Rotations: kip-in/rad

Wednesday, March 23, 2011

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Stiffness in standard X-Y-Z

	DeltaX	DeltaY	DeltaZ	ThetaX	ThetaY	ThetaZ
Fx	0.1129E+05	-0.6469E+03	-0.8368E+02	-0.1902E+06	0.2016E+06	0.1539E+07
Fy	-0.6469E+03	0.6482E+05	-0.6969E+03	-0.1719E+07	0.7327E+05	0.7264E+06
Fz	-0.8368E+02	-0.6969E+03	0.2252E+05	-0.7311E+06	-0.2103E+05	0.1135E+06
Mx	-0.1902E+06	-0.1719E+07	-0.7311E+06	0.9779E+10	0.8972E+08	0.2437E+09
My	0.2016E+06	0.7327E+05	-0.2103E+05	0.8972E+08	0.2781E+10	0.2328E+08
Mz	0.1539E+07	0.7264E+06	0.1135E+06	0.2437E+09	0.2328E+08	0.2128E+10

Columbia River CROSSING

Memorandum

January 21, 2011

TO:	Heather Wills
FROM:	Roger Kitchin
SUBJECT:	STORMWATER MANAGEMENT
COPY:	Andrew Beagle; Jeff Heilman

This memorandum presents proposed stormwater management strategies for the Columbia River Crossing (CRC) project. Figure 1 shows the proposed footprint and location of Ruby Junction, the proposed site for the light rail vehicle (LRV) maintenance facility. The memo does not provide an evaluation of the potential impacts from the strategies; these are addressed in the Biological Assessment and Final Environmental Impact Statement (FEIS) Water Quality Technical Report.

Note that all figures are located at the end of this memorandum.

Introduction

Background

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 Oceanic & Atmospheric Administration (NOAA) Fisheries
- U.S. Environmental Protection Agency (EPA)
- Oregon Department of Environmental Quality (DEQ)
- Washington State Department of Ecology (Ecology)
- City of Portland
- City of Vancouver
- City of Gresham (Ruby Junction only)

The state and federal agencies listed above are signatories of the Interstate Collaborative Environmental Process (InterCEP) agreement with the exception of Gresham. 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 collaborative approach is the adoption of the Oregon Department of Transportation's (ODOT) recent technical memorandum on stormwater water quality [1] 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 collaborative venture by ODOT, the Federal Highway Administration (FHWA), and natural resource agencies (NOAA Fisheries, DEQ, U.S. Fish and Wildlife Service, EPA, and the Oregon Department of Fish and Wildlife). The decision to use this

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[1] Stormwater Management Program, Geo-Environmental Bulletin GE09-02(B). Prepared by the Oregon Department of Transportation. January 27, 2009.

approach on the CRC project has been endorsed by the Washington State Department of Transportation (WSDOT) and Ecology.

The water management strategies presented in this report are based on the Option A full build presented in the FEIS. This option includes:

- Rebuilding and resurfaced approximately 6 miles of Interstate 5 (I-5) between Victory Boulevard interchange in Portland and the Main Street interchange in Vancouver.
- Rebuilding the Victory Boulevard, Marine Drive, Hayden Island, SR 14, Mill Plain, Fourth Plain and SR 500 interchanges.
- Replacing the existing highway bridges across the Columbia River by two 10-lane bridges. The structure will also accommodate light rail and bike-pedestrian facilities.
- Extending the existing MAX Yellow Line light rail transit (LRT) from the Portland Metropolitan Exposition Center (Expo) to Clark College in Vancouver.
- Improvements to bike-pedestrian facilities and local streets. Street improvements include an arterial connection across North Portland Harbor, between Hayden Island and the Marine Drive interchange area. The arterial lanes would be located on the LRT bridge.
- Expanding the maintenance facilities at the existing TriMet facility in the City of Gresham, the design of which is being performed by TriMet.

A discussion is also included for the anticipated differences should Option B or a phased approach be adopted. Option B does not have arterial lanes on the LRT bridge across North Portland Harbor, but instead provides direct access between Marine Drive and Hayden Island with collector-distributor lanes on two new bridges that would be built adjacent to I-5. A phased approach, which could be adopted for either option, would defer construction of part of the Victory Boulevard and Marine Drive interchanges, and most of the SR 500 interchange.

Should these assumptions change, the project team will revisit and revise strategies as necessary to meet project requirements.

Stormwater Management Goals

The CRC project is a bi-state initiative and it is important to note that the implementation of water management objectives differ significantly between Oregon and Washington. The primary differences involve how areas that require pollutant reduction are calculated. These differences, which are described in the following paragraphs, can have an impact of the sizes of water quality facility required, especially for projects like the CRC that involve significant areas of impervious pavement.

Oregon requires runoff from the entire contributing impervious area (CIA) be treated to reduce pollutants regardless of the degree to which the surfaces would contribute pollutants to runoff. Using this approach, runoff from highways would be required to be treated in the same manner as runoff from bike-pedestrian paths. In contrast, Washington focuses on requiring treatment for runoff from the pollutant-generating impervious surfaces (PGIS).

ODOT defines the CIA as consisting of all impervious surfaces within the strict project limits, plus impervious surface owned or operated by ODOT outside the project limits that drain to the project via direct flow or discrete conveyance.[2] NOAA Fisheries has expanded this definition to also include impervious areas that are not owned by ODOT but drain onto the project footprint.

WSDOT and Ecology define PGIS as surfaces that are considered a significant source of pollutants in stormwater runoff including:

- Highways, ramps and non-vegetated shoulders
- LRT guideway subject to vehicular traffic
- streets, alleys and driveways
- bus layover facilities, surface parking lots and the top floor of parking structures

[2] http://www.oregon.gov/ODOT/HWY/GEOENVIRONMENTAL/storm_management_program_cia.shtml

The following types of impervious area are considered non-PGIS:

- LRT guideway not subject to vehicular traffic except the occasional use by emergency or maintenance vehicles (referred to as an exclusive guideway)
- LRT stations
- bicycle and pedestrian paths

Exclusive LRT guideway is considered non-PGIS because light rail vehicles are electric, and that other potential sources of pollution such as bearings and gears are sealed to prevent the loss of lubricants. Light rail vehicle braking is almost exclusively accomplished via (power) regenerative braking, which avoids any friction or wear on the vehicle brake pads and, thus, very few pollutants are generated. In Washington, NOAA Fisheries and U.S. Fish and Wildlife concurred with Sound Transit's conclusion that this type of guideway was non-polluting and, as such, the runoff did not require treatment before being discharged to the receiving waterbody[3]. In Oregon, runoff from this area would require treatment before being released.

In addition, Washington differentiates between stormwater runoff treatment requirements for new and rebuilt[4] versus resurfaced[5] pavement while state and local jurisdictions in Oregon do not. In Washington, water quality treatment is only required for runoff from new and rebuilt PGIS while Oregon does not differentiate; requiring treatment for all impervious surfaces. However, this approach is not consistently applied within Oregon. For example, the Standard Local Operating Procedures for Endangered Species (SLOPES IV)[6], a programmatic biological opinion and incidental take statement by NOAA Fisheries for projects undertaken in Oregon by the U.S. Army Corps of Engineers states that "actions that merely resurface pavement by placing a new surface, or overlay, directly on top of existing pavement with no intervening base course and no change in the subgrade shoulder points, are not subject to these [pollution reduction and flow control] requirements". Regardless, NOAA Fisheries has determined that resurfaced pavement within a project cannot be handled differently from rebuilt pavement unless the resurfacing is conducted within a "hydrologically isolated basin"[7] even though the potential impediments to retrofitting water quality facilities for resurfaced pavement are the same whether the resurfacing is a stand-alone undertaking or within a larger project. These impediments include very limited or non-existent ability to change existing conveyance systems and possible lack of physical space to install a water quality facility.

Since the early stages of development, the overall permanent stormwater management objectives for the CRC project have been:

1) Provide flow control for new and replaced impervious areas in accordance with state and local requirements. Note that flow control is only required for stormwater discharges to Burnt Bridge Creek. Discharges to the Columbia Slough, North Portland Harbor, and Columbia River are exempt.
2) Select and provide water quality facilities for new and rebuilt existing PGIS in accordance with the most restrictive requirements of the agencies that have authority over the drainage area being considered.
3) Where practical and cost-effective, provide water quality facilities for resurfaced and existing PGIS.

Flow control is only required for stormwater discharges to Burnt Bridge and Fairview Creeks: discharges to the Columbia Slough, North Portland Harbor and Columbia River are exempt from flow control

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[3] Central Link Light Rail transit Project, Sound Transit Biological Assessment. Prepared by Sound Transit. November 1999.

[4] Rebuilt impervious surfaces are existing impervious areas that are excavated to a depth at or below the top of the subgrade.

[5] Resurfaced impervious surfaces are those existing impervious surfaces where the asphalt or concrete is not removed down to or below the top of the subgrade.

[6] Revisions to Standard Local Operating Procedures for Endangered Species to Administer Maintenance or Improvement of Road, Culvert, Bridge and Utility Line Actions Authorized or Carried Out by the U.S. Army Corps of Engineers in the Oregon (SLOPES IV Roads, Culverts, Bridges and Utility Lines). National Marine Fisheries Service, Northwest Region. August 13, 2008

[7] Email from Devin Simmons dated July 26, 2010.

requirements. Runoff to Burnt Bridge Creek must be reduced to pre-development (forested) conditions for peak discharges between 50 percent of the 2-year event and the 50-year event. For Fairview Creek, which is associated with the Ruby Junction facility and runoff to which would be under the jurisdiction of the City of Gresham, flow control is currently required only to the extent necessary to ensure that existing flows in the creek would not be increased. Gresham, however, is in the process of revising the Public Works Standards[8] to require runoff for storm events with a recurrence interval less than or equal to 25-years be reduced to what would have occurred prior to any development having taken place (for example, forested conditions).

For objectives 2) and 3), the project has agreed to adopt the requirements of NOAA Fisheries for water quality facilities even though, in our opinion, the additional measures are not expected to provide any measurable increase in the level of protection of listed species. These requirements are that the project treats runoff from the entire CIA in both Oregon and Washington regardless of whether it is considered pollutant-generating or whether it is new, rebuilt, resurfaced, or existing.

The sizing and detailed design of individual water quality facilities will be in accordance with the specific requirements of the state or local agency that has jurisdiction over that facility. For example, water quality facilities within the WSDOT right-of-way will be sized and designed in accordance with the WSDOT Highway Runoff Manual. In Oregon, single rainfall events are used to size water quality facilities. ODOT uses rainfall events that would result in about 85 percent of the cumulative runoff being treated while the City of Gresham's and the City of Portland's design rainfall would result in about 80 and 90 percent of the average annual runoff being treated, respectively. In Washington, the types of water quality facility being proposed would be sized to treat at least 91 percent of the runoff volume regardless of where the facility is located. Unlike Oregon, design flows and volumes for water quality facilities in Washington are estimated using continuous rainfall-runoff simulation models. It should be noted that many of the water quality facilities being proposed rely on infiltration as the primary mechanism for treatment and disposal. Depending on the infiltration rates available at a particular site, these facilities could result in an even higher percentage of runoff treatment.

Existing Conditions

Watersheds

Following is a brief description of watersheds within which the project is located and the waterbodies to which runoff would be discharged. From south to north, the waterbodies are Columbia Slough, Columbia River (including North Portland Harbor) and Burnt Bridge Creek. Fairview Creek, which receives runoff from the Ruby Junction facility, is located east of the project corridor. Figures 2 through 4 show the existing drainage systems, watershed boundaries and outfalls within the project corridor. Figure 5 shows the existing Ruby Junction LRT maintenance facility and Fairview Creek.

Table 1 shows the average monthly discharges for each watercourse based on data available from United States Geological Survey (USGS) gauging stations. See Figure 6 for locations (except Fairview Creek). The information provides an indication of the relative size of each waterbody. Note that discharges in Columbia Slough are influenced by backwater effects from the Willamette River to the extent that the recorded mean monthly discharge was actually negative three times in May (1997, 2006 and 2008) and once in June (1960).

Columbia Slough Watershed

Columbia Slough, located south of the CRC project, discharges to the Willamette River. Its watershed[9] is a 51-square-mile area that extends from Kelly Point to the west to Fairview Lake and Fairview Creek to the east, and comprises the former Columbia River floodplain and before the construction of a levee system and pump stations, would have been subjected to frequent inundation. In the vicinity of I-5, the original ground surface is below the ordinary high water (OHW) level for the Columbia River. There are two drainage districts within the project footprint: Peninsula Drainage Districts No.1 and No.2. I-5 is the boundary between the two districts with No.1 located to the west and No.2 to the east. Day-to-day operations of both districts are managed by the Multnomah County Drainage District (MCDD).

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[8] Public Works Standards. Prepared by the Department of Environmental Services, City of Gresham, Oregon. January 1, 2006.

[9] *Draft 2005 Portland Watershed Management Plan.* Bureau of Environmental Services, City of Portland. October 2005.

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.

TABLE 1

Mean Monthly Discharge (in cubic feet per second)

Month	Fairview Creek at Glisan Street (USGS 14211814)	Columbia Slough at Portland (USGS 14211820)	Columbia River at Vancouver (USGS 14144700)	Burnt Bridge Creek near Mouth (USGS 14211902)
January	11	162	156,000	46
February	9.1	151	163,000	53
March	8.6	135	170,000	39
April	6.3	85	204,000	21
May	5.1	29	286,000	19
June	4.0	65	415,000	14
July	2.4	79	291,000	9.1
August	2.0	74	153,000	7.4
September	2.1	63	117,000	7.0
October	3.4	96	116,000	9.8
November	6.5	112	122,000	34
December	10	123	138,000	41

I-5, Marine Drive and Martin Luther King, Jr. (MLK) Boulevard are elevated on embankments or structures and the drainage systems that serve these and roads do not handle runoff from outside the right-of-way. These embankments are also part of the levee system. Surface runoff from the 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. As shown on Figure 7, runoff from the project area drains to a system of sloughs before being discharged to Columbia Slough via the Portland International Raceway (PIR), Schmeer Road or Pen 2 - NE 13th pump station. These pump stations, which are sized to handle the 1 in 100 year runoff, have installed capacities of 19,700, 40,000 and 32,000 gallons per minute, respectively. Note that Marine Drive west of I-5, while within the confines of the levee system, drains to outfalls on North Portland Harbor and is included in the Columbia River South Watershed.

Within the project CIA, there is approximately 42.8 and 1.6 acres of existing PGIS and non-PGIS, respectively. Runoff from about 3 acres (MLK Boulevard and Union Court) of existing PGIS is dispersed and infiltrated. There are no flow control measures for runoff within the project footprint beyond the regulation of discharges to Columbia Slough provided by pump station operation. In addition, there are no engineered water quality facilities except for a manhole sediment trap located at the Victory Boulevard interchange (see Figure 2) that treats runoff from approximately 6 acres of impervious surfaces at the interchange (not within the project footprint).

Columbia River South Watershed

For convenience, the areas draining to the Columbia River are divided into those within Oregon and those within Washington. The Columbia River South Watershed includes the portion of the project area south of North Portland Harbor (a side channel of the Columbia River) that drains to that waterbody, North Portland Harbor Bridge, Hayden Island and the Columbia River Bridges south of the state line (see Figure 2).

Like the Columbia Slough Watershed, the project footprint within this watershed is located in what was part of the Columbia River floodplain. The portion south of North Portland Harbor is protected against flooding by a levee system, while material dredged from the Columbia River has been used to raise the overall ground surface on Hayden Island east of the Burlington Northern Santa Fe Railway (BNSF) railroad tracks above the 1 in 100-year flood elevation.

Land either side of I-5 on Hayden Island is highly developed and comprises service-related businesses such as retail stores and restaurants, and their parking lots.

Similar to the Columbia Slough Watershed, I-5 is elevated on an embankment across Hayden Island. Surface runoff from the I-5 and local roads within the project footprint is generally confined to the roadway surface by continuous concrete barriers or curbs. Except for the North Portland Harbor and Columbia River Bridges, runoff is collected entirely by closed gravity drainage systems with inlets and stormwater pipes that discharge directly to North Portland Harbor or Columbia River. Runoff from the bridges is discharged through scuppers directly to the water surface below. The project CIA within this watershed contains approximately 59.4 and 3.0 acres of existing PGIS and non-PGIS, respectively. There are no flow control measures or engineered water quality facilities.

Columbia River North Watershed

This watershed comprises the project footprint from the state line in the south to the SR 500 interchange in the north. It comprises the current I-5 corridor as well as Vancouver city streets on which the LRT guideway will be located. Existing impervious surfaces in the CIA comprise about 120.7 and 12.2 acres of PGIS and non-PGIS. There are no flow control measures or engineered water quality facilities with the exception of approximately 3 acres of SR 14 from which runoff is dispersed and infiltrated.

Land west of I-5 comprises downtown Vancouver and residential neighborhoods to the north. The area east of I-5 and south of Fourth Plain Boulevard contains the Pearson Airpark and Fort Vancouver Historic Park, both of which are low density. North of Fourth Plain Boulevard, land east of the highway comprises residential development.

Surface runoff from I-5 and local streets is generally confined to the roadway by continuous curbs and concrete barriers, and is collected almost entirely by closed drainage systems. The only exceptions are the Columbia River Bridges and a few ditches adjacent to the highway. These closed systems discharge runoff directly to the Columbia River via outfalls in the vicinity of the existing highway bridges while runoff from the bridges themselves drains through scuppers to the river below. A pump station located southeast of the SR 14 interchange (see Figure 3) discharges runoff from lower lying portions of the interchange to the Columbia River during high river levels.

The vertical grade of I-5 is generally below the surrounding areas and as a result, the drainage system serving the highway also handles runoff from built-up areas outside the highway right-of-way as shown on Figures 3 and 4. These areas, which are extensive, are estimated to comprise over 50 percent of the total drainage area served by this system, and their contribution to flows was an important consideration when developing the approach to stormwater management in this watershed.

Burnt Bridge Creek Watershed

The CIA within this watershed includes the SR 500 interchange and portions of I-5 to the north and SR 500 to the east. Within the project footprint, the CIA includes about 16.2 and 0.3 acres of existing PGIS and non-PGIS, respectively. Residential developments are located south of the SR 500 interchange and there is a school to the northwest of the SR 500 interchange and a park to the northeast.

Typical of an urban environment, surface runoff from the highways and local streets is generally confined to the roadway by continuous curbs and concrete barriers, and is collected almost entirely by closed drainage systems. In contrast to the other watersheds, runoff from the entire PGIS within the project footprint currently contains some form of treatment. Runoff from about 14.5 and 0.2 acres of PGIS and non-PGIS within the project footprint is conveyed to an infiltration pond at the Main Street interchange and the balance is conveyed to a wet pond north of SR 500 (see Figure 4 for both locations).

The infiltration pond would be considered to provide protection for Endangered Species Act (ESA)-listed species that might be found in Burnt Bridge Creek in terms of water quality (dissolved metals reduction) and flow reduction. The primary water quality function of the wet pond, however, is to reduce sediment and, as such, would not provide adequate protection for ESA species. For this reason, runoff from the area served by this pond is not included in this report as receiving water quality treatment.

Fairview Creek Watershed

The project CIA within this watershed comprises the Ruby Junction LRT operations and maintenance facility which would be expanded to meet the needs of the CRC and TriMet's Milwaukie project, both of which are expected to be constructed at about the same time. The expansion will extend the existing maintenance bays and constructing a new LRV storage yard.

Based on information provided by TriMet, runoff from about 1.5 acres comprising the parking area adjacent to the paint/body shop at the south end of the site (adjacent to Fairview Creek) is treated using proprietary cartridge filters before being conveyed to Fairview Creek. Elsewhere, runoff is infiltrated.

Surficial Soils

Figure 8 shows the approximate areal extent of the surficial soils in the vicinity of the project corridor (excluding Ruby Junction). The descriptions below are from the National Resources Conservation Service (NRCS) website.[10]

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[11] indicates that water tables are at a depth of less than one 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. While depths to water table are not provided for the Wind River and Lauren soils[12] north of the Columbia River, borehole logs for property in downtown Vancouver and the recently-constructed Land Bridge across SR 14 indicate that groundwater levels in that area are close to water levels in the Columbia River.

Soils at the Ruby Junction facility comprise the Multnomah-Urban land complex belonging to Hydrologic Group A. While the NRCS soil survey indicates a depth to groundwater in excess of 80 inches, TriMet personnel have advised that the water table is shallow at the south end of the site, adjacent to Fairview Creek.

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 currently recommended for this area. As noted above, soils are variable and future site investigations may reveal locations where infiltration might be feasible.

On Hayden Island, infiltration is not currently proposed even though the soils are classified as being in Hydrologic Group A. Considering the likely depth of any ponds, there may not be adequate separation

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[10] http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

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

[12] Soil Survey of Clark County, Washington. United States Department of Agriculture, Soil Conservation Service, in cooperation with the Washington Agricultural Experiment Station. November 1972.

between the pond invert and groundwater table for treating runoff. The EPA recommends a "significant separation distance (2 to 5 feet) between the bottom of an infiltration basin and seasonal high groundwater table." Recently installed piezometers are being monitored to determine groundwater elevations and their response to changes in Columbia River water levels.

Pending the results of an ongoing investigation program to determine site-specific infiltration rates and groundwater levels at other proposed pond locations, infiltration is considered feasible for highway-related elements of the project north of the Columbia River. Again, underdrains could be provided should the assumed infiltration rate not be achievable and no options exist for expanding the pond. Infiltration, however, is not recommended for the LRT guideway and associated construction in downtown Vancouver because of the presence of building basements and lack of available sites.

Temporary Construction Activities

Without proper management, construction activities could create temporary adverse affects on water quality in nearby water bodies. Adverse impacts could result in the erosion of disturbed areas, and the accidental release of fuels and soluble or water-transportable construction materials.

As shown in Table 2, up to about 415 acres could be disturbed during construction. The table, which shows potential areas of disturbance on a watershed basis, includes all areas within the rights-of-way proposed for the project but does not include potential areas of construction in or over water or additional land that could be required outside the rights-of way for staging or laydown.

While Table 2 includes temporary construction easements and potential staging areas adjacent to the project footprint, it does not include potential casting/fabrication yards and staging areas identified further away from the project. These include two bridge casting/fabrication yard sites adjacent to the Columbia River, a 95-acre parcel at the Port of Vancouver and a 51-acre parcel north of the Portland-Troutdale Airport (Sundial Site), and a 52-acre staging area in the Port of Vancouver. Although these sites have been identified by the project team, construction contractors may elect to use other locations. In such circumstances, the contractor(s) would typically be required to obtain the necessary permits and comply with any conditions attached by regulatory agencies to those permits.

TABLE 2

Areas of Potential Disturbance during Construction

Watershed	Potential Area of Temporary Disturbance
Columbia Slough	105 acres
Columbia River - Oregon	70 acres
Columbia River – Washington	170 acres
Burnt Bridge Creek	55 acres
Fairview Creek	15 acres

National Pollutant Discharge Elimination System (NPDES) Construction Stormwater Discharge Permits will regulate the discharge of stormwater from construction sites. These permits include discharge water quality standards, runoff monitoring requirements, and provision for preparing a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP contains all the elements of a Temporary Erosion and Sediment Plan and Spill Prevention Control and Countermeasures Plan.

The SWPPP and its adoption by construction personnel are essential for ensuring water quality standards are met during construction, and a single, comprehensive plan would ensure project-wide consistency. Contractors would be required to have a certified Erosion and Sediment Control Lead on staff to ensure proper implementation of the SWPPP. In addition, the agency or agencies responsible for providing construction oversight would also have one or more staff assigned to monitor SWPPP implementation.

An SWPPP typically contains the following elements:

1. Project information
2. Existing site conditions.

3. Potential erosion problem areas.
4. Descriptions and drawings of pollution-prevention measures and best management practices (BMP) for:
   - Preserving vegetation
   - Sequence of clearing operations, including limitations on areas cleared at the same time
   - Construction access, including wheel wash facilities
   - Flow control (where required)
   - Sediment control, including check dams, silt fences and sediment ponds
   - Soil stabilization, including temporary seeding
   - Slope protection
   - Existing drain inlet protection
   - Channel and outlet stabilization
   - Pollution control (including spill prevention)
   - Street cleaning
   - Dewatering control
   - BMP maintenance, inspection and monitoring
   - Construction phasing and implementation schedule for BMPs.
5. Compliance assurance procedures and corrective actions in case performance goals are not achieved.
6. Spill response procedures.
7. Engineering calculations.

Water quality standards, which include turbidity and pH, are usually monitored at the point(s) of discharge. There may also be special requirements in addition to turbidity and pH for discharges to since all receiving watercourses are 303(d) listed watercourses.

The selection of construction BMPs is dependent on the specific site layout and sequence of construction activities and, as such, is beyond the scope of this report.

Permanent Water Quality Facilities – Full Build

This section describes the proposed stormwater management plan for constructing Option A full build. There are alternatives still being considered including Option B and deferring construction of parts of the Victory Boulevard, Marine Drive and SR 500 interchanges to a later date (which could be applied to either option). The potential effect of these alternatives on stormwater management is discussed in a subsequent section.

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), North Portland Harbor (a side channel of the Columbia River), Columbia River mainstem, Burnt Bridge Creek, and Fairview Creek. Columbia Slough, North Portland Harbor and the Columbia River 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 (TMDL).

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:

- 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 NOAA Fisheries. Dissolved copper is known to have a detrimental effect on the olfactory senses of young salmonids.

Based on the ODOT memorandum,[13] the following water quality BMPs are effective in reducing sediments, and particulate and dissolved metals; pollutants of concern for ESA-listed species observed in the waterbodies to which stormwater will be discharged:

- **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 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 and convey it to a stormwater conveyance system. When estimating the size of these facilities, an infiltration rate of 1 inch per hour was assumed. If the soils cannot sustain this rate and there is insufficient space to increase the pond size to accommodate a lower value, underdrains would be installed.
- **Constructed Treatment Wetlands** are shallow, permanent, vegetated ponds that function like natural wetlands. They remove pollutants through sedimentation, sorption, biological uptake and microbial activity.
- 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 grassed. They treat runoff by filtration and sorption as runoff flows through the vegetated surface and amended soils. Amended soils, especially compost-amended, is 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.
- Soil-amended **Filter Strips** are intended to treat sheet runoff from an adjacent roadway surface. In a confined urban setting such as the project corridor, opportunities to use this BMP are limited. Similar to grass swales, filter strips treat runoff by filtration and sorption as runoff flows through the vegetated surface and amended soils.
- Bioslopes, like filter strips, are intended to 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. Bioslopes are also known as Ecology Embankments. The percolating runoff flows through a special mixture of materials, including dolomite and gypsum, which promotes the adsorption of pollutants.

These BMPs would be constructed for the sole purpose of improving stormwater runoff quality and infiltration is the preferred method of runoff treatment. 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.

Other water quality approaches, including Dispersal, Drywells 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, Ecology recently approved[14] 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.

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[13] Stormwater Management Program, Geo-Environmental Bulletin GE09-02(B). Prepared by the Oregon Department of Transportation. January 27, 2009.

[14] General Use Level Designation for Basic (TSS), Enhanced, & Oil Treatment & Conditional Use Level Designation for Phosphorus Treatment for Americast's Filterra®. Washington State Department of Ecology. November 2006 (Revised December 2009).

Proposed water management strategies are presented for runoff to outfalls on a watershed basis. As described previously, the strategies present one set of approaches to water management; approaches that might change as design work progresses. They demonstrate the level of stormwater quality improvements that the project would achieve. As design work progresses, the project will identify and evaluate options for low impact development and the use of more localized water quality facilities that treat runoff closer to its source, thereby reducing the size of the stormwater management facilities currently proposed.

The strategies presented rely in part on "as built" information provided by ODOT, WSDOT, and the cities of Portland and Vancouver. While this information has been accepted on an as-is basis, the data is in the process of independently verified through field measurements.

Columbia Slough Watershed

The project footprint in this watershed comprises highway, local street and LRT improvements south of North Portland Harbor. Overall, the project will increase the total CIA in this watershed by approximately 13.6 acres. The increase may be attributed to new local streets and the addition of runoff from new and existing bridges across the North Portland Harbor.

The project will create approximately 51.6 acres of new, rebuilt and resurfaced PGIS and about 4.3 acres of new sidewalk and bike-pedestrian paths. The remaining 2.1 acres comprises the existing bridge over North Portland Harbor: runoff currently drains via scuppers to the water below. While I-5 will generally follow its current alignment and grade, the Marine Drive interchange will be completely rebuilt and will differ significantly from its existing layout.

Table 3 summarizes the impact of the project on CIA and the areas from which runoff will be treated, and the paragraphs following the table describe the individual water quality facilities, the locations of which are shown on Figure 9. Note that the areas shown on the table do not include a potential staging area in the Expo parking lot since construction contractors may elect to use other locations for temporary staging. Regardless, it is likely that this area will be returned to parking after construction.

TABLE 3

Contributing Impervious Areas[a] for Columbia Slough Watershed

Outfall	Water Quality Facility	Impervious Area Draining to Outfall (acres)					
		PGIS			Non-PGIS		Total CIA
		New/Rebuilt	Resurfaced	Existing	New/Rebuilt	Existing	
CS-01	CS-A	0.9					0.9
	Total area treated	0.9					0.9
	Total area untreated						
	Total CIA	0.9					0.9
CS-02	N/A						
	Total area treated						
	Total area untreated	3.4	3.7				7.1
	Total CIA	3.4	3.7				7.1
CS-03	CS-B	5.2					5.2
	Total area treated	5.2					5.2
	Total area untreated						
	Total CIA	5.2					5.2

Outfall	Water Quality Facility	Impervious Area Draining to Outfall (acres)					
		PGIS			Non-PGIS		
		New/Rebuilt	Resurfaced	Existing	New/Rebuilt	Existing	Total CIA
CS-04	CS-C	1.2					1.2
	CS-D	3.1					3.1
	Total area treated	4.3					4.3
	Total area untreated						
	Total CIA	4.3					4.3
CS-05	CS-E	11.7	4.6	1.9		0.2	18.4
	Total area treated	11.7	4.6	1.9		0.2	18.4
	Total area untreated						
	Total CIA	11.7	4.6	1.9		0.2	18.4
CS-06	CS-F	1.6					1.6
	Total area treated	1.6					1.6
	Total area untreated						
	Total CIA	1.6					1.6
CS-07	CS-G	1.4			0.6		2.0
	Total area treated	1.4			0.6		2.0
	Total area untreated						
	Total CIA	1.4			0.6		2.0
Other		14.8			3.7		18.5
	Total area treated	14.8			3.7		18.5
	Total area untreated						
	Total CIA	14.8			3.7		18.5
TOTAL AREA		43.3	8.3	1.9	4.3	0.2	58.0

a Includes the area of impervious surfaces under bridges. Such duplicate areas would not be included when sizing water quality facilities.

As shown in Table 3, no options have been identified to treat runoff from about 7.1 acres of new and resurfaced I-5 pavement immediately north of Victory Boulevard (see Outfall CS-02). The primary issue is that the proximity of the outfall CS-02 to the highway embankment does not leave adequate room to construct a water quality facility such as a bioretention pond or swale, and the acquisition of additional property at this location would introduce 4f issues. It would also be extremely difficult modify the existing stormwater conveyance system and direct runoff to another location where a water quality facility could be constructed. It should be noted that some runoff treatment would take place as runoff flows through Schmeer Slough before being discharged to Columbia Slough via the Schmeer Road Pump Station. The project team will, however, continue to develop and evaluate options to treat runoff from this area.

Flow control is not required for runoff discharged to Columbia Slough and no new outfalls are proposed. The stormwater management plan for this watershed reflects a request by the MCDD to minimize runoff from the project to the Peninsula Drainage District No.2 surface water system to provide greater flexibility for handling increased runoff from a potential redevelopment of the Hayden Meadows race track.

As described earlier, soils in this area are generally poorly drained and, for this reason, the primary BMP proposed for water quality facilities in this watershed is a constructed treatment wetland. 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.

A new conveyance system, constructed as part of the CRC project, will enable some of the runoff that currently flows to the outlet CS-04 to be re-routed to CS-05; most of the runoff being re-routed would be from the I-5 mainline. 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 CRC minimize runoff from the project to the Peninsula Drainage District No.2 surface water system to provide greater flexibility for handling increased runoff from potential redevelopment of the Hayden Meadows race track.

A ballasted LRT track is proposed between the existing Expo station and south end of the combined LRT-arterial bridge across North Portland Harbor. Since the track is pervious, it is not included in Table 3. Perforated underdrains serving existing ballasted track at the Expo station would be extended to collect runoff from the new guideway: the existing track underdrain system discharges to the channel located immediately south of the Expo Center.

Following is a description of the water quality facilities listed in Table 3.

Water Quality Facility CS-A

CS-A would be sized to handle runoff from the south end of the ramp from Marine Drive to southbound I-5. It is a biofiltration swale located south of Victory Boulevard and west of I-5 and outflows would be discharged to Schmeer Slough at outfall CS-01 via an existing or new stormwater pipe located on Victory Boulevard.

Water Quality Facility CS-B

CS-B is a constructed wetland located within the existing loop ramp from MLK Boulevard to Union Court: the ramp will be removed as part of the project. The pond will serve a portion of the realigned MLK Boulevard east of I-5 and south end of the ramp from westbound MLK to northbound I-5. Outflows will be released via an existing City of Portland stormwater pipe to Walker Slough at outfall CS-03.

Water Quality Facility CS-C

The grades are such that it would be difficult to convey about 1.2 acres of the ramp from northbound I-5 to westbound Marine Drive to the water quality facility CS-D described below. A biofiltration swale, CS-C, is proposed to treat runoff from this area, the flows from which would be released to Walker Slough via Outfall CS-04.

Water Quality Facility CS-D

A constructed treatment wetland CS-D is proposed to treat runoff from about 3.1 acres comprising most of the ramp from MLK Boulevard to northbound I-5. Outflows would be discharged to the upstream end of Walker Slough at outfall CS-02.

Water Quality Facility CS-E

This is the largest water quality facility proposed in the Columbia Slough watershed and takes advantage of the relatively open area in the southwest quadrant of the Marine Drive interchange. It would be a constructed wetland sized to treat runoff from approximately 18.4 acres of impervious surface. This area comprises I-5, including approximately 2.1 acres of the existing North Portland Harbor bridges, and ramps on the west side of the highway.

Outflows from the wetland would be released to the drainage channel located immediately south of Expo at outlet CS-03. The channel and associated pump station may need to be enlarged to handle the additional flows: alternatively, the wetland could be enlarged to provide detention storage and reduce peak outflows provided the water balance would still be conducive to the long-term survival of wetland plants.

Water Quality Facility CS-F

The project would construct new connections between MLK Boulevard and Vancouver Way. Runoff from about 1.6 acres of new and resurfaced pavement would be treated at a biofiltration swale, water quality facility CS-F, adjacent to the connection between MLK and Vancouver Way. Flows from the swale areas would drain to the existing City of Portland stormwater conveyance system under Vancouver Way at outlet CS-06. Additional water quality improvements are expected as runoff flows through over 7,000 feet of open channel before being pumped to Columbia Slough via the Pen 2 – NE 13th Pump Station (see Figure 7).

Water Quality Facility CS-G

Runoff from 2.0 acres of impervious surface comprising MLK, the new connection to Union Court and associated sidewalks would be discharged to constructed wetland, CS-E, located between the two roadways. Flows from the wetland would be released to an existing City of Portland conveyance system on Union Court at outlet CS-07 and would be ultimately be pumped to Columbia Slough via the Schmeer Road Pump Station.

Alternatively, the project may elect to shed runoff (or at least part of the runoff) across the each shoulder, as currently happens, where it would infiltrate and/or evaporate.

Other Water Quality Facilities

Following is a summary of the proposed water quality facilities that comprise this category on Table 3:

- Runoff from the new merge lane south of Victory Boulevard (about 0.5 acre) 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.
- Runoff from approximately 16.9 acres of proposed new, rebuilt and existing local streets and contiguous sidewalks within the CIA would be treated using a mix of semi-continuous biofiltration swales 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.

Columbia River South Watershed

The project-related part of the Columbia River watershed in Oregon is comprises Hayden Island and Marine Drive west of I-5. Although this part of Marine Drive is located within the level system protecting the Delta Park area, runoff is discharged to North Portland Harbor via stormwater pipes located under the levee and floodwall.

The existing impervious area within watershed would be increased by approximately 0.2 acre. On Hayden Island, I-5 will start to deviate from its current alignment and profile immediately north of the existing North Portland Harbor bridges, which will be retained. The Hayden Island interchange would be completely rebuilt, local streets will be reconfigured and the LRT guideway will be extended across the island to the proposed new southbound highway bridge across the Columbia River.

Table 4 summarizes the areas from which runoff will be treated, and the paragraphs following the table describe the individual water quality facilities, the locations of which are shown on Figure 9. This watershed includes existing surface parking that may or may not remain after the project has been completed. While it is uncertain at this time how land use in the vicinity of the Hayden Island interchange might change after completion of the CRC project, it has been assumed that land on the west side of the proposed interchange and transit guideway that might be purchased for staging during construction would be converted into transit-oriented development. This land comprises an area of about 10.0 acres west of the project and bounded by the transit guideway, Center Avenue, Hayden Island Drive and Jantzen Drive. Any redevelopment would need to meet ODOT or City of Portland stormwater requirements and, as such, runoff would either be infiltrated or treated before being released to the Columbia River or North Portland Harbor: Table 4 assumes the latter. This is considered to be a reasonable approach as the areas immediately east of I-5 are currently identified as potential sites for water quality facilities.

TABLE 4

Contributing Impervious Areas[a] for Columbia River South Watershed

Outfall	Water Quality Facility	Impervious Area Draining to Outfall (acres)					
		PGIS			Non-PGIS		
		New/Rebuilt	Resurfaced	Existing	New/Rebuilt	Existing	Total CIA
NPH-01	NPH-A	2.5			0.1		2.6
	NPH-B	1.5			1.2		2.7
	Total area treated	4.0			1.3		5.3
	Total area untreated						
	Total CIA	4.0			1.3		5.3
CR-01/02	CR-A	17.5			0.1		17.6
	CR-B	10.4		2.2	1.1	0.2	13.9
	CR-C	2.5			2.4		4.9
	Total area treated	30.4		2.2	3.6	0.2	36.4
	Total area untreated						
	Total CIA	30.4		2.2	3.6	0.2	36.4
Other		18.4			2.5		20.9
	Total area treated	18.4			2.5		20.9
	Total area untreated						
	Total CIA	18.4			2.5		20.9
TOTAL AREA		52.8		2.2	7.4	0.2	62.6

a Includes the area of impervious surfaces under bridges. Such duplicate areas would not be included when sizing water quality facilities.

Flow control is not required for runoff discharged to North Portland Harbor or Columbia River and no new outfalls are proposed. Although soils in this area belong to Hydrologic Group A, the primary BMP proposed for water quality facilities in this watershed is a constructed treatment wetland due to the assumed lack of separation between the bottom of proposed water quality facilities and groundwater table. This assumption will be revisited as more groundwater data becomes available.

Note that between structures, the LRT guideway will be on pervious ballast and, as such, those areas are not included in Table 4.

Following is a description of the water quality facilities listed in Table 4.

Water Quality Facility NPH-A

The grades are such that it would be difficult to convey runoff from Marine Drive west of the proposed bridge over LRT guideway extension to the constructed treatment wetland CS-E (see previous section). It is proposed to convey runoff from 2.6 acres of new pavement and sidewalk to a biofiltration swale, NPH-A, located immediately north of Marine Drive. Outflows from the swale would be released to North Portland Harbor at outlet NPH-01 via an existing City of Portland stormwater system.

Water Quality Facility NPH-B

Water quality facility NPH-B, a constructed wetland, is proposed at the south end of the proposed LRT-arterial bridge across North Portland Harbor. It would be sized to handle runoff from approximately 2.0 acres of impervious surface on the bridge, including 1.2 acres of transit guideway, sidewalk and bike path, and about 0.7 acres comprising a local street immediately west of the south end of the bridge: runoff from the street will drain towards the proposed constructed wetland.

Outflows from the wetland would be conveyed to North Portland Harbor at outlet NPH-01 via an existing City of Portland stormwater pipe under Marine Drive.

Water Quality Facility CR-A

Runoff from about 17.5 acres of new I-5 mainline between Tomahawk Island Drive extension and the high point across the Columbia River, and a portion of Hayden Island Drive east of I-5 would be conveyed to a constructed treatment wetland located along the east side of the interchange. Outflows from the facility would be released to the Columbia River via one of the two existing ODOT outfalls CS-01 or CS-02, both of which are located under the south end of the existing bridges over the Columbia River.

Water Quality Facility CR-B

This water quality facility would be a constructed wetland located east of I-5 and south of the Tomahawk Island Drive extension. It would be sized to handle about 13.9 acres of new ramps and I-5 pavement between North Portland Harbor and Tomahawk Island Drive extension under I-5, the Tomahawk Island Drive extension, and a portion of the realigned Jantzen Drive under I-5. It would also handle runoff from the north half of the existing North Portland Harbor bridges. Proposed grades are such that drainage from Tomahawk Island Drive and Jantzen Drive would need to be pumped to the wetland.

Outflows from the facility would likely be released to the Columbia River via outfall CS-01 or CS-02.

Water Quality Facility CR-C

Runoff from approximately 4.9 acres of impervious pavement, including 1.2 acres each of transit-only structure and bike-pedestrian path, would be conveyed to a constructed wetland located west of I-5 and immediately south of Hayden Island Drive. Outflows from the facility would likely be released to the Columbia River via outfalls CS-01 or CS-02.

Other Water Quality Facilities

Following is a summary of the proposed water quality facilities that comprise this category on Table 4:

- Runoff from approximately 10.5 acres of proposed new, rebuilt and existing local streets and contiguous sidewalks within the CIA would be treated using a mix of semi-continuous biofiltration swales and proprietary systems such as cartridge filters.
- Approximately 10.0 acres of future transit-oriented development has been assumed on the west side of I-5. Runoff would be treated to either ODOT or City of Portland standards.
- Runoff from about 0.4 acres of the bike-pedestrian pathway west of the south end of the transit-arterial bridge over North Portland Harbor will likely be shed to adjacent landscaped areas where it will infiltrate and/or evaporate. This path is physically separated from the street network.

Columbia River North Watershed

This is the largest watershed from the project perspective and comprises the project footprint from the state line in the south to the SR 500 interchange in the north. It includes the current I-5 corridor as well as Vancouver city streets on which the LRT guideway would be located.

From about 6th Street, I-5 will generally follow its existing alignment and grade. The SR 14 and Mill Plain interchanges would be reconfigured and while the Fourth Plain interchanges would be rebuilt, the footprint will be similar to what currently exists. New streets would be constructed at the SR 14 interchange to improve local connections, and the LRT guideway would be constructed primarily along existing streets. In addition, three park and ride structures would be built to serve the extended LRT system. With the exception of the above-grade guideway between 6th Street and new southbound Columbia River Bridge, the LRT track could be subject to use by buses and would not be considered non-polluting. This is a conservative determination, and one that could change should buses be excluded from the guideway.

The project would increase the impervious area within this watershed by approximately 21.1 acres. The total project CIA would be about 154.0 acres of which approximately 112.8 acres would be new, rebuilt and resurfaced PGIS and about 13.3 acres would be new sidewalk and bike-pedestrian paths. The 27.9-acre balance comprises existing impervious areas, mostly city streets, from which runoff would flow onto the project footprint.

Table 5 summarizes the impact of the project on CIA and the areas from which runoff will be treated, and the paragraphs following the table describe the individual water quality facilities, the locations of which are shown on Figures 10 and 11.

TABLE 5

Contributing Impervious Areas[a] for Columbia River North Watershed

Outfall	Water Quality Facility	Impervious Area Draining to Outfall (acres)					
		PGIS			Non-PGIS		Total CIA
		New/Rebuilt	Resurfaced	Existing	New/Rebuilt	Existing	
CR-03	CR-C	16.1	1.6		0.2		17.9
	CR-D	16.5	2.0		0.2		18.7
	CR-E (2)	2.6			0.6		3.2
	CR-G (2)	16.7	3.9	4.1	0.1	0.6	25.4
	CR-H	0.8					0.8
	CR-I	5.3			0.9		6.2
	CR-J	2.9			1.0		3.9
	CR-K	5.3	5.6		0.3		11.2
	CR-L	3.6		9.0	0.4	1.3	14.3
	CR-M	1.7		0.8	0.1		2.6
	Total area treated	71.5	13.1	13.9	3.8	1.9	104.2
	Total area untreated						
	Total CIA	71.5	13.1	13.9	3.8	1.9	104.2
CR-05	CR-F	3.0	0.9				3.9
	Total area treated	3.0	0.9				3.9
	Total area untreated		1.0				1.0
	Total CIA	3.0	1.9				4.9
Other		23.3		9.0	9.5	3.1	44.9
	Total area treated	23.3	-	9.0	9.5	3.1	44.9
	Total area untreated						
	Total CIA	23.3	-	9.0	9.5	3.1	44.9
TOTAL AREA		**97.8**	**15.0**	**22.9**	**13.3**	**5.0**	**154.0**

a Includes the area of impervious surfaces under bridges. Such duplicate areas would not be included when sizing water quality facilities.

Table 5 demonstrates that the project proposes to treat runoff from the entire CIA with exception of about 1.0 acre comprising the eastbound lanes of SR 14. Existing and proposed highway super-elevation at this location will result in runoff draining to catch basins located adjacent to the center median. Since this portion of SR 14 is only being resurfaced, there are very limited opportunities, if any, to reconfigure the conveyance system. In addition, there are no opportunities to construct a biofiltration swale or media drain at the median and no room to provide either a cartridge vault or an end-of-pipe water quality facility: the outfall CR-05 discharges directly into the Columbia River, and the limited distance between the highway and river is occupied by the BNSF railroad embankment and Columbia Way.

New stormwater conveyance systems are proposed for I-5 and associated interchanges. The existing stormwater trunk main serving I-5 also receives runoff from urban areas to the west, none of which is currently treated. The new conveyance systems will allow runoff from the highway and ramps to collected and treated before being released to the stormwater trunk main.

Flow control is not required for runoff discharged to the Columbia River and no new outfalls are proposed. Soils in this area belong to Hydrologic Group B, which are considered suitable for infiltration; an assessment that is confirmed by soils data recently obtained by the project. Therefore, the primary BMP assumed for water quality facilities in this watershed is a biofiltration pond. This assumption may need to be revisited for facilities in the SR 14 interchange area due to the potential presence of a shallow groundwater table. Regardless of infiltration rates, constructed treatment wetlands would not be considered south of Fourth Plain Boulevard because of the proximity to Pearson Airfield. Such facilities would be regarded as hazardous wildlife attractants and could pose a threat to the safety of planes landing or departing from the airfield.[15]

Following is a description of the water quality facilities listed in Table 5.

Water Quality Facility CR-C

- Runoff from about 17.9 acres of southbound I-5 (including 1.6 acres of resurfaced pavement), ramps on the west side of the interchange, and west side of the Evergreen Boulevard bridge over I-5 would be conveyed to this bioretention pond located on the west side of the SR 14 interchange and east of the Main Street extension.

Any overflow from bioretention pond would be released to the Columbia River at outfall CR-03 via the existing stormwater conveyance system.

Water Quality Facility CR-D

- The water quality facility is located within the loop ramps on the east side of the SR 14 interchange. It would be sized to handle runoff from approximately 18.7 acres of northbound I-5 (including 2.0 acres of resurfaced pavement), ramps on the east side of the interchange, and east side of the Evergreen Boulevard bridge over I-5.

Again, any overflow from the bioretention pond would be released to the Columbia River at outfall CR-03 via the existing stormwater conveyance system.

Water Quality Facility CR-E

Runoff from about 3.2 acres of new impervious area on SR 14 and Main Street would be directed to one or two biofiltration swales located adjacent to the intersection of Main Street and SR 14. Outflows would be released to the Columbia River at outfall CR-03 via the existing stormwater conveyance system.

Water Quality Facility CR-F

Runoff from approximate 3.9 acres comprising the new, rebuilt and resurfaced westbound lanes of SR 14 east of the SR 14 interchange would be conveyed to a biofiltration swale located on the north side of the highway, Alternatively, runoff from the resurfaced westbound lanes may be shed to the shoulder where it would be infiltrated, similar to what currently occurs. Outflows from the swale would be conveyed to outfall CS-05 on the Columbia River via an existing 6-foot by 6-foot culvert.

As mentioned in the preamble to this section, project staff have not yet identified any options for treating runoff from the eastbound lanes.

Water Quality Facility CR-G

CR-G comprises two biofiltration ponds proposed in the northeast and southeast quadrants of the reconfigured Mill Plain interchanges. They will be sized to handle runoff from approximately 25.4 acres of new ramps, new, replaced and resurfaced highway, new collector-distributor road to the north, and Mill Plain Blvd to the east would be conveyed to two bioretention ponds located within the interchange footprint.

The contributing area includes about 3.9 acres of resurfaced highway and approximately 4.7 acres of existing pavement and sidewalk on Mill Plain Boulevard east of the project footprint. Runoff from the latter would drain towards the project. Any overflow from the ponds would be conveyed to outfall CR-03 via the existing stormwater conveyance system under I-5.

Water Quality Facility CR-H

Runoff from approximately 0.8 acre of the ramp from southbound I-5 to Mill Plain Boulevard would be directed to a biofiltration swale west of the ramp. Discharge from the swale would be discharged to outfall CR-03 via the existing stormwater trunk main under I-5.

[15] *Hazardous Wildlife Attractants on or near Airports, Advisory Circular 150/5200-33A*. U.S. Department of Transportation, Federal Aviation Administration. July 27, 2004

Water Quality Facility CR-I

Proposed street grade for Mill Plain Boulevard under I-5 is too low to permit runoff from about 6.2 acres to be conveyed to either of the CR-G bioretention ponds. Instead, runoff would be conveyed to proprietary cartridge filter vault and, if necessary, an oil-water separator pre-treatment facility. Based on available data, there appears to be adequate vertical distance between the low point on Mill Plain Boulevard and invert of the existing stormwater conveyance system under I-5 to install this type of facility. Discharge from the vault would be discharged to outfall CR-03 via the existing stormwater trunk main under I-5.

Water Quality Facility CR-J

- Drainage from the top surface of the Clark College Park and Ride and associated paths (about 3.9 acres) would be conveyed to a biofiltration swale located on the east side of the structure. An oil-water separator would pretreat runoff from the park and ride. Outflow from the swale would be conveyed to outfall CR-03 via the existing stormwater conveyance system under I-5.

Water Quality Facility CR-K

- Runoff from about 11.2 acres of I-5 mainline and access road to the Clark College Park and ride (including 5.6 acres of resurfaced highway) would be conveyed to a bioretention pond located in the southeast interchange area. Any overflows from the pond would be conveyed to outfall CR-03 via the existing stormwater conveyance system under I-5.

Water Quality Facility CR-L

- A bioretention pond proposed in the northwest quadrant of the Fourth Plain interchange would be sized to handle runoff from an impervious area of approximately 14.3 acres. This area includes approximately 4.0 acres of new and rebuilt pavement and sidewalk as well as about 10.3 acres of existing streets and sidewalk in the Shumway neighborhood to the northwest of the interchange. Again, any overflows from the pond would be conveyed to outfall CR-03 via the existing stormwater conveyance system under I-5.

Water Quality Facility CR-M

- Runoff from approximately 1.8 acres of new and rebuilt pavement and sidewalk on Fourth Plain Boulevard east of I-5 and about 0.8 acres of existing impervious area further east would be conveyed to a biofiltration swale south of Fourth Plain Boulevard and east of the collector-distributor road. Outflow from the swale would be conveyed to outfall CR-03 via the existing stormwater conveyance system under I-5.

Other Water Quality Facilities

Following is a summary of the proposed water quality facilities that comprise this category on Table 5:

- Runoff from approximately 41.9 acres of proposed LRT guideway, new, rebuilt and existing local streets, and contiguous sidewalks within the CIA would be treated using a mix of semi-continuous biofiltration swales and proprietary systems such as cartridge filters.
- Runoff from about 2.1 acres comprising the top floors of the Columbia Street and Mill District Park and Ride structures will be conveyed to existing City of Vancouver stormwater conveyance systems via proprietary cartridge filter vaults. Pretreatment would be provided using oil-water separators.
- Runoff from about 0.9 acre 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.

Burnt Bridge Creek Watershed

The full-build scenario would provide full connectivity between I-5 and SR 500 through the construction of a new ramp from southbound I-5 to eastbound SR 500 and tunnel from westbound SR 500 to northbound I-5. Available information indicated that it would be feasible to redirect runoff from about 2.2 acres of the existing highway south of 39th Street from the existing infiltration pond at the Main Street interchange (BBC-C) to a new biofiltration pond proposed as part of the CRC project (BBC-B). There are no transit-related facilities proposed in this watershed.

The project would increase the impervious area by approximately 6.6 acres. The total project CIA would be about 23.1 acres of which approximately 20.5 acres would be new, rebuilt and resurfaced PGIS and about 0.7 acre would be new sidewalk and bike-pedestrian paths. The balance comprises an existing portion of SR 500.

Table 6 summarizes the impact of the project on CIA and the areas from which runoff will be treated, and the paragraphs following the table describe the individual water quality facilities, the locations of which are shown on Figure 11. The table demonstrates that the project proposes to treat runoff from the entire CIA.

TABLE 6

Contributing Impervious Areas[a] for Burnt Bridge Creek Watershed

Outfall	Water Quality Facility	Impervious Area Draining to Outfall (acres)					
		PGIS			Non-PGIS		Total CIA
		New/Rebuilt	Resurfaced	Existing	New/Rebuilt	Existing	
BBC-01	BBC-A	2.2	1.2	1.9	0.2		5.5
	BBC-B	2.5	2.3				4.8
	Total area treated	4.7	3.5	1.9	0.2		10.3
	Total area untreated						
	Total CIA	4.7	3.5	1.9	0.2		10.3
BBC-02	BBC-C	5.6	6.7		0.5		12.8
	Total area treated	5.6	6.7		0.5		12.8
	Total area untreated						
	Total CIA	5.6	6.7		0.5		12.8
TOTAL AREA		10.3	10.2	1.9	0.7		23.1

a Includes the area of impervious surfaces under bridges. Such duplicate areas would not be included when sizing water quality facilities.

As stated above, flow control is required for runoff discharged to Burnt Bridge Creek. No new outfalls are proposed. Soils in this area belong to Hydrologic Group B, which are considered suitable for infiltration; an assessment that is confirmed by soils data recently obtained by the project. Therefore, the primary BMP assumed for water quality facilities in this watershed is a biofiltration pond.

Following is a description of the water quality facilities listed in Table 6.

Water Quality Facility BBC-A

Runoff from approximately 3.6 acres of new, rebuilt eastbound lanes of SR 500 and 39th Street, and 1.9 acres of existing westbound lanes that would not be affected by the project would be conveyed to a bioretention pond south of the highway. Overflows from the pond would be conveyed to an existing outfall, BBC-01.

Water Quality Facility BBC-B

Runoff from about 2.5 acres of rebuilt and new pavement and approximately 2.3 acres of resurfaced pavement would be conveyed to a bioretention pond, BBC-B, located immediately east of I-5 and south of 39th Street. Most of the impervious area comprises I-5 that currently drains to the existing infiltration pond (BBC-C) at the Main Street interchange. Overflows from the pond would be conveyed to an existing outfall, BBC-01.

Water Quality Facility BBC-C

BBC-C is the existing infiltration pond at the Main Street interchange. We do not propose to modify this pond since this type of facility is considered to provide an adequate runoff treatment. Although approximately 12.8 acres of new, rebuilt and resurfaced project pavement would be conveyed to this pond, the total impervious area served by it would be decreased by about 2.2 acres as stated above.

Overflows from the pond are released to Burnt Bridge Creek at outfall BBC-02.

Fairview Creek Watershed

TriMet's Ruby Junction operations and maintenance facility, which is located in this watershed, would be expanded to meet the needs of both the CRC and Milwaukie projects. The expansion would comprise extending the existing maintenance bays and constructing a new storage yard. To facilitate construction, property west and south of the existing facility would be acquired and the south end of NW Eleven Mile Avenue would be vacated. The expansion would result in a net reduction in impervious of about 0.5 acre.

The design of the Ruby Junction expansion is being undertaken independently of the CRC. Based on information provided by TriMet, runoff from existing and proposed impervious areas would be infiltrated; there would be no provision for overflow to Fairview Creek, even in the case of an extreme storm event.Although infiltration has been assumed, it should be noted that other methods of water quality treatment may be selected by TriMet. Regardless, the facility will need to comply with the City of Gresham's water quality requirements[16]. Since the receiving watercourse, Fairview Creek, is 303(d) listed and has TMDLs, these requirements would result in a suite of acceptable stormwater BMPs that would be similar to those proposed elsewhere for the CRC project.

Permanent Flow Control Management Strategies

As stated elsewhere, flow control is only required for discharges to Burnt Bridge Creek. Based on the current project layout, additional flow control measures would not be required for the existing infiltration pond at the Main Street interchange since the total impervious area draining to this facility would be reduced by the project. Preliminary sizing for the proposed new biofiltration ponds is based on ensuring that inflows up to the 1 in 100-year event or greater would be infiltrated.

Facility Maintenance and Inspection

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, appendices at the back of this memorandum contain general inspection and maintenance requirements contained in the ODOT Hydraulics Manual[17] and WSDOT Highway Runoff Manual.[18]

SUMMARY

OPTION A – FULL-BUILD

Overall, the project will increase the total impervious area by approximately 38 acres. Not including the Fairview Creek watershed, the current full build design would result in approximately 225 acres of new and rebuilt impervious surface, and 39 acres of resurfaced pavement. The total CIA of 298 acres also includes about 34 acres of existing pavement and sidewalk that will not be affected by the project. The existing impervious surfaces within the CIA include the North Portland Harbor bridges and Vancouver streets not affected by the project, but from which runoff would drain to proposed water quality facilities.

At this time, the project team has not determined approaches to treat runoff from approximately 8 acres, or about 3 percent of the CIA. This area comprises approximately 7 acres of I-5 pavement immediately north of Victory Boulevard and 1 acre of the eastbound lanes on SR 14. As mentioned elsewhere in this document, project staff are continuing to investigate options to collect and treat runoff from these areas.

PROJECT OPTIONS AND PHASING

This section describes the differences should project or phasing be implemented. Project options being considered and elements that could be constructed at a later date and the overall changes in stormwater-related impacts are:

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[16] Water Quality Manual. Prepared by the Stormwater Division, Department of Environmental Services, City of Gresham. Summer 2003.

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

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

1) Option B – Full Build

   Under this scenario, the proposed arterial connection over North Portland Harbor would be eliminated and the vehicle movements accommodated by highway ramps. The changes would result in nominal increases of 0.3 acre and 0.4 acre in the Columbia Slough Watershed and Columbia River Watershed – Oregon, respectively.

2) Options A and B – with Highway Phasing

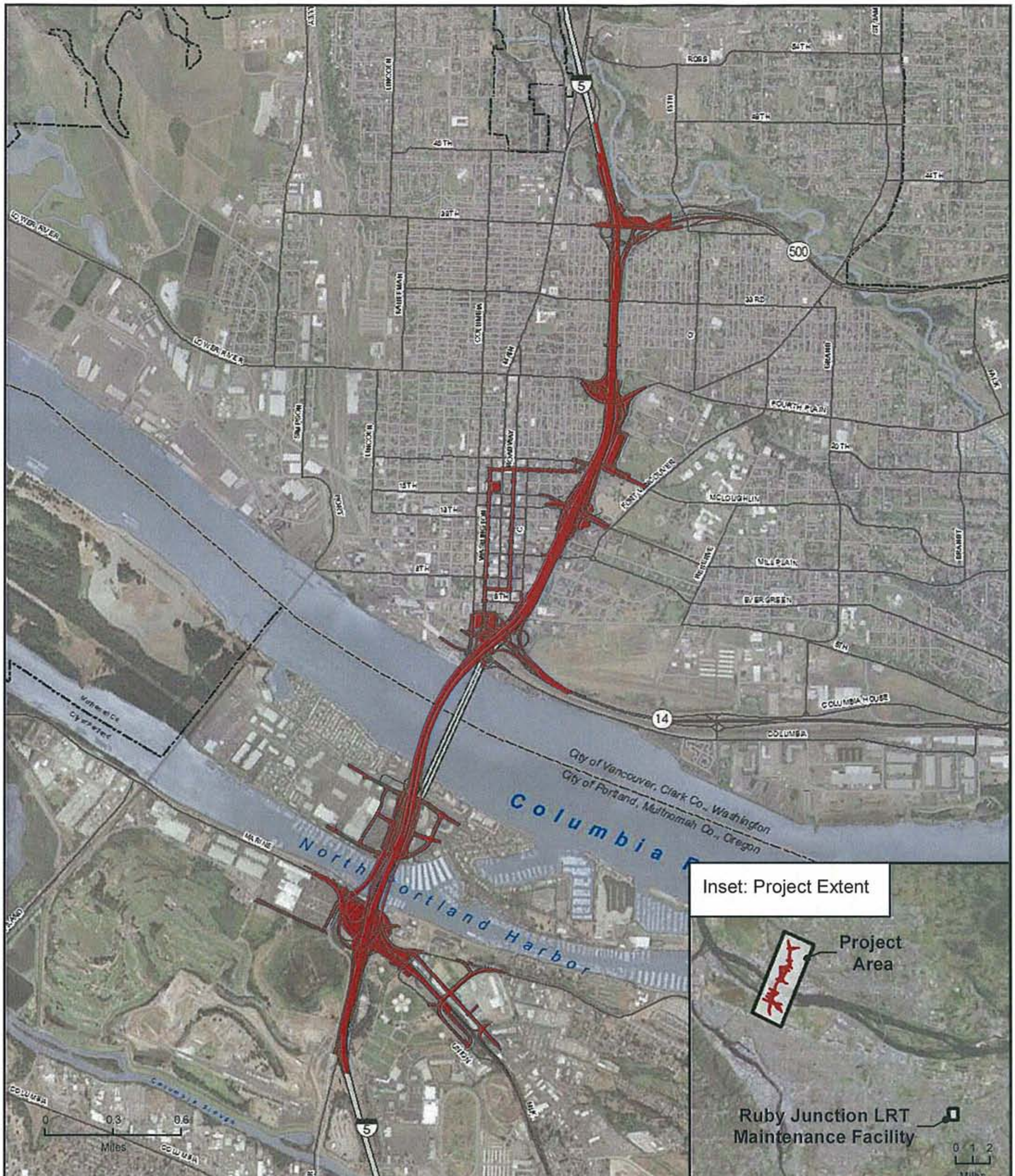
   The braided ramp between Marine Drive and southbound I-5 would be replaced by a shorter ramp merging onto southbound I-5 north of Victory Boulevard and construction of the ramp from eastbound Marine Drive to northbound I-5 would be deferred. In the full-build scenarios, the braided ramp would join I-5 south of Victory Boulevard. This would result in a net reduction in CIA within the Columbia Slough watershed of approximately 5.5 acres, all of which would be PGIS. The 0.9 acre of new impervious surface draining to the proposed biofiltration swale CS-A would be eliminated as would the 0.5 acre merge south of Victory Boulevard (the latter would be conveyed to a swale constructed as part of the Delta Park project). In addition, the new impervious areas draining to constructed wetlands CS-B, CS-D and CS-E would be reduced by 0.8, 0.2, and 3.1 acres, respectively.

   The ramps from southbound I-5 to eastbound SR 500 and from westbound SR 500 to northbound I-5 would be deferred. Phasing this construction would result in a reduction in impervious area of approximately 5 acres, all of which is in the Burnt Bridge Creek watershed, and eliminate the need for water quality facility BBC-A. The CIA draining to water quality facility BBC-B would be reduced by 0.9 acre, all of which is resurfaced pavement on I-5, and the CIA draining to the existing infiltration pond BBC-C would be reduced by 1.3 rather than 2.3 acres.

These alternatives would only affect the impervious area from which runoff would be treated: the untreated area of about 8 acres would remain unchanged.

FIGURES

PRELIMINARY



N
W E
S

Project Footprint

Figure 1. Proposed Project Footprint

Columbia River CROSSING

Analysis by J. Koloszar; Analysis Date: Dec 28, 2010; File Name: Ex1_1_StormwaterProjArea.mxd

PRELIMINARY

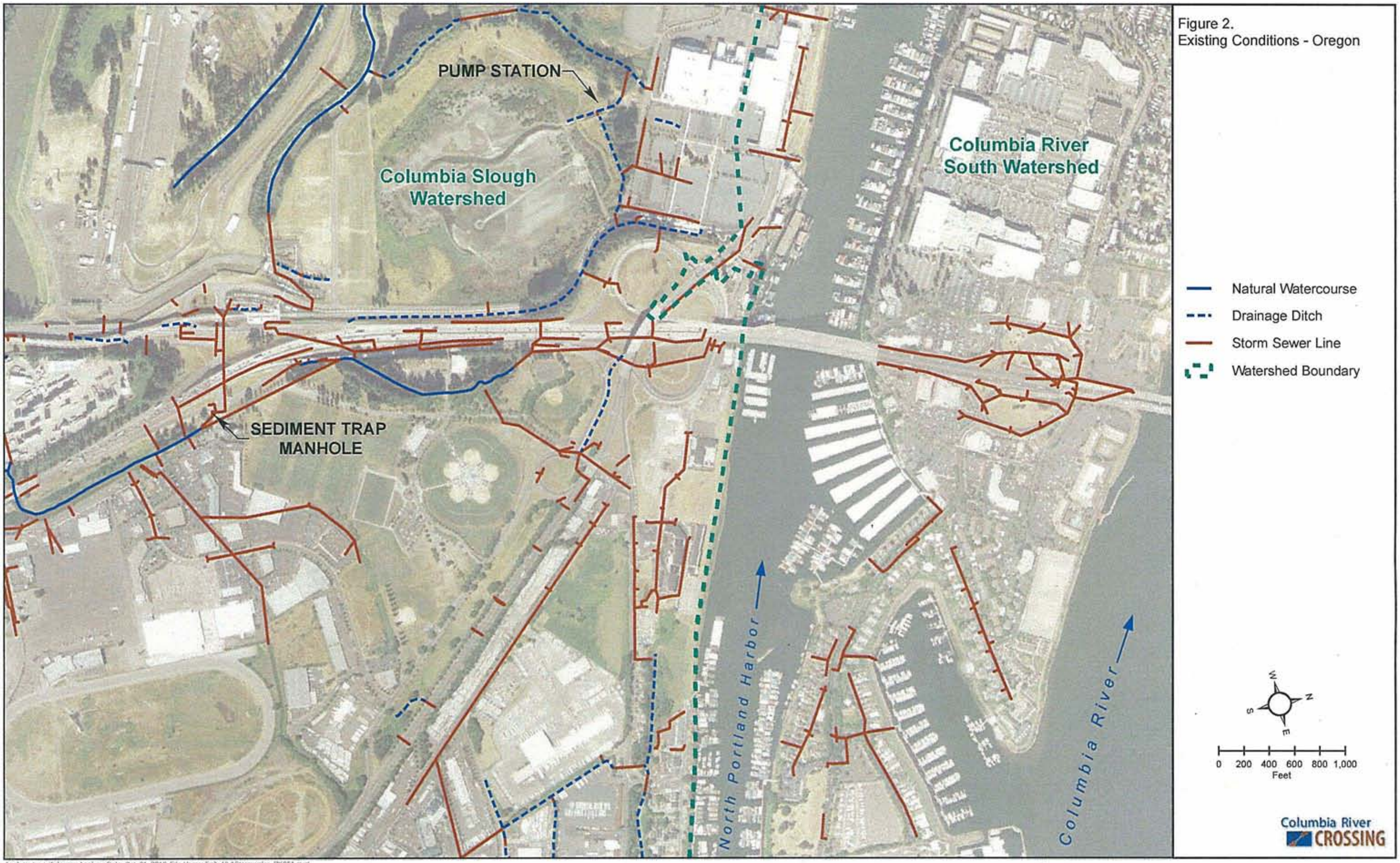


Figure 2.
Existing Conditions - Oregon

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

PRELIMINARY

Figure 3.
Existing Conditions - Washington State (Sheet 1 of 2)

Analysis by J. Koloszar; Analysis Date Feb. 12, 2010, File Name: Ex3_13-2Stormwater_RK251.mxd

7031

PRELIMINARY

PRELIMINARY

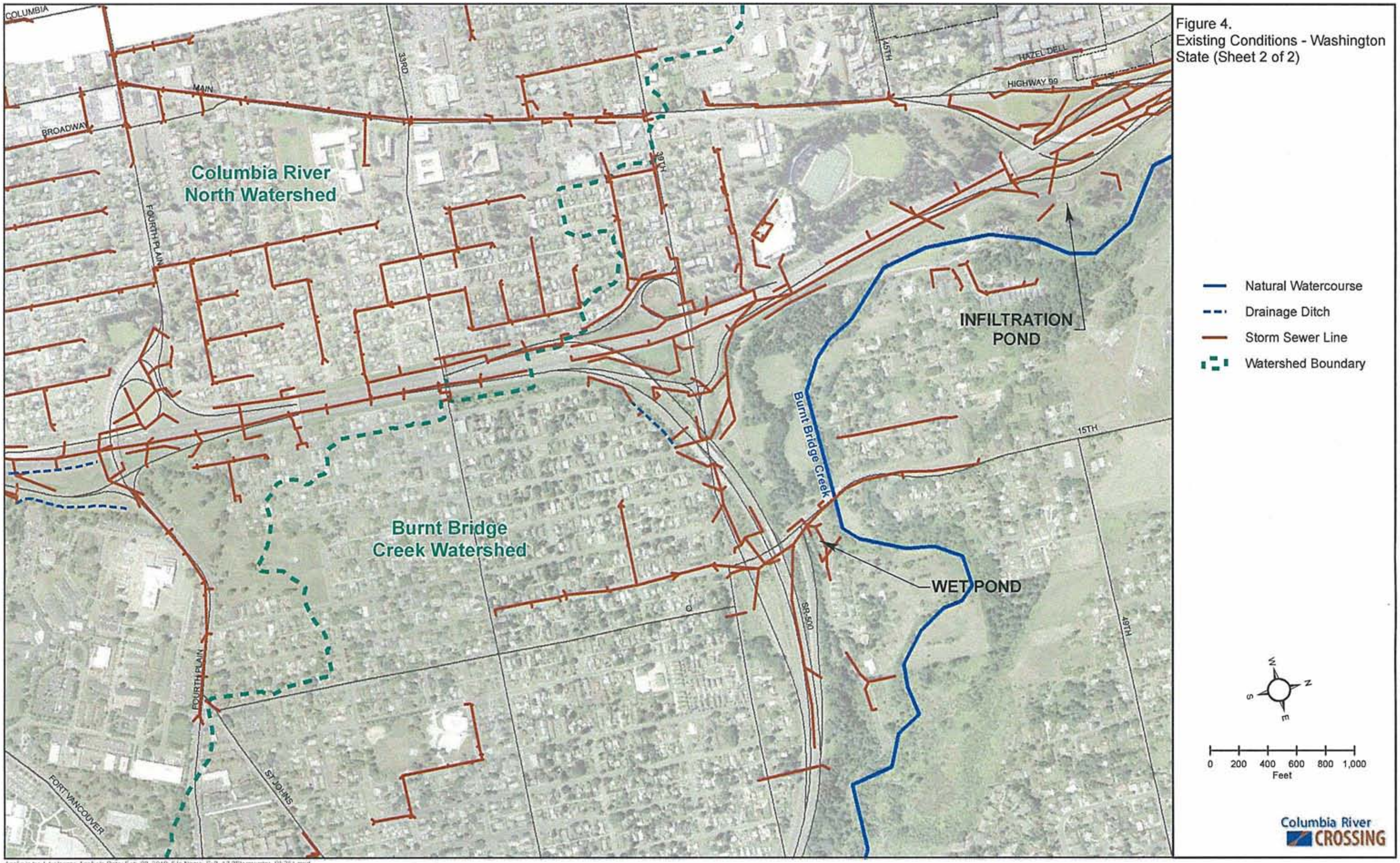


Figure 4.
Existing Conditions - Washington State (Sheet 2 of 2)

7033

PRELIMINARY

PRELIMINARY

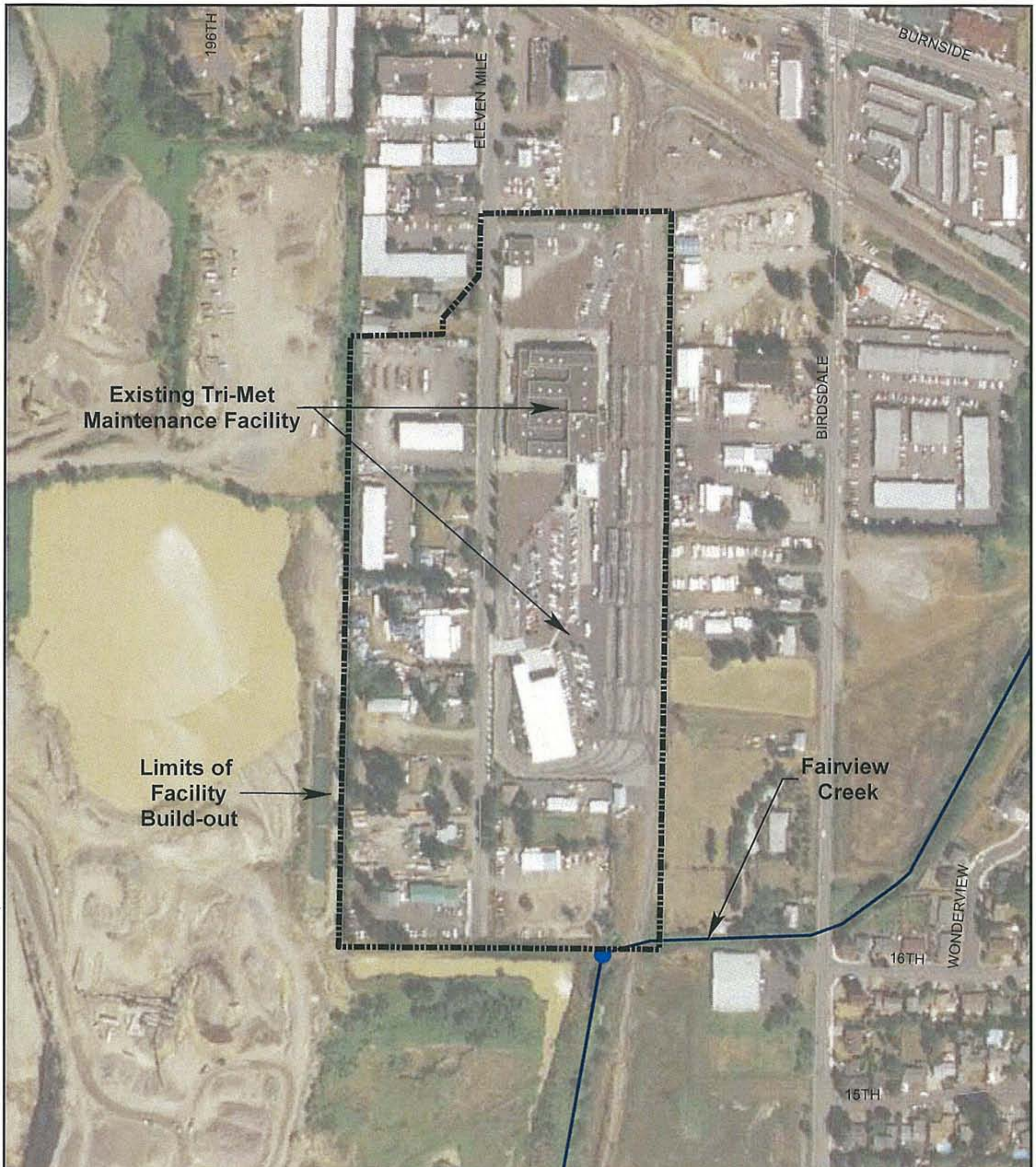


Figure 5.
Threshold Discharge Areas - Ruby Junction

Columbia River CROSSING

Analysis by J. Koloszar; Analysis Date: Oct. 05. 2010; File Name: Fig5_RubyJun_Stormwater_RK251.mxd

Figure 6.
USGS Gauging Station Locations

Columbia River CROSSING

Analysis by J. Koloszar; Analysis Date: Dec. 22, 2010; File Name: Ex_13-4Stormwater_RK251.mxd

PRELIMINARY

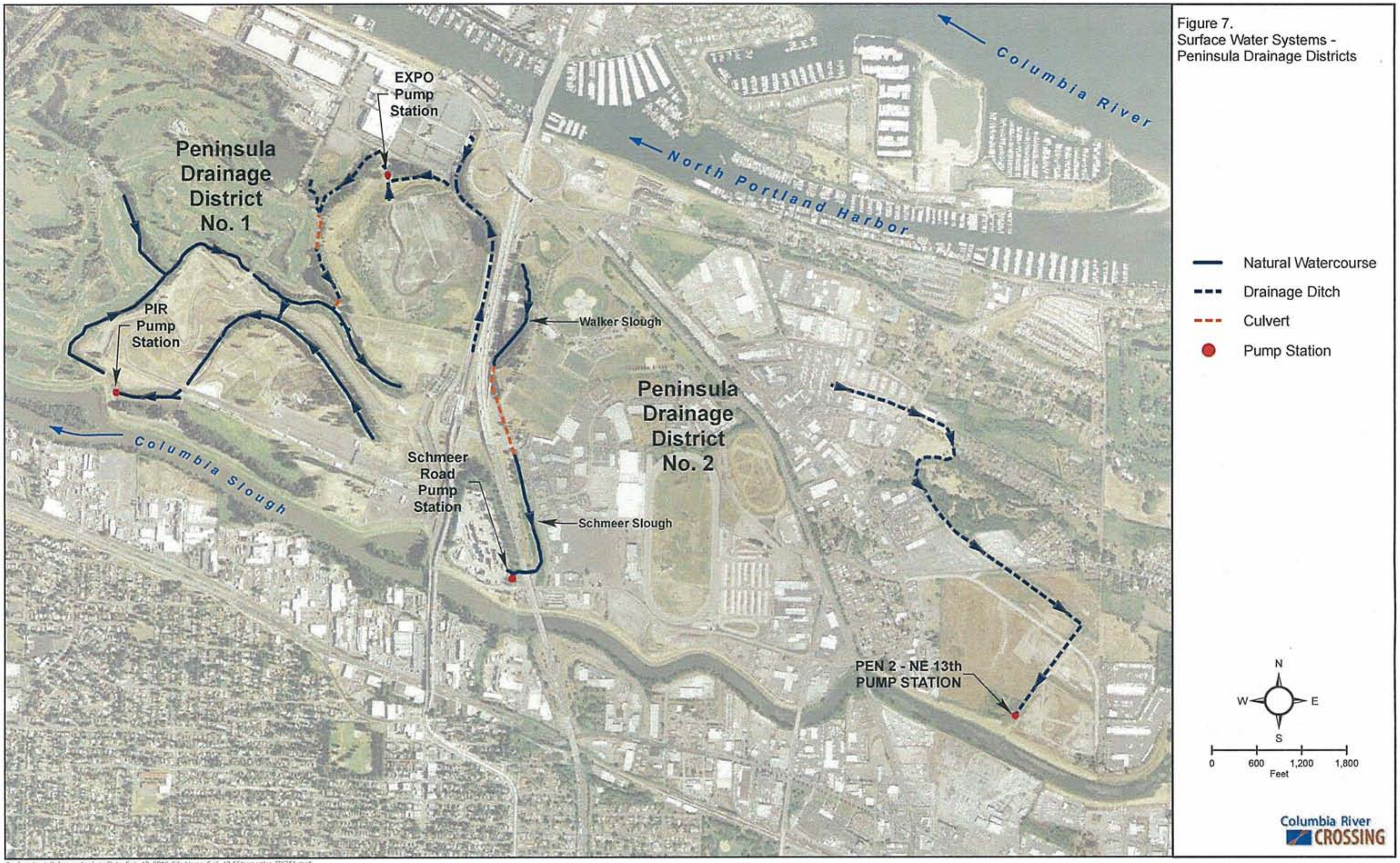


Figure 7.
Surface Water Systems - Peninsula Drainage Districts

Analysis by J. Koloszar; Analysis Date: Feb. 12, 2010; File Name: Ec3_13-5Stormwater_RK251.mxd

7039

PRELIMINARY

PRELIMINARY

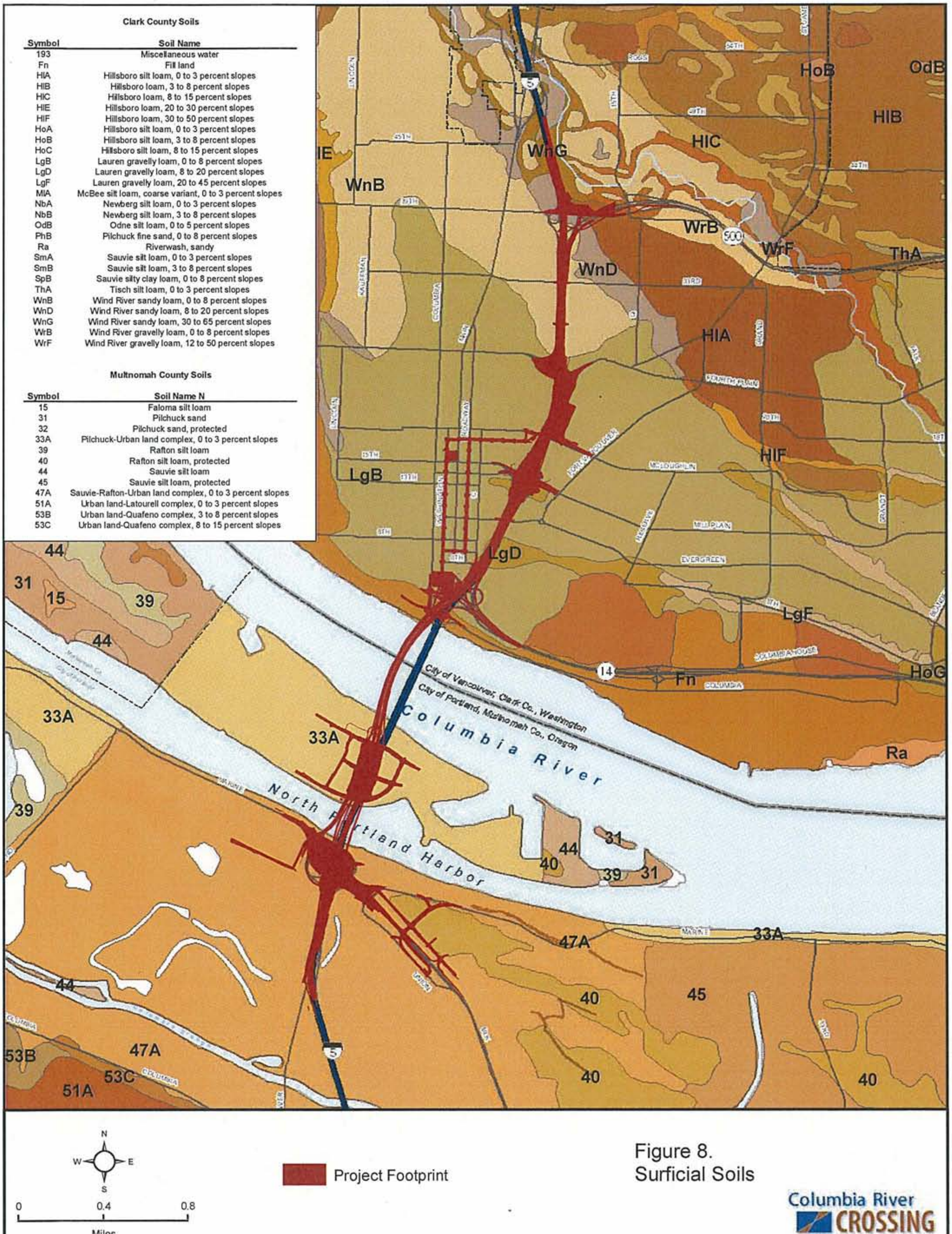


Figure 8.
Surficial Soils

Analysis by J. Koloszar; Analysis Date: Dec. 20. 2010; File Name: Fig8_RK080_100510.mxd

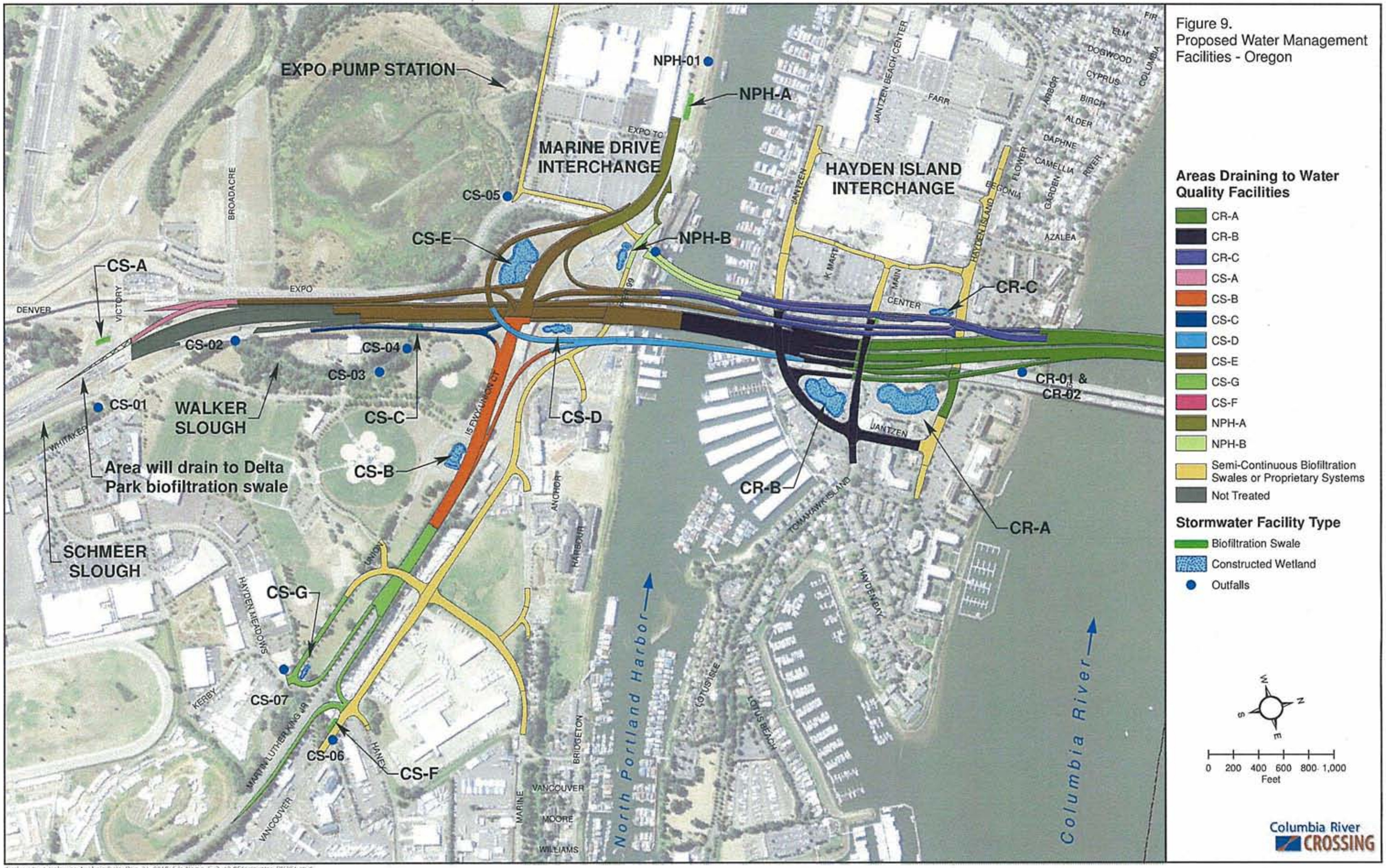


Figure 9.
Proposed Water Management Facilities - Oregon

Analysis by J. Koloszar, Analysis Date: Dec. 31, 2010; File Name: Ec3_13-05stormwater_RK251.mxd

7043

PRELIMINARY

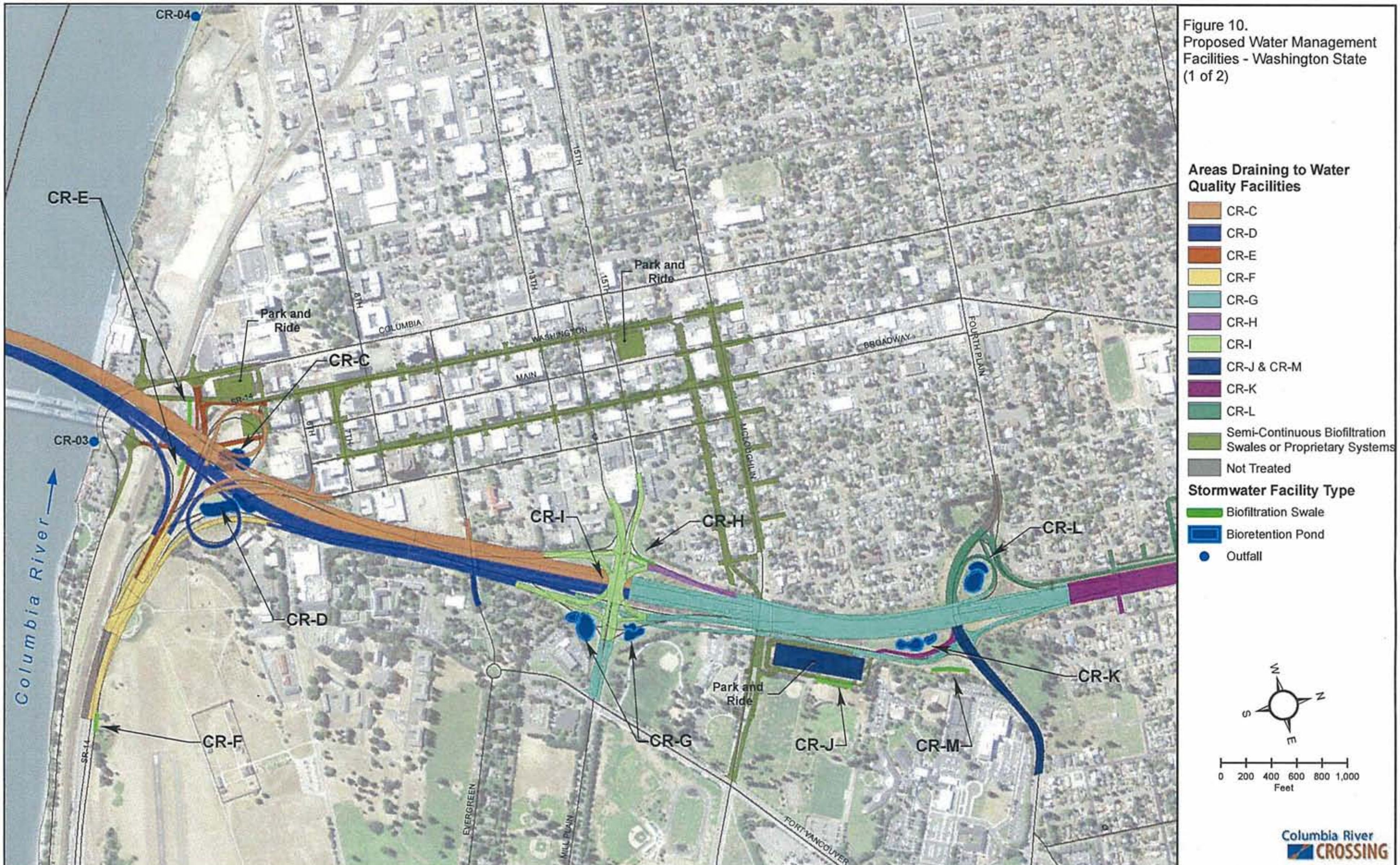


Figure 10.
Proposed Water Management Facilities - Washington State
(1 of 2)
Areas Draining to Water Quality Facilities
CR-C
CR-D
CR-E
CR-F
CR-G
CR-H
CR-I
CR-J & CR-M
CR-K
CR-L
Semi-Continuous Biofiltration Swales or Proprietary Systems
Not Treated
Stormwater Facility Type
Biofiltration Swale
Bioretention Pond
Outfall
0 200 400 600 800 1,000
Feet
Columbia River CROSSING
CR-04
CR-03
CR-E
CR-C
CR-D
CR-F
CR-I
CR-H
CR-G
CR-J
CR-M
CR-K
CR-L
Park and Ride
Columbia River
COLUMBIA
WASHINGTON
MAIN
BROADWAY
FOURTH PLAIN
MCLOUGHLIN
15TH
13TH
6TH
7TH
EVERGREEN
MILL PLAIN
FORT VANCOUVER
SR-14

PRELIMINARY

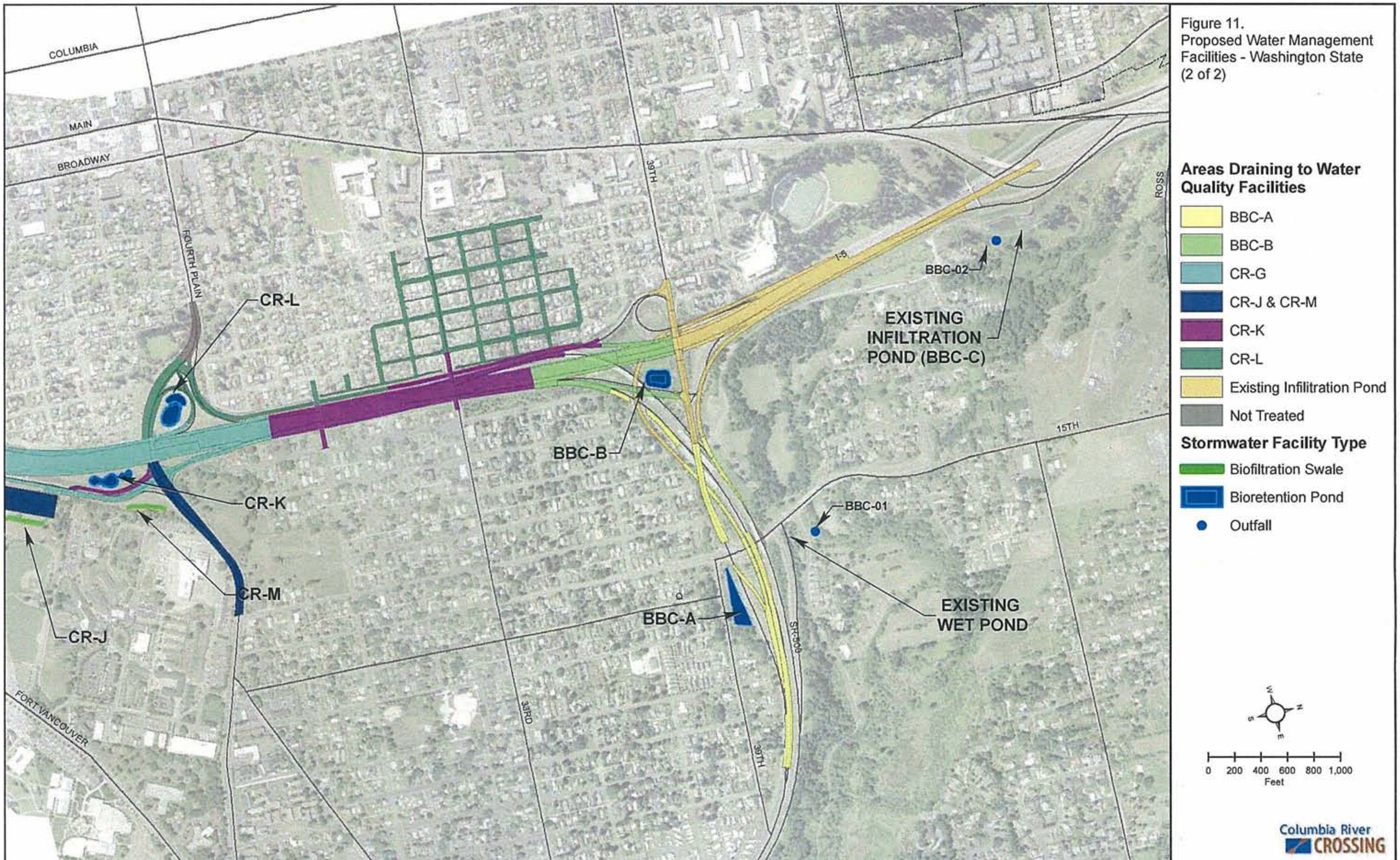


Figure 11.
Proposed Water Management Facilities - Washington State (2 of 2)

Analysis by J. Kolozar, Analysis Date Dec. 21, 2010. File Name: Ex3_13-11Stormwater_RK251.mxd

PRELIMINARY

WSDOT MAINTENANCE STANDARDS

5-5 Operation and Maintenance

Inadequate maintenance is a common cause of failure for stormwater control facilities. All stormwater facilities require routine inspection and maintenance and thus must be designed so that these functions can be easily conducted.

5-5.1 Typical BMP Maintenance Standards

The facility-specific maintenance standards contained in this section (see Tables 5.5.1 through 5.5.13) are intended to be used for determining when maintenance actions are required for conditions identified through inspection. They are not intended to be measures of a facility's required condition at all times between inspections. In other words, exceeding these conditions at any time between inspections or maintenance does not automatically constitute a need for immediate maintenance. Based upon inspection observations, however, the inspection and maintenance schedules must be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

5-5.2 Natural and Landscaped Areas Designated as Stormwater Management Facilities

Maintenance of natural and landscaped areas designated as stormwater management facilities requires special attention. Generally, maintenance in these areas should be performed with light equipment. Heavy machinery and vehicles with large treads or tires can compact the ground surface, decreasing the effectiveness of the BMPs.

Table 5.5.1. Maintenance standards for detention ponds.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and debris	Accumulations exceed 5 cubic feet (about equal to the amount of trash needed to fill one standard-size garbage can) per 1,000 square feet. In general, there should be no visual evidence of dumping. If less than threshold, all trash and debris will be removed as part of the next scheduled maintenance.	Trash and debris are cleared from site.
	Poisonous vegetation and noxious weeds	Poisonous or nuisance vegetation may constitute a hazard to maintenance personnel or the public. Noxious weeds as defined by state or local regulations are evident. (Apply requirements of adopted integrated pest management [IPM] policies for the use of herbicides).	No danger is posed by poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department.) Complete eradication of noxious weeds may not be possible. Compliance with state or local eradication policies is required.
	Contaminants and pollution	Oil, gasoline, contaminants, or other pollutants are evident. (Coordinate removal/cleanup with local water quality response agency.)	No contaminants or pollutants are present.
	Rodent holes	For facilities acting as a dam or berm: rodent holes are evident or there is evidence of water piping through dam or berm via rodent holes.	Rodents are destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
	Beaver dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies.)
	Insects	Insects such as wasps and hornets interfere with maintenance activities.	Insects are destroyed or removed from site. Insecticides are applied in compliance with adopted IPM policies.
	Tree growth and hazard trees	Tree growth does not allow maintenance access or interferes with maintenance activity (slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove. Dead, diseased, or dying trees are observed. (Use a certified arborist to determine health of tree or removal requirements.)	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (such as alders for firewood). Hazard trees are removed.
Side slopes of pond	Erosion	Eroded damage is over 2 inches deep and cause of damage is still present, or there is potential for continued erosion. Erosion is observed on a compacted berm embankment.	Slopes are stabilized using appropriate erosion control measures (such as rock reinforcement, planting of grass, and compaction). If erosion is occurring on compacted berms, a licensed civil engineer should be consulted to resolve source of erosion.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage area	Sediment	Accumulated sediment exceeds 10% of the designed pond depth, unless otherwise specified, or affects inletting or outletting condition of the facility.	Sediment is cleaned out to designed pond shape and depth. Pond is reseeded if necessary to control erosion.
	Liner (if applicable)	Liner is visible and has more than three ¼-inch holes in it.	Liner is repaired or replaced. Liner is fully covered.
Pond berms (dikes)	Settlements	Any part of berm has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Water flow is discernible through pond berm. Ongoing erosion is observed, with potential for erosion to continue. (Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.)	Piping is eliminated. Erosion potential is resolved.
Emergency overflow/ spillway and berms over 4 feet high	Tree growth	Tree growth on emergency spillways reduces spillway conveyance capacity and may cause erosion elsewhere on the pond perimeter due to uncontrolled overtopping. Tree growth on berms over 4 feet high may lead to piping through the berm, which could lead to failure of the berm and related erosion or flood damage.	Trees should be removed. If root system is small (base less than 4 inches), the root system may be left in place; otherwise, the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm/spillway restoration.
	Piping	Water flow is discernible through pond berm. Ongoing erosion is observed, with potential for erosion to continue. (Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.)	Piping is eliminated. Erosion potential is resolved.
Emergency overflow/ spillway	Spillway lining insufficient	Only one layer of rock exists above native soil in area 5 square feet or larger, or native soil is exposed at the top of outflow path of spillway. (Riprap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.

Table 5.5.2. Maintenance standards for bioinfiltration ponds/infiltration trenches/basins.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and debris	See Table 5.5.1 (wet ponds).	See Table 5.5.1 (wet ponds).
	Poisonous/noxious vegetation	See Table 5.5.1 (wet ponds).	See Table 5.5.1 (wet ponds).
	Contaminants and pollution	See Table 5.5.1 (wet ponds).	See Table 5.5.1 (wet ponds).
	Rodent holes	See Table 5.5.1 (wet ponds).	See Table 5.5.1 (wet ponds).
Storage area	Sediment	Water ponds in infiltration pond after rainfall ceases and appropriate time has been allowed for infiltration. (A percolation test pit or test of facility indicates facility is working at only 90% of its designed capabilities. If 2 inches or more of sediment present, remove sediment).	Sediment is removed or facility is cleaned so that infiltration system works according to design.
Rock filters	Sediment and debris	By visual inspection, little or no water flows through filter during heavy rainstorms.	Gravel in rock filter is replaced.
Side slopes of pond	Erosion	See Table 5.5.1 (wet ponds).	See Table 5.5.1 (wet ponds).
Emergency overflow/spillway and berms over 4 feet high	Tree growth	See Table 5.5.1 (wet ponds).	See Table 5.5.1 (wet ponds).
	Piping	See Table 5.5.1 (wet ponds).	See Table 5.5.1 (wet ponds).
Emergency overflow/spillway	Rock missing	See Table 5.5.1 (wet ponds).	See Table 5.5.1 (wet ponds).
	Erosion	See Table 5.5.1 (wet ponds).	See Table 5.5.1 (wet ponds).
Presettling ponds and vaults	Facility or sump filled with sediment or debris	Sediment/debris exceeds 6 inches or designed sediment trap depth.	Sediment is removed.

Table 5.5.3. Maintenance standards for closed treatment systems (tanks/vaults).

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage area	Plugged air vents	One-half of the cross section of a vent is blocked at any point or the vent is damaged.	Vents are open and functioning.
	Debris and sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for ½ length of storage vault or any point depth exceeds 15% of diameter. (Example: 72-inch storage tank requires cleaning when sediment reaches depth of 7 inches for more than ½ the length of the tank.)	All sediment and debris are removed from storage area.
	Joints between tank/pipe section	Openings or voids allow material to be transported into facility. (Will require engineering analysis to determine structural stability.)	All joints between tank/pipe sections are sealed.
	Tank/pipe bent out of shape	Any part of tank/pipe is bent out of shape for more than 10% of its design shape. (Review required by engineer to determine structural stability.)	Tank/pipe is repaired or replaced to design specifications.
	Vault structure: includes cracks in walls or bottom, damage to frame or top slab	Cracks are wider than ½ inch and there is evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault is replaced or repaired to design specifications and is structurally sound.
		Cracks are wider than ½ inch at the joint of any inlet/outlet pipe, or there is evidence of soil particles entering the vault through the walls.	No cracks are more than ¼-inch wide at the joint of the inlet/outlet pipe.
Manhole	Cover not in place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking mechanism not working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than ½ inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
	Cover difficult to remove	One maintenance person cannot remove lid after applying normal lifting pressure. *Intent: To prevent cover from sealing off access to maintenance.*	Cover can be removed and reinstalled by one maintenance person.
	Ladder unsafe	Ladder is unsafe due to missing rungs, misalignment, insecure attachment to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Catch basins	See Table 5.5.5 (catch basins).	See Table 5.5.5 (catch basins).	See Table 5.5.5 (catch basins).

Table 5.5.4. Maintenance standards for control structure/flow restrictor.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and debris (includes sediment)	Accumulation exceeds 25% of sump depth or is within 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris are removed.
	Structural damage	Structure is not securely attached to manhole wall.	Structure is securely attached to wall and outlet pipe.
		Structure is not in upright position; allow up to 10% from plumb.	Structure is in correct position.
		Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are watertight; structure is repaired or replaced and works as designed.
		Holes other than designed holes are observed in the structure.	Structure has no holes other than designed holes.
Cleanout gate	Damaged or missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
Orifice plate	Damaged or missing	Control device is not working properly due to missing, out-of-place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Trash, debris, sediment, or vegetation blocks the plate.	Plate is free of all obstructions and works as designed.
Overflow pipe	Obstructions	Trash or debris blocks (or has the potential to block) the overflow pipe.	Pipe is free of all obstructions and works as designed.
Manhole	See Table 5.5.3 (closed treatment systems).	See Table 5.5.3 (closed treatment systems).	See Table 5.5.3 (closed treatment systems).
Catch basin	See Table 5.5.5 (catch basins).	See Table 5.5.5 (catch basins).	See Table 5.5.5 (catch basins).

Table 5.5.5. Maintenance standards for catch basins.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and debris	Trash or debris is immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No trash or debris is immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) exceeds 60% of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case is clearance less than 6 inches from the debris surface to the invert of the lowest pipe.	No trash or debris is in the catch basin.
		Trash or debris in any inlet or outlet pipe blocks more than ⅓ of its height.	Inlet and outlet pipes are free of trash or debris.
		Dead animals or vegetation could generate odors that might cause complaints or dangerous gases (such as methane).	No vegetation or dead animals are present within the catch basin.
	Sediment	Sediment (in the basin) exceeds 60% of the sump depth as measured from the bottom of the basin to invert of the lowest pipe into or out of the basin, but in no case is clearance less than 6 inches from the sediment surface to the invert of the lowest pipe.	No sediment is in the catch basin.
	Structure damage to frame and/or top slab	Top slab has holes larger than 2 square inches or cracks wider than ¼ inch. *Intent: To make sure no material is running into basin.*	Top slab is free of holes and cracks.
		Frame is not sitting flush on top slab (separation of more than ¾ inch of the frame from the top slab). Frame is not securely attached.	Frame is sitting flush on the riser rings or top slab and is firmly attached.
	Fractures or cracks in basin walls/bottom	Maintenance person judges that structure is unsound.	Basin is replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than ½ inch and longer than 1 foot at the joint of any inlet/outlet pipe, or there is evidence that soil particles have entered catch basin through cracks.	Pipe is regrouted and secure at the basin wall.
	Settlement/ misalignment	Failure of basin has created a safety, function, or design problem.	Basin is replaced or repaired to design standards.
	Vegetation	Vegetation is growing across and blocking more than 10% of the basin opening.	No vegetation blocks the opening to the basin.
		Vegetation growing in inlet/outlet pipe joints is more than 6 inches tall and less than 6 inches apart.	No vegetation or root growth is present.
	Contamination and pollution	Oil, gasoline, contaminants, or other pollutants are evident. (Coordinate removal/cleanup with local water quality response agency.)	No pollution is present.
Catch basin cover	Cover not in place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed.
	Locking mechanism not working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than ½ inch of thread.	Mechanism opens with proper tools.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Catch basin cover (continued)	Cover difficult to remove	One maintenance person cannot remove lid after applying normal lifting pressure. *Intent: To prevent cover from sealing off access to maintenance.*	Cover can be removed by one maintenance person.
Ladder	Ladder unsafe	Ladder is unsafe due to missing rungs, insecure attachment to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance staff safe access.
Metal grates (if applicable)	Grate opening unsafe	Grate opening is wider than ⅞ inch.	Grate opening meets design standards.
	Trash and debris	Trash and debris block more than 20% of grate surface inletting capacity.	Grate is free of trash and debris.
	Damaged or missing	Grate is missing or components of the grate are broken.	Grate is in place and meets design standards.

Table 5.5.6. Maintenance standards for debris barriers (such as trash racks).

Maintenance Components	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and debris	Trash or debris plugs more than 20% of the openings in the barrier.	Barrier is cleared to design flow capacity.
Metal	Damaged/missing bars	Bars are bent out of shape more than 3 inches.	Bars are in place with no bends more than ¾ inch.
		Bars are missing or entire barrier is missing.	Bars are in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of barrier.	Barrier is replaced or repaired to design standards.
	Inlet/outlet pipe	Debris barrier is missing or not attached to pipe.	Barrier is firmly attached to pipe.

Table 5.5.7. Maintenance standards for energy dissipaters.

Maintenance Components	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
External:			
Rock pad	Missing or moved rock	Only one layer of rock exists above native soil in area 5 square feet or larger, or native soil is exposed.	Rock pad is replaced to design standards.
	Erosion	Soil erosion is evident in or adjacent to rock pad.	Rock pad is replaced to design standards.
Dispersion trench	Pipe plugged with sediment	Accumulated sediment exceeds 20% of the design depth.	Pipe is cleaned/flushed so that it matches design.
	Not discharging water properly	There is visual evidence of water discharging at concentrated points along trench—normal condition is a "sheet flow" of water along trench. *Intent: To prevent erosion damage.*	Trench is redesigned or rebuilt to standards.
	Perforations plugged	Over ½ of perforations in pipe are plugged with debris and sediment.	Perforated pipe is cleaned or replaced.
	Water flows out top of "distributor" catch basin	Maintenance person observes or receives credible report of water flowing out during any storm less than the design storm, or water is causing (or appears likely to cause) damage.	Facility is rebuilt or redesigned to standards.
	Receiving area over-saturated	Water in receiving area is causing (or has potential of causing) landslide problems.	There is no danger of landslides.
Internal:			
Manhole/chamber	Worn or damaged post, baffles, side of chamber	Structure dissipating flow deteriorates to ½ of original size or any concentrated worn spot exceeds 1 square foot, which would make structure unsound.	Structure is replaced to design standards.
	Other defects	See entire contents of Table 5.5.5 (catch basins).	See entire contents of Table 5.5.5 (catch basins).

Table 5.5.8. Maintenance standards for biofiltration swale.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment accumulation on grass	Sediment depth exceeds 2 inches.	Remove sediment deposits on grass treatment area of the swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
	Standing water	Water stands in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages; improve grade from head to foot of swale; remove clogged check dams; add underdrains; or convert to a wet biofiltration swale.
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
	Constant baseflow	Small quantities of water continually flow through the swale, even when it has been dry for weeks, and an eroded, muddy channel has formed in the swale bottom.	Add a low-flow pea gravel drain the length of the swale, or bypass the baseflow around the swale.
	Poor vegetation coverage	Grass is sparse or bare, or eroded patches occur in more than 10% of the swale bottom.	Determine why grass growth is poor and correct that condition. Replant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals; or reseed into loosened, fertile soil.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow vegetation or remove nuisance vegetation so that flow is not impeded. Grass should be mowed to a height of 6 inches. Mowing is not required for wet biofiltration swales. However, fall harvesting of very dense vegetation after plant die-back is recommended.
	Excessive shading	Grass growth is poor because sunlight does not reach swale.	If possible, trim back overhanging limbs and remove brushy vegetation on adjacent slopes.
	Inlet/outlet	Inlet/outlet areas are clogged with sediment/debris.	Remove material so there is no clogging or blockage in the inlet and outlet area.
	Trash and debris	Trash and debris have accumulated in the swale.	Remove trash and debris from bioswale.
	Erosion/scouring	Swale bottom has eroded or scoured due to flow channelization or high flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large (generally greater than 12 inches wide), the swale should be regraded and reseeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.

Table 5.5.9. Maintenance standards for vegetated filter strip.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment accumulation on grass	Sediment depth exceeds 2 inches.	Remove sediment deposits. Relevel so slope is even and flows pass evenly through strip.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow grass and control nuisance vegetation so that flow is not impeded. Grass should be mowed to a height between 3 and 4 inches.
	Trash and debris	Trash and debris have accumulated on the vegetated filter strip.	Remove trash and debris from filter.
	Erosion/scouring	Areas have eroded or scoured due to flow channelization or high flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the vegetated filter strip should be regraded and reseeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width.

Table 5.5.10. Maintenance standards for media filter drain.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment accumulation on grass filter strip	Sediment depth exceeds 2 inches or creates uneven grading that interferes with sheet flow.	Remove sediment deposits on grass treatment area of the embankment. When finished, embankment should be level from side to side and drain freely toward the toe of the embankment slope. There should be no areas of standing water once inflow has ceased.
	No-vegetation zone/flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire embankment width.	Level the spreader and clean so that flows are spread evenly over entire embankment width.
	Poor vegetation coverage	Grass is sparse or bare, or eroded patches are observed in more than 10% of the grass strip surface area.	Consult with roadside vegetation specialists to determine why grass growth is poor and correct the offending condition. Replant with plugs of grass from the upper slope or reseed into loosened, fertile soil or compost.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow vegetation or remove nuisance vegetation so that flow is not impeded. Grass should be mowed to a height of 6 inches.
	Media filter drain mix replacement	Water is seen on the surface of the media filter drain mix from storms that are less than a 6-month, 24-hour precipitation event. Maintenance also needed on a 10-year cycle and during a preservation project.	Excavate and replace all of the media filter drain mix contained within the media filter drain.
	Excessive shading	Grass growth is poor because sunlight does not reach embankment.	If possible, trim back overhanging limbs and remove brushy vegetation on adjacent slopes.
	Trash and debris	Trash and debris have accumulated on embankment.	Remove trash and debris from embankment.

Table 5.5.11. Maintenance standards for permeable pavement.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment accumulation	Collection of sediment is too coarse to pass through pavement.	Remove sediment deposits with high-pressure vacuum sweeper.
	Accumulation of leaves, needles, and other foliage	Accumulation on top of pavement is observed.	Remove with a leaf blower or high-pressure vacuum sweeper.
	Trash and debris	Trash and debris have accumulated on the pavement.	Remove by hand or with a high-pressure vacuum sweeper.
	Oil accumulation	Oil collection is observed on top of pavement.	Immediately remove with a vacuum and follow up by a pressure wash or other appropriate rinse procedure.
Visual facility identification	Not aware of permeable pavement location	Facility markers are missing or not readable.	Replace facility identification where needed.
Annual minimum maintenance			Remove potential void-clogging debris with a biannual or annual high-pressure vacuum sweeping.

Table 5.5.12. Maintenance standards for dispersion areas (natural and engineered).

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment accumulation on dispersion area	Sediment depth exceeds 2 inches.	Remove sediment deposits while minimizing compaction of soils in dispersion area Relevel so slope is even and flows pass evenly over/through dispersion area. Handwork is recommended rather than use of heavy machinery.
	Vegetation	Vegetation is sparse or dying; significant areas are without ground cover.	Control nuisance vegetation. Add vegetation, preferably native ground cover, bushes, and trees (where consistent with safety standards) to bare areas or areas where the initial plantings have died.
	Trash and debris	Trash and debris have accumulated on the dispersion area.	Remove trash and debris from filter. Handwork is recommended rather than use of heavy machinery.
	Erosion/scouring	Eroded or scoured areas due to flow channelization, or high flows are observed.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel/compost mix (see Section 5-4.3.2 for the compost specifications). The grass will creep in over the rock mix in time. If bare areas are large (generally greater than 12 inches wide), the dispersion area should be reseeded. For smaller bare areas, overseed when bare spots are evident. Look for opportunities to locate flow spreaders, such as dispersion trenches and rock pads.
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width.

Table 5.5.13. Maintenance standards for wet ponds.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Water level	First cell is empty, doesn't hold water	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.
	Trash and debris	Accumulations exceed 1 cubic foot per 1000 square feet of pond area.	Remove trash and debris from pond.
	Inlet/outlet pipe	Inlet/outlet pipe is clogged with sediment or debris material.	Unclog and unblock inlet and outlet piping.
	Sediment accumulation in pond bottom	Sediment accumulations in pond bottom exceed the depth of sediment zone plus 6 inches, usually in the first cell.	Remove sediment from pond bottom.
	Oil sheen on water	Oil sheen is prevalent and visible.	Remove oil from water using oil-absorbent pads or Vactor truck. Locate and correct source of oil. If chronic low levels of oil persist, plant wetland species such as *Juncus effusus* (soft rush), which can uptake small concentrations of oil.
	Erosion	Pond side slopes or bottom show evidence of erosion or scouring in excess of 6 inches and the potential for continued erosion is evident.	Stabilize slopes using proper erosion control measures and repair methods.
	Settlement of pond dike/berm	Any part of the pond dike/berm has settled 4 inches or lower than the design elevation, or the inspector determines dike/berm is unsound.	Repair dike/berm to specifications.
	Internal berm	Berm dividing cells are not level.	Level berm surface so that water flows evenly over entire length of berm.
	Overflow/spillway	Rock is missing and soil exposed at top of spillway or outside slope.	Replace rocks to specifications.

ODOT MAINTENANCE STANDARDS

10.11 Operation and Maintenance

The proper operation, performance, structural integrity, and aesthetics of a stormwater treatment facility are dependent on routine inspection and adequate maintenance. Facility inspection schedule and maintenance guidelines are summarized in an Operation and Maintenance Manual prepared to assist personnel who maintain the facility.

General requirements include:

- All facilities must have an operation and maintenance manual prepared and a copy must be distributed to the appropriate district maintenance office and Geo-Environmental's Senior Hydraulics Engineer.
- All stormwater treatment facility structures should be accessible by foot and vactor truck for inspection and maintenance.
- Outline an inspection schedule. Inspection schedule guidelines are summarized in Table 6. Include schedule in the facility's Operation and Maintenance Manual.
- Outline maintenance requirements depending on the type of facility and its facility components. General maintenance requirements for extended dry ponds, biofiltration swales, filter strips, and bioslopes are provided in Tables 7 through 10. General maintenance requirements for proprietary structures should be obtained from the appropriate manufacturers. Include any additional requirements needed to maintain proper operation and performance. Include maintenance requirements in the facility's Operation and Maintenance Manual.

Table 6 Inspection Schedule to Determine and Perform Maintenance

Type of Treatment Facility	Additional Inspection	Annual Inspection
Extended Detention Dry Pond	As needed	Required
Bioretention Pond	As needed	Required
Biofiltration Swale	As needed	Required
Filter Strip	As needed	Required
Bioslopes	As needed	Required
Proprietary Structures	See manufacturer's literature	See manufacturer's literature

Table 7 Maintenance Requirements for Stormwater Ponds

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and debris	Trash and debris has accumulated in the pond.	Trash and debris are removed from site.
	Contaminants and pollution	Oil, gasoline, contaminants, or other pollutants are evident following any hazmat spill event. (Additional information is provided in the waste material handling section of the operation and maintenance manual).	No contaminants or pollutants are present.
	Rodent holes	For facilities acting as a dam or berm: rodent holes are evident or there is evidence of water piping through dam or berm via rodent holes.	Rodents are removed from site.
	Beaver dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate regulatory agencies).
	Insects	Insects such as wasps and hornets interfere with maintenance activities.	Insects are removed from site.
	Vegetation growth	Excessive growth does not allow maintenance access, interferes with maintenance activity, or weeds are out of control.	Side slopes are mowed so that vegetation growth does not hinder maintenance activities. Noxious weeds are removed following state or local policies. Herbicides should not be used to control vegetation.
	Tree growth and hazard trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove. Dead, diseased, or dying trees are observed. (Use a certified arborist to determine health of tree or removal requirements).	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard trees.
	Conveyance piping	Conveyance piping is clogged with sediment or debris material.	Conveyance piping are not clogged or blocked.
	Sediment accumulation in pond bottom,	Sediment accumulations exceed the depth of 12 inches.	Sediment is removed.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	manhole, catch basin or other structure		
	Erosion	Pond side slopes or bottom show evidence of erosion in excess of 4 inches and the potential for continued erosion is evident.	Slopes are stabilized using proper erosion control measures and repair methods.
	Bioretention mix failure	Ponding for (7) consecutive days or longer from May through October. Contact a Region Hydraulics Engineer to evaluate condition of bioretention pond.	The bioretention mix is excavated and replaced with new mix that meets design standard.
Pond berms	Settlement	Any part of the pond dike/berm has settled 4 inches or lower than the design elevation.	Berm is repaired to design standards.
	Piping	Water flow is apparent through pond berm. Ongoing erosion is observed, with potential for erosion to continue. (Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.)	Piping is eliminated. Erosion potential is resolved.
Split flow Manhole, Outlet Control Structure, and Auxiliary Outlet	Orifice assembly/Riser pipe damage or missing	Assembly is not working properly due to not securely attached, bent or other apparent damage.	Assembly is repaired or replaced to design standards.
	Obstruction	Trash, debris, sediment, or vegetation is clogging the assembly.	Assembly is free of all obstructions and design function is restored.
	Auxiliary outlet spillway lining insufficient	Minimal layer of spillway rip rap exists or native soil is exposed.	Rip rap depth is restored to design standards
Outfall	Bank armoring insufficient	Minimal layer of rip rap exists or native soil is exposed.	Rip rap depth is restored to design standards

Modified from reference 19.

Table 8 Maintenance Requirements for Biofiltration Swales

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation along bottom of swale	Sediment depth exceeds 2 inches.	Sediment deposits removed along bottom of swale. Swale slope and geometry restored to design standards. Areas with minimal grass cover reseeded. There should be no areas of standing water once inflow has ceased.
	Ponding water	Ponding water in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages; improve grade from head to foot of swale; or add an under drain
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed through entire swale width.	Spreader is re-leveled and cleaned to restore sheet flow conditions along the swale.
	Poor vegetation coverage	Grass is sparse or bare, or eroded patches occur in more than 10 percent of the swale bottom.	Poor grass growth is corrected and bare areas reseeded.
	Vegetation growth	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Vegetation is mowed and nuisance vegetation removed so that flow is not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings. Noxious weeds are removed following state or local policies. Herbicides should not be used to control vegetation.
	Excessive shading	Grass growth is poor because the lack of sunlight.	Overhanging limbs are trimmed. Brushy vegetation on adjacent slopes is removed.
	Inlet/outlet conveyance piping and structures	Inlet/outlet areas are clogged with sediment and/or debris.	Material removed so there is no clogging or blockage in the inlet and outlet area.
	Trash and debris	Trash and debris have accumulated in the swale.	Trash and debris removed from swale.
	Erosion	Swale bottom has eroded due to flow channelization or high flows.	Bare areas are regarded and reseeded.

Modified from reference 19.

Table 9 Maintenance Requirements for Filter Strips

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation along filter strip	Sediment depth exceeds 2 inches.	Sediment deposits removed, uneven areas are regarded and bare areas are reseeded.
	Vegetation growth	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Vegetation is mowed and nuisance vegetation removed so that flow is not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings. Noxious weeds are removed following state or local policies. Herbicides should not be used to control vegetation.
	Excessive shading	Grass growth is poor because the lack of sunlight.	Overhanging limbs are trimmed. Brushy vegetation on adjacent slopes is removed.
	Trash and debris	Trash and debris have accumulated on the vegetated filter strip.	Trash and debris removed along filter strip.
	Erosion	Areas have eroded or scoured due to flow channelization or high flows.	Bare areas are re-garded and reseeded.
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire filter width.	Spreader is re-leveled and cleaned so that flows are spread evenly over entire filter width.

Modified from reference 19.

Table 10 Maintenance Requirements for Bioslopes

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation	Sediment depth exceeds 2 inches	Sediment deposits removed, uneven areas are regarded and bare areas are reseeded.
	Poor vegetation coverage	Grass is sparse or bare, or eroded patches are observed in more than 10% of the vegetated filter strip surface area.	Poor grass growth is corrected and bare areas reseeded.
	Vegetation growth	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Vegetation is mowed and nuisance vegetation removed so that flow is not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings. Noxious weeds are removed following state or local policies. Herbicides should not be used to control vegetation.
	Ecology mix failure	Low and medium flows are seen bypassing the bioslope. Contact a Region Hydraulics Engineer to evaluate condition of bioslope.	The ecology mix is excavated and replaced with new mix that meets design standard.
	Excessive shading	Grass growth is poor because the lack of sunlight.	Overhanging limbs are trimmed. Brushy vegetation on adjacent slopes is removed.
	Trash and debris	Trash and debris have accumulated along the bioslope.	Trash and debris removed from the bioslope.

Modified from reference 19.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

Refer to NMFS No:
2010/03196

January 19, 2011

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Re: Endangered Species Act Section 7 Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Conservation Recommendations for the Columbia River Crossing (Federal #: HPP S001(250), Lower Columbia–Clatskanie Rivers (4th field HUC 17080003), Lower Columbia River (4th field HUC 17080006), and Lower Willamette River (4th field HUC 17090012), Oregon and Washington

Dear Messrs. Krochalis and McAvoy:

The enclosed document contains a biological Opinion (Opinion) prepared by the National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act (ESA) on the effects of the Federal Highway Administration (FHWA) and the Federal Transit Authority (FTA) partially funding the proposed Columbia River Crossing (CRC). The proposed CRC includes the replacement of the Interstate 5 freeway bridges across the lower Columbia River between Portland, Oregon and Vancouver, Washington. As co-leads, funding to design and engineer this project originates from the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), under sections 1101, 1701, 1702, and 5309 (23 U.S.C.) (New Starts Program).

In this Opinion, NMFS concluded that the proposed action is not likely to jeopardize the continued existence of Lower Columbia River (LCR) Chinook salmon (*Oncorhynchus tshawytscha*), Upper Willamette River (UWR) Chinook salmon, Upper Columbia River (UCR) spring-run Chinook salmon, Snake River (SR) spring/summer run Chinook salmon, SR fall-run Chinook salmon, Columbia River (CR) chum salmon (*O. keta*), LCR coho salmon (*O. kisutch*), SR sockeye salmon (*O. nerka*), LCR steelhead (*O. mykiss*), UWR steelhead, Middle Columbia River (MCR) steelhead, UCR steelhead, Snake River Basin (SRB) steelhead, southern green sturgeon (*Acipenser medirostris*), eulachon (*Thaleichthys pacificus*), or eastern Steller sea lion (*Eumetopias jubatus*), or result in the destruction or adverse modification of critical habitats designated for any of the above listed species, except LCR coho salmon, for which critical habitat is not proposed or designated, eulachon, for which critical habitat is proposed but not yet designated, and eastern Steller sea lion, which does not have critical habitat designated in the action area.

In addition, NMFS concurred with the FHWA and FTA's determination that the proposed action is not likely to adversely affect the southern resident killer whale (*Orcinus orca*). The southern resident killer whale does not have critical habitat designated in the action area.

As required by section 7 of the ESA, NMFS is providing an incidental take statement with the Opinion. The incidental take statement describes reasonable and prudent measures NMFS considers necessary or appropriate to minimize the impact of incidental take associated with this action. The take statement sets forth nondiscretionary terms and conditions, including reporting requirements, that the FHWA and FTA must comply with to carry out the reasonable and prudent measures. Incidental take from actions that meet these terms and conditions will be exempt from the ESA's prohibition against the take of listed species considered in this Opinion, except for eastern Steller sea lion.

The NMFS did not include take of eastern Steller sea lions in this exemption because the FHWA and FTA are not authorized to take sea lions under section 101(a)(5) of the Marine Mammal Protection Act. If the FHWA and FTA obtain that authorization, they may request an amendment that will add eastern Steller sea lions to this exemption.

This document also includes the results of our analysis of the action's likely effects on essential fish habitat (EFH) pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and includes two conservation recommendations to avoid, minimize, or otherwise offset potential adverse effects on EFH. These conservation recommendations are a subset of the ESA take statement's terms and conditions. Section 305(b)(4)(B) of the MSA requires Federal Agencies to provide a detailed written response to NMFS within 30 days after receiving these recommendations.

If the response is inconsistent with the EFH conservation recommendations, the FHWA and FTA must explain why the recommendations will not be followed, including the justification for any disagreements over the effects of the action and the recommendations. In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we request that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

If you have questions regarding this consultation, please contact Devin Simmons, Fishery Biologist in the Willamette Basin Habitat Branch of the Oregon State Habitat Office, at 503.231.2313.

Sincerely,

for Michael Tehan

William W. Stelle, Jr.
Regional Administrator

cc: Jim Brick, ODFW
Frannie Brindle, ODOT
Jaimee Davis, USACE
Anne Friesz, WDFW
Alex Liverman, DEQ
Steve Morrow, CRC
Kathy Roberts, USFWS
Terry Swanson, WDOE
Yvonne Valette, USEPA

Endangered Species Act
Section 7 Biological Opinion

and

Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Conservation Recommendations

for the

Columbia River Crossing (Federal #: HPP S001(250),
Lower Columbia–Clatskanie Rivers (4th field HUC 17080003),
Lower Columbia River (4th field HUC 17080006), and
Lower Willamette River (4th field HUC 17090012),
Oregon and Washington

Lead Action Agencies: Federal Highway Administration
Federal Transit Authority

Consultation Conducted By: National Marine Fisheries Service
Northwest Region

Date Issued: January 19, 2011

Issued by: Michael Jehan for
William W. Stelle, Jr.
Regional Administrator

NMFS No.: **2010/03196**

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

BA	Biological Assessment
BMP	Best Management Practice
CFR	Code of Federal Regulations
CHART	Critical Habitat Analytical Review Team
CIA	Contributing Impervious Area
CRC	Columbia River Crossing
dB	Decibel
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FHWA	Federal Highway Administration
FR	Federal Register
FTA	Federal Transit Authority
HUC	Hydraulic Unit Code
I-5	Interstate Freeway 5
LCR	Lower Columbia River
MCR	Mid Columbia River
MP	Mile Post
MSA	Magnuson Stevens Act
NMFS	National Marine Fisheries Service
ODOT	Oregon Department of Transportation
OHW	Ordinary High Water
PCE	Primary Constituent Element
Re: 1µPa	Reference 1 MicroPascal
RM	River Mile
RMS	Root Mean Squared
ROW	Right of Way
SEL	Sound Exposure Level
SR	Snake River, or State Route
SRB	Snake River Basin
TRT	Technical Review Team
UCR	Upper Columbia River
U.S.C.	United States Code
UWR	Upper Willamette River
VSP	Viable Salmonid Population
WLC	Willamette/Lower Columbia
WDOT	Washington State Department of Transportation

INTRODUCTION

This document contains a biological Opinion (Opinion) that was prepared by the National Marine Fisheries Service (NMFS) in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, *et seq.*), and implementing regulations at 50 CFR 402.[1] It also contains essential fish habitat (EFH) conservation recommendations prepared by NMFS in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801, *et seq.*) and implementing regulations at 50 CFR 600. The Opinion and EFH conservation recommendations are both in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Data Quality Act) (44 U.S.C. 3504 (d)(1) and 3516), and underwent pre-dissemination review. The administrative record for this consultation is on file at the Oregon State Habitat Office in Portland, Oregon

Background and Consultation History

The Federal Highway Administration (FHWA) and Federal Transit Authority (FTA) propose to use their authority under the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), under sections 1101, 1701, 1702, and 5309 (New Starts Program) to complete preliminary engineering and an environmental impact statement (EIS) for the Interstate 5 (I-5) Columbia River Crossing (CRC). The CRC project planning team (CRC Team) consists of staff from the FHWA and FTA and their agents, the Washington Department of Transportation (WDOT) and the Oregon Department of Transportation (ODOT). This Opinion is necessary to complete the EIS.

On August 23-24, 2005, the NMFS began coordination with the CRC Team at an interagency workshop to coordinate development of an EIS.

On February 28, 2006, NMFS agreed to participate in the CRC Interstate Collaborative Environmental (InterCEP) Process Group, a NEPA compliance streamlining effort, by signing the January 25, 2006 InterCEP Agreement (CRCP 2006).

On November 9, 2006, NMFS submitted official technical guidance for use within the draft EIS.

On August 6, 2008, NMFS submitted official comments on the CRC Draft EIS.

On October 20, 2009, NMFS facilitated a CRC Team and Fish Passage Advisory Group (FPAC) coordination meeting to gain the best available fish abundance, presence, and timing data available for the 13 species of Pacific salmon and steelhead species affected by the action.

[1] With respect to designated critical habitat, the following analysis relied only on the statutory provisions of the ESA, and not on the regulatory definition of "destruction or adverse modification" at 50 CFR 402.02.

On June 25, 2010, after an extended period of informal consultation, the FHWA and FTA requested formal consultation under section 7 of the ESA and EFH consultation under the MSA. They concluded that the proposed action is not likely to adversely affect southern resident killer whale (*Orcinus orca*), and is likely to adversely affect the following 16 ESA-listed species and their designated critical habitats (critical habitat has not been designated or proposed for LCR coho salmon or eulachon), and would adversely affect EFH designated for Chinook and coho salmon:

- Lower Columbia River (LCR) Chinook salmon (*Oncorhynchus tschawtscha*),
- Upper Willamette River (UWR) Chinook salmon,
- Upper Columbia River (UCR) spring-run Chinook salmon,
- Snake River (SR) spring/summer run Chinook salmon,
- SR fall-run Chinook salmon,
- Columbia River (CR) chum salmon (*O. keta*),
- LCR coho salmon,
- SR sockeye salmon (*Oncorhynchus nerka*),
- LCR steelhead (*O. mykiss*),
- UWR steelhead,
- MCR steelhead,
- UCR steelhead,
- Snake River Basin (SRB) steelhead
- southern green sturgeon (*Acipenser medirostris*)
- eulachon (*Thaleichthys pacificus*), and
- eastern Steller sea lion (*Eumetopias jubatus*).

On August 11, 2010, NMFS notified the FHWA and FTA that the BA was complete and that NMFS will complete a biological opinion by November 7, 2010.

On September 22, 2010, the CRC Team provides NMFS with the final data summaries of ESA-listed salmon, steelhead, and eulachon of presence, abundance, timing, and calculated hydroacoustic related take estimates for use in formal consultation. This represents a culmination of coordination with NMFS and the FPAC.

On September 23, 2010, the FHWA and FTA submit a draft final stormwater design package for use in the Opinion.

On September 28, 2010, the FHWA and FTA replied to a letter from the NMFS Office of Protected Resources, dated August 12, 2010, regarding the CRC Team's request for a Letter of Authorization for incidental take under the Marine Mammal Protection Act.

On October 4, 2010, the FHWA and FTA submit final details qualifying the September 23, 2010 transmittal. Final engineering will continue as final design of the action occurs.

On October 13, 2010, the FHWA and FTA notified NMFS that service changes to the new North Portland Harbor bridges is likely after the conclusion of consultation. This would add a direct local connection between Hayden Island and North Marine Drive. However, this addition would not change the degree or amount of effects addressed in this Opinion due to using already planned for bridge structure. In addition, the project may be phased due to funding, which could prolong the construction.

On October 19, 2010, the FHWA and FTA provided an additional response to the NMFS Office of Protected Resources. This response included a new analysis of the effects of the proposed CRC on eastern Steller sea lions, and an addendum to BA Appendix K with final calculations of the impacts of underwater noise to fish.

On October 21, 2010, the FHWA and FTA submit final elements of the proposed action, including a test pile program to be completed before CRC construction begins.

On November 17, 2010, the FHWA and FTA submitted a final application for incidental take under the Marine Mammal Protection Act that revised the analysis of effects of the CRC on eastern Steller sea lions.

On December 8, 2010, NMFS, FHWA and FTA concur that the test pile program has separate utility and function from the CRC, and would be consulted on separately (see NMFS 2010).

Description of the Proposed Action

The FHWA and FTA will complete a multimodal transportation improvement project within a 5-mile corridor of I-5 to improve safety; reduce traffic congestion; increase mobility of motorists, freight, bicyclists, and pedestrians from Vancouver, Washington to Portland, Oregon; and to extend the light-rail train (Tri-MET's Yellow Line MAX) from Delta Park, in Portland, Oregon, to Clark College in Vancouver, Washington (Figure 1). Construction will begin in September 2012, and end in December 2020.

The proposed action will include replacement of the current pair of I-5 bridges spanning the lower Columbia River. It will also add three new bridges that cross the North Portland Harbor, and widen the existing I-5 crossing over the harbor as well. Construction of the lower Columbia River bridges would occur from 2013 – 2017, and Harbor bridge construction would occur from 2013-2016. FHW and FTA plan to complete construction below ordinary high water (OHW) for both bridges by April 2017. The in-channel portion of the work will occur within a tidally influenced area that terminates approximately 40 river miles upstream of the project area at Bonneville Dam.

Figure 1. Alignments of the proposed Columbia River Crossing highway improvements, bridges, and light rail features.

Columbia River Bridge

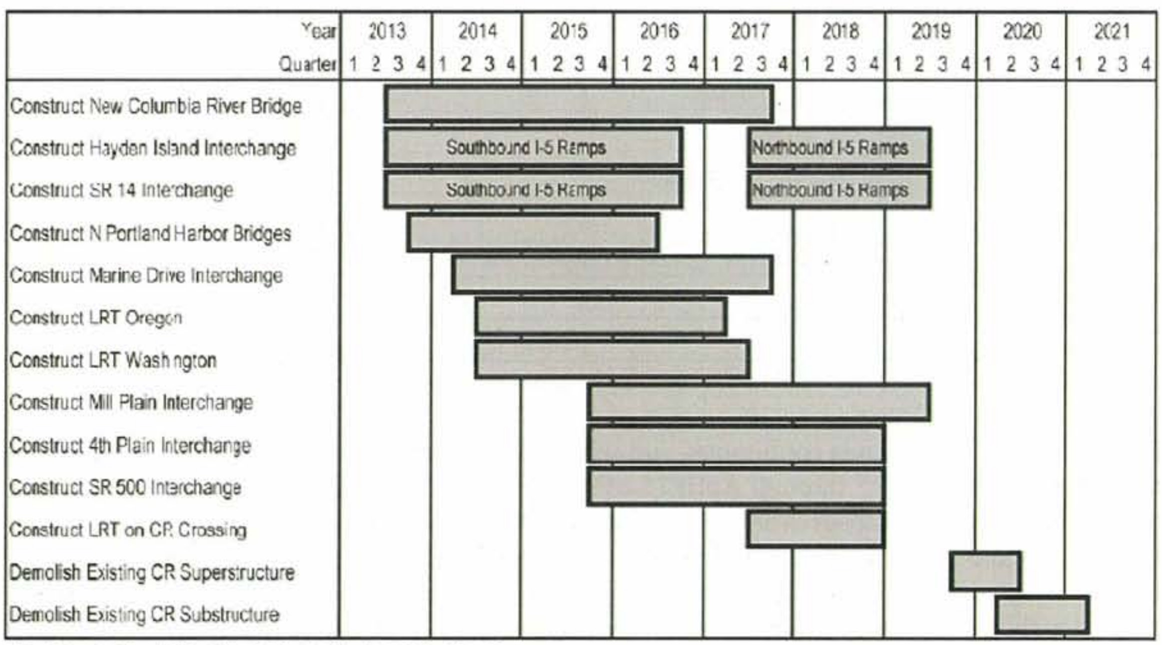
The northbound and southbound replacement structures located at Columbia river mile (RM) 106 will be constructed downstream of the current crossing on a curved alignment to preserve the existing points of landward alignment for ingress and egress of the crossing. These bridges will have a 15 foot gap between them, spanning the lower Columbia River from Vancouver, Washington, to Hayden Island, Portland, Oregon (Table 1):

Table 1. Approximate width, length and clearance of the proposed Columbia River Crossing bridge over the mainstem of the lower Columbia River.

Bridge	I-5 Northbound	I-5 Southbound (with light rail)
Width over water (ft)	Varies: 91-130	Varies: 91-130
Length over water (ft)	2,700	2,650
Bridge Clearance (ft)	Varies: 95	Varies: 95

The bridges' substructure will be supported by eight matched pier sets, 16 piers total, each supported by a complex of up to nine 10 foot diameter columns and a pier cap. These pier sets are numbered 1-8 with the sequence beginning landward on Hayden Island and ending landward in the City of Vancouver. Only sets 2-7 will be built below OHW (*i.e.*, 17.6 feet National Geodetic Vertical Datum) (Corps 2004), and use 88 columns. The FHWA and FTA will construct these columns using a sequential drilled-shaft technique (Table 2).

Table 2. Estimated timeline for construction of the proposed Columbia River Crossing bridge over the mainstem of the lower Columbia River.



CR = Columbia River; LRT = Light Rail Transit; N = North; SR = State Route

Each shaft will be constructed by first advancing a 10 foot diameter steel casing either by use of a vibratory hammer or by using hydraulic rams to oscillate or rotate it through river bottom sediments into the Troutdale Formation, a geologic layer of consolidated aggregate. Advancement would continue several feet into this formation, which may be up to approximately

272 feet below OHW. The casing is then drilled (hollowed) and the tailings removed for disposal, a re-bar cage is dropped into place, and the shaft is filled with concrete. The casing will be removed for re-use. Once all of the columns within a complex are finished then they are joined by poured (in-place) concrete and steel fittings to form a pile-cap. This kind of work is typically contained by a form that is floated into place by barges. The cap and its columns bear the load placed upon the pier that it supports entirely.

To construct the bridge piers, temporary round hollow-steel pile will be installed to create temporary work platforms, work bridges, falsework, and vessel tethers that will support equipment and people necessary to construct the piers and the superstructure of the bridge itself (Table 3). Equipment likely to be supported includes but is not limited to cranes, generators, and hydraulic rams. Load-bearing piles will be installed by first advancing them to a point of refusal using a vibratory hammer, and then using an impact hammer to proof, or test, each pile for a specified vertical load bearing capacity. Non-load bearing piles will be advanced to refusal only.

Table 3. Estimated number of cofferdams and piles necessary to complete the temporary in-water structure for the proposed Columbia River Crossing bridge over the mainstem of the lower Columbia River.

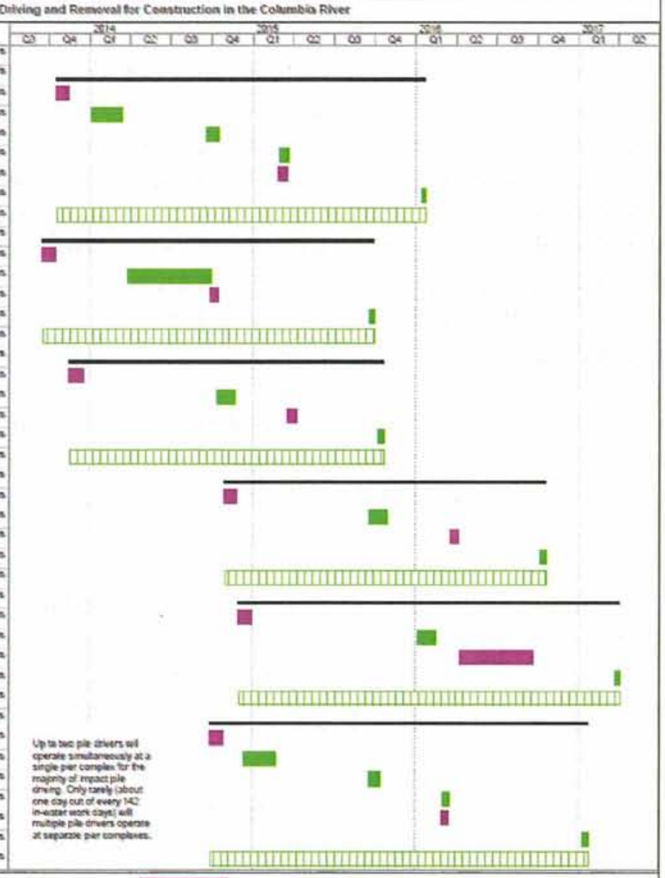
	Count
Cofferdams	2
Pipe Piles	
Load Bearing 18-24 inches	600
Load Bearing 36-48 inches	240
Non-Load Bearing 18-24 inches	384
Total	**1,224**
Support Structures	18
Barges	Up to 12 at a single time

Impact driving will be non-continuous, and within discrete blocks across 31-weeks of in-water work from September 15 through April 15 of each year (Table 4). Pile driving will occur every year for 6-years. The impact driving strike rate is 40-strikes per minute. Daily pile installation includes up to 6-piles, three 18-24 inch piles and three 36-48 inch piles. Impact driving may occur across a 12-hour period each day, but will not include more than 1-hour of actual pile driving activity. Vibratory driving without impact driving will occur year-round, as needed. The total number of days of impact pile driving in the Columbia River will be between 138 and 142 days.

Table 4. Example of sequence of pile driving and removal for the Columbia River Crossing bridges.

Figure 3-6. Sequencing of Pile Driving and Removal for Construction in the Columbia River

Task Name	Start	Finish	Duration
Bridge Construction Scenario 2/5/13	**9/16/13**	**4/5/17**	**928 days**
Pier 2	**10/16/13**	**1/22/16**	**593 days**
Install Work Bridge Piles (Vibratory & Impact Pile Driving)	10/16/13	11/14/13	22 days
Install Cofferdam (Vibratory Installation)	12/31/13	3/11/14	51 days
Remove Work Bridge & Piles (Vibratory Removal)	9/16/14	10/13/14	20 days
Remove Cofferdam (Vibratory Removal)	2/27/15	3/19/15	15 days
Erect Tower Crane (Vibratory & Impact Pile Driving)	2/27/15	3/19/15	15 days
Remove Tower Crane (Vibratory Removal)	1/11/16	1/22/16	10 days
Barge Moorings (Vibratory Installation & Removal)	10/16/13	1/22/16	593 days
Pier 3	**9/16/13**	**9/29/15**	**532 days**
Install Work Bridge Piles (Vibratory & Impact Pile Driving)	9/16/13	10/15/13	22 days
Remove Work Platform & Piles (Vibratory Removal)	3/24/14	9/26/14	135 days
Erect Tower Crane (Vibratory & Impact Pile Driving)	9/29/14	10/17/14	15 days
Remove Tower Crane (Vibratory Removal)	9/16/15	9/29/15	10 days
Barge Moorings (Vibratory Installation & Removal)	9/16/13	9/29/15	532 days
Pier 4	**11/15/13**	**10/20/15**	**503 days**
Install Work Bridge Piles (Vibratory & Impact Pile Driving)	11/15/13	12/17/13	23 days
Remove Work Platform & Piles (Vibratory Removal)	10/9/14	11/19/14	30 days
Erect Tower Crane (Vibratory & Impact Pile Driving)	3/20/15	4/9/15	15 days
Remove Tower Crane (Vibratory Removal)	10/7/15	10/20/15	10 days
Barge Moorings (Vibratory Installation & Removal)	11/15/13	10/20/15	503 days
Pier 5	**10/29/14**	**10/19/16**	**516 days**
Install Work Bridge Piles (Vibratory & Impact Pile Driving)	10/29/14	11/28/14	23 days
Remove Work Platform & Piles (Vibratory Removal)	9/16/15	10/27/15	30 days
Erect Tower Crane (Vibratory & Impact Pile Driving)	3/21/16	4/8/16	15 days
Remove Tower Crane (Vibratory Removal)	10/6/16	10/19/16	10 days
Barge Moorings (Vibratory Installation & Removal)	10/29/14	10/19/16	516 days
Pier 6	**12/1/14**	**4/5/17**	**613 days**
Install Work Bridge Piles (Vibratory & Impact Pile Driving)	12/1/14	12/31/14	23 days
Remove Work Platform & Piles (Vibratory Removal)	1/5/16	2/15/16	30 days
Erect Tower Crane (Vibratory & Impact Pile Driving)	4/11/16	9/23/16	120 days
Remove Tower Crane (Vibratory Removal)	3/23/17	4/5/17	10 days
Barge Moorings (Vibratory Installation & Removal)	12/1/14	4/5/17	613 days
Pier 7	**9/29/14**	**1/23/17**	**606 days**
Install Work Bridge Piles (Vibratory & Impact Pile Driving)	9/29/14	10/28/14	22 days
Install Cofferdam (Vibratory Installation)	12/11/14	2/20/15	52 days
Remove Work Bridge & Piles (Vibratory Removal)	9/16/15	10/13/15	20 days
Remove Cofferdam (Vibratory Removal)	2/29/16	3/18/16	15 days
Erect Tower Crane (Vibratory & Impact Pile Driving)	2/29/16	3/18/16	15 days
Remove Tower Crane (Vibratory Removal)	1/10/17	1/23/17	10 days
Barge Moorings (Vibratory Installation & Removal)	9/29/14	1/23/17	606 days



Conceptual Schedule Only

Pier Activity Summary — Vibratory and Impact Activities — Vibratory Activities — Vibratory Activities (Intermittent)

Note: This is a proposed schedule, so activity dates are likely to change.

April 2010

FHWA and FTA expect that temporary pile will be advanced 70-140 feet below the channel bottom. Additionally, cofferdams are likely to be installed around the sites of pier sets 2 and 7. These shallow areas may preclude the use of barges, so that temporary work bridges and cofferdams will be constructed to allow equipment and construction worker access.

Above water structures will be fabricated at an off-site location, barged into alignment, and lifted by crane into place for attachment. Off-site locations used for overall construction staging and pre-fabrication of bridge segments are likely to occur at the following locations:

- The Port of Vancouver near Terminal 3 (52 acres)
- The Red Lion at the Quay Hotel (2.6 acres), acquired through right-of-way (ROW).
- The vacant Thunderbird Hotel (5.6 acres), acquired through ROW.

Demolition of the current bridges will occur over approximately 1.5 years, from September 2018 through March 2020. Demolition will commence once the following project components are complete: (1) Construction of the north and southbound replacement bridges; (2) redevelopment of the SR 14 interchange; (3) redevelopment of the Hayden Island interchange; and (4) routing of north and southbound traffic onto the new bridges. Demolition of the superstructure will begin with removal of the counterweights. The contractor will lock the lift-span into place and the counterweights cut into pieces and transferred off-site via truck or barge. Next, the contractor will cut the lift towers into manageable pieces and load them onto barges. Prior to removal of the trusses, the deck will be removed by cutting it into manageable pieces; these pieces will be transported by barge or truck or by using a breaker, in which case debris will be caught on a barge or other containment system below the work area. After contractors demolish the deck, they will lift the trusses onto barges and transfer them to off-site locations for final demolition. Finally, the contractors will use a diamond wire saw to cut the piers into manageable sections before transporting them offsite to complete demolition.

In addition, nine sets of the 11 existing Columbia River bridge piers are below the OHW level and are supported on a total of approximately 1,800 driven timber piles that are assumed to be treated with a creosote wood preservative- direct evidence is not evident nor readily accessible. The FHWA and FTA would remove only those vacant piles that pose a navigation hazard within the navigation channels and protrude above the surface channel bed. These would be removed via vibratory extraction, direct pull, clamshell dredge, or use of an underwater saw to cut below channel bottom. The number of piles is unknown as original spec sheets are not demonstrable of this element. If treated, the removal of piles or containment is of concern due to the presence of polycyclic aromatic hydrocarbons and heavy metals, which are toxic to aquatic life including fish.

North Portland Harbor Bridge

The current I-5 bridge that crosses the North Portland Harbor, a channel of the lower Columbia River, will be widened with the addition of a south-bound automobile ramp. Widening of the existing structure will require the addition of eight, 10-foot diameter drilled shaft columns. Unlike the Columbia River bridges, these columns will connect directly to the superstructure, avoiding the need for a pile-cap. The addition of three new bridge alignments will carry local traffic from Hayden Island to Marine Drive, the I-5 northbound collector distributor ramp, the I-5 southbound collector distributor, and the light rail train and bike/pedestrian path (Figure 2). These alignments diverge from the I-5 alignment on Hayden Island. The first requires five drilled shafts, the second requires five drilled shafts, and the third requires 12 drilled shafts. Construction of the North Portland Harbor bridge will follow the same sequence of pile driving and removal as the Columbia River bridge (Table 4) and require the use of barges and temporary piles (Tables 5 and 6).

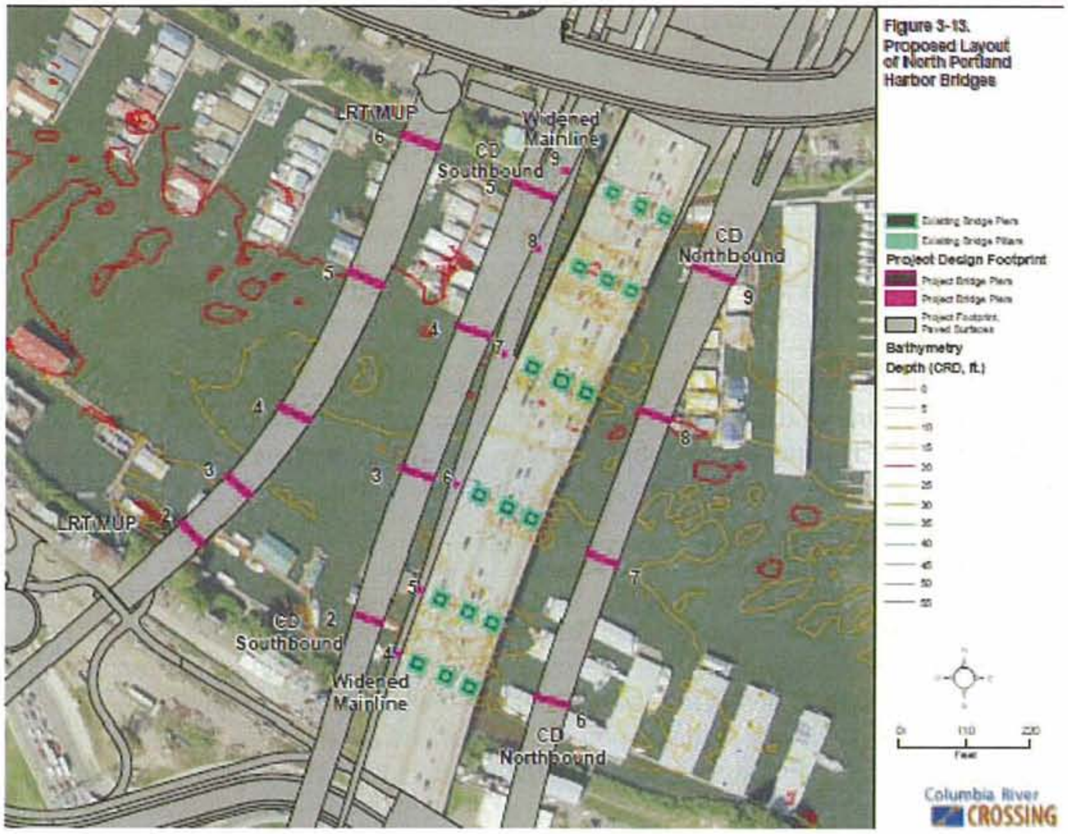


Figure 2. Substructure locations for the proposed Columbia River Crossing bridges over the North Portland Harbor.

Table 5. Estimated number of piles necessary to complete the temporary in-water structure for the proposed Columbia River Crossing bridges over the North Portland Harbor.

	Count
Pipe Piles	
Load Bearing 18-24 inch	600
Load Bearing 36-48 inch	240
Non-Load Bearing 18-24 inch	384
Total	**1,224**
Support Structures	18
Barges	Up to 12 at a single time

Table 6. Approximate length and width of the proposed Columbia River Crossing bridges over the North Portland Harbor.

Bridge	LRT and Bike/Ped Path	I-5 Southbound Collector-Distributor	Widened Mainline	I-5 Northbound Collector-Distributor
Width Over Water	Varies 50-65 ft	Varies 50-82 ft	Varies 162-200 ft	Varies 57-82 ft
Length Over Water	Approx. 875 ft	Approx. 945 ft	Approx. 990 ft	Approx. 1,020 ft

Unlike at the Columbia River mainstem location, cofferdams will not be used in North Portland Harbor, and only those parts of the remnant structure that are in the way of the new structure will be removed. The material is generally at or below grade, and will be removed via a clamshell dredge will be used to minimize material loss into the channel.

Roadways

Improvements will modify the I-5 thoroughfare for the length of the project from Oregon milepost (MP) 305.9 to Washington MP 3.1, approximately 5-miles. Of that, approximately 2.5 miles constitute the landward or non-bridge portions of I-5 itself. Depending on the road segment, modifications will include some combination of lane widening, lane additions, repaving, pavement overlays, shoulder expansion, road-prism elevation increase, and replacement.

Three interchanges in Portland and four in Vancouver will be improved. These include from south to north the Marine Drive, Victory Boulevard, Hayden Island, Washington State Route (SR) 14, Mill Plain Blvd., Fourth Plain Blvd, and the Washington SR 500 interchanges.

In addition to interchange improvements, highway safety and mobility will be improved with a series of auxiliary (add/drop) lanes that will be sequentially added and then dropped at strategic locations through the corridor. The add/drop lanes will allow vehicles to travel between given points without merging into mainline interstate traffic, and will allow vehicles exiting or entering to minimize conflicts with through traffic. From the south end of the project area, I-5 northbound will add one auxiliary lane starting where the Victory Boulevard on-ramp enters I-5. Another auxiliary lane will be added where the Marine Drive on-ramp enters I-5. An optional third auxiliary lane will be added where Hayden Island traffic enters I-5 over the river. One of these lanes will be dropped at the SR 14 off-ramp, and a second will be dropped at the Mill Plain off-ramp. North of the Mill Plain off-ramp, the number of auxiliary lanes will vary between one and three.

Lanes will be added or dropped as the various on-ramps and off-ramps enter or exit I-5 at each subsequent interchange. Southbound I-5 and the associated interchanges and ramps will have a similar series of add/drop lanes. The interchanges and lane improvements will extend roadway improvements to local roadways within the jurisdiction of the cities of Portland and Vancouver.

Transit

Currently light rail train operated by TriMET originates and terminates in Oregon without service to Vancouver. The action would extend TriMet owned light rail train service from Portland to Vancouver northwest through Washington and Broadway Street to and onto W 17th Street northeast until its terminus at Clark College. Three park-and-ride facilities will be constructed in Vancouver: The SR 14 Park and Ride (I-5 and SR 14), Mill District (Washington, East 16th, main, and East 15th Street block), and Clark College (Figure 3). To support this extra capacity expansion of the TriMet Ruby Junction Maintenance Facility in Gresham Oregon will occur. Approximately 5.4 acres of pavement will be added to the site. Bus routes and capacity will changed as well, and will be incorporated into the park-and-ride and light rail train path improvements. As discussed previously, the addition of light rail train will result in the construction of a new bridge across North Portland Harbor, to be incorporated into the CRC bridges, and the addition of a landward ingress/egress path on Hayden Island and within Vancouver.

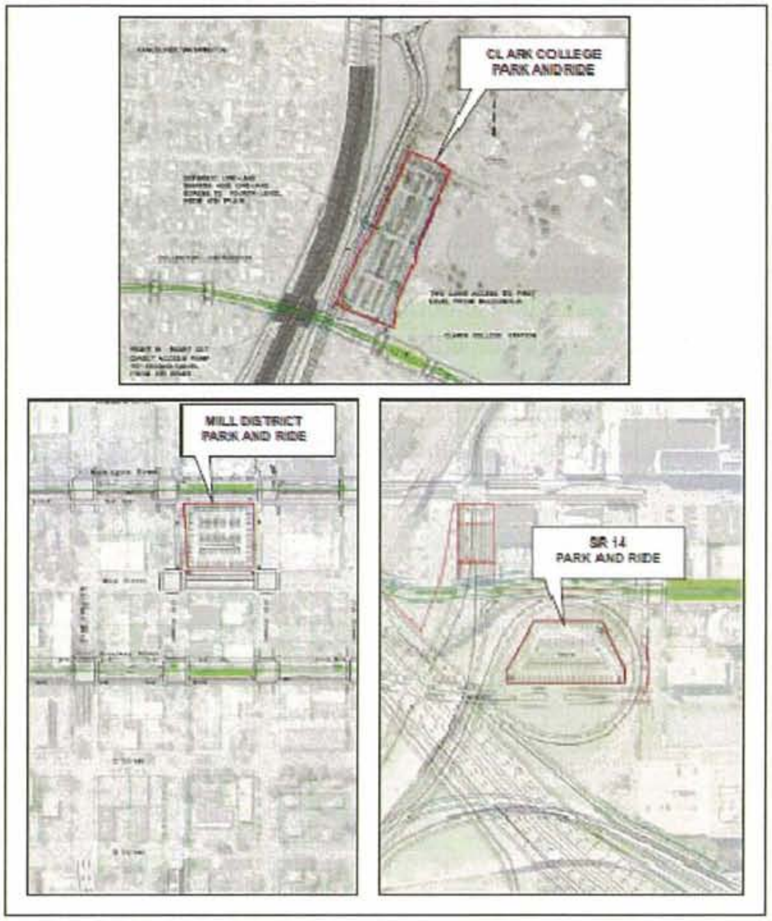


Figure 3. Light rail train Park and Ride facilities for the proposed Columbia River Crossing.

Off-site Construction and Staging

The FHWA and FTA have proposed to use non-CRC corridor locations for use for material and equipment staging, pre-fabrication of bridge elements, and for final demolition of current bridge element. The FHWA and FTA have identified and included sites likely for this use in the action area. They are as follows:

- **Port of Vancouver Staging Area**. This 52-acre site is located along SR 501 near the Port of Vancouver's Terminal 3 North facility. This site is without river frontage, so materials would be transported over land to the construction site. Activities will consist of material storage, material fabrication, equipment storage and repair, and temporary buildings.
- **Alcoa/Evergreen**. This 94.5-acre site would be a major casting/staging yard and is located on the north shore of the lower Columbia River at approximately River Mile

(RM) 102. It is undergoing environmental remediation prior to the anticipated 2013 start date.

- **Red Lion Staging Area.** This is a 2.6-acre site on the north shore of the lower Columbia River, immediately downstream of the existing bridge alignment. Acquisitions would occur through ROW, possibly through purchase. It requires partial demolition of the Red Lion at the Quay Motel. This site would be a staging site for materials and equipment and for fabrication of smaller bridge and roadway components. Temporary buildings, such as trailers or other mobile units would also be included.
- **Thunderbird Staging Area.** This is a 5.6-acre site on Hayden Island on the south shore of the lower Columbia River, immediately downstream of the existing bridge alignment. A large portion of the parcel will be acquired as new ROW for the new bridge alignment. The site is relatively large and it is adjacent to the river and the construction zone. The same types of activities could occur on this site as on the Red Lion Hotel site.
- **Sundial Casting Area.** This 56-acre site lies on the south shore of the lower Columbia River near RM 120.2. This currently serves as an industrial rock product processing facility.

Stormwater Management

The action will include management and treatment for a contributing impervious area (CIA) of approximately 296 acres. The FHWA and FTA have delineated the CIA to be equal to the boundaries of the Columbia River Crossing corridor, which includes I-5 ROW and any work done to local roadways in Portland and Vancouver. The CIA include any terrestrial roadway or bridges, bridge decks that function as the I-5 thoroughfare, ingress and egress ramps, local access, and mass transit/automobile mergers. Stormwater management through treatment will reduce pollutant loads and alter pollutant speciation of stormwater before discharge into ESA-fish bearing watersheds. The CIA consists of from south to north the Columbia Slough basin, the Columbia River basin, and the Burnt Bridge Creek basin (Figures 4 – 6). The FHWA and FTA plan to capture and treat all stormwater runoff from the CIA up to the design storm, although a stormwater management plan for 6.8 acres of CIA is still incomplete (Table 7).

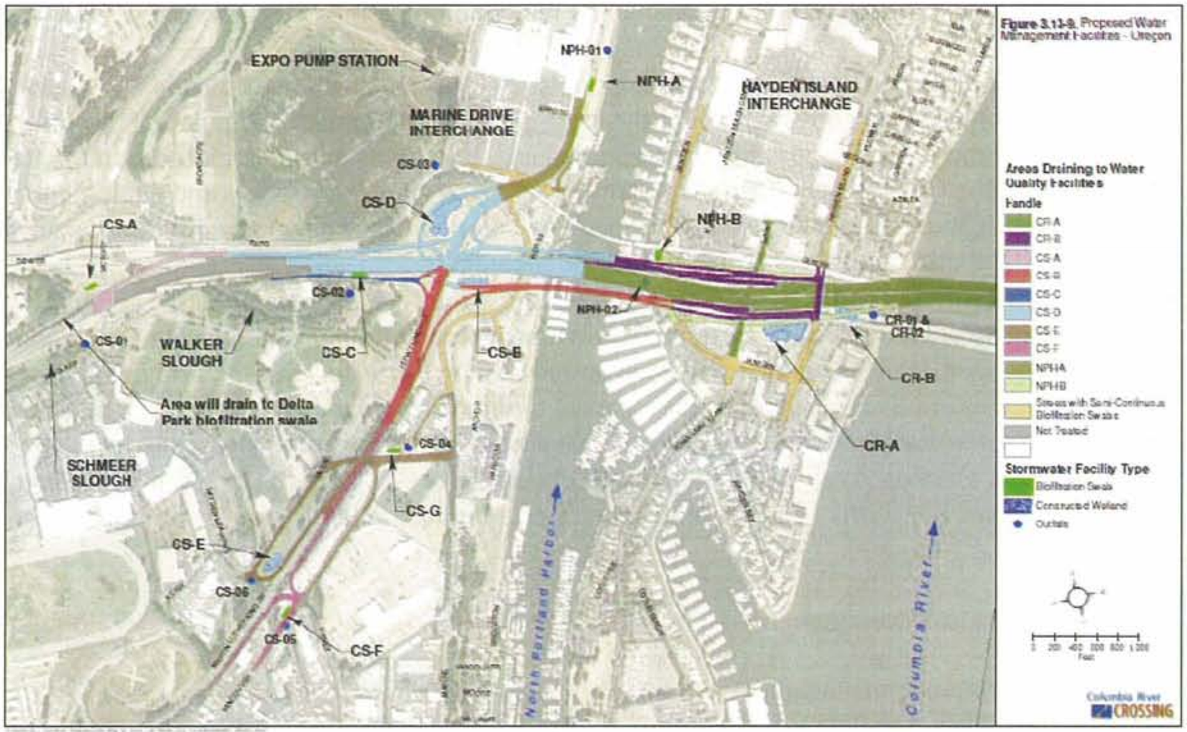


Figure 4. Overview of the contributing impervious area and stormwater treatment basins (southern segment) for the proposed Columbia River Crossing project.

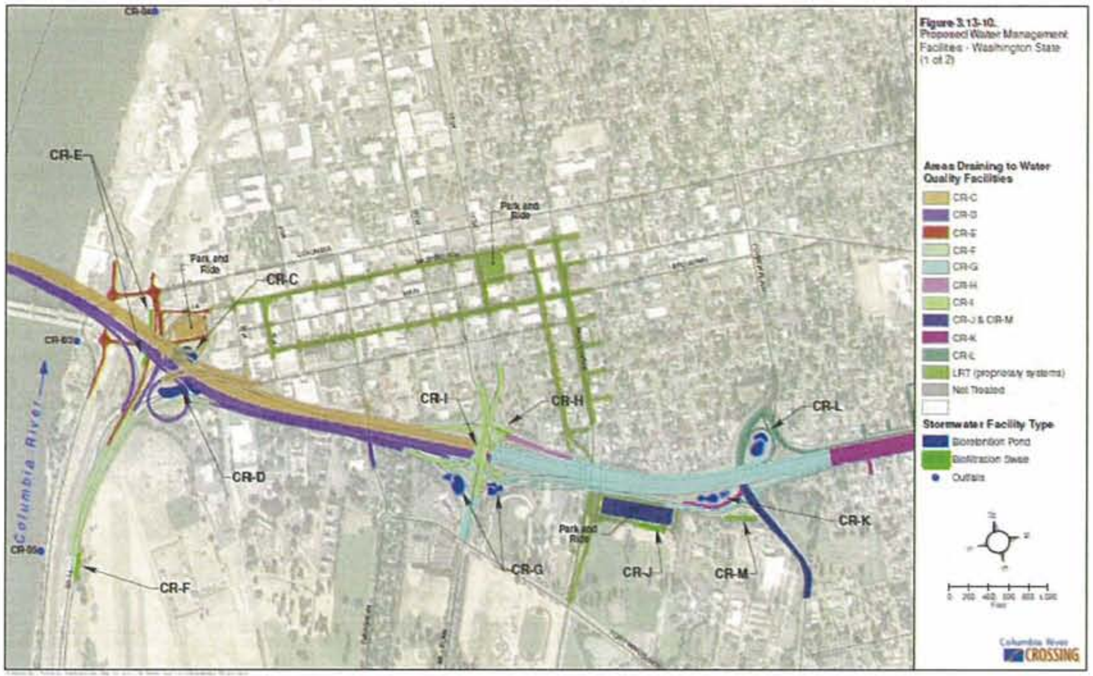


Figure 5. Overview of the contributing impervious area and stormwater treatment basins (middle segment) for the proposed Columbia River Crossing project.

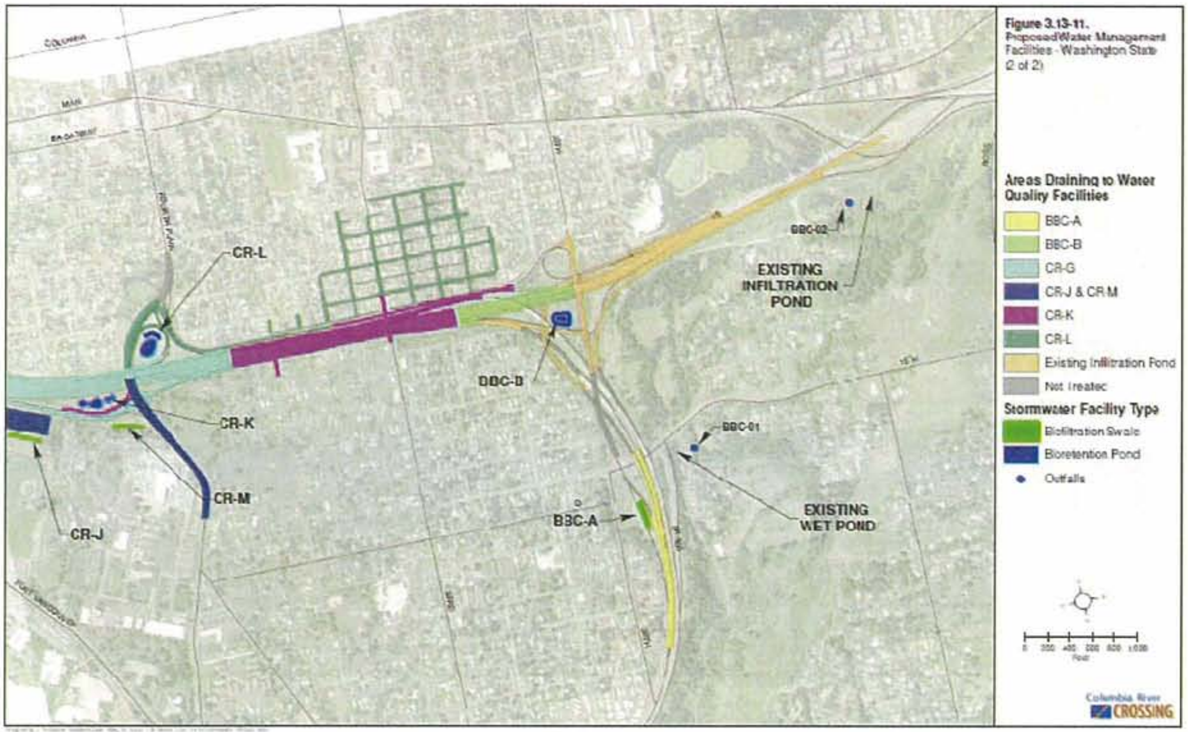


Figure 6. Overview of the contributing impervious area and stormwater treatment basins (northern segment) for the proposed Columbia River Crossing.

Table 7. Summary of the contributing impervious area management for the Columbia River Crossing at time of consultation.

Watershed	Total CIA (acres)	Treated CIA (acres)	Untreated CIA (acres)
Burnt Bridge Creek	21.9	21.9	0
Columbia River	217.9	216.9	1.0
Columbia Slough	55.7	49.9	5.8
Total	295.5	288.7	6.8

Final engineering and design of the roadways, bridge decks, and stormwater treatment facilities is not complete. For the consultation, the FHWA and FTA have submitted design and engineering at varying stages of completeness for stormwater management, up to 30%. Design elements while mostly fixed are approximate and subject to change. 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 WDOT's Highway Runoff Manual (WDOT 2010a), and thus exceed 50% of the 2-year, 24-hour storm.
2. The CIA in the Burnt Bridge Creek watershed is the only area that requires stormwater quantity treatment because it is the only non-mainstem or non-tidal waterbody that will receive stormwater discharge from the project area. This treatment will ensure that the stormwater runoff does not alter change stream hydrology by limiting the rate of stormwater discharge to 50% of the 2-year event.
3. 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.
    e. 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 WDOT Runoff Manual (WDOT 2010a) will be used and met when designing these facilities.

Additional Impact Avoidance and Minimization Measures

The applicant proposes to implement the following BMPs as impact avoidance and minimization measures. These BMPs were included in the BA and are a nondiscretionary part of the proposed action. The FHWA and FTA will ensure that their contractors will:

1. Prepare and carry out an Erosion and Sediment Control Plan for any part of the project that requires a ground disturbing activity, such as land clearing, vegetation removal, grading, ditching, filling, embankment compaction, or excavation, including any erosion that may result from weather, the nature of the construction materials used, or the stage or work.
2. Prepare and carry out a Spill Prevention Control and Countermeasures and an Erosion and Spill Control Plan for any potentially hazardous material that will be stored or used at the project site to prevent or contain accidental spills in the work/repair area to insure no contaminants escape containment to surface waters.
3. Limit entrapment and disturbance to benthic habitats through use of wire-saw demolition of existing bridge piers instead of cofferdams.
4. Reduce underwater sound from underwater structure installation through use of the drilled shaft method to install the permanent in-water bridge structure, use of the 'vibe and proof' pile installation technique to install temporary piles, and complete all monitoring as described in the underwater sound monitoring plan.
5. Use directional techniques for all construction lighting to reduce nighttime illumination of the lower Columbia River.

Interrelated and Interdependent Actions

Effects of the action under consultation are analyzed together with the effects of other activities that are interrelated to, or interdependent with, that action (50 CFR 402.01). Interrelated actions are those that are part of a larger action and depend on the larger action for their justification, and interdependent actions are those that have no independent utility apart from the action under consideration.

The BA identified the following actions and interrelated and interdependent with CRC: (1) CRC maintenance; (2) compensatory mitigation to comply with section 404 of the Clean Water Act; (3) utility relocation during construction; (4) construction and operation of additional staging areas; (5) acquisition and relocation of existing floating homes in North Portland Harbor; (6) design and operation of a pump station in an unnamed channel of the Columbia Slough; and (7) transit-oriented development on Hayden Island.

The present level of planning for these actions is not sufficient to support a complete analysis of effects that are reasonably certain to occur on ESA-listed species or their designated critical habitats. Nonetheless, after due consideration, NMFS concluded that the effects of CRC maintenance, compensatory mitigation, and utility relocation are likely to be within the range of actions that have already completed formal consultation (*e.g.*, NMFS 2008a, 2008b). Additional staging areas are within the range of effects considered in this consultation. Acquisition and relocation of existing floating homes, the Columbia Slough pump station, and development on Hayden Island are actions that will have independent utility and, depending on their eventual disposition, are likely to be the object of a future consultation.

Action Area

Action area means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For this consultation, the action area will include: (1) The area where underwater noise caused by pile driving will exceed background; (2) the lower Columbia River where dissolved and suspended pollutants caused by stormwater runoff from CRC is redistributed to the Pacific Ocean; and (3) the eastern Pacific Ocean where southern resident killer whales overlap with Chinook salmon from the Columbia basin.

Background noise levels for the project site are not available.[2] However, due to the curvature of the river and islands present, underwater sound from impact pile driving is expected to reach land well before attenuating to assumed background sound levels of 120 dB (re: 1 μPa) root mean square. Thus, the action area is not expected to extend beyond Sauvie Island, about 5.5 miles downstream of the project site, and Lady Island, about 12.5 miles upstream. This distance encompasses the lower Columbia River from approximately RM 101 to 119. As no pile driving activities will occur within North Portland Harbor, there will be no aquatic effects from underwater pile driving noise in this area.

Sixteen ESA-listed species and 12 designated critical habitats occur in the action area and were considered in this opinion (Table 8). Southern resident killer whales do not occur in this action area but were nonetheless considered in this Opinion because Chinook salmon is the preferred

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[2] One measurement of 136 dB peak has been reported for the lower Columbia River at RM 45 where the river is tidally influenced (Carlson *et al.* 2001, cited in the BA). A crude approximation of the root mean square (RMS) values is approximately 121 dB RMS (subtracting 15 dB, Jim Laughlin 2009, personal communication).

prey of southern resident killer whales and a reduction in Chinook salmon could reduce the available quantity of that prey within the range of the killer whale. For reasons explained in Appendix A of this Opinion, NMFS concluded that the proposed action is not likely to adversely affect southern resident killer whales.

The action area is also designated as EFH for Pacific Coast groundfish (PFMC 2006), coastal pelagic species (PFMC 1998), and Pacific Coast salmon (PFMC 1999), or is in an area where environmental effects of the proposed action may adversely affect designated EFH for those species.

Table 8. Federal Register notices for final rules that list threatened and endangered species, designate critical habitats, or apply protective regulations to listed species considered in this consultation. Listing status: T means listed as threatened under the ESA; E means listed as endangered.

Species	Listing Status	Critical Habitat	Protective Regulations
Marine and Anadromous Fish			
Chinook salmon (*Oncorhynchus tshawytscha*)			
Lower Columbia River	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Willamette River	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Columbia River spring-run	E 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	ESA section 9 applies
Snake River spring/summer run	T 6/28/05; 70 FR 37160	10/25/99; 64 FR 57399	6/28/05; 70 FR 37160
Snake River fall-run	T 6/28/05; 70 FR 37160	12/28/93; 58 FR 68543	6/28/05; 70 FR 37160
Chum salmon (*O. keta*)			
Columbia River	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Coho salmon (*O. kisutch*)			
Lower Columbia River	T 6/28/05; 70 FR 37160	Not applicable	6/28/05; 70 FR 37160
Sockeye salmon (*O. nerka*)			
Snake River	E 6/28/05; 70 FR 37160	12/28/93; 58 FR 68543	ESA section 9 applies
Steelhead (*O. mykiss*)			
Lower Columbia River	T 1/05/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Willamette River	T 1/05/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Middle Columbia River	T 1/05/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Columbia River	T 1/05/06; 71 FR 834	9/02/05; 70 FR 52630	2/01/06; 71 FR 5178
Snake River Basin	T 1/05/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Green sturgeon (*Acipenser medirostris*)			
Southern	T 4/07/06; 71 FR 17757	10/09/09; 74 FR 52300	6/02/10; 75 FR 30714
Eulachon (*Thaleichthys pacificus*)			
Eulachon	T 3/18/10; 75 FR 13012	01-05-2011; 76 FR 515	Not applicable
Marine Mammals			
Steller sea lion (*Eumetopias jubatus*)			
Eastern	T 5/5/1997; 63 FR 24345	8/ 27/93; 58 FR 45269	11/26/90; 55 FR 49204
Killer whale (*Orcinus orca*)			
Southern Resident	E 11/18/05; 70 FR 69903	11/29/06; 71 FR 69054	ESA section 9 applies

ENDANGERED SPECIES ACT BIOLOGICAL OPINION

Section 7(a)(2) of the ESA requires Federal FHWA and FTA to consult with NMFS to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The Opinion that follows records the results of the interagency consultation for this proposed action. The ITS provided after the Opinion specifies the impact of taking of threatened or endangered species that will be incidental to the proposed action; reasonable and prudent measures that NMFS considers necessary and appropriate to minimize such impact, and nondiscretionary terms and conditions (including, but not limited to, reporting requirements) that must be complied with by the FHWA and FTA to carry out the reasonable and prudent measures.

To complete the jeopardy analysis presented in this Opinion, NMFS reviewed the status of each listed species[3] considered in this consultation, the environmental baseline in the action area, the effects of the action, and cumulative effects (50 CFR 402.14(g)). From this analysis, NMFS determined whether effects of the action were likely, in view of existing risks, to appreciably reduce the likelihood of both the survival and recovery of the affected listed species.

For the critical habitat adverse modification analysis, NMFS considered the status of the entire designated area of the critical habitat considered in this consultation, the environmental baseline in the action area, the likely effects of the action on the function and conservation role of the affected critical habitat, and cumulative effects. NMFS used this assessment to determine whether, with implementation of the proposed action, critical habitat would remain functional, or retain the current ability for the primary constituent elements (PCE) to become functionally established, to serve the intended conservation role for the species.[4]

If the action under consultation is likely to jeopardize the continued existence of an ESA-listed species, or destroy or adversely modify critical habitat, NMFS must identify any reasonable and prudent alternatives for the action that avoid jeopardy or destruction or adverse modification of critical habitat and meet other regulatory requirements (50 CFR 402.02).

Status of the Species and Critical Habitat

The summaries that follow describe the status of ESA-listed species, their designated critical habitats, southern green sturgeon and eastern Steller sea lions that occur within the geographic area of the action area affected by the FHWA and FTA. These summaries are a synthesis of information presented across a large body of scientific publications and reports, and are the basis for the analyses we present in the Effects of the Action section of this Opinion. More detailed

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[3] An "evolutionarily significant unit" (ESU) of Pacific salmon (Waples 1991) and a "distinct population segment" (DPS) (Policy Regarding the Recognition of District Vertebrate Population; 61 FR 4721, Feb 7, 1996) are both "species" as defined in section 3 of the ESA.

[4] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (November 7, 2005) (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act).

information on the status and trends of these listed resources, and their biology and ecology, occur in the listing regulations and critical habitat designations published in the Federal Register (Table 8) and in many publications available from the NMFS Northwest Region, Protected Resources Division, Portland, Oregon.

The status of species and critical habitat sections below are organized into two recovery domains (Table 9) to better integrate recovery-planning information that NMFS is developing on the conservation status of the species and critical habitats considered in this consultation. Recovery domains are the geographically based areas that NMFS is using to prepare multi-species recovery plans.

Although southern green sturgeon, eulachon and eastern Steller sea lion are not part of this recovery domain structure, they are presented here for convenience as part of the Willamette/Lower Columbia Recovery Domain. Southern green sturgeon are under the jurisdiction of NMFS' Southwest Region, which has not yet convened a recovery team for this species. Nor has a recovery team yet been convened for eulachon, a species under the jurisdiction of NMFS' Northwest Region. The Steller sea lion recovery plan is under the jurisdiction of NMFS' Protected Resources Division, Silver Springs, Maryland (NMFS 2008c).

Table 9. Recovery planning domains identified by NMFS and the ESA-listed species considered in this consultation.

Recovery Domain	Species
Willamette-Lower Columbia	LCR Chinook salmon
	UWR Chinook salmon
	CR chum salmon
	LCR coho salmon
	LCR steelhead
	UWR steelhead
	Southern green sturgeon
	Eulachon
	Eastern Steller sea lion
Interior Columbia	UCR spring-run Chinook salmon
	SR spring/summer Chinook salmon
	SR fall-run Chinook salmon
	SR sockeye salmon
	UCR steelhead
	MCR steelhead
	SRB steelhead

For each recovery domain, a technical review team (TRT) appointed by NMFS has developed, or is developing, criteria necessary to identify independent populations within each species, recommend viability criteria for that species, and analyze factors that limit species survival. The definition of a population used by each TRT to analyze Pacific salmon and steelhead is set forth in the viable salmonid population (VSP) document prepared by NMFS for use in conservation assessments of Pacific salmon and steelhead (McElhany *et al.* 2000). The boundaries of each population are defined using a combination of genetic information, geography, life-history traits, morphological traits, and population dynamics that indicate the extent of reproductive isolation among spawning groups. To-date, the TRT have divided the 13 species of Pacific salmon and steelhead considered in this Opinion into 189 populations. The overall viability of a species is a function of the VSP attributes of its constituent populations. Those attributes are abundance, population growth rate, population spatial structure, and diversity. Until a viability analysis of a species is completed, the VSP guidelines recommend that all populations should be managed to retain the potential to achieve viable status to ensure a rapid start along the road to recovery, and that no significant parts of the species are lost before the full recovery plan is implemented (McElhany *et al.* 2000).

The status of critical habitat was based primarily on a watershed-level analysis of conservation value that focused on the presence of listed ESA-listed species and physical features (*i.e.*, the PCEs) that are essential to their conservation. This analysis for the 2005 designations of Pacific salmon and steelhead species was completed by Critical Habitat Analytical Review Teams (CHARTs) that focused on large geographical areas corresponding approximately to recovery domains (NOAA Fisheries 2005). Each watershed was ranked using a conservation value attributed to the quantity of stream habitat with PCEs, the present condition of those PCEs, the likelihood of achieving PCE potential (either naturally or through active restoration), support for rare or important genetic or life history characteristics, support for abundant populations, and support for spawning and rearing populations. In some cases, our understanding of these interim conservation values has been further refined by the work of TRTs and other recovery planning efforts that have better explained the habitat attributes, ecological interactions, and population characteristics important to each species.

A similar team, referred to as a Critical Habitat Review Team (CHRT) was convened for southern green sturgeon, as reported in the proposed rule. That team identified and analyzed the conservation value of particular areas occupied by southern green sturgeon, and unoccupied areas they felt may be necessary to ensure the conservation of the species. The CHRT did not identify those particular areas using HUC nomenclature, but did provide geographic place names for those areas, including the names of freshwater rivers, the bypasses, the Sacramento-San Joaquin Delta, coastal bays and estuaries, and coastal marine areas (within 110-meter depth) extending from the California/Mexico border north to Monterey Bay, California, and from the Alaska/Canada border northwest to the Bering Strait; and certain coastal bays and estuaries in California, Oregon, and Washington.

Status of the Species

Natural variations in freshwater and marine environments have substantial effects to the abundance of salmon, steelhead, southern green sturgeon, eulachon, and eastern Steller sea lion populations. Of the various natural phenomena that affect most populations of Pacific salmon and steelhead, changes in ocean productivity are generally considered the most important. Pacific salmon and steelhead are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Ocean predation probably contributes to significant natural mortality, although the levels of predation are largely unknown. In general, Pacific salmon and steelhead are eaten by pelagic fishes, birds, and marine mammals.

Over the past few decades, the sizes and distributions of the Pacific salmon and steelhead populations considered in this Opinion, like the other salmon and steelhead species that NMFS has listed, generally have declined because of natural phenomena and human activity, including the operation of hydropower systems, over-harvest, hatcheries, and habitat degradation. Enlarged populations of terns, seals, sea lions, and other aquatic predators in the Pacific Northwest were identified as factors that may be limiting the productivity of some Pacific salmon and steelhead populations (Bottom *et al.* 2005, Fresh *et al.* 2005). It is also likely that climate change will play an increasingly important role in determining the abundance of Pacific salmon and steelhead by exacerbating long-term problems related to temperature, stream flow, habitat access, predation, and marine productivity (CIG 2004, Scheuerell and Williams 2005, Zabel *et al.* 2006, ISAB 2007).

Willamette and Lower Columbia (WLC) Recovery Domain. Species in the WLC recovery domain include LCR Chinook, UWR Chinook, CR chum, LCR coho, LCR steelhead, and UWR steelhead, southern green sturgeon, and eulachon. Although the WLC-TRT has not yet addressed southern green sturgeon or eulachon, it has identified 107 demographically-independent populations of Pacific salmon and steelhead (Table 10). These populations were further aggregated into strata, groupings above the population level that are connected by some degree of migration, based on ecological subregions. All 107 populations use parts of the mainstem of the lower Columbia River and the Columbia River estuary for migration, rearing, and smoltification.

McElhany *et al.* (2007) found that, for populations in Oregon, the combined extinction risk is very high for LCR Chinook, UWR Chinook salmon, CR chum salmon, LCR coho salmon, and moderate for LCR steelhead and UWR steelhead, although the status of those species with populations in Washington is still under assessment.

Table 10. Demographically-independent populations in the WLC recovery domain.

Species	Populations	Combined Extinction Risk
LCR Chinook salmon	32	Very High
UWR Chinook salmon	7	Very High
CR chum salmon	17	Very High
LCR coho salmon	24	Very High
LCR steelhead	23	Moderate
UWR steelhead	4	Moderate

LCR Chinook salmon. This species includes all naturally-spawned populations of Chinook salmon in the Columbia River and its tributaries from its mouth at the Pacific Ocean upstream to a transitional point between Washington and Oregon east of the Hood River and the White Salmon River; the Willamette River to Willamette Falls, Oregon, exclusive of spring-run

Chinook salmon in the Clackamas River; and progeny of seventeen artificial propagation programs. The WLC-TRT identified 22 historical populations of LCR Chinook salmon – seven in the coastal subregion, six in the Columbia Gorge, and nine in the western Cascades. Twelve of those populations occur within the action area (Table 11) and only Sandy River late fall Chinook is considered viable (McElhany *et al.* 2007).

The major factors limiting recovery of LCR Chinook salmon include altered channel morphology, loss of habitat diversity, excessive sediment, high water temperature, reduced access to spawning/rearing habitat, and harvest impacts (NMFS 2006).

Table 11. LCR Chinook salmon populations.

Stratum		Spawning Population (Watershed)
Ecological Subregion	Run Timing	
Coast Range	Fall	Young Bay
		Grays River
		Big Creek
		Elochman River
		Clatskanie River
		Mill Creek
		Scappoose River
Columbia Gorge	Spring	Upper Cowlitz River
		Cispus River
		Tilton River
		Big White Salmon River
		Hood River
	Early Fall (tule)	Upper Gorge Tributaries
		Big White Salmon River
	Fall	Upper Cowlitz River
		Lower Cowlitz River
		Coweeman River
		Toutle River
		Lower Gorge Tributaries
		Hood River
Western Cascade Range	Spring	Toutle River
		Kalama River
		Lewis River
		Sandy River
	Early Fall (tule)	Lewis River
		Salmon Creek
		Sandy River
	Fall	Kalama River
		Clackamas River
		Washougal River
	Late Fall (bright)	Lewis River
		Sandy River

UWR Chinook salmon. The species includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River, and its tributaries, above Willamette Falls, Oregon, and progeny of seven artificial propagation programs. All seven historical populations of UWR Chinook salmon identified by the WLC-TRT occur within the action area and are contained within a single ecological subregion, the western Cascade Range (Table 12); only the Clackamas population is characterized as viable (McElhany *et al.* 2007).

The major factors limiting recovery of UWR Chinook salmon identified by NMFS include lost/degraded floodplain connectivity and lowland stream habitat, degraded water quality, high water temperature, reduced streamflow, and reduced access to spawning/rearing habitat (NMFS 2006).

Table 12. UWR Chinook salmon populations. Overall viability risk: extinct or very high means greater than 60% chance of extinction within 100 years; relatively high means 60 to 25% risk of extinction in 100 years; moderate means 25 to 5% risk of extinction in 100 years, low or negligible means 5 to 1% risk of extinction in 100 years; very low means less than 1% chance of extinction in 100 years, and NA means not available. A low or negligible risk of extinction is considered viable.

Stratum		Spawning Population (Watershed)	Overall Viability Risk
Ecological Subregion	Run Timing		
Western Cascade Range	Spring	Clackamas	Low
		Molalla	Relatively High
		North Santiam	Very high
		South Santiam	Very high
		Calapooia	Very high
		McKenzie	Moderate
		Middle Fork Willamette	Very high

CR chum salmon. This species includes all naturally-spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon, and progeny of three artificial propagation programs. The WLC-TRT identified 17 historical populations of CR chum salmon and aggregated these into four strata (Myers *et al.* 2006). Unlike other species in the WLC recovery domain, CR chum salmon spawning aggregations were identified in the mainstem Columbia River. These aggregations generally were included in the population associated with the nearest river basin. Three strata and eight historical populations of CR chum salmon occur within the action area (Table 13); of these, none are viable (McElhany *et al.* 2007).

The major factors limiting recovery of CR chum salmon include altered channel morphology, loss of habitat diversity, excessive sediment, reduced streamflow, harassment of spawners, and harvest impacts (NMFS 2006).

Table 13. CR chum salmon populations.

Stratum		Spawning Population (Watershed)
Ecological Subregion	Run Timing	
Coast Range	Fall	Young's Bay
		Grays River
		Big Creek
		Elochman River
		Clatskanie River
		Mill Creek
		Scappoose Creek
Columbia Gorge	Summer	Cowlitz River
	Fall	Cowlitz River
		Lower Gorge Tributaries
		Upper Gorge Tributaries
Western Cascade Range	Fall	Kalama River
		Salmon Creek
		Lewis River
		Clackamas River
		Washougal River
		Sandy River

LCR coho salmon. This species includes all naturally-spawned populations of coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia up to and including the Big White Salmon and Hood rivers; in the Willamette River to Willamette Falls, Oregon; and progeny of 25 artificial propagation programs. The WLC-TRT identified 24 historical populations of LCR coho salmon and divided these into two strata based on major run timing: early and late (Myers *et al.* 2006). Three strata and nine historical populations of LCR coho salmon occur within the action area (Table 14). Of these nine populations, Clackamas River is the only population characterized as viable (McElhany *et al.* 2007).

In general, late coho salmon spawn in smaller rivers or the lower reaches of larger rivers from mid-November to January, coincident with the onset of rain-induced freshets in the fall or early winter. Spawning typically takes place within a few days to a few weeks of freshwater entry. Late-run fish also tend to undertake oceanic migrations to the north of the Columbia River, extending as far as northern British Columbia and southeast Alaska. As a result, late coho salmon are known as Type N coho. Alternatively, early coho salmon spawn in the upper reaches of larger rivers in the lower Columbia River and in most rivers inland of the Cascade Crest. During their oceanic migration, early coho salmon tend to migrate to the south of the Columbia River and are known as Type S coho salmon. They may migrate as far south as the waters off northern California. While the ecological significance of run timing in coho salmon is fairly well understood, it is not clear how important ocean migratory pattern is to overall diversity and the relative historical abundance of Type N and Type S life histories largely is unknown.

The major factors limiting recovery of LCR coho salmon include degraded floodplain connectivity and channel structure and complexity, loss of riparian areas and large wood recruitment, degraded stream substrate, loss of stream flow, reduced water quality, and impaired passage (NMFS 2007).

Table 14. LCR coho salmon spawning populations.

Stratum		Spawning Population (Watershed)
Ecological Subregion	Run Type	
Coast Range	N	Young's Bay
		Grays River
		Big Creek
		Elochman Creek
		Clatskanie River
		Mill, Germany, Abernathy Creeks
		Scappoose River
Columbia Gorge	N	Lower Gorge Tributaries
	S	Upper Gorge Tributaries
		Big White Salmon River
		Hood River
Western Cascade Range	N	Lower Cowlitz River
		Coweeman River
		Salmon Creek
	N and S	Cispus River
		Upper Cowlitz River
		Tilton River
		North Fork Toutle River
		South Fork Toutle River
		Kalama River
		North Fork Lewis River
		East Fork Lewis River
		Clackamas River
		Washougal River
		Sandy River

LCR steelhead. The species includes all naturally-spawned steelhead populations below natural and manmade impassable barriers in streams and tributaries to the Columbia River between and including the Cowlitz and Wind rivers, Washington; in the Willamette and Hood rivers, Oregon; and progeny of ten artificial propagation programs; but excluding all steelhead from the upper Willamette River basin above Willamette Falls, Oregon, and from the Little and Big White Salmon rivers, Washington. The WLC-TRT identified 23 historical populations of LCR steelhead (Myers *et al.* 2006). Within these populations, the winter-run timing is more common in the west Cascade subregion, while farther east summer steelhead are found almost exclusively.

Summer steelhead return to freshwater long before spawning. Winter steelhead, in contrast, return from the ocean much closer to maturity and spawn within a few weeks. Summer steelhead spawning areas in the lower Columbia River are found above waterfalls and other features that create seasonal barriers to migration. Where no temporal barriers exist, the winter-run life history dominates. Six strata and 23 historical populations of LCR steelhead occur within the action area (Table 15).

The major factors limiting recovery of LCR steelhead include altered channel morphology, lost/degraded floodplain connectivity and lowland stream habitat, excessive sediment, high water temperature, reduced streamflow, and reduced access to spawning/rearing habitat (NMFS 2006).

Table 15. LCR steelhead populations spawning.

Stratum		Population (Watershed)
Ecological Subregion	Run Timing	
Columbia Gorge	Summer	Wind River
		Hood River
	Winter	Lower Gorge Tributaries
		Upper Gorge Tributaries
		Hood River
West Cascade Range	Summer	Kalama River
		North Fork Lewis River
		East Fork Lewis River
		Washougal River
	Winter	Cispus River
		Tilton river
		Upper Cowlitz River
		Lower Cowlitz River
		North Fork Toutle River
		South Fork Toutle River
		Coweeman River
		Kalama River
		North Fork Lewis River
		East Fork Lewis River
		Clackamas River
		Salmon Creek
		Sandy River
		Washougal River

UWR steelhead. This species includes all naturally-spawned steelhead populations below natural and manmade impassable barriers in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River. The WLC-TRT identified five historical populations of UWR steelhead, all with winter run timing (Myers *et al.* 2006). Only winter steelhead historically existed in this area because flow conditions over Willamette Falls allowed only late winter steelhead to ascend the falls, until a fish ladder was constructed in the early 1900s and summer steelhead were introduced. Summer steelhead have become established in the McKenzie River where historically no steelhead existed, although these fish were not considered in the identification of historical populations. UWR steelhead are currently found in many tributaries that drain the west side of the upper Willamette River basin. Analysis of historical observations, hatchery records, and genetic analysis strongly suggested that many of these spawning aggregations are the result of recent introductions and do not represent a historical population. Nevertheless, the WLC-TRT recognized that these tributaries may provide juvenile rearing habitat or may be temporarily (for one or more generations) colonized during periods of high abundance.

One stratum and five historical populations of UWR steelhead occur within the action area (Table 16), although the west-side tributaries population was included only because it is important to the species as a whole, and not because it is independent. Of these five populations, none are viable (McElhany *et al.* 2007).

The major factors limiting recovery of UWR steelhead include lost/degraded floodplain connectivity and lowland stream habitat, degraded water quality, high water temperature, reduced streamflow, and reduced access to spawning/rearing habitat (NMFS 2006).

Table 16. UWR steelhead populations. Overall viability risk: extinct or very high means greater than 60% chance of extinction within 100 years; relatively high means 60 to 25% risk of extinction in 100 years; moderate means 25 to 5% risk of extinction in 100 years, low or negligible means 5 to 1% risk of extinction in 100 years; very low means less than 1% chance of extinction in 100 years, and NA means not available. A low or negligible risk of extinction is considered viable.

Stratum		Population Spawning (Watershed)	Overall Viability Risk
Ecological Subregion	Run Type		
West Cascade Range	Winter	Molalla	Moderate
		North Santiam	Moderate
		South Santiam	Moderate
		Calapooia	Moderate
		West-side Tributaries	Moderate

Southern green sturgeon. Southern green sturgeon includes all naturally-spawned populations of green sturgeon that occur south of the Eel River in Humboldt County, California. When not spawning, this anadromous species is broadly distributed in nearshore marine areas from Mexico to the Bering Sea. Although it is commonly observed in bays, estuaries, and sometimes the deep riverine mainstem in lower elevation reaches of non-natal rivers along the west coast of North America, the distribution and timing of estuarine use are poorly understood.

The principal factor for the decline of southern green sturgeon is the reduction of its spawning area to a single known population limited to a small portion of the Sacramento River. Other factors include degradation of freshwater and estuarine habitat quality, water diversions, and fishing. The viability of this species is still under assessment. Southern green sturgeon occur in three recovery domains: Puget Sound (although this area was excluded from proposed critical habitat), the Willamette and Lower Columbia, Oregon Coast, and Southern Oregon/Northern California Coasts.

Eulachon. The ESA-listed population of eulachon includes all naturally spawned populations that occur in rivers south of the Nass River in British Columbia to the Mad River in California. Core populations for this species include the Fraser River, Columbia River and (historically) the Klamath River. The most significant factor responsible for the decline of eulachon is change in ocean conditions due to climate change (EBRT 2010). Other factors include many adverse effects related to dams and water diversions, artificial fish passage barriers, increased water temperatures, insufficient streamflow, altered sediment balances, water pollution, over-harvest, and predation.

The viability of this species is under assessment although abrupt and continuing declines in abundance throughout its range and the added vulnerability that a small population size presents for this type of highly fecund, broadcast spawning species are of particular concern. Eulachon occur in four recovery domains: Puget Sound, the Willamette and Lower Columbia, Oregon Coast, and Southern Oregon/Northern California Coasts. Within the Columbia River, major tributaries that support spawning runs include the Grays, Skamokawa, Elochoman, Kalama, Lewis and Sandy rivers. In the early 1990's, there was an abrupt decline in the abundance of Eulachon returning to the Columbia River with no evidence of returning to their former population levels since then (Drake *et al.* 2008).

Of the four components of species viability criteria, abundance of the southern Eulachon has declined in the Columbia River to historic low levels, productivity is of concern due to climate change, diversity is limited to a single age class, and spatial structure is declining as runs sizes dwindle throughout their range (Drake *et al.* 2008). Based on these factors, the Biological Review Team (BRT) determined that the southern Eulachon was at moderate risk of extinction (Drake *et al.* 2008).

Eastern Steller sea lion. The eastern Steller sea lion ranges from southeast Alaska to southern California with a minimum abundance of 44,404 animals (NMFS 2009a), and has increased at 3% per year for the past 30 years (NMFS 2008c). The greatest increases have occurred in southeast Alaska and British Columbia (together accounting for 82% of pup production), but performance has remained poor in California at the southern extent of their range. In Southeast Alaska, British Columbia and Oregon, the number of Steller sea lions has more than doubled since the 1970s. There are no substantial threats to the species, and the population continues to increase at approximately 3% per year. The final Steller sea lion recovery plan identifies the need to initiate a status review for the eastern Steller sea lion and consider removing it from the Federal List of Endangered Wildlife and Plants (NMFS 2008c). The eastern Steller sea lions breeds on rookeries located in southeast Alaska, British Columbia, Oregon, and California; there are no rookeries located in Washington. Haulouts are located throughout the eastern population's range (NMFS 2008c).

Steller sea lions are generalist predators, able to respond to changes in prey abundance. Their primary prey includes a variety of fishes and cephalopods. Some prey species are eaten seasonally when locally available or abundant, and other species are available and eaten year-round (review in NMFS 2008c). Pacific hake appears to be the primary prey item across the range of eastern Steller sea lion (NMFS 2008c). Other prey items include Pacific cod, walleye Pollock, salmon, and herring, among other species.

Interior Columbia (IC) Recovery Domain. Species in the IC recovery domain include UCR spring-run Chinook salmon, SR spring/summer run Chinook salmon, SR fall-run Chinook salmon, SR sockeye salmon, UCR steelhead, MCR steelhead, and SRB steelhead. The IC-TRT identified 82 demographically-independent populations of those species based on genetic, geographic (hydrographic), and habitat characteristics (Table 17). In some cases, the IC-TRT further aggregated populations into major groupings based on dispersal distance and rate, and drainage structure, primarily the location and distribution of large tributaries (IC-TRT 2003). All 82 populations identified use the lower mainstem of the Snake River, the mainstem of the Columbia River, and the Columbia River estuary, or part thereof, for migration, rearing, and smoltification.

Table 17. Demographically-independent populations of ESA-listed Pacific salmon and steelhead in the IC recovery domain.

Species	Populations
UCR spring-run Chinook salmon	3
SR spring/summer Chinook salmon	31
SR fall-run Chinook salmon	1
SR sockeye salmon	1
UCR steelhead	4
MCR steelhead	17
SRB steelhead	25

The IC-TRT also recommended viability criteria that follow the VSP framework (McElhany *et al.* 2006) and described biological or physical performance conditions that, when met, indicate a population or species has a 5% or less risk of extinction over a 100-year period (IC-TRT 2007, see also NRC 1995). As of this writing, the IC-TRT has applied the viability criteria to 68 populations, although it has only completed a draft assessment for 55 populations (IC-TRT 2006). Of those assessments, the only population that the TRT found to be viable was the North Fork John Day population of MCR steelhead. The strength of this population is due to a combination of high abundance and productivity, and good spatial structure and diversity, although the genetic effects of the large number of out-of-species strays and of natural spawners that are hatchery strays are still significant long-term concerns.

UCR spring-run Chinook salmon. This species includes all naturally-spawned populations of Chinook salmon in all river reaches accessible to Chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam in Washington (excluding the Okanogan River), the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to Chief Joseph Dam in Washington, and progeny of six artificial propagation programs. The IC-TRT identified four independent populations of UCR spring-run Chinook salmon in the upriver tributaries of Wenatchee, Entiat, Methow, and

Okanogan (extirpated), but no major groups due to the relatively small geographic area affected (IC-TRT 2003, McClure *et al.* 2005). The IC-TRT considered that this species is at high risk of extinction because all extant populations are at high risk (IC-TRT 2006).

The major factors limiting recovery of UWR spring-run Chinook salmon include altered channel morphology and flood plain, riparian degradation and loss of in-river large wood, reduced streamflow, impaired passage, hydropower system mortality, and harvest impacts (NMFS 2006).

SR spring/summer run Chinook salmon. This species includes all naturally-spawned populations of spring/summer run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River sub-basins; and progeny of fifteen artificial propagation programs. The IC-TRT identified 31 historical populations of SR spring/summer run Chinook salmon, and aggregated these into major population groups (Table 18) (IC-TRT 2003, McClure *et al.* 2005). This species includes those fish that spawn in the Snake River drainage and its major tributaries, including the Grande Ronde River and the Salmon River, and that complete their adult, upstream migration past Bonneville Dam between March and July. Each of these populations are part of the Grande Ronde and Imnaha River major group, and all face a high risk of extinction (IC-TRT 2006).

The major factors limiting recovery of SR spring/summer run Chinook salmon include altered channel morphology and flood plain, excessive sediment, degraded water quality, reduced streamflow, and hydropower system mortality (NMFS 2006).

Table 18. SR spring/summer run Chinook salmon populations.

Major Group	Spawning Populations (Watershed)	Major Group	Spawning Populations (Watershed)
Lower Snake River	Tucannon River	Middle Fork Salmon River (continued)	Camas Creek
	Asotin River		Loon Creek
Grande Ronde and Imnaha rivers	Wenaha River		Pistol Creek
	Wallowa-Lostine River		Sulphur Creek
	Minam River		Bear Valley Creek
	Catherine Creek		March Creek
	Upper Grande Ronde		U. Middle Fork main
	Imnaha River mainstem	Upper Mainstem Salmon	N. Fork Salmon River
	Big Sheep Creek		Lemhi River
Looking-glass Creek			Pahsimeroi River
Little Salmon	Little Salmon River		Upper Salmon l. main
South Fork Salmon River	South Fork Main Stem		East Fork Salmon River
	Secesh River		Yankee Fork
	East Fork South Fork		Valley Creek
Chamberlin Creek			Upper Salmon main
Middle Fork Salmon River	Big Creek	Panther Creek	
	L. Middle Fork main		

SR fall-run Chinook salmon. This species includes all naturally-spawned populations of fall-run Chinook salmon in the mainstem Snake River below Hells Canyon Dam, and in the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River, and progeny of four artificial propagation programs. The IC-TRT identified three populations of this species, although only the lower mainstem population exists at present, and it spawns in the lower main stem of the Clearwater, Imnaha, Grande Ronde, Salmon and Tucannon rivers (IC-TRT 2003, McClure *et al.* 2005). Unlike the other listed Chinook species in this recovery domain, most SR fall-run Chinook have a subyearling, ocean-type life history in which juveniles out-migrate the next summer, rather than rearing in freshwater for 13 to 14 months before outmigration. The IC-TRT has not completed a viability assessment of this species.

The major factors limiting recovery of SR fall-run Chinook salmon include reduced spawning/rearing habitat, degraded water quality, hydropower system mortality, and harvest impacts (NMFS 2006).

SR sockeye salmon. This species includes all anadromous and residual sockeye salmon from the Snake River basin, Idaho, and artificially-propagated sockeye salmon from the Redfish Lake captive propagation program. The IC-TRT identified historical sockeye production in at least five Stanley Basin lakes and in lake systems associated with Snake River tributaries currently cut off to anadromous access (*e.g.,* Wallowa and Payette Lakes), although current returns of SR sockeye are extremely low and limited to Redfish Lake (IC-TRT 2007).

The major factors limiting recovery of SR sockeye salmon include altered channel morphology and flood plain, reduced streamflow, impaired passage, and hydropower system mortality (NMFS 2006).

MCR steelhead. This species includes all naturally-spawned steelhead populations below natural and artificial impassable barriers in streams from above the Wind River, Washington, and the Hood River, Oregon (exclusive), upstream to, and including, the Yakima River, Washington, excluding steelhead from the Snake River basin; and progeny of seven artificial propagation programs. The IC-TRT identified 20 historical populations of MCR steelhead in five major groups (Table 19) (IC-TRT 2003, McClure *et al.* 2005).

The major factors limiting recovery of MCR steelhead include altered channel morphology and flood plain, excessive sediment, degraded water quality, reduced streamflow, impaired passage, and hydropower system mortality (NMFS 2006).

Table 19. MCR steelhead populations.

Major Group	Population (Watershed)
Cascade Eastern Slope Tributaries	Klickitat River
	Fifteenmile Creek
	Deschutes River Eastside Tributaries
	Deschutes River Westside Tributaries
	White Salmon (access blocked above Condit Dam)
	Deschutes (extirpated above Pelton Dam)
	Crooked River (extirpated)
John Day River	Lower Mainstem John Day River
	North Fork John Day River
	Middle Fork John Day River
	South Fork John Day River
	Upper Mainstem John Day River
	Willow Creek (extirpated)
Rock Creek	Rock Creek
Walla Walla and Umatilla rivers	Umatilla River
	Walla Walla River
	Touchet River
Yakima River	Satus Creek
	Toppenish Creek
	Naches River
	Upper Yakima

UCB steelhead. This species includes all naturally-spawned steelhead populations below natural and manmade impassable barriers in streams in the Columbia River basin upstream from the Yakima River, Washington, to the U.S.-Canada border, and progeny of six artificial propagation programs. Four independent populations of UCR steelhead were identified by the IC-TRT in the same upriver tributaries as for the previous species (*i.e.*, Wenatchee, Entiat, Methow, and Okanogan) and, similarly, no major population groupings were identified due to the relatively small geographic area involved (IC-TRT 2003, McClure *et al.* 2005). The IC-TRT has not completed a viability assessment of this species, although all extant populations are considered to be at high risk of extinction (IC-TRT 2006).

The major factors limiting recovery of UCR steelhead include altered channel morphology and flood plain, riparian degradation and loss of in-river large wood, excessive sediment, degraded water quality, reduced streamflow, hydropower system mortality, harvest impacts, and hatchery impacts (NMFS 2006).

SRB steelhead. This species includes all naturally-spawned steelhead populations below natural and manmade impassable barriers in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho, and progeny of six artificial propagation programs. These fish are genetically differentiated from other interior Columbia steelhead populations and spawn at higher altitudes (up to 6,500 feet) after longer migrations (more than 900 miles). The IC-TRT identified 25 historical populations in five major groups (Table 20) (IC-TRT 2003, McClure *et al.* 2005). The IC-TRT has not completed a viability assessment of this species. The major factors limiting recovery of SRB steelhead include altered channel morphology and flood plain, excessive sediment, degraded water quality, reduced streamflow, hydropower system mortality, harvest impacts, and hatchery impacts (NMFS 2006).

Table 20. SRB steelhead populations.

	Spawning Populations (Watershed)
Lower Snake River	Tucannon River
	Asotin River
Clearwater River	Lower Clearwater River
	S. Fork Clearwater
	Lolo Creek
	Selway Creek
	Lochsa River
	N. Fork Clearwater (extirpated)
Grande Ronde River	Lower Grande Ronde
	Joseph Creek
	Wallowa River
	Upper Grande Ronde
Salmon River	Little/Lower Salmon
	South Fork Salmon
	Secesh River
	Chamberlain Creek
	L. Middle Fork Salmon
	U. Middle Fork Salmon
	Panther Creek
	North Fork Salmon
	Lemhi River
	Pahsimeroi River
	East Fork Salmon
	Upper Main Salmon
Imnaha	Imnaha River
Hells Canyon	Hells Canyon Tributaries

Status of the Critical Habitats

NMFS designated critical habitat for all species considered in this Opinion, except LCR coho salmon, for which critical habitat is not proposed or designated, and eulachon, for which critical habitat is proposed but not yet designated; eastern Steller sea lion does not have critical habitat designated in the action area (Table 8). To assist in the designation of critical habitat for ESA-listed species of Pacific salmon and steelhead in 2005, NMFS convened Critical Habitat Analytical Review Teams, or CHARTs, organized by major geographic areas that roughly correspond to salmon recovery planning domain (NOAA Fisheries 2005). Each CHART consisted of Federal biologists and habitat specialists from NMFS, the U.S. Fish and Wildlife Service, the U.S. Forest Service, and the U.S. Bureau of Land Management, with demonstrated expertise regarding Pacific salmon and steelhead habitat and related protective efforts within that domain.

Each CHART assessed biological information pertaining to areas under consideration for designation as critical habitat to identify the areas occupied by listed Pacific salmon and steelhead, determine whether those areas contained PCEs essential for the conservation of those species, and whether unoccupied areas existed within the historical range of the listed Pacific salmon and steelhead that may also be essential for conservation. The CHART then scored each habitat area based on the quantity and quality of the physical and biological features; rated each habitat area as having a "high," "medium," or "low" conservation value; and identified management actions that could affect habitat for Pacific salmon and steelhead.

The ESA gives the Secretary of Commerce discretion to exclude areas from designation if he determines that the benefits of exclusion outweigh the benefits of designation. Considering economic factors and information from CHARTs, NMFS partially or completely excluded the following types of areas from the 2005 critical habitat designations:

1. Military areas. All military areas were excluded because of the current national priority on military readiness, and in recognition of conservation activities covered by military integrated natural resource management plans.

2. Tribal lands. Native American lands were excluded because of the unique trust relationship between tribes and the federal government, the federal emphasis on respect for tribal sovereignty and self governance, and the importance of tribal participation in numerous activities aimed at conserving salmon.

3. Areas With Habitat Conservation Plans. Some lands covered by habitat conservation plans were excluded because NMFS had evidence that exclusion would benefit our relationship with the landowner, the protections secured through these plans outweigh the protections that are likely through critical habitat designation, and exclusion of these lands may provide an incentive for other landowners to seek similar voluntary conservation plans.

4. Areas With Economic Impacts. Areas where the conservation benefit to the species would be relatively low compared to the economic impacts.

In designating these critical habitats, NMFS organized information at scale of the watershed or 5th field HUC because it corresponds to the spatial distribution and site fidelity scales of Pacific salmon and steelhead populations (WDF *et al.* 1992, McElhany *et al.* 2000). For earlier critical habitat designations for Snake River, similar information was not available at the watershed scale, so NMFS used the scale of the sub-basin or 4th field HUC to organize critical habitat information. For southern green sturgeon, the CHART identified and designated critical habitat as specific areas within freshwater rivers, the bypasses, the Sacramento-San Joaquin Delta, coastal bays and estuaries, and coastal marine areas
(within 110-meter depth).

NMFS reviews the status of designated critical habitat affected by the proposed action by examining the condition and trends of PCEs throughout the designated area. These PCEs vary slightly for some species, due to biological and administrative reasons, but all consist of site types and site attributes associated with life history events (Tables 21 – 23).

Table 21. Primary constituent elements of critical habitats designated for ESA-listed salmon and steelhead species considered in the Opinion (except SR spring/summer run Chinook salmon, SR fall-run Chinook salmon, and SR sockeye salmon), and corresponding species life history events.

Primary Constituent Elements		Species Life History Event
Site Type	**Site Attribute**	
Freshwater spawning	Substrate Water quality Water quantity	Adult spawning Embryo incubation Alevin growth and development
Freshwater rearing	Floodplain connectivity Forage Natural cover Water quality Water quantity	Fry emergence from gravel Fry/parr/smolt growth and development
Freshwater migration	Free of artificial obstruction Natural cover Water quality Water quantity	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Estuarine areas	Forage Free of artificial obstruction Natural cover Salinity Water quality Water quantity	Adult sexual maturation and reverse smoltification Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Nearshore marine areas	Forage Free of artificial obstruction Natural cover Water quantity Water quality	Adult growth and sexual maturation Adult spawning migration Nearshore juvenile rearing
Offshore marine areas	Forage Water quality	Adult growth and sexual maturation Adult spawning migration Subadult rearing

Table 22. Primary constituent elements of critical habitats designated for SR spring/summer run Chinook salmon, SR fall-run Chinook salmon, SR sockeye salmon, and corresponding species life history events.

Primary Constituent Elements		Species Life History Event
Site	**Site Attribute**	
Spawning and juvenile rearing areas	Access (sockeye) Cover/shelter Food (juvenile rearing) Riparian vegetation Space (Chinook, coho) Spawning gravel Water quality Water temp (sockeye) Water quantity	Adult spawning Embryo incubation Alevin growth and development Fry emergence from gravel Fry/parr/smolt growth and development
Adult and juvenile migration corridors	Cover/shelter Food (juvenile) Riparian vegetation Safe passage Space Substrate Water quality Water quantity Water temperature Water velocity	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Areas for growth and development to adulthood	Ocean areas – not identified	Nearshore juvenile rearing Subadult rearing Adult growth and sexual maturation Adult spawning migration

Table 23. Primary constituent elements of critical habitat proposed for southern green sturgeon and corresponding species life history events.

Primary Constituent Elements		Life History Event
Site Type	**Site Attribute**	
Freshwater riverine system	Food resources Migratory corridor Sediment quality Substrate type or size Water Depth Water flow Water quality	Adult spawning Embryo incubation, growth and development Larval emergence, growth and development Juvenile metamorphosis, growth and development
Estuarine areas	Food resources Migratory corridor Sediment quality Water flow Water depth Water quality	Juvenile growth, development, seaward migration Subadult growth, development, seasonal holding, and movement between estuarine and marine areas Adult growth, development, seasonal holding, movements between estuarine and marine areas, upstream spawning movement, and seaward post-spawning movement
Coastal marine areas	Food resources Migratory corridor Water quality	Subadult growth and development, movement between estuarine and marine areas, and migration between marine areas Adult sexual maturation, growth and development, movements between estuarine and marine areas, migration between marine areas, and spawning migration

Climate change is likely to have negative implications for the conservation value of designated critical habitats in the Pacific Northwest (CIG 2004, Scheuerell and Williams 2005, Zabel *et al.* 2006, ISAB 2007). Average annual Northwest air temperatures have increased by approximately 1°C since 1900, or about 50% more than the global average warming over the same period (ISAB 2007). The latest climate models project a warming of 0.1 to 0.6°C per decade over the next century. According to the ISAB, these effects may have the following physical impacts within the next 40 or so years:

- Warmer air temperatures will result in a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a shift to more rain and less snow, the snowpack will diminish in those areas that typically accumulate and store water until the spring freshet.
- With a smaller snowpack, these watersheds will see their runoff diminished and exhausted earlier in the season, resulting in lower stream flows in the June through September period.
- River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.

- Water temperatures will continue to rise, especially during the summer months when lower stream flows and warmer air temperatures will contribute to the warming regional waters.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Sites with elevations high enough to maintain temperatures well below freezing for most of the winter and early spring would be less affected. Low-lying areas that historically have received scant precipitation are likely to be more affected. The ISAB (2007) also identified the likely effects of projected climate changes on Columbia River salmon and their habitat. These effects may include, but are not limited to, depletion of cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species. Similar effects are likely to occur to some extent throughout the Pacific Northwest.

W LC Recovery Domain. Critical habitat was designated in the WLC recovery domain for UWR spring-run Chinook salmon, LCR Chinook salmon, LCR steelhead, UWR steelhead, and CR chum salmon. In addition to the Willamette and Columbia River mainstems, important tributaries on the Oregon side of the WLC include Youngs Bay, Big Creek, Clatskanie River, and Scappoose River in the Oregon Coast sub-basin; Hood River in the Gorge; and the Sandy, Clackamas, Molalla, North and South Santiam, Calapooia, McKenzie, and Middle Fork Willamette rivers in the West Cascades sub-basin.

The Willamette River, once a highly braided river system, has been dramatically simplified through channelization, dredging, and other activities that have reduced rearing habitat by as much as 75%. In addition, the construction of 37 dams in the basin blocked access to more than 435 miles of stream and river spawning habitat. The dams alter the temperature regime of the Willamette River and its tributaries, affecting the timing and development of naturally-spawned eggs and fry. Agriculture, urbanization, and gravel mining on the valley floor logging in the Cascade and Coast Ranges contribute to increased erosion and sediment loads throughout the basin.

The mainstem Willamette River has been channelized and stripped of large wood. Development began to encroach on the riparian forest beginning in the 1870s (Sedell and Froggatt 1984). Gregory *et al.* (2002a) calculated that the total mainstem Willamette River channel area decreased from 41,000 to 23,000 acres between 1895 and 1995. They noted that the lower reach, from the mouth of the river to Newberg (RM 50), is confined within a basaltic trench, and that due to this geomorphic constraint, less channel area has been lost than in upstream areas. The middle reach from Newberg to Albany (RM 50 to 120) incurred losses of 12% primary channel area, 16% side channels, 33% alcoves, and 9% islands. Even greater changes occurred in the upper reach, from Albany to Eugene (RM 187). There, approximately 40% of both channel length and channel area were lost, along with 21% of the primary channel, 41% of side channels, 74% of alcoves, and 80% of island areas.

The banks of the Willamette River have more than 96 miles of revetments; approximately half were constructed by the U.S. Army Corps of Engineers. Generally, the revetments were placed in the vicinity of roads or on the outside bank of river bends, so that while only 26% of the total length is revetted, 65% of the meander bends are revetted (Gregory *et al.* 2002b). The majority of dynamic sections have been armored, reducing adjustments in channel bed and sediment storage by the river, and thereby diminishing both the complexity and productivity of aquatic habitats (Gregory *et al.* 2002b).

Riparian forests have diminished considerably in the lower reaches of the Willamette River (Gregory *et al.* 2002c). Sedell and Frogatt (1984) noted that agriculture and cutting of streamside trees were major agents of change for riparian vegetation, along with snagging of large wood in the channel. The reduced shoreline, fewer and smaller snags, and reduced riparian forest comprise large functional losses to the river, reducing structural features, organic inputs from litter fall, entrained allochthonous materials, and flood flow filtering capacity. Extensive changes began before the major dams were built, with navigational and agricultural demands dominating the early use of the river. The once expansive forests of the Willamette River floodplain provided valuable nutrients and organic matter during flood pulses, food sources for macroinvertebrates, and slow-water refugia for fish during flood events. These forests also cooled river temperatures as the river flowed through its many channels.

Gregory *et al.* (2002c) described the changes in riparian vegetation in river reaches from the mouth to Newberg, from Newberg to Albany, and from Albany to Eugene. They noted that the riparian forests were formerly a mosaic of brush, marsh, and ash tree openings maintained by annual flood inundation. Below the City of Newberg, the most noticeable change was that conifers were almost eliminated. Above Newberg, the formerly hardwood-dominated riparian forests along with mixed forest made up less than half of the riparian vegetation by 1990, while agriculture dominated. This conversion represents a loss of recruitment potential for large wood, which functions as a component of channel complexity, much as the morphology of the streambed does, to reduce velocity and provide habitat for macroinvertebrates that support the prey base for Pacific salmon and steelhead. Declining extent and quality of riparian forests have also reduced rearing and refugia habitat provided by large wood, shading by riparian vegetation, which can cool water temperatures, and the availability of leaf litter and the macroinvertebrates that feed on it.

Hyporheic flow in the Willamette River has been examined through discharge measurements and was found to be significant in some areas, particularly those with gravel deposits (Fernald *et al.* 2001). The loss of channel complexity and meandering that fosters creations of gravel deposits decreases the potential for hyporheic flows, as does gravel mining. Hyporheic flow processes water and affects its quality on reemerging into the main channel, stabilizing variations in physical and chemical water characteristics. Hyporheic exchange was found to be significant in the National Water-Quality Assessment of the Willamette basin (Wentz *et al.* 1998). In the transient storage zone, hyporheic flow is important for ecological functions, some aspects of water quality (such as temperature and dissolved oxygen), and some benthic invertebrate life stages. Alcove habitat, limited by channelization, combines low hydraulic stress and high food availability with the potential for hyporheic flows across the steep hydraulic gradients in the gravel separating them from the main channel (Fernald *et al.* 2001).

On the mainstem of the Columbia River, hydropower projects, including the Federal Columbia River Hydropower System (FCRPS), have significantly degraded Pacific salmon and steelhead habitats (Bottom *et al.* 2005, Fresh *et al.* 2005, NMFS 2005, and NOAA Fisheries 2006). The series of dams and reservoirs that make up the FCRPS block an estimated 12 million cubic yards of debris and sediment that would otherwise naturally flow down the Columbia and replenish shorelines along the Washington and Oregon coasts.

Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom *et al.* 2005, Fresh *et al.* 2005, NMFS 2005, and NOAA Fisheries 2006). Since 1878, 100 miles of the mainstem Columbia River, its estuary, and Oregon's Willamette River has been dredged as a navigation channel by the Army Corps of Engineers. Originally dredged to a 20 foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The lower Columbia River supports five ports on the Washington State side: Kalama, Longview, Skamania County, Woodland, and Vancouver. In addition to loss of riparian habitat, and disruption of benthic habitat due to dredging, high levels of several sediment chemicals, such as arsenic and polycyclic aromatic hydrocarbons (PAHs), have been identified in lower Columbia River watersheds in the vicinity of the ports and associated industrial activities.

The most extensive urban development in the lower Columbia River sub-basin occurs in the Portland/Vancouver area. Outside of this major urban area, the majority of residences and businesses rely on septic systems. Common water quality issues with urban development and residential septic systems include higher water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff.

The Columbia River estuary has lost a significant amount of tidal marsh and tidal swamp habitat that are critical to juvenile Pacific salmon and steelhead, particularly small or ocean-type species (Bottom *et al.* 2005, Fresh *et al.* 2005, NMFS 2005, and NOAA Fisheries 2006). Edges of marsh areas provide sheltered habitats for juvenile Pacific salmon and steelhead where food, in the form of amphipods or other small invertebrates, which feed on marsh detritus, is plentiful, and larger predatory fish can be avoided. Historically, floodwaters of the Columbia River inundated the margins and floodplains along the estuary, allowing juvenile Pacific salmon and steelhead access to a wide expanse of low-velocity marshland and tidal channel habitats. In general, the riverbanks were gently sloping, with riparian and wetland vegetation at the higher elevations of the river floodplain becoming habitat for Pacific salmon and steelhead during flooding river discharges or flood tides. Sherwood *et al.* (1990) estimated that the Columbia River estuary lost 20,000 acres of tidal swamps, 10,000 acres of tidal marshes, and 3,000 acres of tidal flats between 1870 and 1970. This study further estimated an 80% reduction in emergent vegetation production and a 15% decline in benthic algal production.

Habitat and food-web changes within the estuary, and other factors affecting salmon population structure and life histories, have altered the estuary's capacity to support juvenile salmon (Bottom *et al.* 2005, Fresh *et al.* 2005, NMFS 2005, and NOAA Fisheries 2006). Diking and filling activities that decrease the tidal prism and eliminate emergent and forested wetlands and floodplain habitats have likely reduced the estuary's salmon-rearing capacity. Moreover, water and sediment in the lower Columbia River and its tributaries have levels of toxic contaminants that are harmful to fish and wildlife (LCREP 2007). Contaminants of concern include dioxins and furans, heavy metals, polychlorinated biphenyls (PCBs) and organochlorine pesticides such as dichlorodiphenyltrichloroethane (DDT). Simplification of the population structure and life-history diversity of salmon possibly is yet another important factor affecting juvenile salmon viability. Restoration of estuarine habitats, particularly diked emergent and forested wetlands, reduction of avian predation by terns, and flow manipulations to restore historical flow patterns might significantly enhance the estuary's productive capacity for salmon, although historical changes in population structure and salmon life histories may prevent salmon from making full use of the productive capacity of estuarine habitats, even in their presently altered state.

The NMFS recently designated critical habitat for southern green sturgeon, including coastal U.S. marine waters within 110 m depth from Monterey Bay, California, including Monterey Bay, north to Cape Flattery, Washington, including the Straits of Juan de Fuca, Washington, to its U.S. boundary; the Sacramento River, lower Feather river, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; the lower Columbia River estuary up to RM 46; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, and Yaquina Bay), and Washington (Willapa Bay and Grays Harbor). In addition to the general exclusions listed above, the CHART determined that the following areas within the SONCC Domain will be excluded from critical habitat designations: Elkhorn Slough, Tomales Bay, Noyo Harbor, Eel River estuary, Klamath/Trinity River estuary, and the Rogue River estuary. Excluded estuary areas extend to the head of tide. The CHART based their determination on these areas having a low or ultra-low conservation value and a lack of documentation that southern green sturgeon use these areas extensively.

IC Recovery Domain. Critical habitat has been designated in the IC recovery domain, which includes the Snake River basin, for SR spring/summer run Chinook salmon, SR fall-run Chinook salmon, UCR spring-run Chinook salmon, SR sockeye salmon, MCR steelhead, UCR steelhead, and SRB steelhead. Major tributaries in the Oregon portion of the IC recovery domain include the Deschutes, John Day, Umatilla, Walla Walla, Grande Ronde, and Imnaha rivers.

Habitat quality in tributary streams in the IC recovery domain varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development (Wissmar *et al.* 1994, NMFS 2009b). Critical habitat throughout the IC recovery domain has been degraded by intense agriculture, alteration of stream morphology (*i.e.*, channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas.

Migratory habitat quality in this area has been severely affected by the development and operation of the FCRPS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and Upper Columbia river basins. For example, construction of Hells Canyon Dam eliminated access to several likely production areas in Oregon and Idaho, including the Burnt, Powder, Weiser, Payette, Malheur, Owyhee, and Boise river basins (Good *et al.* 2005), and Grande Coulee and Chief Joseph dams completely block anadromous fish passage on the upper mainstem Columbia River. Hydroelectric development modified natural flow regimes, resulting in higher water temperatures, changes in fish community structure leading to increased rates of piscivorous and avian predation on juvenile Pacific salmon and steelhead, and delayed migration for both adult and juveniles. Physical features of dams such as turbines also kill migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles.

Similarly, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have drastically altered hydrological cycles. A series of large regulating dams on the middle and upper Deschutes River affect flow and block access to upstream habitat, and have extirpated one or more populations from the Cascades Eastern Slope major population (IC-TRT 2003). Similarly, operation and maintenance of large water reclamation systems such as the Umatilla Basin and Yakima Projects have significantly reduced flows and degraded water quality and physical habitat in this domain.

Many stream reaches designated as critical habitat in the IC recovery domain are over-allocated under state water law, with more allocated water rights than existing streamflow conditions can support. Irrigated agriculture is common throughout this region and withdrawal of water increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence *et al.* 1996). Reduced tributary stream flow has been identified as a major limiting factor for all listed Pacific salmon and steelhead species in this area except SR fall-run Chinook salmon.

Many stream reaches designated as critical habitat are listed on the state of Oregon's Clean Water Act section 303(d) list for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Contaminants such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste are common in some areas of critical habitat.

Environmental Baseline

This section describes the effects of past and ongoing human and natural factors within the action area, on the current status of the species, their habitats and ecosystems. The environmental baseline includes, "the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

The action area exists in the lower Columbia River basin, that portion of the mainstem Columbia River and its tributaries downstream of Bonneville Dam to its Pacific Ocean terminus. The baseline includes the existing Columbia River I-5 crossing (circa 1917 and 1958) and its connected stormwater infrastructure, thereby creating a transect in which all ESA-listed Columbia basin salmon, steelhead, sturgeon, and eulachon must intersect to fulfill their life histories. Though the Willamette River is downstream of the crossing, NMFS includes UWR fish albeit a lesser degree than other Columbia River basin species due to assumed natural straying. This point and the project's action area serve primarily as a migratory corridor for these species and to a lesser extent rearing. The action and all of its elements will occur in the lower Columbia River.

The current state of the lower Columbia River and the action area baseline originates from hydro effects (Federal Columbia River Power System), tributary habitat effects, estuary and plume habitat effects, predation and disease effects, hatchery effects, harvest effects, and large-scale environmental factors. In general, Columbia River salmon have been adversely affected by a broad number of human activities including habitat losses from all causes (population growth, urbanization, roads, diking, etc.), fishing pressure, flood control, irrigation dams, pollution, municipal and industrial water use, introduced species, and hatchery production (NRC 1996). In addition, salmon populations have been strongly affected by ocean and climate conditions.

The quality and quantity of habitat in many Columbia River basin watersheds have declined dramatically in the last 150 years. Forestry, farming, grazing, road construction, hydrosystem development, mining, and urbanization have changed the historical habitat conditions. Water diversions in Oregon have significantly depleted tributaries flows (NPPC 1992). Depleted tributary streamflows have been identified a major limiting factors for most species in the Interior Columbia basin (PCSRF 2007). Effects in the tributaries extend down into the mainstem Columbia as described in the following section Mainstem Effects.

Historically, the lower Columbia River sub-basin had an active connection between the channel and its floodplain, forming habitat diversity via flow and formation of side channels and deposition of woody debris. The Columbia River estuary is estimated to have once had 75% more tidal swamps. These areas provided feeding and resting habitat for juvenile salmonids in the form of low-velocity marshland and tidal channel habitats (Bottom *et al.* 2005).
The construction of dams, levees, dikes, and shipping channels through dredging between the 1930s and 1970s significantly altered the timing and magnitude of hydrologic events, and significantly reduced connection between the river and its floodplain. The Columbia River estuary historically received annual spring freshet flows that averaged 75–100% higher than current freshet flows. In addition, historical winter flows (October through March) were approximately 35–50% lower than current flows. The greater historical peak and variable flows encouraged greater sediment transport and more flooding wetlands, contributing to a more complex ecosystem than exists today (ISAB 2000). Reduced flow poses particularly high risks for juvenile anadromous fish. Dramatic reductions in flow compared to the historical spring freshet have increased the travel time of juvenile outmigrants. This increases potential exposure to predation, elevated temperatures, disease, and other environmental stressors (NMFS 2008d, Bottom *et al.* 2005).

Land-use practices and the development of multiple reservoir complexes in the Columbia's sub-basins significantly reduced the delivery of large wood and sediment. Availability of aquatic habitat for native fish, particularly those that rely heavily on low-velocity side channel habitat for holding, feeding, and rearing, has declined because of these changes to habitat-forming processes. Active navigation channel management by the Corps of Engineers through dredging has resulted in the filling of shallow-off channel habitats and expanded/created main-stem islands.

Water quality throughout the action area is degraded. Urban, industrial, and agriculture practices across the basin contribute multiple pollutants at levels harmful to aquatic life. The following exhibits the current conditions of pollutant loads within the lower Columbia River. The River and North Portland Harbor are on the DEQ 303(d) list for the following parameters: temperature, PCBs, PAHs, DDT metabolites such as dichlorodiphenyldichloroethylene (DDE), and arsenic (DEQ 2007a). The lower Columbia River is on the Washington State 303(d) list for temperature, PCBs, and dissolved oxygen (WDOE 2009b). The U.S. Environmental Protection Agency (EPA) has approved total maximum daily loads (TMDLs) for dioxin and total dissolved gas in the lower Columbia River (DEQ 1991, 2002).

In addition to the contaminants listed above, dissolved copper, a neurotoxin that damages the olfactory abilities of fish, is known to be present above naturally occurring levels in the lower Columbia River. Studies indicate that dissolved copper in the action area may occur at levels known to injure salmonids (WDOT 2005; WDOE 2006; DEQ 2009). In addition, fertilizers, pesticides and heavy metal contaminants are present in lower Columbia River sediments (DEQ 2007b, as cited in NMFS 2008c). Potentially, resulting in immunosuppression, and reduced growth rates in juvenile fish during their residence in the estuary (Arkoosh *et al.* 1991, 1994, 1998; Varanasi *et al.* 1993; Casillas *et al.* 1995a, 1995b, and 1998a, all cited in NMFS 2008c). It is recognized that roadways contribute pollutants such as copper, zinc, and PAHs into waterways through direct inputs via vehicular wear and by transporting anthropogenic atmospheric sources as well. The network of roadways within the lower Columbia River basin funded, built and maintained by the FHWA and its state DOT and local partners is vast, affecting the hydrology and water quality of the entire basin.

Species within the Action Area

All populations spawning within the Columbia River basin use the Columbia River mainstem and estuary to complete part of their life history, including migration, rearing and smoltification. With few exceptions for populations that spawn below RM 106, every individual from each of those populations must pass through the action area at least twice, during downstream migration as a juvenile and upstream migration as an adult.

The Columbia River and estuary serve three primary roles for outmigrating juveniles as they transition from shallow, freshwater environments to the ocean: (1) A place where juvenile fish can gradually acclimate to salt water; (2) a feeding area (main, and tidal channel, unvegetated shoals, emergent and forested wetlands, and mudflats) capable of sustaining increased growth rates; and (3) a refuge from predators while fish acclimate to salt water. Thus, though the

Columbia River and estuary is important to the survival and recovery of all ESA-listed salmonids, it is particularly important to ocean-type salmon. These stocks may be particularly sensitive to ecosystem changes because of their longer residence times and dependence on this portion of the river for growth and survival. In this consultation, NMFS focused on ocean-type salmon as an indicator of the importance of the lower Columbia River and estuary to all ESA-listed salmonids. NMFS focused on ocean-type salmon because they are an indicator of the most sensitive salmonid response to changes in estuary and river habitats. Neither critical habitat, nor take prohibitions exist for eulachon. For the purposes of this Opinion, the Lower River designates the freshwater fluvial portion of the river from Bonneville Dam downstream to a point above marine and fresh-water mixing or dominance. The Columbia River estuary extends from RM 47 to the Pacific Ocean and includes the zone where marine and freshwater mix.

Ocean-type salmon species in the Columbia River include Chinook species (LCR, SR fall-run, and UWR) and CR chum salmon. These species are the most likely to be affected by potential impacts of the Project, and thus are discussed in detail below. Ocean-type salmon migrate downstream to and through the estuary as subyearlings, generally leaving the spawning area where they hatched within days to months following their emergence from the gravel. Consequently, subyearlings commonly spend weeks to months rearing within the lower portion of the action area before reaching the size at which they migrate to the ocean.

The first outbound migrants of the Columbia River fall Chinook and chum may arrive in the action area as early as late February (Herrmann 1970; Craddock *et al.* 1976; Healey 1980; Congleton *et al.* 1981; Healey 1982; Dawley *et al.* 1986; Levings *et al.*1986). The majority of these fish are present from March through June. Outbound Snake River fall Chinook begin their migration much farther upstream and arrive in the Columbia River approximately a month later.

Ocean-type subyearlings arrive in the lower river and estuarine portion of the action area at a small size. The earliest migrants can be as small as 30 to 40 mm fork length when they arrive because some of these fish hatch only a short distance upstream from the action area. Later spring migrants are generally larger, ranging up to 50 to 80 mm. Subyearlings from the mid-Columbia and Snake Rivers tend to be substantially larger (70 to 100 mm) by the time they reach the lower Columbia River. The larger size of the lower Snake River fall Chinook, compared with the lower Columbia River Chinook and chum, likely indicates some differences in suitable habitat. The larger subyearlings from the Snake River can likely use a greater range of depth and current conditions than the subyearlings of the Columbia River species can.

Once ocean-type subyearlings arrive in the lower Columbia River, they may remain for weeks to months. Because these fish arrive small in size, they undergo extended lower river and estuary rearing before they reach the transitional size necessary to migrate into the ocean (70 to 100 mm). This larger size is necessary to deal with the physical conditions and predators they face in the ocean environment, as well as to be successful in obtaining prey in that environment. At growth rates of about 0.3 to 1 mm per day (Levy *et al.* 1979; Argue *et al.* 1985; Fisher and Pearcy 1990), the subyearlings require weeks to months to reach this larger size. During this time, young Chinook increase by about 5 to 8 grams per day or approximately 6% of their body weight (Herrmann 1970; Healey 1980).

Ocean-type subyearlings migrate through the riverine reach of the action area of the Project during their downstream migration (about 93 miles). Because of this, many spend some time rearing within the riverine reach; however, there is considerable variability in the freshwater rearing period of subyearling populations. Some subyearlings spawned in the lower reaches of coastal tributaries migrate almost immediately to marine areas following emergence from the gravel. Other subyearlings rear in freshwater for weeks to months, particularly those spawned well upstream in larger river systems such as the Columbia. The migration rate for subyearlings undergoing the rearing migration through the riverine reach is likely to be a few to ten km per day. Subyearlings migrating directly to the estuary migrate at rates of 15 to 30 km per day (MacDonald 1960; Simenstad *et al.* 1982; MacDonald *et al.* 1987; Murphy *et al.* 1989; Fisher and Pearcy 1990). Adult salmon returning to the Columbia River migrate through the river mouth throughout the year. The majority move through this area from early spring through autumn.

A number of physical characteristics in the riverine reach affect the quality and quantity of habitat available for salmonids. These include the availability of prey, temperature, turbidity, and suspended solids. Subyearlings are commonly found within a 10 feet of the shoreline at water depths of less than 3 feet. Although they migrate between areas over deeper water, they generally remain close to the water surface and near the shoreline during rearing, favoring water no more than 2 meters deep and areas where currents do not exceed 1 foot per second. They seek lower energy areas where waves and currents do not require them to expend considerable energy to remain in position while they consume invertebrates that live on or near the substrate. These areas are characterized by relatively fine grain substrates. However, it is not uncommon to find young salmonids in areas with steeper and harder substrates, such as sand and gravel.

Young Chinook in the lower Columbia River action area consume a variety of prey, primarily insects in the spring and fall and *Daphnia* from July to October (Craddock *et al.* 1976). *Daphnia* are the major prey during the summer and fall months, selected more than other planktonic organisms. Young salmonids consume diptera, hymenoptera, coleoptera, tricoptera, and ephemeroptera in the area just upstream from the estuary (Dawley *et al.* 1986). Bottom and Jones (1990) recently reported that young Chinook ate primarily *Corophium*, *Daphnia*, and insects, with *Corophium* being the dominant prey species in winter and spring and *Daphnia* the dominant prey species in summer. Salmonids commonly feed on *Corophium* males, which apparently are more readily available than the larger females.

Corophium is commonly discussed as a primary prey item of juvenile salmonids in the Columbia River. *Corophium salmonis* is a euryhaline species tolerating salinities in the range of zero to 20 ppt (Holton and Higley 1984). As shown by the above investigations, it is one of several major prey species consumed by juvenile Chinook under existing conditions. No data are available that indicate its historical role in the diet of Columbia River salmon before substantial modification of the river system. Nutritionally, *Corophium* may not be as desirable as other food sources for young salmon. According to Higgs *et al.* (1995), gammarid amphipods such as *Corophium* are high in chitin and ash and low in available protein and energy relative to daphnids and chironomid larvae.

Subyearling Chinook and chum first enter the estuary at about the same time that they enter the riverine potion of the lower Columbia River because some of the fry move rapidly to the estuary by mid-March rather than rearing in the riverine areas (Craddock *et al.* 1976; Dawley *et al.* 1986; Levy and Northcote 1982; Healey 1982; Hayman *et al.* 1996). As Chinook fry migrate to the estuary, they may remain in the low salinity or even freshwater areas for some time until they have grown somewhat larger (more than 75 mm) (Kjelson 1982; Levings 1982; Levy and Northcote 1982; MacDonald *et al.* 1986; Shreffler *et al.* 1992; Hayman *et al.* 1996). However, some Chinook fry appear to move immediately to the outer edges and higher salinity portions of the estuary (Stober *et al.* 1971; Kask and Parker 1972; Healey 1980; Johnson *et al.* 1992; Beamer *et al.* 2000).

Ocean-type fish commonly have the capacity to adapt to highly saline waters shortly after emergence from the gravel. Tiffan *et al.* (2000) determined that, once active migrant fall Chinook passed McNary Dam 470 km upstream from the Columbia River's mouth, 90% of the subyearlings were able to survive challenge tests in 30 ppt seawater at 18.3°C. Other investigators have found that very small Chinook fry are capable of adapting to estuarine salinities within a few days (Clark and Shelbourn 1985). Wagner *et al.* (1969) found that all fall Chinook alevins tested were able to tolerate 15 to 20 ppt salinity immediately after hatching.

In addition, young salmonids in the estuary continue to eat many of the same organisms as are consumed in the riverine reach of the lower Columbia River, but there are shifts in prey abundance. Young Chinook and chum at Miller Sands in the upper estuarine reach feed primarily on the pelagic prey *Daphnia longispina* and *Eurytemora hirundoides*, the benthic prey *Corophium salmonis*, and chironomid larvae and pupae (McConnell *et al.* 1978). Diet overlaps considerably among the different species. Many yearlings passing through the lower river were found to have empty or less than full stomachs (Dawley *et al.* 1986).

Adult salmon returning to the Columbia River migrate through the river mouth throughout the year although most move through this area from early spring through autumn (Appendix B).

Southern green sturgeon. The following information is summarized from NMFS 2009c and NMFS 2008x. The Columbia River estuary is the center of the largest observed aggregation of North American green sturgeon. Southern green sturgeon mix with non-ESA designated northern fish in large aggregations in marine waters of the lower Columbia River estuary. Patterns of telemetry data suggest that southern fish use the Columbia as summering grounds and overwinter in coastal waters off central California and between Vancouver Island, BC, and southeast Alaska. The upriver extent of marine waters in the Columbia is approximately RM 46, coinciding with the extent of designated critical habitat. However, green sturgeon are assumed to travel to Bonneville Dam (RM 146), though in significantly lower numbers, based on lack of barriers and harvest studies. Tagging studies have only sampled individuals to RM 46, while commercial data suggests some movement to Bonneville Dam based on commercial zone harvest reports. Data from 1981–2004 shows a combined catch of 290 southern and northern fish above RM 52, and approximately 37,000 caught below, primarily below RM 20. The CRC footprint is at RM 106.

After leaving their natal grounds in the Sacramento River at around the age of three years and traveling as sub-adults in marine waters they distribute themselves along the West Coast and estuarine waters. Those adult and subadult green sturgeon that spend transient time in the Columbia River estuary feed on crangonid shrimp, burrowing thalassinidean shrimp (primarily the burrowing ghost shrimp (*Neotrypaea californiensis*), but possibly other related species), amphipods, clams, juvenile Dungeness crab (*Cancer magister*), anchovies, sand lances (*Ammodytes hexapterus*), lingcod (*Ophiodon elongatus*), and other unidentified fishes. Burrowing ghost shrimp made up about 50% of the stomach contents of green sturgeon sampled in 2003. Subadults and adults feeding in bays and estuaries may be exposed to contaminants that may affect their growth and reproduction. Studies on white sturgeon in estuaries indicate that the bioaccumulation of pesticides and other contaminants adversely affects growth and reproductive development and may result in decreased reproductive success. Green sturgeon are believed to experience similar risks from contaminants.

Eulachon. The Columbia River and its tributaries support the largest eulachon run in the world (Hay *et al.* 2002). Eulachon use the mainstem Columbia River portion of action area primarily to migrate to spawning grounds as adults, and as larvae to emigrate out of freshwater into marine waters soon after emergence. Large spawning runs of eulachon occur in the mainstem lower Columbia River and the tributary Cowlitz, Lewis, Sandy (Craig and Hacker 1940), Grays (Smith and Saalfeld 1955), Kalama (DeLacy and Batts 1963), and Elochoman rivers and Skamokawa Creek (WDFW and ODFW 2001). Smith and Saalfeld (1955) stated that eulachon were occasionally reported to spawn up to the Hood River on the Oregon side of the Columbia River prior to the construction of Bonneville Dam in the 1930s. In times of great abundance (*e.g.*, 1945, 1953) eulachon have been known to migrate as far upstream as Bonneville Dam (Smith and Saalfeld 1955, WDFW and ODFW 2008) and may extend above Bonneville Dam by passing through the ship locks (Smith and Saalfeld 1955). The Status Review Update for Eulachon in Washington, Oregon, and California (EBRT 2010) reports that evidence of mainstem exists as well, but notes that additional sampling is needed to determine the extent and amount.

The majority of reproduction occurs in those tributaries downstream of the CRC, with reproduction unpredictable upstream of the CRC. Annual catch records show eulachon to be absent from the Sandy River in 12 one or more consecutive years (JCRMS 2006). Eulachon runs have been recorded 31 of 81 years (1929–2009), with sustained absences in 1958–1970 and 1989–2000. Return run timing of eulachon is varied, the majority of adults entering the Columbia River from the middle of February. Using the Lewis and Sandy Rivers as a proxy to the CRC, the nearest downstream and upstream spawning areas, the majority of the adults should pass through the CRC project area in April and May. Impact driving of pile would occur up to April 15 each year.

Habitat preferences of eulachon within the Columbia River are not well understood. With the exception of preferred spawning habitat (which is typically coarse sand or pea-sized gravel substrate), observational data suggest that migrating eulachon exhibit little preference for habitat type, and may use deep, shallow, brightly lit, and/or shaded portions of the river. Outmigrants may occur anywhere along the river's transect, and at all depths (Langness 2009 personal communication). Larval eulachon have been found in some studies at greater densities at the bottom of the water column, compared to mid-level or near the surface, and may occur in greater densities outside the navigation channel than within the channel (Howell *et al.* 2001). However, because they are relatively weak swimmers, larval eulachon distribution and use of the water column is thought to be determined by local hydraulic conditions rather than by depth at a particular site (Langness 2009 personal communication; Howell *et al.* 2001). Typical or optimal water velocities for eulachon migration or spawning are not known (Langness 2009 personal communication).

The eulachon have declined to what appear to be nearly historically low levels in the Columbia River. The Eulachon Biological Review Team (EBRT 2010) ranked climate change and its impacts to ocean conditions as the most serious threat to eulachon. As well, climate change impacts on freshwater habitat and eulachon bycatch were scored as moderate to high risk, and dams and water diversions in the Columbia River. Variable year-class strength in marine fishes with pelagic larvae is dependent on survival of larvae prior to recruitment and is driven by match-mismatch of larvae and their planktonic food supply (Lasker 1975, Sinclair and Tremblay 1984), oceanographic transport mechanisms (Parrish *et al.* 1981), variable environmental ocean conditions (Shepherd *et al.* 1984, McFarlane *et al.* 2000), and predation (Bailey and Houde 1989). The operation of these dynamic ocean conditions and their impacts on eulachon recruitment were amply illustrated in the Columbia River population where high larval densities were observed in 2000–2003, followed by lower than average adult returns in 2004, 2005, and 2006 (JCRMS 2007). However, the ability of the Columbia River eulachon stock to respond rapidly to the good ocean conditions of the late 1999-early 2002 period illustrates the species' resiliency and the BRT viewed this resiliency as providing the species with a buffer against future environmental perturbations. Recent invasions of Asian copepods into the Columbia River estuary (Cordell *et al.* 2008) may have a negative influence on the Columbia River population as well.

Eulachon, like Pacific salmon and steelhead, must pass through the lower Columbia River, estuary and river mouth twice: Once as juveniles en route to the Pacific Ocean and again as adults when they return to spawn. Moreover, eulchon that spawn in the Sandy River pass through the part of the action area where underwater noise is expected to reach injurious levels. Like other individuals in this species, those fish are likely to be in a stressed condition due to increased water temperatures, insufficient streamflow, altered sediment balances, water pollution, over-harvest, predation, and other adverse habitat conditions in the lower Columbia River.

Eastern Steller Sea Lion. Eastern Steller sea lions occur in Oregon waters throughout the year, and use breeding rookeries at Rogue Reef and Orford Reef and haulout locations along the Oregon coast. There are four haulout sites used by Steller sea lions in the lower Columbia

River and these include the tip of the South Jetty, where greater than 500 Steller sea lions commonly occur, and three locations proximate to and at the Bonneville Dam tailrace area where Steller sea lions occasionally occur.

Over the last nine years, the number of eastern Steller sea lions seasonally present at the Bonneville dam has increased from zero individuals in 2002 to a minimum estimate of 75 subadult and adult male Steller sea lions in 2010, which although an increase is still a relatively small number of individuals (Stansell *et al.* 2008, 2009, Stansell and Gibbons 2010, Stansell *et al.* 2010).

The few eastern Steller sea lions that travel up the lower Columbia River to the tailrace area of Bonneville Dam travel there to forage on anadromous fishes. Some individual Steller sea lions occur at the tailrace area as early as fall; their numbers peak in winter to early spring and they depart by late spring (Stansell *et al.* 2008, 2009, Stansell and Gibbons 2010). Individuals are likely to transit through the river up to the tailrace area within 1-2 days with transit speeds of 4.6 km/hr in the upstream direction and 8.8 km/hr in the downstream direction (based on the transit times of California sea lions, Brown *et al.* 2010). Therefore, individuals likely spend little time in any one location prior to their arrival in the tailrace area.

In-season return trips between the river mouth and the tailrace area may occur, but limited data suggest that eastern Steller sea lions make few if any return trips until their departure from the tailrace area by late spring. Only one of less than 10 individual eastern Steller sea lions tagged with acoustic/satellite-tags was observed to make an in-season return trip; all others made a single trip, departing by late spring (data collected in 2010, B. Wright unpublished data). However, tags were deployed in the middle of the season, and therefore, return trips could occur more commonly or regularly in the early part of the season.

Eastern Steller sea lions that would transit through the action area were affected by an upriver deterrence program from 2008 to 2010 to reduce pinniped impacts on ESA-listed Pacific salmon and steelhead below Bonneville Dam on the lower Columbia River. NMFS previously consulted on the effects of this program, and concluded that the non-lethal deterrence activities that target Steller sea lions are likely to adversely affect, but not likely to jeopardize Steller sea lions (NMFS 2008e).

Eastern Steller sea lions that are likely to be affected by this proposed action have shown increasing habituation in recent years to the various hazing techniques used to deter the animals from foraging on sturgeon and salmon in the Bonneville tailrace area, including acoustic deterrent devices, boat chasing, and above-water pyrotechnics (Stansell *et al.* 2010, Brown *et al.* 2010). Additionally, many of the individuals that travel to the tailrace area return in subsequent years (NMFS 2008e).

Critical Habitat within the Action Area

Critical habitat units are described by their PCEs. PCEs are the physical and biological features of critical habitat essential to the conservation of listed species, including, but not limited to:

(1) Space for individual and population growth and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and (5) habitats that are protected from disturbance or are representative of the historic geographic and ecological distributions of a species (USFWS and NMFS 1998).

Pacific salmon and steelhead. Four of the six PCEs used to describe Pacific salmon and steelhead critical habitats occur within the action area: freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. PCEs related to nearshore and marine areas are important elsewhere but do not occur within the action area.

Freshwater spawning sites. Spawning habitat is extremely limited in the action area, and is present for only three species. CR chum spawn in shallow habitat on the north shore of the lower Columbia River, near Government Island at approximately RM 115, where water quantity and quality conditions and substrate do not fully support spawning, incubation, and larval development. The rest of the action area appears to lack suitable spawning habitat, such as gravel substrate influenced by groundwater seeps, or else is at risk when river management lowers water levels and expose the eggs to the atmosphere. Economic development in some upland areas adjacent to spawning sites threatens to reduce groundwater seeps that support good spawning conditions. This PCE has marginal conservation in the action area.

Freshwater rearing sites. Freshwater rearing occurs throughout the action area although it lacks water quantity and floodplain connectivity necessary to form and maintain physical habitat conditions that fully support juvenile growth and mobility; water quality and forage necessary to fully supporting juvenile development; and has extremely limited natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Without these features, juvenile Pacific salmon and steelhead cannot access and use areas as necessary for them forage, grow, and develop behaviors (*e.g.*, predator avoidance, competition) that help ensure their survival. Floodplain connectivity with associated off-channel refugia is limited or absent in the action area. Dikes, levees, and bank armoring are common and urban development extends up to river's edge in many locations. Natural cover is reduced or absent due to the highly altered and managed nature of the river channel. Flow control at Bonneville Dam leads to rapid changes in water levels and sometimes strand or entrap juveniles when water levels drop. The absence of productive riparian vegetation and complex shallow water habitat severely reduce the abundance and diversity of forage available for juvenile salmonids.

Freshwater migration corridors. The entire action area is a migration corridor for juveniles and adults. Although the action area is relatively free of obstruction, it has high levels of predation, poor water quantity and quality conditions, and lacks well-developed natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks that support juvenile and adult mobility and survival. The deficiency of those features reduces access within the action area to the variety of habitats necessary for juveniles to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, lack of these features reduce the ability of adults in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores. Although no physical barrier completely blocks fish passage through the action area, habitat and food web degradation increase the difficulty of migration and decrease the conservation value of this PCE.

Estuarine areas. The action area includes most of the Columbia River estuary and, although it is relatively free of physical obstructions, water quality, water quantity, and salinity conditions there do not fully support juvenile and adult physiological transitions between fresh- and saltwater. Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels are poor. Juvenile and adult forage is also poor, including lack of aquatic invertebrates and fishes that provide the energy to support growth and maturation. Without better access to those resources in the action area, juveniles are less likely to reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, lack of those features do not fully support adults because they provide less abundant forage as necessary to provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas. As noted in the Status of Critical Habitat section, above, development of hydropower, industrial harbors and ports, and urban areas have contributed to extensive losses of tidal marshes and swamps in the estuary, and other changes in aquatic habitats and food webs that reduce the conservation value of this important PCE.

Southern green sturgeon. PCEs used to describe critical habitat for southern green sturgeon are less differentiated than PCEs for Pacific salmon and steelhead, but two of the three are present within the action area from the mouth of the Columbia River up to RM 46, including freshwater riverine systems and estuarine areas. PCEs related to coastal marine areas do not occur within the action area.

Freshwater riverine systems. The action area includes poor forage for subadult and adult sturgeon likely to occur there, although substrates for spawning are unnecessary as this population spawns exclusively in the Sacramento River. Management of the lower Columbia River flow regime is likely to have altered the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time that is less than optimal for the normal behavior, growth, and survival of southern green sturgeon. Water quality impairments, including temperature, salinity, oxygen content, and other chemical characteristics, are also likely to limit normal behavior, growth, and viability. Conditions for the safe and timely passage of southern green sturgeon within the river, and between the river and the estuary, are present, with many pools greater than 15 feet deep for upstream and downstream holding of adult or subadult fish.

Estuarine habitats. As noted in the Status of Critical Habitat section above, development of hydropower, industrial harbors and ports, and urban areas have contributed to extensive losses of tidal marshes and swamps in the estuary, and other changes in aquatic habitats and food webs that reduce the conservation value of this important PCE. The action area includes poor forage for subadult and adult sturgeon, although it is likely that flows within the estuary are adequate to subadults and adults to successfully orient to the incoming flow and migrate upstream. The water quality impairments that affect the freshwater riverine PCE Water quality also impair the Columbia River estuary. Conditions for the safe and timely passage of southern green sturgeon within the river, and between the river and the estuary, are present, with many pools greater than 15 foot deep for upstream and downstream holding of adult or subadult fish.

Effects of the Action

Effects of the action refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those caused by the proposed action and are later in time, but still are reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those lacking independent utility apart from the action under consideration.

The primary effects of CRC will include elevated levels of underwater noise, reduced water quality, and physical habitat alteration associated with the structural footprint of the CRC bridges. For reasons explained below, the underwater noise will occur as short-term pulses (*i.e.,* minutes to hours), separated by virtually instantaneous and complete recovery periods. These disturbances are likely to occur several times a day for up to a week, two to 14 weeks per year, for six years (Table 4). Water quality impairment will also occur as short-term pulses (*i.e.,* minutes to hours) during construction, most likely due to erosion during precipitation events, and will continue due to stormwater runoff for the design life of CRC. Physical habitat alteration due to modification and replacement of existing in-water and over-water structure also occur intermittently during construction, and will remain as the final, as-built project footprint for the design life of CRC.

Impact pile driving will produce a variety of underwater noise levels within radii here referred to collectively as the impact zone (Table 24). In the absence of site-specific data, these radii were calculated using the Practical Spreading Loss model for determining the extent of sound from a source (Thomsen *et al.* 2006, Stadler 2010). The contractor will use a bubble curtain and similar devices to provide sound attenuation during impact pile driving. Underwater noise caused by vibratory installation will be less than impact driving (CALTRANS 2009, WDOT 2010b). Moreover, oscillating and rotating steel casements for drilled shafts are not likely to elevate underwater sound to a level that is likely to cause injury or noise that would cause adverse changes to fish behavior.

Table 24. Maximum predicted effects of impact pile driving for the Columbia River Crossing. FHWA and FTA assume that attenuation such as bubble curtains and dewatered cofferdams will achieve a 10 dB noise reduction.

Effect Characteristics ("impact zone")	**24-inch Pile**		**48-inch Pile**	
	Without Attenuation	With Attenuation	Without Attenuation	With Attenuation
Root mean square sound pressure level radius exceeds 150 dB re: 1 μPa (distance in feet)	13,058	2814	66,144[1]	17,751
Cumulative sound exposure level radius that exceeds 183 dB re: 1 μPa^2•sec (distance in feet)	1466	177	3250	774
Cumulative sound exposure level radius that exceeds 187 dB re: 1 μPa^2•sec (distance in feet)	823	164	1771	449
Peak sound pressure level that exceeds 206 dB re: 1 μPa (distance in feet)	23	16	112	82

[1] Upstream distance; downstream radius is 29,031 feet due to topographic interception.

Pile installation and removal, and installation and operation of the bubble curtain, will disturb the sediments in the action area and result in some re-suspension of coarse-grained material into the water column. Pile removal is likely to expose a greater amount of sediment due to adhesion of sediment to pile. However, because pile occupies a small area of primarily sandy substrates that are often rearranged by river currents, any increase in turbidity will be small.

Sediment and contaminants are likely to be released into the water by construction activities that are part of the proposed action, including geotechnical surveys, excavation, grading, filling, and in-water work area isolation that is necessary to rehabilitate or replace existing roads, culverts, and bridges, and to construct and maintain stormwater facilities. Soil disturbance will increase the rate at which wind and water erosion will carry sediment into the lower Columbia River. Contamination of sediment from the project area is probable from urban practices, industry and automobile releases. Additionally, the use of heavy construction equipment results in small, unpredictable releases of fuel, lubricant, and hydraulic fluids. The release of construction material, though minor is likely to occur as well (grinding slurry, concrete, and rubble). Grinding slurry will be released from the use of underwater wire-cable saws to dismantle the existing I-5 bridge piers. The traceable turbidity extent of slurry is not anticipated to exceed three-hundred feet.

Discharge of stormwater runoff from CIA associated with the proposed action will also contribute a variety of pollutants to the lower Columbia River that originate directly from automobiles and indirectly via aerial deposition from industrial and agricultural production. These pollutants will include, but are not limited to, nutrients, metals (arsenic, copper, chromium, lead, mercury, and nickel), PAHs, sediment, and pesticides (LCREP 2007; Buckler and Granato 1999, Colman *et al.* 2001, Kayhanian *et al.* 2003).

Pollutants like these travel long distances in rivers either in solution, adsorbed to suspended particles, or retained in sediments until mobilized, transported by future sediment moving flows (Anderson *et al.* 1996, Alpers *et al.* 2000a, 2000b). The toxicity of these pollutants varies other water quality speciation and concentration. Regarding dissolved heavy metals, Santore *et al.* (2001) indicates that the presence of natural organic matter and changes in pH and hardness affect the potential for toxicity (increase and decrease). Additionally, organics such (living and dead) can adsorb and absorb other pollutants such as PAHs. The variables of organic decay further complicate the path and cycle of pollutants. The persistence and speciation of these pollutants cause effects and consequentially the action area to extend from the points of stormwater discharge to the downstream terminus of the Columbia River, approximately 106 RM.

Stormwater treatment proposed by the FHWA and FTA is based on a design storm (50% of the 2-year, 24 hour storm) that will generally result in more than 95% of the runoff from all impervious surfaces within the CRC area being infiltrated at or near the point at which rainfall occurs. The treatment will consist of infiltration practices such as bioretention, bioslopes, infiltration ponds, and porous pavement, supplemented with appropriate soil amendments as needed. [5] The stormwater literature identifies these practices as excellent treatments to reduce or eliminate contaminants from highway runoff (Barrett *et al.* 1995, CWP and MDE 2000, NCHRP 2006, WDOT 2006, Hirshman *et al.* 2008).

The FHWA and FTA propose to capture, manage, and treat all of the CIA for the CRC, but 6.8 acres of CIA are still unaccounted for in a stormwater management plan (Table 7). Moreover, the proposed treatment will not eliminate all stormwater pollutants. Thus, some adverse effects of stormwater runoff will exist for the design life of the CRC and, because little to no treatment currently exists for this portion of the I-5 corridor, the CRC will decrease in the level of stormwater pollutants currently discharged into the lower Columbia River.

Construction of the CRC bridges will temporarily displace 2.0 acres in-channel habitat for the isolation of in-water work areas, including temporary sheet piles, and permanently displace 0.17 acres of benthic habitat for bridge columns. CRC will also temporarily create 2.28 acres of new over-water structure due to barges, work platforms, and in-water work isolation areas, and 1.58 acres of permanent over-water structure, although the specific amount of habitat area displaced at any time will vary throughout the construction period.

The river-spanning portion of the CRC is approximately 28 acres, based on an assumed bridge width of 300 feet. Of the 28 acres, approximately 3 acres are shallow-water or nearshore habitat and most of that will occur in the river channel portion of the project footprint, where high water velocities and highly mobile sand substrates reduce habitat values. High quality off-channel habitat does not exist in the project footprint due to the effects of past diking, dredging, and bank hardening.

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[5] See also Memos from Ronan Igloria, HDR (Henningson, Durham, and Richardson, Inc.), to Jennifer Sellers and William Fletcher, Oregon Department of Transportation, dated December 28, 2007 (Stormwater Treatment Strategy Development – Water Quality Design Storm Performance Standard), February 28, 2008 (Stormwater Treatment Strategy Development – Water Quantity Design Storm Performance Standard - Final), and April 15, 2008 (Stormwater Treatment Strategy Development – BMP Selection Tool).

Construction of the CRC will also cause the loss of approximately 10,000 square feet of riparian canopy, including 15 trees, in areas where riparian vegetation has a patchy distributed due to past development.

Conversely, construction of the CRC will remove all in-water components of the I-5 bridges that currently span the mainstem lower Columbia River. The North Portland Harbor bridges will be retained and widened. Because the replacement structures will occupy less in-channel area than the current ones, removal of their in-water components down to the riverbed will release approximately 3,000 square feet of overhead space for unencumbered ecological function.

Of these physical habitat effects, those associated with shade from the temporary work decks and barges area likely to be the most ecologically important because those temporary structures will be in contact or close proximity to the water's surface where, under well-lighted conditions, they can create a sharp contrast to the ambient light gradient (Table 25). Permanent CRC features, like bridge superstructures, will all be approximately 95 feet above the river surface and therefore less likely to affect local light levels.

Table 25. Summary of predicted shade due to over-water for the Columbia River Crossing.

Type of Structure	Columbia River	North Portland Harbor
	Area (acres)	Area (acres)
Temporary		
Work platforms for drilled shafts	3.40	0.69
Tower cranes	0.06	--
Oscillator support platforms	0	0.64
Construction barges	2.44	24.91
Demolition barges	0.10	--
Total acres	5.89	26.23
Permanent		
Shaft caps	1.54	--
New bridge spans	15.52	7.12-9.55
Existing bridge spans to be removed	- 6.52	--
Other overwater structure to be removed	- 0.29-0.81	--
Total acres	9.53-10.04	7.12-9.55

Species within the Action Area

All populations of Pacific salmon and steelhead and eulachon that spawn within the Columbia River basin use the Columbia River mainstem and estuary to complete part of their life history, including migration, rearing and smoltification. Except for populations that spawn below RM

106, every individual from each of those populations must pass through the action area at least twice, during downstream migration as a juvenile and upstream migration as an adult. Southern green sturgeon do not spawn in the Columbia River basin although large aggregations of subadults and adults occur in estuary and occasionally venture as far upstream and the CRC.

Work area isolation. If work area isolation is necessary for Piers 2 and 7, or any other part of the work site, any juvenile salmon or steelhead present in the work isolation area will be captured and released. It is unlikely that any adult salmon or steelhead, or any southern green sturgeon or eulachon will be affected by this procedure, however, because it will occur when adults are unlikely to be present and, if any are present, their size allows them to easily escape from the containment area. Capturing and handling fish causes them stress though they typically recover fairly rapidly from the process and therefore the overall effects of the procedure are generally short-lived (NMFS 2002). The primary contributing factors to stress and death from handling are differences in water temperature between the river where the fish are captured and wherever the fish are held, dissolved oxygen conditions, the amount of time that fish are held out of the water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 18°C (64°F) or dissolved oxygen is below saturation. Proposed design criteria regarding fish capture and release, use of pump screens during the de-watering phase, and fish passage around the isolation area will comply with NMFS guidance to reduce the adverse effects of these activities (NMFS 2000, 2008f).

Underwater noise. Underwater sound pressure waves can injure or kill fish (Reyff 2003, Abbott and Bing-Sawyer 2002, Caltrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001). Fish with swim bladders, including Pacific salmon and steelhead and southern green sturgeon are particularly sensitive to underwater impulsive sounds with a sharp sound pressure peak occurring in a short interval of time (Caltrans 2001). As the pressure wave passes through a fish, the swim bladder is rapidly squeezed due to the high pressure, and then rapidly expanded as the under pressure component of the wave passes through the fish. The pneumatic pounding may rupture capillaries in the internal organs as indicated by observed blood in the abdominal cavity, and maceration of the kidney tissues (Caltrans 2001). Although eulachon lack a swim bladder, they are also susceptible to general pressure wave injuries including hemorrhage and rupture of internal organs, as described above, and damage to the auditory system. Direct take can cause instantaneous death, latent death within minutes after exposure, or can occur several days later. Indirect take can occur because of reduced fitness of fish making it susceptible to predation, disease, starvation, or ability to complete its life cycle.

A multi-agency work group consisting of key technical and policy staff, supported by national experts on sound propagation activities that affect fish and wildlife species of concern, determined that to protect listed species, , sound pressure waves should be within a single strike threshold of 206 dB re: 1 μPa, and for cumulative strikes sound pressure waves should be less than 187 dB re: 1 μPa^2•sec sound exposure level for fish that are larger than 2 grams and less than 183 dB re: 1 μPa^2•sec sound exposure level for fish that are smaller than 2 grams (FHWG 2008). Any salmon or steelhead that occurs within the radius where the root mean square sound pressure level will exceed 150 dB re: 1 μPa^2 may experience a temporary threshold shift in hearing due to a temporary fatiguing of the auditory system that can reduce the survival, growth, and reproduction of the affected fish by increasing the risk of predation and reducing foraging or spawning success (Stadler and Woodbury 2009).

Thus, noise levels that are predicted to be produced by CRC (Table 24) are likely to injure or kill OC chum salmon embryos and alevins, and any juvenile salmon or steelhead weighing less than 2 grams, that occur within the radius where the noise produced by a strike pile strike will exceed 206 dB re: 1 μPa, or where the cumulative sound exposure level will exceed 183 dB re: 1 μPa^2•sec. Similarly, any juvenile salmon and steelhead that weigh more than 2 grams, and any adult salmon or steelhead, that occur within the radius where the noise produced by a pile strike will exceed 206 dB re: 1 μPa, or where the cumulative sound exposure level will exceed 183 dB re: 1 μPa^2•sec are likely to be injured or killed. Finally, any ESA-listed fish that occurs within the radius where the root mean square sound pressure level will exceed 150 dB re: 1 μPa^2 may experience an temporary threshold shift in hearing that will increase the risk that those individuals will be subject to predation and reduce their likelihood of foraging or spawning success.

Reduced water quality. The discharge of stormwater will expose adult and juvenile ESA-listed fish in the Columbia River from the points of discharge within the channel downstream to the mouth. Additionally, effects to LCR species will occur in Burnt Bridge Creek, and exposure of both LCR and UWR juveniles will occur in the Columbia Slough. The later is a terminal slough without adult habitat. Though treatment will occur, the ability to remove pollutants to a level without effect upon ESA-listed fish, or that does not synergistically combine with other sources is technologically limited and unfeasible. Exposure to these ubiquitous contaminants even in low concentrations is likely to affect the survival and productivity of salmonids-juveniles in particular (Loge *et al.* 2006, Hecht *et al.* 2007, Johnson *et al.* 2007, Sandahl *et al.* 2007, Spromberg and Meador 2006). Short-term exposure to contaminants such as pesticides and dissolved metals may disrupt olfactory function (Hecht 2007) and interfere with associated behaviors such as foraging, anti-predator responses, reproduction, imprinting (odor memories), and homing (the upstream migration to their natal stream). The toxicity of these pollutants varies other water quality speciation and concentration. Regarding dissolved heavy metals, Santore *et al.* (2001) indicates that the presence of natural organic matter and changes in pH and hardness affect the potential for toxicity (increase and decrease). Additionally, organics such (living and dead) can adsorb and absorb other pollutants such as PAH. The variables of organic decay further complicate the path and cycle of pollutants.

The release of contaminants is likely to occur. Wind and water erosion is likely to entrain and transport soil from disturbed areas contributing fine sediments that are likely to contain pollutants, and the use of the use of heavy equipment, including stationary equipment like generators and cranes, also creates a risk that accidental spills of fuel, lubricants, hydraulic fluid, coolants, and other contaminants may occur. Petroleum-based contaminants, such as fuel, oil, and some hydraulic fluids, contain PAHs, which are acutely toxic to salmonid fish and other aquatic organisms at high levels of exposure and cause sublethal adverse effects on aquatic organisms at lower concentrations (Heintz *et al.* 1999, 2000, Incardona *et al.* 2004, 2005, 2006).

However, due to the relatively small amount of time that any heavy equipment will be in the water and the use of proposed conservation measures, including site restoration after construction is complete, any increase in contaminants is likely to be small, infrequent, and limited to the construction period. In addition, pile driving, pile extraction, the use of a bubble curtain, and underwater wire-sawing will cause suspended sediment and increase turbidity. Because these actions will take place in a sandy substrate and will be limited to a small area and a brief portion of the work period, the increase in turbidity is expected to be small. However, fish close to the actions may experience abrasion to their gills and alteration in feeding and migration behavior.

Physical habitat alteration. The action will remove existing riparian and benthic habitat. Juvenile salmonids will experience a reduction of macroinvertebrate prey originating from benthic and riparian habitat, as well as macroinvertebrates likely to feed on or colonize allochthonous riparian plant materials. However, this effect is not likely to be significant since the area removed will be small in comparison to the action area, less than 10,000 square feet. As well, the loss of benthic habitat from the replacement structure will be in more swift and deeper mid-channel portions of the channel. Foraging by juvenile fish is expected to be low as well as the area is primarily a migration zone. Benefits will be realized through the completion of the action. The replacement bridges will have fewer structures in the channel that displace less area than the existing in-water structures, as well as move these bridge elements away from the near-shore and shallow water habitat to the mid-channel with deeper and faster water. While some of this habitat is still lost in the North Portland Harbor, the net increase to habitat available to fish for foraging and migration is approximately 3,000 square feet.

Juvenile and adult fishes' ability to use habitat, how they will use it, and the effects they subsequently experience will be altered by the presence of temporary and permanent structures that alter aquatic habitat. The direct effects include migration behavior modification and fish salvage, while indirect effects include predation.

Migration is likely to affected by the presence of temporary and permanent structure in the path of downstream migrating juveniles and upstream migrating adults. Juveniles have been shown to avoid and circumnavigate lines of shade cast by artificial structure. The use of work trestles, barges, and decks may cause juvenile fish to use habitat not usually used (*e.g.*, deep-water) and expose them to indirect effect including but limited to predation. As well, the path of individual migrating adults is likely to change as navigate around in-water structure causing them to use deep-water instead of shallow water habitat or vice versa depending on flows, species behavior, diurnal cycles *etc*. This may also cause them to slow or pause migration, causing them more vulnerable to predation as well. However, temporary and permanent structure will not occupy a large portion of the channel so its ability to alter migration is considered minimal.

Predation on juvenile salmon and steelhead is likely to increase due to the increase in over-water structure. The project will install multiple piles across the river crossing. Roosting by cormorants is likely, due to their affinity and need for above water structure to roost and dry-out. Without the ability to dry, they are unable to maintain buoyancy or warmth. This is of a concern since juvenile fish from all species migrate through the area. However, the FHWA and FTA have proposed to minimize this effect by installing anti-perching devices to piles planned to be in place 6-months or longer. This and construction work is likely to partially dissuade use.

Northern pike-minnow (*Ptychocheilus oregonensis*), small-mouth bass (*Micropterus dolomieu*), and large-mouth bass (*Micropterus salmoides*) are also predators that consume juvenile salmon and occupy the river-channel. In addition, both species have an affinity for in-water structure such as multiple pile structures. As well, structure such as docks provide a sharp contrast (shade) to ambient light conditions increasing the opportunity of ambush predation upon juvenile salmonids and eulachon.

Both California and Steller sea lions use the action area including the project area. Alterations to adult eulachon and salmon behavior may make them more vulnerable to predation by these species. Changes in cover that congregate fish or cause them to slow or pause migration would likely attract sea lions and take advantage of the opportunity. While individuals of these species are likely to take advantage of such conditions it is not expected to increase predation rates across the run as these features would be small when in comparison to the channel and other ample similar opportunities exist, such as wing walls, throughout the lower Columbia River.

Predation has been identified as one of the limiting factors for all salmonid species in the Columbia River basin, except chum salmon (NMFS 2008g). Increased predator abundance may result from climate change (ISAB 2007). Predator species such as northern pikeminnow, and introduced predators such as largemouth bass, smallmouth bass, black crappie (*Pomoxis nigromaculatus*) white crappie (*P. annularis*) and, potentially, walleye (*Stizostedion vitreum*) (Ward *et al.* 1994, Poe *et al.* 1991, Beamesderfer and Rieman 1991, Rieman and Beamesderfer 1991, Pflug and Pauley 1984, and Collis *et al.* 1995) may use habitat created by in-water structures (Ward and Nigro 1992, Pflug and Pauley 1984) such as piers, float houses, floats and docks (Phillips 1990). Carrasquero (2001), in reviewing the literature regarding impacts of overwater structures, reports that smallmouth and largemouth bass have a strong affinity to structures; forage and spawn in the vicinity of docks, piers and pilings; and, largemouth and smallmouth bass are common predators of juvenile salmonids.

Major habitat types used by largemouth bass include vegetated areas, open water and areas with cover such as docks and submerged trees (Mesing and Wicker 1986). During the summer, bass prefer pilings, rock formations, areas beneath moored boats, and alongside docks. Colle *et al.* (1989) found that, in lakes lacking vegetation, largemouth bass distinctly preferred habitat associated with piers, a situation analogous to slack water areas of the lower Columbia River. Marinas also provide wintering habitat for largemouth bass out of mainstem current velocities (Raibley *et al.* 1997). Wanjala *et al.* (1986) found that adult largemouth bass in a lake were generally found near submerged structures suitable for ambush feeding. Bevelhimer (1996), in studies on smallmouth bass, indicates that ambush cover and low light intensities create a predation advantage for predators and can also increase foraging efficiency.

Pribyl *et al.* (2005), in studies on piscivorous fish in the lower Willamette River found that smallmouth bass were the most prevalent species captured. They found that smallmouth bass were found near beaches and rock outcrops more frequently in the winter and spring, and highly associated with pilings regardless of the season. For largemouth bass, they found that they were found near pilings and beach sites in summer and autumn and near pilings, rock and beach areas during winter and spring. They also indicated that large sized predators were present at very low densities, but juveniles were fairly abundant. Smallmouth densities were highest in riprap, mixed riprap/beach and rock outcrop areas. Largemouth bass densities were low throughout the year, with riprap sites and alcoves being the highest density areas. Zimmerman (1999) and Sauter *et al.* (2004) both indicate that wild fall Chinook are the most vulnerable to smallmouth predation due to their smaller size during emigration.

Black crappie and white crappie are known to prey on juvenile salmonids (Ward *et al.* 1991). Ward *et al.* (1991), in their studies of crappies within the Willamette River, found that the highest density of crappies at their sampling sites occurred at a wharf supported by closely spaced pilings. They further indicated that suitable habitat for crappies includes pilings and riprap areas. Walters *et al.* (1991) also found that crappie were attracted to overwater structures.

Ward (1992) found that stomachs of northern pikeminnow in developed areas of Portland Harbor contained 30% more salmonids than those in undeveloped areas, although undeveloped areas contained more northern pikeminnow. Pribyl *et al.* (2005) found no fish in the stomachs of pikeminnow, but did find fish remains in the stomachs of smallmouth bass.

In addition to piscivorous predation, overwater structures also provide perching platforms for avian predators such as double-crested cormorants (*Phalacrocorax auritis*), from which they can launch feeding forays or dry plumage. Krohn *et al.* (1995) indicate that cormorants can reduce fish populations in forage areas, thus possibly affecting adult returns because of smolt consumption. Because their plumage becomes wet when diving, cormorants spend considerable time drying out feathers (Harrison 1983) on pilings and other structures near feeding grounds (Harrison 1984). Depending upon the final super-structure design the action may provide roosting areas for piscivorous birds.

Structure in the harbor is likely to provide resting and foraging habitat for piscivorous fish, able to prey on juvenile salmonids and adult and juvenile eulachon. Species such as large-mouth bass, northern pike minnow, and walleye pike reside in this portion of the river and are ambush predators in need of slower water velocities provided by in-water structure. While significant structure will occur in the main-stem Columbia River, velocities will remain in excess of these species needs. In addition, a reduction of prey quantity and abundance will occur through the displacement of benthic habitat. However, in higher order streams the food base is primarily pelagic including but not limited to copepods and zooplankton.

Eastern Steller sea lion. Eastern Steller sea lions may be present during the proposed in-water work windows from 2013 through 2021. As described above, the installation of steel sheet and pipe piles will elevate underwater sound in the action area. Sound pressure generated by this activity could injure or disturb Steller sea lions. NMFS is currently developing comprehensive guidance on sound levels likely to cause injury and behavioral disruption for marine mammals in the context of the Marine Mammal Protection Act and Endangered Species Act, among other statutes. Until formal guidance is available, NMFS uses the following thresholds of sound pressure levels from broadband sounds that cause behavioral disturbance - 160 dBrms re: 1μPa for impulse sound and 120 dBrms re: 1μPa for continuous sound - and injury 190 dBrms re: 1μPa for pinnipeds (70 FR 1871).

Based on these thresholds, the FHWA and FTA anticipate that their proposed pile driving would produce sound pressure levels that could disturb or injure eastern Steller sea lions. To insure injury does not occur during project construction, the FHWA and FTA will implement a safety zone during all impact pile driving and during vibratory installation of 120-inch steel casings out to the 190 dB isopleths. FHWA and FTA will also slowly ramp up the initiation of pile installation. These ramp-up procedures provide added insurance to avoid injury of Steller sea lions. For example, in the unlikely event that a Steller sea lion is within the safety zone, but not visually detected, the ramp-up of sound levels will allow the Steller sea lion an opportunity to depart the immediate area prior to the onset of pressure levels that could cause injury. FHWA and FTA established the initial size of safety zones based on worst-case underwater sound modeling (30 feet and 177 feet for 18- to 24-inch and 36- to 48-inch steel piles, respectively, and 16 feet for 120-inch steel casing). FHWA and FTA will monitor the safety zone throughout impact pile installation and vibratory installation of 120-inch steel casings, and pile-driving operations will not initiate or will suspend if a Steller sea lion is detected approaching or entering the safety zone. The safety zone monitoring makes any potential injury of Steller sea lions extremely unlikely, and therefore discountable. FHWA and FTA do not anticipate that noise levels for vibratory installation of steel sheet or pipe piles will be above 190 dB, and therefore do not anticipate implementing a safety zone during vibratory pile driving, with the exception of installing 120-inch steel casings. Hydroacoustic monitoring of both impact and vibratory installation will confirm the anticipated sound levels. FHWA and FTA will use the actual SPL measurements from this monitoring to enlarge or reduce the size of safety zones, based on the most conservative SPL measurements.

Although the safety zone monitoring and shutdown procedures will avoid injury of eastern Steller sea lions, beyond this zone behavioral disruption may occur out to the 160 dB and 120dB isopleths for impact and vibratory driving, respectively. Based on conservative sound modeling, FHWA and FTA anticipate that noise from vibratory installation will not attenuate to the 120dB disturbance threshold before encountering land on the opposite shore and up and down river in either direction. Noise from impact installation is likewise anticipated to extend across the river to the opposite shore, but will attenuate to the 160 dB disturbance threshold both up and down river in closer proximity (within a river reach of 0.4 mile with an attenuation device and within 3.4 miles without an attenuation device).

FHWA and FTA estimated the number of annual eastern Steller sea lion exposures to sound levels above the disturbance thresholds in the project area during the years of in-water construction. They conservatively estimate that the number of individuals traveling up the lower Columbia River will be a three-fold increase above the largest minimum count in 2010 (an increase of this magnitude has occurred in the past year, and may continue). They further estimate that all individual Steller sea lions travelling past the project area will be exposed each time they pass the area and that all exposures would cause disturbance. NMFS agrees that this represents a worst-case scenario and is therefore sufficiently precautionary. Based on their analysis, a combined total of up to 225 subadult and adult males per year and up to 6 repeat exposures per individual per year (three round trips each), or 1,350 total exposures per year could occur each year from 2013 to 2021. NMFS next considers the range of possible behavioral and other changes that such exposures could cause.

It is unlikely that eastern Steller sea lions exposed to sound levels above the disturbance thresholds will temporarily avoid traveling through the affected area. Steller sea lions en route to the Bonneville tailrace area are highly motivated to travel through the action area in pursuit of foraging opportunities upriver (NMFS 2008e). As stated in the Environmental Baseline section, Steller sea lions have shown increasing habituation in recent years to various hazing techniques used to deter the animals from foraging on sturgeon and salmon in the Bonneville tailrace area, including acoustic deterrent devices, boat chasing, and above-water pyrotechnics (Stansell *et al.* 2009). Many of the individuals that travel to the tailrace area return in subsequent years (NMFS 2008). Therefore, it is likely that Steller sea lions will continue to pass through the action area even when sound levels are above disturbance thresholds.

Although eastern Steller sea lions are unlikely to be deterred from passing through the area, even temporarily, they may respond to the underwater noise by passing through the area more quickly, or they may experience stress as they pass through the area. As described in the Environmental Baseline, Steller sea lions already move quickly through the lower river on their way to foraging grounds below Bonneville. Any increase in transit speed is therefore likely to be slight. Another possible effect is that the underwater noise will evoke a stress response in the exposed individuals, regardless of transit speed. However, the period of time during which an individual would be exposed to sound levels that might cause stress is short given their likely speed of travel through the affected areas. In addition, there would be few repeat exposures for the individual animals' involved (estimated six exposures per animal). Thus, it is unlikely that the potential increased stress will have an effect on individuals or the population as a whole.

Therefore, NMFS finds it unlikely that the amount of anticipated disturbance would significantly change eastern Steller sea lions' use of the lower Columbia River or significantly change the amount of time they would otherwise spend in the foraging areas below Bonneville Dam. Even in the event that either change was significant and animals were displaced from foraging areas in the lower Columbia River, there are alternative foraging areas available to the affected individuals. NMFS does not anticipate any effects on haulout behavior because there are no proximate haulouts within the areas affected by elevated sound levels. All other effects of the proposed action are at most expected to have a discountable or insignificant effect on Steller sea lions, including an insignificant reduction in the quantity and quality of prey otherwise available to Steller sea lions where they would intercept the affected species.

Additionally, the test pile program to commence prior to project construction will include a marine mammal monitoring plan. Under the plan, FHWA and FTA will monitor an area from the location of impact and vibratory pile installation and removal out to the isopleths where the applicable disturbance threshold would be reached (as initially estimated based on worst-case modeled distances described above). FHWA and FTA will not initiate or will suspend pile driving if they detect a eastern Steller sea lion within the monitoring area. The monitoring plan makes it extremely unlikely, and therefore discountable that Steller sea lions will be exposed to sound pressure levels that could cause injury or disturbance.

Effects on Critical Habitat within the Action Area

Designated critical habitat within the action area for the ESA-listed Pacific salmon and steelhead considered in this Opinion consists of a freshwater rearing site and freshwater migration corridor and their essential physical and biological features as listed below. The effects of the proposed action on these features are summarized below as a subset of the habitat-related effects of the action that were discussed more fully above. The noise and water quality effects described will be short-term (minutes to weeks) during and immediately following in-water work involving pile driving.

Pacific salmon and steelhead.

1. Freshwater spawning sites
    a. Substrate. No effect.
    b. Water quality. *Direct* – Increased temperature, suspended sediment, and contaminants; decreased dissolved oxygen; and impoverished community structure, including the composition, distribution, and abundance of prey, due to increased upland erosion and runoff and channel disturbance. *Indirect* – More normal temperature and sediment load, reduced contaminants, and increased dissolved oxygen due to improved stormwater management; more normative community structure.
    c. Water quantity. No effect.
2. Freshwater rearing
    a. Floodplain connectivity. No effect.
    b. Forage. *Direct* – Decreased quantity and quality of forage due to increased suspended sediment and contaminants, decreased space, decreased dissolved oxygen, loss of habitat diversity and productivity, and impoverished community structure due to increased upland erosion and runoff and channel disturbance. *Indirect* – Increased quantity and quality of forage due to increased habitat diversity and productivity caused by improved stormwater management and more normative community structure.
    c. Natural cover. *Direct* – Decreased natural cover quantity and quality for predator refugia due to physical habitat alteration and increase in predator cover. *Indirect* – Return to approximately pre-construction conditions.
    d. Water quality. *Direct* – Increased temperature, suspended sediment, and contaminants; decreased dissolved oxygen; and impoverished community structure, including the composition, distribution, and abundance of prey, due to increased upland erosion and runoff and channel disturbance. *Indirect* – More normal temperature and sediment load, reduced contaminants, and increased dissolved oxygen due to improved stormwater management; more normative community structure.
    e. Water quantity. No effect.

3. Freshwater migration corridors
    a. Forage. As above.
    b. Free of artificial obstruction. *Direct* – Decrease due to decreased water quality and in-water work isolation. *Indirect* – Return to approximately pre-construction conditions.
    c. Natural cover. As above.
    d. Water quality. As above.
    e. Water quantity. As above.
4. Estuarine areas
    a. Forage. As above.
    b. Free of artificial obstruction. As above.
    c. Natural cover. As above.
    d. Salinity. No effect.
    e. Water quantity. As above.
    f. Water quality. As above.

Southern Green Sturgeon.

1. Freshwater riverine systems
    a. Food resources. *Direct* – Decreased quantity and quality of forage due to increased suspended sediment and contaminants, decreased space, decreased dissolved oxygen, loss of habitat diversity and productivity, and impoverished community structure due to increased upland erosion and runoff and channel disturbance. *Indirect* – Increased quantity and quality of forage due to increased habitat diversity and productivity caused by improved stormwater management and more normative community structure.
    b. Migratory corridor. No effect.
    c. Sediment quality. No effect.
    d. Substrate type or size. No effect.
    e. Water depth. No effect.
    f. Water flow. No effect.
    g. Water quality. *Direct* – Increased temperature, suspended sediment, and contaminants; decreased dissolved oxygen; and impoverished community structure, including the composition, distribution, and abundance of prey, due to increased upland erosion and runoff and channel disturbance. *Indirect* – More normal temperature and sediment load, reduced contaminants, and increased dissolved oxygen due to improved stormwater management; more normative community structure.
2. Estuarine
    a. Food resources. *Direct* – Decreased quantity and quality of forage due to increased suspended sediment and contaminants, decreased space, decreased dissolved oxygen, loss of habitat diversity and productivity, and impoverished community structure due to increased upland erosion and runoff and channel disturbance. *Indirect* – Increased quantity and quality of forage due to increased

habitat diversity and productivity caused by improved stormwater management and more normative community structure.

b. Migratory corridor. No effect.

c. Sediment quality. No effect.

d. Water flow. No effect.

e. Water depth. No effect.

f. Water quality. *Direct* – Increased temperature, suspended sediment, and contaminants; decreased dissolved oxygen; and impoverished community structure, including the composition, distribution, and abundance of prey, due to increased upland erosion and runoff and channel disturbance. *Indirect* – More normal temperature and sediment load, reduced contaminants, and increased dissolved oxygen due to improved stormwater management; more normative community structure.

Cumulative Effects

Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02).

Although the CRC is intended to address a range of issues related to regional travel safety and mobility, and thus is likely to affect transportation patterns over time, the BA only identified one project likely to occur in the action area. That is the Vancouver Waterfront Access Project, also known as the Gramor Development Project, to redevelop the former 32-acre Boise Cascade site. Because this action involves waterfront development, it will require permits from the U.S. Army Corps of Engineers that will be subject to section 7 consultation under the ESA and EFH consultation under the MSA.

Projections to 2040 of population growth rates for the interior Columbia River basin range from 0.3 percent per year to 1.6 percent per year (McCool and Haynes 1996). If the largely migration-driven population growth continues unabated, it will result in a three to seven-fold increase in the population in the Columbia River basin region (Lackey *et al.* 2006).

This trend is likely to include rapid growth of human density in areas with recreational and scenic values adjacent to Federal lands, conflict between demands for fresh-water and needs for salmon, rapid urbanization and human density in areas previously sparsely populated, and land conversion from agriculture to urban uses (ISAB 2007). It will also include the positive effects of on-going regional and local salmon conservation and planning efforts that are underway to address all salmon species within the Columbia River basin, and will involve stakeholders on a more local level (Beamsderfer *et al.* 2010, LCFRB 2010).

Synthesis and Integration of Effects

Species at the Population Scale

ESA-listed Fish. Of 13 species and 189 independent populations and of ESA-listed Pacific fish that are likely to be adversely affected by this proposed action, and that have had a viability analysis completed, few are rated as "viable" and the overall risk of extinction varies from low (1 to 5% chance of extinction in 100 years) to very high (greater than 60% chance of extinction in 100 years). NMFS identified many factors as limiting the recovery of these species, most notably degraded habitat (especially floodplain connectivity and function, channel structure and complexity, riparian areas and large wood recruitment, stream substrate and streamflow), hatchery and harvest-related effects, and adverse effects related to mainstem hydropower development.

The NMFS designated critical habitat for all of the species considered in this opinion, except LCR coho salmon and eulachon, for which critical habitat has not been designated or proposed. Critical habitat for Steller sea lion does not have critical habitat designated within the action area. PCEs designated for Pacific salmon and steelhead include physical and biological features that support adult migration and juvenile rearing and migration. The lower Columbia River has been largely significantly altered by the effects of dam and reservoir development upstream, channelized, revetted, and stripped of large wood, thereby significantly diminishing both the complexity and productivity of aquatic habitats.

The environmental baseline within the action area includes a channelized mainstem with highly regulated streamflow, simplified channel habitats, and a river that is disconnected from its floodplain. Extensive development for residential, commercial and recreational use converted much of the shoreline to riprap with little relief, few trees, and many over and in-water structures. The proposed test pile program is in a relatively narrow and deep stretch of the Columbia River that does not provide slow water, shallow areas preferred by juvenile salmonids.

The effects of the proposed action that will have intermittent adverse effects on ESA-listed fish for a period of six years during construction are capture and release of individual fish during work area isolation, underwater noise created during pile driving, reduced water quality due to the construction effects of upland and in-water construction, and physical habitat alteration due to changes in overwater structure. The proposed action will also have adverse effects on ESA-listed fish for the design life of CRC due to reduced water quality from stormwater discharge and physical habitat alteration due to the final, as-built project footprint for the design life of CRC. The intensity, or magnitude, of each of these effects will be such that they are likely to injure or kill individual fish within the action area. Although the effects of impact pile driving are likely to be the most severe, those effects are limited to the construction period.

The CRC Team used the relationship between underwater noise due to pile driving (Table 24) and run timing and duration data for each species of Pacific salmon and steelhead and eulachon considered in this Opinion to evaluate the effects of CRC construction at the population level (Figure 7) (BA, Appendix K). Results of this analysis show that impact pile driving for CRC is likely to have the largest effect on juvenile LCR Chinook salmon, CR chum salmon, and LCR coho salmon, and may injure or kill between 0.4 and 1.0% of the runs and life stages runs of those species over the construction period (Figure 7). All other runs and life stages are likely to have between 0.6 to less than 0.1% mortality over the construction period. Although this model was not able to assign those mortalities to individual populations, these levels are likely to be too low to reduce the abundance or productivity of any affected population because the construction phase of the action has a relatively short duration and adaptive management will be used during the construction phase to allow impacts to be reduced if harm occurs in excess of the estimated levels. Thus, NMFS does not expect CRC to exceed a reasonable level of mortality for Columbia River species when added to take other biological opinions (NMFS 2008d, 2008g, 2008i; Wagner 2011).

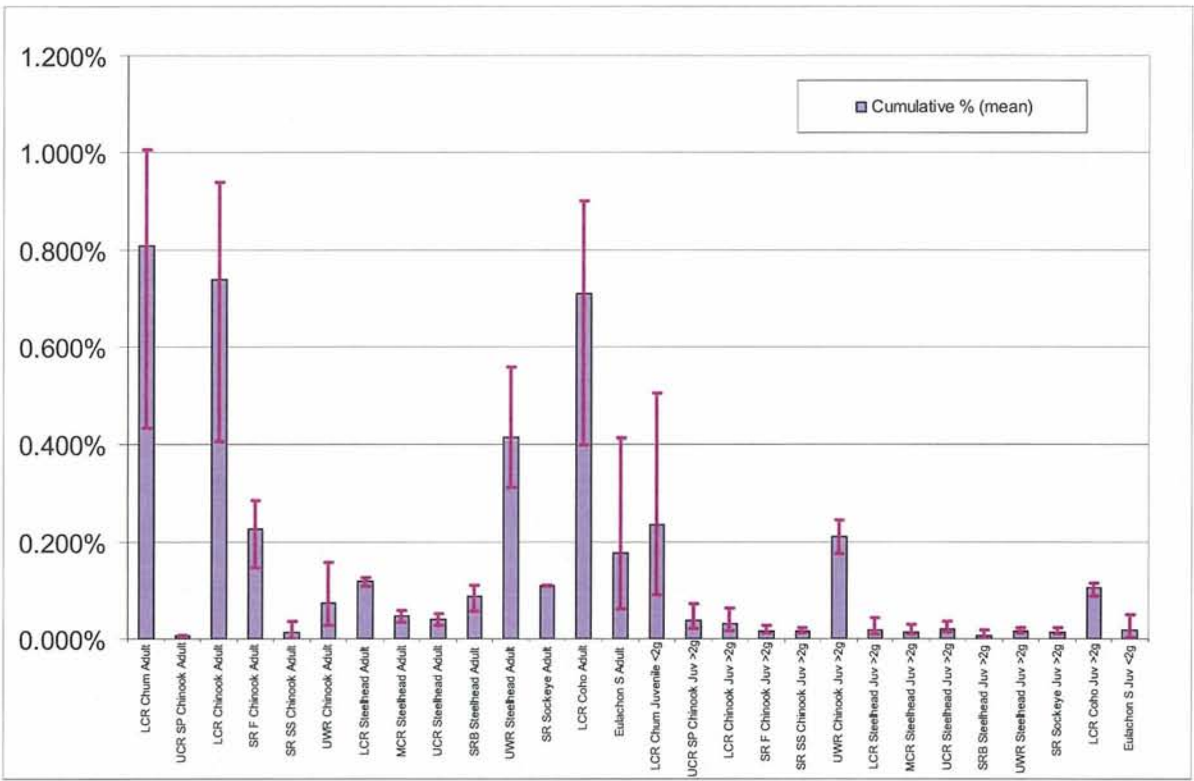

Figure 7. Mean cumulative percent mortality by species and life-stage due to the effect of impact pile driving for the proposed Columbia River Crossing project.

NMFS cannot accurately quantify the short and long-term habitat-related effects of this action that will occur in addition to the effects of pile driving because the precise distribution and abundance of adult and juvenile fish within the action area are not a simple function of the quantity, quality, or availability of predictable habitat resources within that area. Nonetheless, the relatively short-term adverse effects related to underwater noise (four years) and, to a lesser extent, to reduced water quality and physical habitat alteration (six years), caused by construction or CRC are similar to impacts that created the currently degraded baseline conditions for ESA-listed species in the lower Columbia River. These effects are likely to displace juvenile and adult fish from their preferred habitat, reduce benthic prey production, reduce growth or reproductive rates, increase juvenile predation, delay out-migration, and modify migratory or rearing behavior. Modeling of the population-level effects pile driving, the primary source of impacts from CRC, shows that the magnitude and temporary duration of those effects will not increase the risk of extinction faced by these species. Over the long term, for the design life of CRC (50-80 years), stormwater runoff from the project footprint, a heavily used urban transportation corridor that now drains into the Columbia River essentially untreated, will be captured and treated using the best management practices available for removal of PAHs, heavy metals, and other relevant pollutants. Reducing levels of toxic contaminants in the estuary will improve both habitat capacity and the fitness level of individual ESA-listed fish.

These short- and long-term effects can be put into a recovery context using three recovery plans and an estuary module now under development for species considered in this Opinion (NMFS 2008h, Beamesderfer *et al.* 2010a, Beamesderfer *et al.* 2010b, ODFW 2010, LCRFP 2010), and a recovery plan has been completed for MCR steelhead in the IC Recovery Domain (NMFS 2009b). Each of those plans recommend measures to improve water quality, and better stormwater management in particular, as among the most potent and high priority recovery actions. Thus, the long-term contribution of CRC to comprehensive stormwater management and improved water quality is consistent with recovery actions indentified in recovery plans for the lower Columbia River and, combined with the likelihood that take will not exceed 1% of LCR species or 0.6% of all other species, it is unlikely that the proposed action will appreciably reduce the likelihood of survival and recovery of any listed species.

Eastern Steller Sea Lion. Eastern Steller sea lions have a large population, which over the past 30 years has increased approximately 3% per year. Steller sea lions are generalist predators, and able to respond to changes in prey abundance. There are no substantial threats to the species, and the final recovery plan identifies the need to initiate a status review and consider removing the Eastern DPS from the federal List of Endangered Wildlife and Plants (NMFS 2008c).

In recent years, as many as 53 subadult and adult male eastern Steller sea lions have travelled up the Columbia River past the project area en route to the tailrace area of Bonneville dam, where they forage on anadromous fishes. This number has increased at least two-fold in recent years, and the increasing trend may continue into the future. Individuals have exhibited an increasing tolerance for deterrence measures, including acoustic deterrence. The proposed installation of steel sheet and pipe piles will elevate underwater sound within a reach of the Columbia River, and sound pressure generated by this activity could injure or disturb passing Steller sea lions. Although the FHWA and FTA will implement a safety zone, monitoring and shutdown procedures as well as sound ramp-up procedures to avoid potential injury of Steller sea lions, the proposed project may result in as many as 636 exposures of Steller sea lions to sound levels above disturbance thresholds per year, each year from 2013 to 2021.

Eastern Steller sea lions are highly motivated to pass through the project area in order to forage in the tailrace area of Bonneville Dam. Additionally, Steller sea lions have habituated to directed deterrence activities, including acoustic deterrence in the tailrace area. Given these considerations, NMFS finds it unlikely that the amount of anticipated acoustic harassment in the project area would significantly change Steller sea lions' use of the Columbia River or significantly change the amount of time they would otherwise spend in the foraging area below Bonneville Dam. Even in the event that either change was significant and animals were displaced from foraging areas in the Columbia River, there are alternative foraging areas available to the affected individuals. Therefore, the proposed action is not likely to reduce the reproductive success or increase the risk of mortality for any individual Steller sea lions.

Critical Habitat at the Watershed Scale

The same effects of the proposed action that will have an adverse affect on ESA-listed fish and eastern Steller sea lions will also have an adverse affect on critical habitat PCEs for Pacific salmon and steelhead and southern green sturgeon, *i.e.*, underwater noise, water quality reduction, and increase in undesirable over-water structure. Together, these effects are likely reduce the conservation value of critical habitat PCEs for the rearing and migration corridor within the action area, particularly in the impact area for pile driving while that part of construction is taking place. However, those effects are too local and brief to affect the conservation value of the lower Columbia River, or any designated critical habitat, as a whole. Further, the long-term effects of CRC will include the addition of comprehensive stormwater management for the I-5 corridor and improved water quality throughout the lower Columbia River, outcomes with are consistent with actions indentified in recovery plans for the lower Columbia River. Thus, it is likely that critical habitat will remain functional and retain the current ability for PCEs to become functionally established, to serve the intended conservation role for the species.

Conclusion

After reviewing the status of LCR Chinook salmon, UWR Chinook salmon, UCR spring-run Chinook salmon, SR spring/summer run Chinook salmon, SR fall-run Chinook salmon, CR chum salmon, LCR coho salmon, SR sockeye salmon, LCR steelhead, UWR steelhead, UCR steelhead, MCR steelhead, SRB steelhead, southern green sturgeon, eulachon, and eastern Steller sea lion, the environmental baseline, the effects of the action, and cumulative effects, NMFS concludes that the proposed action will not jeopardize the continued existence of those species.

After reviewing the status of critical habitats of those species (with the exceptions of LCR coho salmon, for which critical habitat is not proposed or designated; eulachon, for which critical habitat is proposed but not designated; and eastern Steller sea lion, which does not have critical habitat designated in the action area) NMFS also concludes that the proposed action will not destroy or adversely modify critical habitat of those species.

For reasons explained in Appendix A of this Opinion, NMFS also concludes that the proposed action is not likely to adversely affect southern resident killer whales.

Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the U.S. Fish and Wildlife Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not prohibited under the ESA, provided that such taking is in compliance with the terms and conditions of an incidental take statement.

The NMFS is not including an incidental take authorization for eastern Steller sea lions at this time because the incidental take of marine mammals has not been authorized under section 101(a)(5) of the Marine Mammal Protection Act or its 1994 Amendments. Following issuance of such regulations or authorizations, the NMFS may amend this biological opinion to include an incidental take statement for Steller sea lions.

Amount or Extent of Take

Actions necessary to complete the CRC will take place in the active channel of the Columbia River when LCR Chinook salmon, UWR Chinook salmon, UCR spring-run Chinook salmon, SR spring/summer run Chinook salmon, SR fall-run Chinook salmon, CR chum salmon, LCR coho salmon, SR sockeye salmon, LCR steelhead, UWR steelhead, MCR steelhead, UCR steelhead, SRB steelhead, eulachon, and southern green sturgeon are likely to be present.

The action area is used, in a small part, by CR chum salmon as a spawning area, by juveniles of all of these fish species for rearing and migration, by adults of all of fish these species for migration. The habitat that will be affected is rated as having high conservation value (NOAA Fisheries 2005) for each Pacific salmon and steelhead species considered in this consultation, although present conditions in the action area are degraded and the habitat that will be affected is not limited at the site or watershed scale.

Completion of the CRC is reasonably likely to cause the following type of incidental take of ESA-listed fish: 1) capture of juvenile fish during in-water work area isolation, some these fish will be injured or killed; and 2) harassment or harm of fish and sea lions due to the following habitat-related effects of CRC construction and operation: reduced water quality, barotrauma, and loss of benthic foraging habitats.

For this Opinion, the extent of take is defined as the area where the CRC action will: (1) Reduce water quality during construction and through stormwater discharge for the life of the CRC;

(2) produce harmful underwater noise during construction; and (3) convert benthic foraging habitat to less productive aquatic habitat types during construction and for the life of the CRC.

In the accompanying Opinion, NMFS determined that this level of incidental take is not likely to result in jeopardy to the listed species. Exceeding any of these indicators of take will trigger the reinitiation provisions of this Opinion.

Capture of Juvenile Fish during In-water Work Area Isolation. Take due to capture of juvenile fish during work area isolation will occur within the work area isolation site. Construction of the CRC will require two work area isolations. Each work area isolation is likely to result in the capture of 200 or fewer of the ESA-listed fish considered in this Opinion. Of the fish captured, less than 2% are likely to be injured or killed, including by delayed mortality, and the remainder are likely to survive with no long-term adverse effects. Thus, NMFS anticipates that up to 400 juvenile individuals of the ESA-listed fish species considered in the consultation will be captured, and less than eight are likely to be injured or killed because of work necessary to isolate in-water construction areas. Because these fish are from different species that are similar to each other in appearance and life history, and to unlisted species that occupy the same area, it is not possible to assign this take to individual species. NMFS does not anticipate that FHWA and FTA will take any adult fish in this manner.

Habitat-related Effects. Take caused by the habitat-related effects of this action cannot be accurately quantified as a number of ESA-listed fish because the distribution and abundance of fish and sea lions that occur within an action area is affected by habitat quality, competition, predation and the interaction of processes that influence genetic, population, and environmental characteristics. These biotic and environmental processes interact in ways that may be random or directional, and may operate across far broader temporal and spatial scales than are affected by the proposed action. Thus, the distribution and abundance of fish and sea lions within the action area cannot be attributed entirely to habitat conditions, nor can NMFS precisely predict the number of fish or sea lions that are reasonably certain to be injured or killed if their habitat is modified or degraded by the proposed action. As explained in the synthesis and integration of effects, NMFS estimates that the proposed action is likely to injure or kill an insignificant percentage of the affected populations.

Reduced water quality. Take caused by reduced water quality due to CRC construction activities will occur within 300 feet of the project site. Reduced water quality due to CRC also includes residual pollutants in stormwater runoff that discharge into the Columbia River after passing through the CRC stormwater facilities. These discharges mix with other pollutants in the lower Columbia River where they degrade food webs, reduce the growth and survival of juvenile fish, reduce the survival and fitness of adult fish, and contribute to a variety of additive and synergistic toxic effects throughout the lower Columbia River. Thus, take caused by reduced water quality due to stormwater runoff from CRC during operation will occur in a zone that extends from the project footprint to the confluence of the Columbia River with the Pacific Ocean.

The best available indicators for the extent of take due to reduced water quality are: (1) Turbidity released during construction; and (2) completion of the maintenance program used to maintain stormwater treatment facilities. The first variable is proportional to the amount of construction-related disturbance of upland and stream channel habitats that results in an erosion and suspended sediment in runoff and the water column. NMFS anticipates that these effects should not result in visible turbidity plume more than 300 feet from the project footprint. The second variable is completion of the stormwater maintenance program because that ensures that stormwater runoff from the CRC is receiving the planned level of treatment and consequently removing the identified types and levels of pollutants.

The best available indicators for the extent of take due to reduced water quality are: (1) No more than a 10% cumulative increase in natural stream turbidity 300 feet from an upland or in-water CRC construction activity, as measured relative to a control point immediately upstream of the turbidity causing activity, except for short-term emergency activities; and (2) regular and timely completion of the maintenance program used to maintain stormwater treatment facilities.

Barotrauma. Take due to barotrauma will occur in a zone between approximately RMs 101 and 119. The extent of take due to barotraumas caused by underwater noise is described by an area affected by the radius of underwater noise that will be created by impact driving an attenuated 48-inch pile, *i.e.*, for fish:

1. For all fish, behavioral disturbance, or auditory injury due to impulse sound from impact driving for approximately 66,000 feet upstream and 29,000 feet downstream within the radius where the RMS sound pressure level will exceed 150 dB re: 1 μPa^2.

2. For fish weighing less than 2 grams, external and internal hemorrhage, rupture of internal organs due to impulse sound from impact driving for approximately 3,250 feet upstream and downstream within the radius where cumulative sound exposure exceeds 183 dB re: 1 $\mu Pa^2 \bullet sec$.

3. For fish weighing more than 2 grams, external and internal hemorrhage, rupture of internal organs due to impulse sound from impact driving for approximately 1,771 feet upstream and downstream within the radius where cumulative sound exposure level exceeds 187 dB re: 1 $\mu Pa^2 \bullet sec$.

4. For all fish, external and internal hemorrhage, and rupture of internal organs for approximately 16 feet upstream and downstream where peak sound pressure level that exceeds 206 dB re: 1 μPa.

Benthic foraging habitat. The extent of take due to loss of benthic foraging habitat is described by the area permanently displaced by bridge columns, *i.e.*, 0.17 acre. Thus, the best available indicator for the extent of this loss is 0.17 acre.

Reasonable and Prudent Measures

The following measures are necessary and appropriate to minimize the impact of incidental take of listed species from the proposed action.

The FHWA and FTA shall:

1. Coordinate with NMFS to insure that completed project plans and updates specific to stormwater management, pile driving, in-water work area isolation, and containment are implemented and include comprehensive monitoring and reporting.

2. Minimize incidental take by applying contract conditions that avoid or minimize the project's adverse effects on aquatic habitats.

Terms and Conditions

The measures described below are non-discretionary, and must be undertaken by the FHWA or FTA for the exemption in section 7(o)(2) to apply. The FHWA and FTA have a continuing duty to regulate the activity covered by this incidental take statement. If the FHWA and FTA (1) fail to assume and implement the terms and conditions or (2) fail to require their grantees to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the grant document, the protective coverage of section 7(o)(2) may lapse. To monitor the impact of incidental take, the FHWA and FTA must report the progress of the action and its impact on the species to the NMFS as specified below.

1. To implement reasonable and prudent measure #1 the FHWA and FTA shall ensure the following:

    a. <u>NMFS Coordination</u> will be regular and shall include an annual report coordination meeting (by June 15 annually) from the FHWA and FTA to discuss the report, and discuss conservation measure effectiveness and any necessary corrective actions. Other meetings will include the FHWA and FTA and their contractors (construction and design), to review the following design plans (30% completion) and reports when available:

        i. A stormwater management plan that addresses treatment of the project's contributing impervious area as described or referenced in the BA.
        ii. A pile-driving and underwater sound management plan.
        iii. In-water work area isolation plans for all in-water work areas.
        iv. <u>Salvage notice</u>. The following notice shall be included as part of the contract and be provided in writing to the general contractor and each subcontractor employed for in-water work:

            If a sick, injured or dead specimen of a threatened or endangered species is found, the finder must notify NMFS' Office of Law Enforcement at 503-231-6240 or 206-526-6133. The finder must take care in handling of sick or injured specimens to ensure effective treatment, and in handling dead specimens to preserve biological material in the best possible condition for later analysis of cause of death. The finder also has the responsibility for carrying out instructions provided by the Office of Law Enforcement to ensure that evidence intrinsic to the specimen is not disturbed unnecessarily.

v. Annual program report. The FHWA and FTA shall submit a comprehensive annual program report to NMFS by June 1 each year, beginning following the test pile program and continuing until FHWA and FTA confirm that all site restoration is complete. These reports shall give NMFS information about the FHWA and FTA's efforts to carry out these terms and conditions throughout the preceding calendar year and must include the following information:

(1) The FHWA and FTA contacts for all monitoring and reporting.
(2) A summary of overall construction activity.
(3) A summary of coordination conducted with NMFS during the reporting period.
(4) A completed fish salvage reporting form for any project component that required fish capture and removal.
(5) The start and end dates for any in-water work.
(6) A summary of pile installation and removal activity, including the number, type and diameter of any pilings installed, removed, or broken during removal, and results of underwater noise monitoring.
(7) A summary of the results of pollution and erosion control inspections, including construction discharge water management, and any erosion control failures or contaminant releases and the subsequent corrections.
(8) A description of any riparian area cleared within 150 feet of ordinary high water, including the linear feet of bank alteration.
(9) A summary of any project components for which the FHWA and FTA confirm the completion of site restoration or compensatory mitigation.
(10) Any other data or analyses that FHWA and FTA deem necessary or helpful to assess impacts of the project actions on habitat trends.
(11) Annual monitoring reports shall be submitted to:

National Marine Fisheries Service
Oregon State Habitat Office
Attn: **2010/03196**
1201 NE Lloyd Boulevard, Suite 1100
Portland, OR 97232-2778

b. Full Implementation Required. Conservation measures and best management practices outlined in the BA and these terms and condition shall be included as enforceable provisions of the design-build contract. Failure to comply with all applicable conservation measures outlined in the BA, unless they conflict with provisions in these terms and conditions, and all terms and conditions included here may invalidate protective coverage of ESA section 7(o)(2) regarding the incidental take of listed species, and may lead NMFS to a different conclusion regarding the effects of the CRC project on listed species and designated critical habitats.

c. Failure to Provide Reporting May Trigger Reinitiation of Consultation. NMFS shall have the opportunity to conduct timely review and approval (where noted) of information identified above, and FHWA and FTA shall provide annual monitoring reports and participate in the annual coordination meeting, or NMFS may assume the CRC project has been modified in a manner and to an extent not previously considered and may recommend reinitiation of this consultation.

2. To implement reasonable and prudent measure #2 (avoid or minimize adverse effects of construction on aquatic habitats), the FHWA and FTA shall ensure the following:

a. In-water Work Timing. In-water work timing will occur by activity as follows:

i. Impact pile driving will be completed between September 15 and April 15, unless FHWA and FTA demonstrate that sound levels will not equal or exceed the following values (re: 1 micropascal):

(1) 206 dB peak SPL
(2) 183 dB cumulative SEL between April 15 and July 31
(3) 187 dB cumulative SEL between August 1 and September 15
(4) 190 dB RMS at 164 feet from the pile year-round

ii. Use of an impact hammer will be limited to daylight hours (beginning 30 minutes after civil sunrise and ending 30 minutes before civil sunset) at Pearson Airfield, to avoid peak movements of juvenile and adult Pacific salmon and steelhead.

iii. Necessary underwater debris removal will occur between November 1 and February 28, using a clamshell bucket.

iv. Construction and demolition may occur within the active channel year-round, provided that it does not because sound pressures that are injurious to fish, will not violate water quality standards established by ODEQ and WDOE.

b. Pile Installation. Pile installation shall be conducted as follows:

i. When engineering limits do not require impact driving, piles shall be advanced by vibration, oscillation, rotation, or pressing.

ii. During impact driving underwater sound attenuation shall be conducted as follows:

(1) Completely isolate the pile from flowing water by dewatering the area around the pile while ensuring no physical contact between the pile and confinement vessel.

(2) if water velocity is 1.6 feet per second or less, surround the piling being driven by a confined or unconfined bubble curtain, as described in NMFS and USFWS (2006), that will distribute small air bubbles around 100% of the piling perimeter for the full depth of the water column.

(3) if water velocity is greater than 1.6 feet per second, surround the piling being driven by a confined bubble curtain (*e.g.*, a bubble ring surrounded by a fabric or non-metallic sleeve) that will distribute air bubbles around 100% of the piling perimeter for the full depth of the water column.

c. Underwater Noise Monitoring. An underwater noise monitoring plan for pile installation shall be developed and carried out as described in WDOT (2009), and shall be sufficient to analyze the effects of underwater noise produced by the full range of pile types, installation methods, and environmental conditions that are relevant to construction of the CRC project.

d. Fish Entrapment, Capture and Removal. The following measures shall apply to the treatment of fish in areas of in-water isolation:

i. Isolation will occur in such a manner as to promote fish emigration.

ii. Fish capture and removal shall occur in any isolation area before water quality conditions become unfavorable to fish.

iii. Capture and handling of fish shall comply with NMFS' electrofishing guidelines (NMFS 2000).

iv. A supervisory fish biologist experienced with work area isolation and fish capture will supervise the safe capture, handling and release of all fish and complete the fish salvage reporting forms.

v. Fish may be captured using a seine, electrofishing, or other method that maximizes efficiency and minimizes injury.

vi. Juvenile fish shall be released at a safe release site downstream of the work area; adults shall be released safely upstream.

e. Construction Discharge Water. The following measures shall apply to construction water discharges:

i. All discharge water created by construction (*e.g.*, concrete washout, pumping for work area isolation, vehicle wash water, shall be treated using the best available technology available (given site conditions) to remove debris, nutrients, sediment, petroleum products, metals and other pollutants.

ii. Pollutants such as green concrete, contaminated water, silt, welding slag, sandblasting abrasive, or grout cured less than 24 hours shall not contact any waterbody, wetland, or stream channel below ordinary high water.

f. Temporary Access Routes. The following measures shall apply to temporary access routes:

i. Temporary access routes for motorized equipment shall avoid steep slopes, where grade, soil, or other features suggest a likelihood of excessive erosion (*e.g.*, rills or gullies) or failure.

ii. When possible, construction vehicles shall use existing access routes that will minimize soil disturbance and compaction within 150 feet of any waterbody.

iii. When no longer needed, temporary access routes shall be obliterated, the soil stabilized and the vegetation restored.

iv. Temporary routes in wet or flooded areas shall be restored before the end of the applicable in-water work period.

g. Stationary Power Equipment, Vehicles, and Other Heavy Equipment. Generators, cranes, and any other stationary equipment operated within 150 feet of any waterbody. The following measures shall apply:

i. Equipment will be selected and operated as necessary to minimize adverse effects on the environment.

ii. All vehicles and other heavy equipment will be:

(1) Stored, fueled, and maintained in a vehicle staging area placed 150 feet or more from any waterbody, or in an isolated hard zone with suitable containment measures as outlined in the Spill Prevention, Control and Countermeasures (SPCC). Suitable hard zones include a paved parking lot, barge or work platform.

(2) Inspected daily for fluid leaks before leaving the vehicle staging area for operation within 50 feet of any waterbody.

(3) Steam-cleaned before operation below ordinary high water, and as often as necessary during operation to remain free of all external oil, grease, mud, and other visible contaminants.

h. Preconstruction Activity. Before significant alteration of the action area, contractors shall flag the boundaries of the clearing limits associated with site access and construction to minimize soil and vegetation disturbance, and shall ensure that all temporary erosion controls are in place and functional.

i. Site Preparation. The following measures shall apply to site preparation:

i. Native materials shall be conserved for restoration, including large wood, vegetation, topsoil and channel materials (gravel, cobble, and boulders) displaced by construction.

ii. Native materials shall not be disturbed unnecessarily.

iii. In temporary clearing areas, vegetation shall be clipped at ground level to retain root mass and encourage reestablishment of native vegetation.

j. Drilling and Boring. The following measures shall apply to drilling and boring. The FHWA and FTA shall insure that contractors shall:

i. Isolate drilling operations in wetted stream channels using a steel casing or other appropriate isolation method to prevent drilling fluids from contacting water.

ii. Use containment measures to prevent drilling debris from entering the channel.

iii. Isolate sampling and directional drill recovery/recycling pits, and any associated waste or spoils, from surface waters, off-channel habitats and wetlands.

iv. Cover all waste or spoils if precipitation is falling or imminent.

v. Recover and dispose, or recycle, all drilling fluids and waste to prevent entry into flowing water, off-channel habitats, and wetlands.

vi. Implement all possible efforts to contain drilling fluid or waste when visible in water or a wetland or a drilling casing breaks. Notify NMFS within 48 hours.

vii. Contain, recover, and recycle or dispose of all drilling equipment, drill recovery and recycling pits, and any waste or spoil produced, as necessary to prevent entry into any waterway. Contractors shall use a tank to recycle drilling fluids.

viii. Remove as much of the remaining drilling fluid as possible from the casing (*e.g.*, by pumping) to reduce turbidity when the casing is removed.

k. Pollution and Erosion Control. At any part of the project where there will be materials that are hazardous or toxic to aquatic life, such as motor fuel, oil, or drilling fluid, or where there will be earthwork that is likely to cause discharge of sediment into surface water, contractors must employ effective pollution and erosion control measures, including practices to:

i. Inventory, store, handle, and monitor any hazardous products or materials that will be used as part of the action.

ii. Contain and control a spill of those hazardous materials.

iii. Confine, remove, and dispose of excess concrete, cement, grout, and other mortars or bonding agents, including washout facilities.

iv. Avoid or minimize pollution and erosion at all roads, stream crossings, drilling sites, construction sites, borrow pits, equipment and material storage sites, fueling operations, and staging areas.

v. Prevent construction debris from dropping into any waterbody, and to remove any material that does drop with a minimum of disturbance.

vi. Avoid or minimize resource damage if the action area is inundated by precipitation or high streamflow.

vii. Stabilize all disturbed soils following any break in work unless construction will resume within seven days (May 1-September 30) or two days (October 1 – April 30).

l. Work Area Isolation Plan. At any part of the project, except for piling installation or removal, that involves excavation, backfilling, embankment construction, or similar work below ordinary high water where adult or juvenile listed fish might reasonably be to be present, or 300 feet or less upstream from spawning habitats, contractors must have a plan to ensure that area will be effectively isolated from the active stream. The plan shall:

i. Explain how the work area will be isolated and describe practices to ensure the area will remain effectively isolated throughout the range of flows likely to occur during construction.

ii. Include site sketches, drawings, specifications, calculations, or other information at a level of detail commensurate with the scope of the work area; and include contact information for the person responsible for designing this part of the action.

m. Stormwater Management. The FHWA and FTA shall have a Stormwater Management Plan applicable to stormwater runoff produced by the project's entire CIA. The Stormwater Management Plan shall ensure that stormwater runoff from that area will meet the pollution reduction and flow control requirements described below. The plan shall:

i. Explain how treatment facilities design will capture and remove pollutants from all contributing impervious areas (treatment basins), using site sketches, drawings, specifications, calculations, or other information at a level of detail commensurate with the scope of the work area. The explanation shall:

(1) Specify pollutants of concern and targeted for treatment

(2) Identify and all contributing and non-contributing impervious areas for the project area.

(3) Calculate the volume of stormwater runoff that produced from those contributing impervious areas by the design storm (0.86-in).

(4) Capture and treat a design storm defined as 50% of the 2-year, 24-hour storm as determined by a single event model; or 91% of the average annual runoff, as determined by a continuous flow model.

(5) Describe how stormwater will be treated using one or more of the following specific primary treatment practices and supplemented with appropriate soil amendments, as needed:

(a) bioretention

(b) bioslope

(c) infiltration pond

(d) porous pavement

(e) constructed wetlands

(f) vegetated and soil amended swale designed for infiltration

(g) a treatment train as described in FHWA (2002).

(6) Address unavoidable design constraints limiting successful implementation of the list of primary treatment practices through alternative methods demonstrating pollutant removal equivalency.

ii. Explain how treatment facilities design will capture and manage stormwater discharged into Burnt Bridge Creek, including a description of how flow control methods will achieve a pre-development hydrologic condition using design standards described in the Stormwater Management Manual for Western Washington (WDOE 2005).

iii. Explain how the engineered conveyance and treatment facilities will be maintained and operated. The explanation shall be a completed Maintenance and Operation Plan, and include:

(1) Pollutants of concern.

(2) Provide an inspection and maintenance schedule for each treatment facility.

(3) Identify expiration timelines of treatment media and require amendment and or replacement of treatment media needed to maintain engineered standards.

(4) Identify what FHWA and FTA are responsible for maintaining each engineered treatment facility.

iv. Stormwater Management Commitment Tracking. Coordinate every 6 months or prior to application for 401 Certification as identified by the Critical Path Method to insure that permanent stormwater treatment of the CIA is achieved to a level identified in the Opinion for the CIA and treatment for areas identified in the action as untreated is addressed. FTA and FHWA shall supply sufficient documentation for the aforementioned portions of the CIA, and NMFS will review to ensure consistency and compliance with this Opinion. This coordination process is to ensure the entire CIA shall have permanent stormwater treatment meeting the terms and conditions here in.

n. Site Restoration. Any part of the project that will result in a significant disturbance of riparian vegetation, soils, streambanks, or stream channel must have a post-construction restoration plan to ensure that disturbed areas meet the restoration requirements described below. FHWA and FTA will confirm when site restoration criteria are met.

i. Site restoration. Any part of the project that will result in a significant disturbance of riparian vegetation, soils, streambanks, or stream channel must have a post-construction restoration plan to ensure that disturbed areas meet the restoration requirements described below. FHWA and FTA will confirm when site restoration criteria are met. The post-construction site restoration plan shall consist of practices necessary to ensure that site restoration criteria, including:

(1) Restoring damaged streambanks to a natural slope, pattern and profile suitable for establishment of permanent woody vegetation.

(2) Replanting each area requiring revegetation before the first April 15 following construction with a diverse assemblage of species native to the project area or region, including grasses, forbs, shrubs and trees (noxious or invasive species may not be used); and reusing, when possible, the large wood, vegetation, topsoil and channel materials conserved during site preparation.

(3) Within reasonable limits of natural and management variation, restored upland sites should exhibit these characteristics:

(a) Continuing physical disturbance, if any, is confined to small areas necessary for access or other special management situations.

(b) Areas with signs of significant past erosion are completely stabilized and healed, bare soil spaces are small and well-dispersed.

(c) Soil movement, such as active rills and soil deposition around plants or in small basins, is absent or slight and local.

(d) Native woody and herbaceous vegetation, and germination micro-sites, are present and well-distributed across the site.

(4) Plants have normal, vigorous growth form, and a high probability of remaining vigorous, healthy, and dominant over undesired competing vegetation.

(5) Vegetation structure is resulting in rooting throughout the available soil profile.

(6) Plant litter is well-distributed and effective in protecting the soil with little or no litter accumulated against vegetation as a result of active sheet erosion ("litter dams).

(7) A continuous corridor of shrubs and trees appropriate to the site are present to provide shade and other habitat functions for the entire streambank.

(8) Streambanks are stable, well-vegetated, and protected at margins by roots that extend below baseflow elevation, or by coarse-grained alluvial debris.

Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal Agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. The NMFS has determined that the FHWA and FTA should implement the following discretionary measure to be consistent with this obligation:

> The FHWA and FTA should continue to develop and carry out plans to better equip their staff and partners with the skills, tools and resources necessary to support collaborative processes such as those used to good effect in the CRC project consultation, and extend them to other FHWA actions in Oregon. FHWA and FTA should also continue to support problem-solving during the ESA consultation process, develop accountability systems that align with higher expectations for collaboration, and to achieve and recognize the superior environmental outcomes that accrue through collaborative problem-solving efforts.

Please notify NMFS if the FHWA and FTA carry out this recommendation so that we will be kept informed of actions that are intended to improve the conservation of listed species or their designated critical habitats.

Reinitiation of Consultation

Reinitiation of formal consultation is required and shall be requested by the Federal agency or by NMFS where discretionary Federal involvement or control over the action has been retained or is authorized by law and: (a) If the amount or extent of taking specified in the incidental take statement is exceeded; (b) if new information reveals effects of the action that may affect listed species or designated critical habitat in a manner or to an extent not previously considered; (c) if the identified action is subsequently modified in a manner that has an effect to the listed species or designated critical habitat that was not considered in the biological Opinion; or (d) if a new species is listed or critical habitat is designated that may be affected by the identified action (50 CFR 402.16).

To reinitiate consultation, contact the Oregon State Habitat Office of NMFS, and refer to the NMFS Number assigned to this consultation: 2010/03196.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

The consultation requirement of section 305(b) of the MSA directs Federal Agencies to consult with NMFS on all actions, or proposed actions that may adversely affect EFH. Adverse effects include the direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitats, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside EFH, and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that may be taken by the action agency to conserve EFH.

The Pacific Fishery Management Council (PFMC) described and identified EFH for groundfish (PFMC 2005), coastal pelagic species (PFMC 1998), and Chinook salmon, coho salmon, and Puget Sound pink salmon (PFMC 1999). The proposed action and action area for this consultation are described in the Introduction to this document. The action area includes areas designated as EFH for various life-history stages of Chinook and coho. Based on information provided by the action agency and the analysis of effects presented in the ESA portion of this document, NMFS concludes that proposed action will have the following adverse effects on EFH designated for Pacific Coast salmon:

- Degradation of water quality required for rearing and migration in the lower Columbia River as described in the Opinion, above.
- Short and discrete alteration of under sound via pile-driving. The elevation of underwater sound will raise underwater sound preventing normal use by Chinook and coho salmon.
- Reduction of benthic habitat that prey species and reduces foraging opportunities.

Essential Fish Habitat Conservation Recommendations

The following two conservation measures are necessary to avoid, mitigate, or offset the impact of the proposed action on EFH. These conservation recommendations include a subset of the ESA Opinion's conservation recommendations and the ESA terms and conditions, and therefore NMFS recommends that FHWA implement the following from the ESA Opinion.

1. Minimize adverse effects due to elevated levels of underwater noise, reduced water quality, and physical habitat alteration associated with the structural footprint of the CRC bridges by applying conservation measures or BMPs for pile driving and construction,

except for fish salvage, as described in Term and Condition 1 in the accompanying Opinion.

2. Ensure completion of a monitoring and reporting program as described in Term and Condition 2 in the accompanying Opinion to confirm the action is meeting its objective of minimizing habitat modification from permitted activities.

The FHWA and FTA must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations [50 CFR 600.920(k)].

DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (Data Quality Act) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section addresses these Data Quality Act (DQA) components, documents compliance with the DQA, and certifies that this Opinion has undergone pre-dissemination review.

Utility: Utility principally refers to ensuring that the information contained in this document is helpful, serviceable, and beneficial to the intended users.

The Opinion in this document concludes that the proposed Columbia River Crossing Project will not jeopardize the affected listed species. Therefore, the FHWA and FTA can fund this action in accordance with its authority under SAFETEA-LU. The intended users are the FHWA, ODOT, and WDOT.

Individual copies were provided to the FHWA, FTA, ODOT, and WDOT. This consultation will be posted on the NMFS Northwest Region website (http://www.nwr.noaa.gov). The format and naming adheres to conventional standards for style.

Integrity: This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

Objectivity:

Information Product Category: Natural Resource Plan.

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the ESA Consultation Handbook, ESA regulations (50 CFR 402.01 *et seq*.) and the MSA implementing regulations regarding EFH [50 CFR 600.920(j)].

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the Literature Cited section. The analyses in this Opinion/EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with Northwest Region ESA quality control and assurance processes.

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APPENDIX A. SOUTHERN RESIDENT KILLER WHALE DETERMINATION

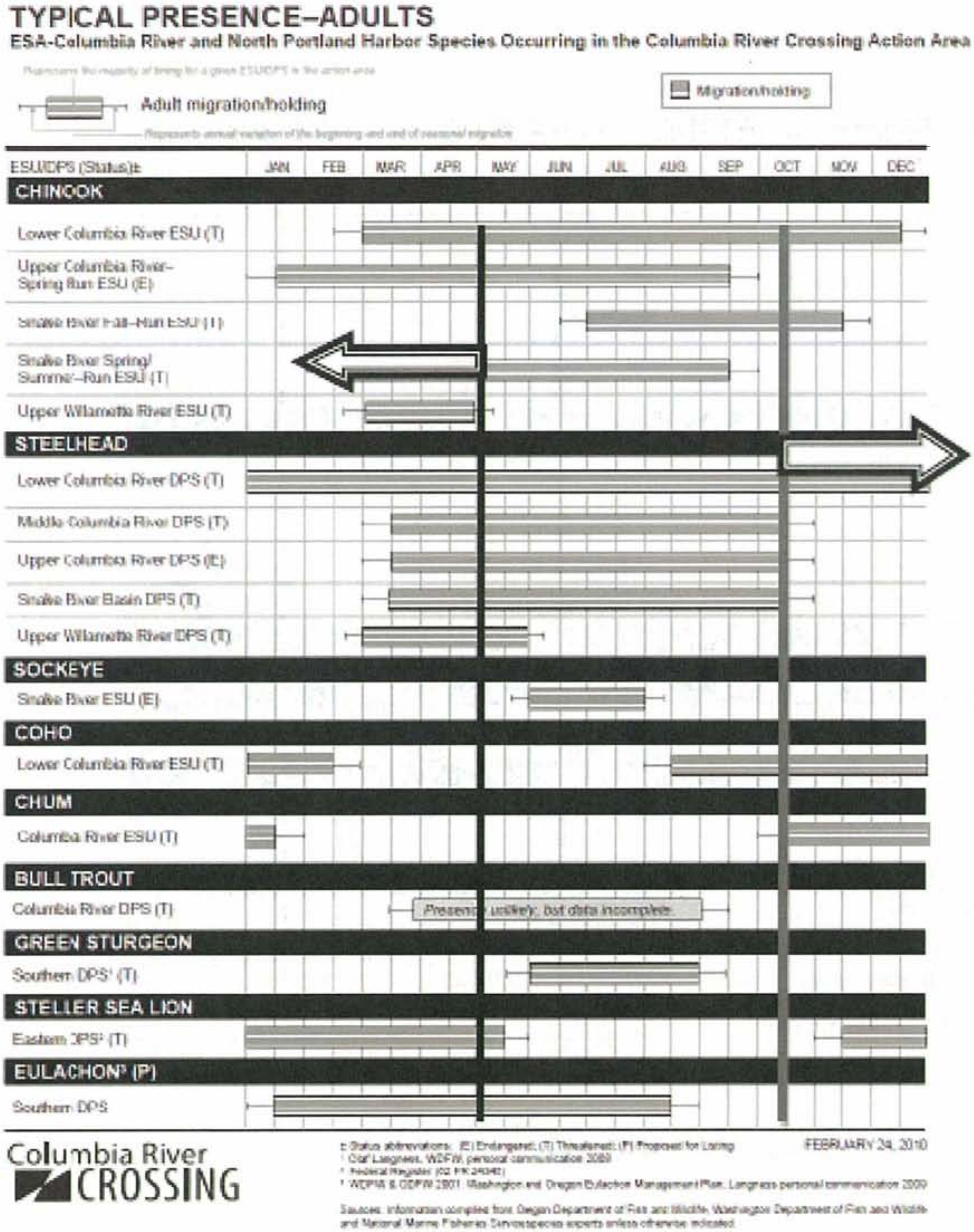
Southern Resident killer whales spend considerable time in the Georgia Basin from late spring to early autumn, with concentrated activity in the inland waters of Washington State around the San Juan Islands, and typically move south into Puget Sound in early autumn (NMFS 2008). Pods make frequent trips to the outer coast during this season. In the winter and early spring, Southern Resident killer whales move into the coastal waters along the outer coast from the Queen Charlotte Islands south to central California, including coastal Oregon and off the Columbia River (NMFS 2008). There are no documented sightings of Southern Resident killer whales in Oregon coastal bays. There is no documented pattern of predictable Southern Resident occurrence along the Oregon outer coast and any potential occurrence would be infrequent and transitory. Southern Residents primarily eat salmon and prefer Chinook salmon (NMFS 2008, Hanson *et al.* 2010).

NMFS finds that all effects of the proposed action will either cause no effect or are expected to be discountable, insignificant or beneficial (NLAA) for Southern Resident killer whales. The proposed action would take place in the Columbia River, where Southern Resident killer whales do not occur. Therefore, NMFS does not anticipate any direct effects on Southern Resident killer whales.

As stated above for Steller sea lions, the proposed action may affect the quantity of their preferred prey, Chinook salmon. Any salmonid take including Chinook salmon up to the aforementioned maximum extent and amount would result in an insignificant reduction in adult equivalent prey resources for Southern Resident killer whales that may intercept these species within their range.

Therefore, NMFS finds that the proposed action may affect, but is not likely to adversely affect Southern Resident killer whales.

APPENDIX B. RUN TIMING AND PRESENCE OF LISTED FISH IN THE I-5/CRC



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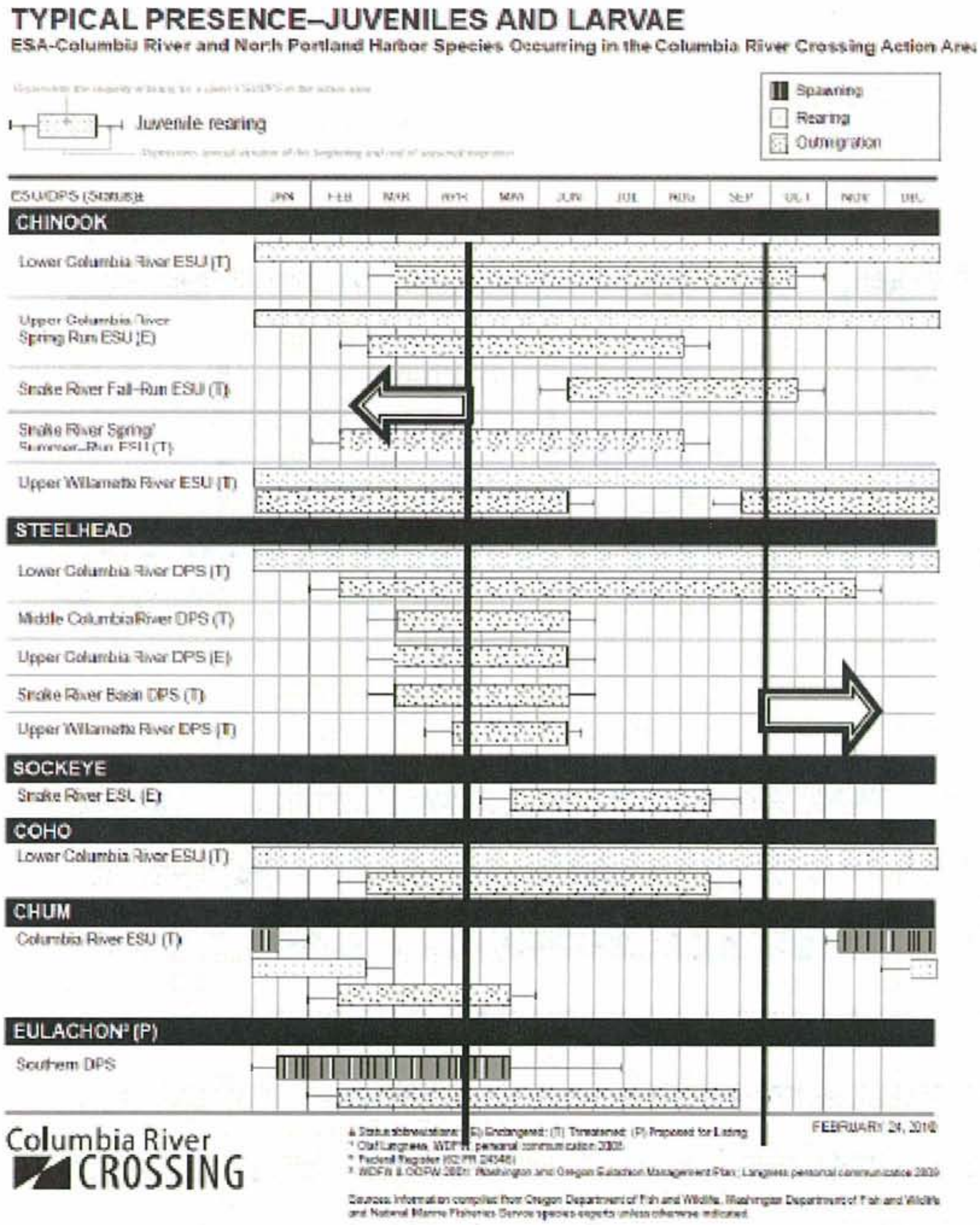

Note: Timing of impact pile-driving =

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Columbia River CROSSING

Memorandum

January 14, 2011

TO: Readers of the CRC Navigation Technical Report

FROM: CRC Project Team

SUBJECT: Update to the Navigation Technical Report since the publication of the Draft Environmental Impact Statement (EIS)

COPY: Project Files

In 2008, the CRC Draft Environmental Impact Statement was published and included in its appendices the Navigation Technical Report and the Navigation Technical Report, Transit in a Box Supplement (TIAB Supplement). Most of the information presented in these Draft EIS Reports is still applicable to and accurate for the alternatives analyzed in the Final EIS. The purpose of this memorandum is to provide a brief update to the Draft EIS Technical Report and TIAB Supplement, highlighting any new information that has been made available since the publication of these reports.

New Information Developed Since the Publication of the Technical Report

The description of alternatives in the Navigation Technical Report has not been updated to incorporate the adoption of the Locally Preferred Alternative (LPA). The following describes the primary transportation improvements included in the LPA:

- The new river crossing over the Columbia River and the I-5 highway improvements, including seven interchanges, north and south of the river.
- 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 changes, and expansion of a light rail transit maintenance facility.
- Bicycle and pedestrian improvements throughout the project corridor.
- A new toll on motorists using the river crossing.
- Transportation demand and system management measures to be implemented with the project.

Since publication of the Navigation Technical Report and TIAB Supplement, project design has been refined to retain the existing North Portland Harbor Bridge; the existing bridge would be widened and would receive limited seismic upgrades. In addition, three new narrower parallel structures would be built across the waterway, two on the west side and one on the east side of the existing structure. All of the new structures would have at least as much vertical clearance over the river as the existing bridge.
For a more detailed description of the LPA, please see Chapter 2 of the Final EIS.

Alternatives Analyzed in the Technical Report

The existing bridges over the main channel of the Columbia River require vessels to navigate an "S" curve to avoid the existing lift spans and line up with and pass through the Burlington Northern Santa Fe Railroad Bridge swing span. Vessels that do not navigate the "S" curve must utilize the lift span which is subject to lift span restriction periods.

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The range of alternatives evaluated in the Navigation Technical Report included No-Build, two supplemental bridge options (Alternatives 4 and 5), and two replacement bridge options (Alternatives 2 and 3).

The No-build option would continue to adversely affect navigation on the main channel due to retention of the existing "S" curve. The supplemental bridge options would adversely affect navigation on the main channel because adding more piers in the river would increase the difficulty of navigating the "S" curve. The replacement bridge options over the Columbia would improve navigation on the main channel due to the removal of the "S" curve.

Information Specific to the LPA

The LPA, as adopted, is a refinement of Alternative 3, which includes downstream replacement bridges over the main channel and light rail. The LPA is expected to beneficially affect navigation due to removal of the lift spans and associated "S" curve. The new bridges will provide a minimum proposed navigation clearance envelope of 300 feet wide by 95 feet high.

Because recreational vessels traveling at slow speeds are the predominant vessel type navigating the North Portland Harbor, constructing new adjacent bridge structures would not adversely impact navigation in any of the options analyzed in the Navigation Technical Report. Although the location of the adjacent bridge structures would differ between LPA Option A and Option B, the number and location of piers in the water would be the same, so there would be no difference in impacts to navigation between the options.

The other physical components of the LPA--light rail extension, interchanges, and bicycle and pedestrian improvements--are not expected to have an effect on navigation.

Impacts from temporary effects will be similar to that described in the Navigation Technical Report and TIAB Supplement.

Mitigation of long-term and temporary effects will be similar to that described in the Navigation Technical Report and TIAB Supplement.

INTERSTATE 5 COLUMBIA RIVER CROSSING

Navigation Technical Report

Columbia River CROSSING

May 2008

Title VI

The Columbia River Crossing project team ensures full compliance with Title VI of the Civil Rights Act of 1964 by prohibiting discrimination against any person on the basis of race, color, national origin or sex in the provision of benefits and services resulting from its federally assisted programs and activities.

Americans with Disabilities Act (ADA) Information

If you would like copies of this document in an alternative format, please call the Columbia River Crossing project office at (360) 737-2726 or (503) 256-2726. Persons who are deaf or hard of hearing may contact CRC using Telecommunications Relay Service by dialing 7-1-1.

¿Habla usted español? La informacion en esta publicación se puede traducir para usted. Para solicitar los servicios de traducción favor de llamar al (503) 731-3490.

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Cover Sheet

Interstate 5 Columbia River Crossing

Navigation Technical Report:

Submitted By:

Matt Deml

Parsons Brinckerhoff

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TABLE OF CONTENTS

List of Exhibits

ACRONYMS

Acronym	Description
ADA	Americans with Disabilities Act
API	Area of Potential Impact
BNSF	Burlington Northern Santa Fe Railroad
BPA	Bonneville Power Administration
BRT	Bus Rapid Transit
COE	U.S. Army Corps of Engineers
CRC	Columbia River Crossing
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
NEPA	National Environmental Policy Act
RM	River Mile
ROW	Right-of-way
USCG	U.S. Coast Guard
WSDOT	Washington State Department of Transportation

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1. Summary

1.1 Introduction

The I-5 bridge crosses both the main channel of the Columbia River and a channel on the south side of Hayden Island known as North Portland Harbor. Both channels are designated Federally Navigable Waterways. The height and alignment of the existing crossing creates difficulties for navigation. This report examines the existing conditions and uses of the river, and how the CRC alternatives would affect river navigation.

1.2 Description of the Alternatives

The alternatives being considered for the CRC project consist of a diverse range of highway, transit and other transportation choices. Some of these choices – such as the number of traffic lanes across the river – could affect transportation performance and impacts throughout the bridge influence area or beyond. These are referred to as "system-level choices." Other choices – such as whether to run high-capacity transit (HCT) on Washington Street or Washington and Broadway Streets – have little impact beyond the area immediately surrounding that proposed change and no measurable effect on regional impacts or performance. These are called "segment-level choices." This report discusses the impacts from both system- and segment-level choices, as well as "full alternatives." The full alternatives combine system-level and segment-level choices for highway, transit, pedestrian, and bicycle transportation. They are representative examples of how project elements may be combined. Other combinations of specific elements are possible. Analyzing the full alternatives allows us to understand the combined performance and impacts that would result from multimodal improvements spanning the bridge influence area.

Following are brief descriptions of the alternatives being evaluated in this report, which include:

- System-level choices,
- Segment-level choices, and
- Full alternatives.

1.2.1 System-Level Choices

System-level choices have potentially broad influence on the magnitude and type of benefits and impacts produced by this project. These options may influence physical or operational characteristics throughout the project area and can affect transportation and other elements outside the project corridor as well. The system-level choices include:

- River crossing type (replacement or supplemental)
- High-capacity transit mode (bus rapid transit or light rail transit)
- Tolling (no toll, I-5 only, I-5 and I-205, standard toll, higher toll)

This report compares replacement and supplemental river crossing options. A replacement river crossing would remove the existing highway bridge structures across the Columbia River and replace them with three new parallel structures – one for I-5 northbound traffic, another for I-5 southbound traffic, and a third for HCT, bicycles, and pedestrians. A supplemental river crossing would build a new bridge span downstream of the existing I-5 bridge. The new supplemental bridge would carry southbound I-5 traffic and HCT, while the existing I-5 bridge would carry northbound I-5 traffic, bicycles, and pedestrians. The replacement crossing would include three through-lanes and two auxiliary lanes for I-5 traffic in each direction. The supplemental crossing would include three through-lanes and one auxiliary lane in each direction.

Two types of HCT are being considered – bus rapid transit and light rail transit. Both would operate in an exclusive right-of-way through the project area, and are being evaluated for the same alignments and station locations. The HCT mode – LRT or BRT – is evaluated as a system-level choice. Alignment options and station locations are discussed as segment-level choices. BRT would use 60-foot or 80-foot long articulated buses in lanes separated from other traffic. LRT would use one- and two-car trains in an extension of the MAX line that currently ends at the Expo Center in Portland.

Under the efficient operating scenario, LRT trains would run at approximately 7.5 minute headways during the peak periods. BRT would run at headways between 2.5 and 10 minutes depending on the location in the corridor. BRT would need to run at more frequent headways to match the passenger-carrying capacity of the LRT trains. This report also evaluates performance and impacts for an increased operations scenario that would double the number of BRT vehicles or the number of LRT trains during the peak periods.

1.2.2 Segment-Level Choices

1.2.2.1 *Transit Alignments*

The transit alignment choices are organized into three corridor segments. Within each segment the alignment choices can be selected relatively independently of the choices in the other segments. These alignment variations generally do not affect overall system performance but could have important differences in the impacts and benefits that occur in each segment. The three segments are:

- Segment A1 – Delta Park to South Vancouver
- Segment A2 – South Vancouver to Mill Plain District
- Segment B – Mill Plain District to North Vancouver

In Segment A1 there are two general transit alignment options - offset from, or adjacent to, I-5. An offset HCT guideway would place HCT approximately 450 to 650 feet west of I-5 on Hayden Island. An adjacent HCT guideway across Hayden Island would locate HCT immediately west of I-5. The alignment of I-5, and thus the alignment of an adjacent HCT guideway, on Hayden Island would vary slightly depending upon the river crossing and highway alignment, whereas an offset HCT guideway would retain the same station location regardless of the I-5 bridge alignment.

HCT would touch down in downtown Vancouver at Sixth Street and Washington Street with a replacement river crossing. A supplemental crossing would push the touch down location north to Seventh Street. Once in downtown Vancouver, there are two alignment options for HCT – a two-way guideway on Washington Street or a couplet design that would place southbound HCT on Washington Street and northbound HCT on Broadway. Both options would have stations at Seventh Street, 12th Street, and at the Mill District Transit Center between 15th and 16th Streets.

From downtown Vancouver, HCT could either continue north on local streets or turn east and then north adjacent to I-5. Continuing north on local streets, HCT could either use a two-way guideway on Broadway or a couplet on Main Street and Broadway. At 29th Street, both of these options would merge to a two-way guideway on Main Street and end at the Lincoln Park and Ride located at the current WSDOT maintenance facility. Once out of downtown Vancouver, transit has two options if connecting to an I-5 alignment: head east on 16th Street and then through a new tunnel under I-5, or head east on McLoughlin Street and then through the existing underpass beneath I-5. With either option HCT would connect with the Clark College Park and Ride on the east side of I-5, then head north along I-5 to about SR 500 where it would cross back over I-5 to end at the Kiggins Bowl Park and Ride.

There is also an option, referred to as the minimum operable segments (MOS), which would end the HCT line at either the Mill Plain station or Clark College. The MOS options provide a lower cost, lower performance alternative in the event that the full length HCT lines could not be funded in a single phase of construction and financing.

1.2.2.2 *Highway and Bridge Alignments*

This analysis divides the highway and bridge options into two corridor segments, including:

- Segment A – Delta Park to Mill Plain District
- Segment B – Mill Plain District to North Vancouver

Segment A has several independent highway and bridge alignment options. Differences in highway alignment in Segment B are caused by transit alignment, and are not treated as independent options.

The replacement crossing would be located downstream of the existing I-5 bridge. At the SR 14 interchange there are two basic configurations being considered. A traditional configuration would use ramps looping around both sides of the mainline to provide direct connection between I-5 and SR 14. A less traditional design could reduce right-of-way requirements by using a "left loop" that would stack both ramps on the west side of the I-5 mainline.

1.2.3 Full Alternatives

Full alternatives represent combinations of system-level and segment-level options. These alternatives have been assembled to represent the range of possibilities and total impacts at the project and regional level. Packaging different configurations of highway, transit, river crossing, tolling and other improvements into full alternatives allows project staff to evaluate comprehensive traffic and transit performance, environmental impacts and costs.

Exhibit 1-1 summarizes how the options discussed above have been packaged into representative full alternatives.

Exhibit 1-1. Full Alternatives

	Packaged Options				
Full Alternative	River Crossing Type	HCT Mode	Northern Transit Alignment	TDM/TSM Type	Tolling Method[a]
1	Existing	None	N/A	Existing	None
2	Replacement	BRT	I-5	Aggressive	Standard Rate
3	Replacement	LRT	I-5	Aggressive	Two options[b]
4	Supplemental	BRT	Vancouver	Very Aggressive	Higher rate
5	Supplemental	LRT	Vancouver	Very Aggressive	Higher rate

[a] *In addition to different tolling rates, this report evaluates options that would toll only the I-5 river crossing and options that would toll both the I-5 and the I-205 crossings.*

[b] *Alternative 3 is evaluated with two different tolling scenarios, tolling and non-tolling.*

Modeling software used to assess alternatives' performance does not distinguish between smaller details, such as most segment-level transit alignments. However, the geographic difference between the Vancouver and I-5 transit alignments is significant enough to warrant including this variable in the model. All alternatives include Transportation Demand Management (TDM) and Transportation System Management (TSM) measures designed to improve efficient use of the transportation network and encourage alternative transportation options to commuters such as carpools, flexible work hours, and telecommuting. Alternatives 4 and 5 assume higher funding levels for some of these measures.

Alternative 1: The National Environmental Policy Act (NEPA) requires the evaluation of a No-Build or "No Action" alternative for comparison with the build alternatives. The No-Build analysis includes the same 2030 population and employment projections and the same reasonably foreseeable projects assumed in the build alternatives. It does not include any of the I-5 CRC related improvements. It provides a baseline for comparing the build alternatives, and for understanding what will happen without construction of the I-5 CRC project.

Alternative 2: This alternative would replace the existing I-5 bridge with three new bridge structures downstream of the existing bridge. These new bridge structures would carry Interstate traffic, BRT, bicycles, and pedestrians. There would be three through-lanes and two auxiliary lanes for I-5 traffic in each direction. Transit would include a

BRT system that would operate in an exclusive guideway from Kiggins Bowl in Vancouver to the Expo Center station in Portland. Express bus service and local and feeder bus service would increase to serve the added transit capacity. BRT buses would turn around at the existing Expo Station in Portland, where riders could transfer to the MAX Yellow Line.

Alternative 3: This is similar to Alternative 2 except that LRT would be used instead of BRT. This alternative is analyzed both with a toll collected from vehicles crossing the Columbia River on the new I-5 bridge, and with no toll. LRT would use the same transit alignment and station locations. Transit operations, such as headways, would differ, and LRT would connect with the existing MAX Yellow Line without requiring riders to transfer.

Alternative 4: This alternative would retain the existing I-5 bridge structures for northbound Interstate traffic, bicycles, and pedestrians. A new crossing would carry southbound Interstate traffic and BRT. The existing I-5 bridges would be re-striped to provide two lanes on each structure and allow for an outside safety shoulder for disabled vehicles. A new, wider bicycle and pedestrian facility would be cantilevered from the eastern side of the existing northbound (eastern) bridge. A new downstream supplemental bridge would carry four southbound I-5 lanes (three through-lanes and one auxiliary lane) and BRT. BRT buses would turn around at the existing Expo Station in Portland, where riders could transfer to the MAX Yellow Line. Compared to Alternative 2, increased transit service would provide more frequent service. Express bus service and local and feeder bus service would increase to serve the added transit capacity.

Alternative 5: This is similar to Alternative 4 except that LRT would be used instead of BRT. LRT would have the same alignment options, and similar station locations and requirements. LRT service would be more frequent (approximately 3.5 minute headways during the peak period) compared to 7.5 minutes with Alternative 3. LRT would connect with the existing MAX Yellow Line without requiring riders to transfer.

1.3 Long-Term Effects

The I-5 Columbia River Crossing (CRC) project will have significant long-term effects on navigation of the Columbia River. Effects vary greatly between the replacement and supplemental alternatives, but do not vary at all between the BRT or LRT transit modes.

1.3.1 North Portland Harbor - All Alternatives

Navigation effects on North Portland Harbor will be similar between the replacement and supplemental alternatives; both will maintain or slightly improve navigation conditions when compared with the existing condition.

1.3.2 Columbia River - Replacement Alternatives

Vessel operators currently avoid delays associated with using the Primary Channel and its lift span by opting to travel through the Interstate Bridges' Barge or Alternate Barge Channels as vertical clearance allows. The use of these channels requires a more complex maneuver than the straight route through the Primary Channel and requires the vessel to navigate an "S" curve path in the relatively short distance between the Interstate Bridges and the BNSF Bridge. The "S" curve is required in order to line up with and pass through the BNSF swing span.

Replacement alternatives increase navigation safety by eliminating the need for vessels to navigate the "S" curve, which is used to avoid the existing lift spans. A more direct route to the BNSF railroad bridge swing span will be available through the location of the existing lift spans. This more direct route will not be inhibited by lift spans and their associated restrictions, as is the case today.

The navigation clearances beneath replacement structures will allow the overwhelming majority of vessels passage. A boat survey and public comments have indicated that a few tall sailboats and marine contractors will not be able pass beneath the replacement structures with out partial dismantling or some other reduction in height.

A replacement alternative will beneficially effect navigation on the Columbia River when compared to the existing condition.

1.3.3 Columbia River - Supplemental Alternatives

Supplemental alternative will adversely effect navigation. The existing Interstate Bridges will remain in place and still require the use of the "S" curve maneuver. However, seismic retrofits will increase the footprint of the existing piers, narrowing the existing navigation channels, making the "S" curve more precarious than the existing condition. This decrease in navigational safety may prompt the United States Coast Guard (USCG) to eliminate current lift restrictions.

The supplemental bridge would not reduce the existing horizontal navigation channels. A supplemental bridge would impose the same vertical restrictions described above for the replacement alternatives. Similar to the replacement alternative, a few tall sailboats and marine contractors will not be able to pass without some reduction in height.

A supplemental alternative will adversely effect navigation when compared to the existing condition.

1.3.4 River Crossing Alternative and Capacity: How does the supplemental crossing compare to the replacement crossing?

Both the supplemental and replacement alternatives would have similar effects on navigation through North Portland Harbor. Both alternatives will increase the horizontal clearance of the navigation channel, while maintaining or exceeding the existing vertical clearance.

Replacement alternatives would beneficially effect navigation on the Columbia River by allowing full time access to the primary channel that lines up with the BNSF swing span. This would eliminate the need for vessels to perform the "S" curve maneuver to avoid the existing Interstate Bridges' lift spans and the lift restrictions associated with them.

Supplemental alternatives would adversely effect navigation on the Columbia River. Seismic retrofit of the existing Interstate Bridges will likely increase the footprint of the existing bridge piers, reducing the horizontal clearance available making the “S” curve maneuver more dangerous compared with the existing condition.

1.3.5 Transit Mode: How does BRT compare to LRT?

The transit mode used on the river crossing has no effect of navigation on the Columbia River or North Portland Harbor. Both transit modes can use almost identical river crossing structure types.

1.4 Temporary Effects

Temporary effect to navigation on North Portland Harbor and Columbia River will be dependant on the construction methods and staging.

1.4.1 North Portland Harbor

Select structure types, such as concrete segmental, coupled with careful staging could minimize temporary effect to navigation of North Portland Harbor. While temporary encroachments into the navigation channel are inevitable, North Portland Harbor will be available for vessel traffic, sometimes with a reduced capacity, throughout construction. Temporary effects to navigation on North Portland Harbor due to construction will be similar in nature and duration, regardless of the alternative selected (supplemental or replacement).

1.4.2 Columbia River

The structure type, span configuration, and construction staging will determine the temporary effects the I-5 CRC project will have on navigation. At least one of the three navigation channels could be open to river traffic at all times during construction. This will be possible for both the supplemental and replacement options. For the supplemental alternative, there will likely be times when the lift span will be inoperable and therefore the maximum vertical clearance will be unavailable. This will occur when the retrofit of the lift span, lift span towers, and foundation of piers adjacent to the lift span strengthening are underway. However, the maximum clearance can be made available at all times during construction of the replacement options.

1.5 Mitigation

Mitigation of temporary effects, due almost exclusively to construction, will be accomplished through careful staging of the bridge construction.

1.5.1 Mitigation for Temporary Effects

It is possible to develop construction staging schemes that minimize intrusion into North Portland Harbor’s single navigation channel. Temporary partial obstructions of the navigation envelop are inevitable, but it will be possible to keep North Portland Harbor open to the recreational and other small crafts that make up the majority of users of North Portland Harbor.

Conceptual staging schemes have been developed showing that at least one of the three navigation channels will be open at all times during construction of either the supplemental or the replacement options. However, at least two shipping channels could remain open, possibly in a reduced capacity, throughout most of the construction.

1.5.2 Mitigation for Long-Term Effects

Long-term effects for navigation on North Portland Harbor will be similar among all of the alternatives under consideration. Each of the proposed alternatives will increase the navigation clearance available on North Portland Harbor when compared to the existing condition. Therefore, the I-5 CRC project can beneficially affect navigation on North Portland Harbor regardless of the alternative constructed.

Long-term effects on the Columbia River requiring mitigation from the I-5 CRC project vary depending upon the alternative chosen.

The supplemental alternative will likely have an adverse effect on Columbia River navigation. The "S" curve maneuver would be more dangerous than in the existing condition. In order to help mitigate adverse effects on navigation, the USCG may remove current lift restrictions on the existing Interstate Bridges, adversely affecting highway traffic on I-5. Additionally, the "S" curve could be eliminated by moving the swing span on the downstream BNSF railroad bridge to be in line with the existing Barge Channel.

The replacement alternatives would improve navigation safety when compared to the "No Build" condition. Therefore, no mitigation would be required.

2. Methods

2.1 Introduction

This section describes the assessment method that was used to identify and evaluate potential effects of replacement and supplemental alternatives for the I-5 CRC project on navigation of the Columbia River and North Portland Harbor (Oregon Slough). The Columbia River Bridge includes the northbound highway, southbound highway and combined high capacity transit, bicycle and pedestrian structures. North Portland Harbor Bridges consist of at least four structures; the I-5 mainline bridge, two ramp structures, and one combined high capacity transit, bicycle, and pedestrian bridge.

2.2 Study Area

The analysis area was limited to the primary Area of Potential Impact (API) for navigation, which is the Columbia River section, between the Burlington Northern Santa Fe (BNSF) Railroad Bridge and the Interstate Bridges (see Exhibit 2-1). Within this section, there are two bodies of water that have been declared Federally Navigable Waters: the Columbia River and North Portland Harbor (also known as the North Portland Harbor).

Exhibit 2-1. API for Navigation

2.3 Effects Guidelines

The Federally Navigable Waterways designation of the Columbia River and North Portland Harbor signifies that all construction or alteration of bridges crossing these waterways must first be approved by the U.S. Coast Guard (USCG).

The USCG is responsible for the regulation of drawbridge operations to balance both land and marine transportation needs. Part of the USCG mission, as outlined in their mission statement, is to: "Facilitate maritime commerce and eliminate interruptions and impediments to the efficient and economical movement of goods and people, while maximizing recreational access to and enjoyment of the water."

The USCG is the permitting authority for all new bridge crossings. Agreements between the USCG and the Federal Highway Administration require that the potential effects of bridge projects on navigable waterways be evaluated through the National Environmental Policy Act (NEPA) process.

This document investigates how project alternatives may effect navigation on the Columbia River and North Portland Harbor. Additionally, the temporary river navigation effects, due to bridge construction are also evaluated. Both beneficial and adverse effects are presented.

An assessment of the impacts to river navigation for each Bridge has been performed, using the river navigation data collected, on the following:

- The location of new bridge piers in relation and whether they maintain or enhance the navigation and safety levels for vessels and their impact on the "S" curve maneuver (described below).
- The new bridge's vertical and horizontal clearances and any possible impact to vessels.

To aid in the assessment, each bridge alternative was developed using MicroStation (a computer-aided drafting software program) and presented on a Plan and Elevation plot. The Plan view was overlaid on a color ortho-rectified aerial photograph showing existing pertinent features such as highways, existing bridges, and the proposed bridge plan. The corresponding Elevation view shows features such as the proposed roadway profile, and vertical and horizontal navigation clearances and pier locations.

The following list contains applicable Federal regulations and brief description of each;

- 33 CFR 114, "General," and 33 CFR 115, "Bridge Locations and Clearances; Administrative Procedures," Code of Federal Regulations. Rules and regulations governing the USCG bridge permit program are listed in Parts 114 and 115.
- 33 CFR 116, "Alteration of Unreasonably Obstructive Bridges," Code of Federal Regulations. This section describes the process taken to alter obstructive bridges. It also includes the application process for funding under the Truman-Hobbs Act.

- 33 CFR 117, "Drawbridge Operation Regulations," Code of Federal Regulations. Columbia River. The draws of the Interstate 5 Bridges, mile 106.5, between Portland, OR, and Vancouver, WA, shall open on signal except that the draws need not be opened for the passage of vessels from 6:30 a.m. to 9 a.m. and from 2:30 p.m. to 6 p.m. Monday through Friday except federal holidays.
- 33 CFR 118.140, "Painting bridge piers," Code of Federal Regulations. The District Commander may require painting the sides of bridge channel piers below the superstructure facing traffic white or yellow when they are significantly darkened by weathering or other causes so as to be poorly visible against a dark background.
- 33 CFR 118.160, "Vertical clearance gauges," Code of Federal Regulations. When necessary for reasons of safety of navigation, the District Commander may require or authorize the installation of clearance gauges. Clearance gauges must indicate the vertical distance between ``low steel'' of the bridge channel span and the level of the water, measured to the bottom of the foot marks, read from top to bottom. Each gauge must be installed on the end of the right channel pier or pier protection structure facing approaching vessels and extend to a reasonable height above high water so as to be meaningful to the viewer. Other or additional locations may be prescribed by the District Commander if particular conditions or circumstances warrant.

2.4 Data Collection Methods

The primary sources of data used for the assessment of each proposed bridge included vertical clearance data gathered from the Boat Survey (Parsons Brinckerhoff Inc. 2004), Boat Survey validation meetings, and telephone calls conducted by the agencies with key stakeholders, such as vessel operators and the USCG.

A list of vessels traveling this river section was assembled, analyzed, and summarized in the 2006 Boat Survey Technical Memorandum. This study provided valuable information on the types of vessels traveling the Columbia River, their clearance requirements, and was used as a basis for determining vertical clearances for the new bridges. The data in this Technical Memorandum was verified in 2006 through a series of discussions with vessel operators.

2.5 Analysis Methods

There are many factors that are evaluated in determining the "S" curve path that a vessel pilot will take between the Interstate Bridges and the BNSF bridge. Some of these factors include the gross weight and dimensions of the vessel, river water elevation, and river velocity. As such, there isn't an exact path that vessel pilots use to traverse the "S" curve; they must rely primarily on their experience. The evaluation of the impact of new bridge pier locations on river navigation, to a large part, depends on the anecdotal input provided by vessel pilots.

The USCG is the permitting agency, and they have stated navigation through this section of the Columbia River cannot be made worse than the existing condition. To that end, piers for a supplemental structure must align with the existing bridges' piers. Similarly, the piers of replacement bridges must line up with the existing Interstate Bridges' piers to maintain adequate navigation channels during construction and ultimately improve navigation once the existing Interstate Bridges are removed. "As-Built" drawings of the Interstate Bridges were used to accurately locate the new bridge piers in relation to the existing bridge piers for the evaluation of construction staging and temporary impacts.

Comments generated from USCG preliminary hearings provided key input and aided in the evaluation of a proposed bridge's effect on river navigation.

3. Coordination

The following section briefly discusses external coordination that has occurred with other groups.

3.1 Boat Survey

A list of vessels traveling this river section was assembled, analyzed, and summarized in the Boat Survey Technical Memorandum. This study provided valuable information on the types of vessels traveling this river section and their clearance requirements and was used as a basis for determining vertical clearances for the new bridges. The data in this Technical Memorandum was verified in 2006 through a series of discussions with vessel operators.

3.1.1 Boat Survey validation

The 2004 boat survey was revisited in 2006 by the I-5 CRC Project. Interviews were conducted with key stakeholders such as vessel operators and the U.S. Coast Guard. From these interviews, it was concluded that the information presented in the Boat Survey is still valid.

Open House and Public Hearing – September 21, 2006

The public hearing was held in order to give all interested parties an opportunity to state their views regarding the impacts of the proposed project.

3.2 USCG meetings

September 7, 2005 meeting with USCG

This initial meeting with the USCG presented project history, an initial schedule, and determined the points of contact at both the USCG and CRC project team. Design requirements, applicable criteria, and the processes for major project decisions were all discussed.

May 18, 2006 CRC meeting with USCG

USCG said they have jurisdiction over all bridges over navigable waterways with or without piers in the waterway or officially marked and maintained channels. There were also discussions regarding construction. The USCG indicated that tug assistance could be used during construction, and short closure periods have been used in the past. They also asked that project be sensitive to shipments and consider water levels.

January 25, 2007 CRC meeting with USCG

USCG has jurisdiction over channel modifications. They agreed that 95 feet of clearance above zero (Columbia River Datum) CRD was in the ballpark of what may be acceptable. The USCG cannot accept or reject proposed clearances until a Record of Decision (ROD) is issued for the project. Recreational vessels that cannot meet this clearance at all times of year must justify why they need to have this clearance at all times of year. Likewise, cranes unable to make the proposed clearance must justify why they need clearance all times of the year.

3.3 Coordination that is still to occur

As project alternatives are refined and narrowed down to a locally preferred alternative, the USCG will be given regular updates. As previously mentioned, the USCG has stated that they cannot accept or reject any CRC project alternative until a ROD is issued. However, the USCG will be regularly presented with current information so that they are aware of what the recommended alternative is and its associated effect on navigation.

4. Affected Environment

4.1 Introduction

The I-5 CRC project may affect navigable waters in two distinct areas; the Columbia River, north of Hayden Island and North Portland Harbor, south of Hayden Island. The following discussion identifies the navigational characteristics of these two navigable waters.

4.2 Regional Conditions

4.2.1 North Portland Harbor

Use of North Portland Harbor can be characterized in two distinctive portions: the eastern portion, which contains moorages for floating homes and recreational vessels and the western portion, which services the Port of Portland facility.

4.2.1.1 *North Portland Harbor - Eastern Portion*

Two bridges span over North Portland Harbor in the eastern portion; the BNSF Bridge and North Portland Harbor Bridge. North Portland Harbor Bridge carries I-5 and connects Marine Drive with Hayden Island and points north. The I-5 CRC project will likely replace North Portland Harbor Bridge and therefore affect navigation on that body of water.

Although previous studies have not defined vessel heights and types that use this portion of the slough, some conclusions can be drawn from the surroundings and the existing constraints. As previously mentioned, the eastern portion of the slough contains moorages for floating homes and recreational vessels. The existing North Portland Harbor Bridge has fixed spans and provides one navigation channel with a navigation clearance of 215 feet wide with a variable height of 35 feet to 40 feet. Existing clearance under the bridge and the surrounding moorages indicate that the dominant vessel type is recreational (requiring less than 40 feet of vertical clearance).

Further toward the west, vessels pass under the BNSF Railroad Bridge. Similar to the situation on the Columbia River, a BNSF Railroad Bridge is located approximately one mile downstream and accommodates vessels in excess of a 35 foot height through a movable swing span. From aerial photos, it appears that the swing span provides a horizontal navigation clearance of roughly 150 feet.

4.2.1.2 *North Portland Harbor - Western Portion*

Vessels traveling the western portion of North Portland Harbor appear to be primarily associated with the Port of Portland facility. This facility receives ocean going vessels (large tankers and cargo ships) containing automobiles and shipping containers.

Vessel count information for North Portland Harbor is available through the Department of the Army Corps of Engineers, some of which is presented in the Exhibit 4-1.

Exhibit 4-1. North Portland Harbor Vessel Count

	North Portland Harbor	2000	2001	2002	2003	2004
Downbound	Cargo	1558	1365	1252	1097	1097
	Tanker	5	1	1	1	0
	Passenger	436	384	351	382	321
	Total	**1999**	**1750**	**1604**	**1480**	**1418**
Upbound	Cargo	1602	1355	1294	1100	1135
	Tanker	3	0	1	1	0
	Passenger	441	400	348	385	326
	Total	**2046**	**1755**	**1643**	**1486**	**1461**

Data obtained for Exhibit 4-1 does not state whether these vessel trip totals are reflective of the entire length of North Portland Harbor or specific portions. The vessel counts are similar in magnitude to those on the Columbia River, which indicate that they are more closely related to the western portion (Port of Portland) than the eastern portion (floating homes and recreational vessels). The similarity of North Portland Harbor vessel counts with Columbia River Vessel counts along with the limitations of navigational clearances beneath the I-5 North Portland Harbor Bridge indicate larger commercial vessels do not use the navigation channels of the I-5 North Portland Harbor Bridge.

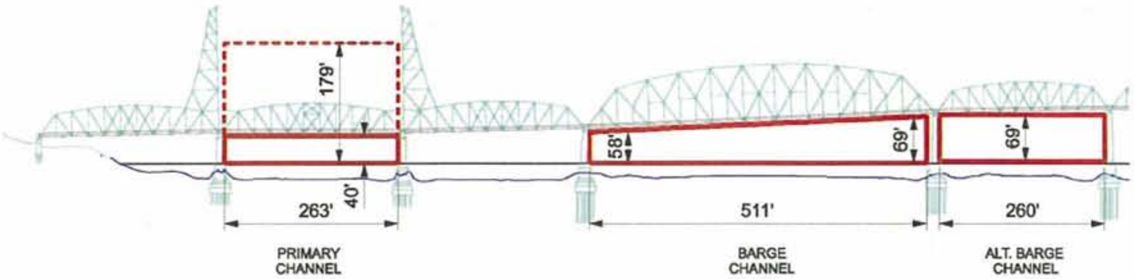
4.2.2 Existing Interstate Bridges

Vessels that currently travel this portion of the Columbia River pass three bridges: the Northbound and Southbound structures of the Interstate Bridges and the BNSF Railroad Bridge.

Under the Interstate Bridges, vessels pass through one of three channels: the Primary Channel, the Barge Channel and the Alternate Barge Channel (see Exhibit 4-2).

The Primary Channel lies under the bridges' lift spans and has a horizontal clearance of 263 feet and a vertical clearance of 40 feet in the closed position and 179 feet in the raised position. The Barge Channel lies under the wide spans of the bridges and has a horizontal clearance of 511 feet and a vertical clearance ranging from 58 feet to 69 feet. The Alternate Barge Channel occupies the span directly to the south of the wide span and has a horizontal clearance of 260 feet and a vertical clearance of 69 feet.

Exhibit 4-2. Existing Columbia River Navigation Clearances



The third bridge, the BNSF Railroad Bridge, is located approximately one mile downstream (westerly) from the Interstate Bridges and accommodates vessels with heights in excess of 35 feet using a 200 foot wide movable swing span. The swing span is aligned with the Interstate Bridges lift spans.

The most direct vessel route through this river section is through the Interstate Bridges Primary Channel lift span and through the BNSF Bridge's swing span. This route is relatively straight and is preferred during times of high velocity river flow. This route, designated the Primary Channel, is represented in Exhibit 4-3. For vessels requiring a vertical clearance in excess of 40 feet, this route is subject to lift span restriction time periods. These lift span restriction periods can cause vessel travel delays. The Federal Code of Regulations stipulates that the span need not be raised, Monday through Friday, from 6:30 a.m. to 9 a.m. and from 2:30 p.m. to 6 p.m.

Vessel operators can avoid delays by opting to travel through the Interstate Bridges' Barge or Alternate Barge Channels as vertical clearance allows. The use of these channels requires a more complex maneuver than the route through the Primary Channel and requires the vessel to navigate an "S" curve path between the Interstate Bridges and the BNSF Bridge in order to pass through the BNSF swing span. These routes are represented in Exhibit 4-3 and are designated as the Barge Channel Route and the Alternate Barge Channel Route.

Exhibit 4-3. Existing Columbia River Navigation Channels

Information on the number of trips through this portion of the Columbia River is available through the Department of the Army Corps of Engineers and is shown in Exhibit 4-4.

Exhibit 4-4. Columbia River Vessel Count

North Portland Harbor		2000	2001	2002	2003	2004
Downbound	Cargo	1495	1356	1083	1540	1466
	Tanker					
	Passenger	412	536	28	3	0
	Total	**1907**	**1892**	**1111**	**1543**	**1466**
Upbound	Cargo	1526	1285	1173	1540	1579
	Tanker					
	Passenger	418	531	26	3	0
	Total	**1944**	**1816**	**1199**	**1543**	**1579**

Tugs and tows are the predominant users, and in 2004 accounted for 100% of the recorded self-propelled vessel trips in both the upbound and downbound directions. Recreational vessels appear not to have been counted.

4.2.2.1 *Horizontal Navigation Clearance*

The horizontal navigation clearance through this portion of the river is controlled by the BNSF Railroad Bridge downstream of the Interstate Bridges and the Glenn Jackson Bridge upstream of the Interstate Bridges.

The BNSF Railroad Bridge, to the west, accommodates vessels through a 200 foot wide swing span. From existing plans, the 200 foot dimension appears to be measured to the face of the pier. The Glenn Jackson Bridge lies to the east and provides a 300 foot horizontal navigation channel. From these horizontal dimensions, it is reasonable for a new bridge to provide a minimum of 300 feet of horizontal navigation clearance. The USCG has requested that a 300 foot horizontal clearance be provided.

4.2.2.2 *Vertical Navigation Clearance*

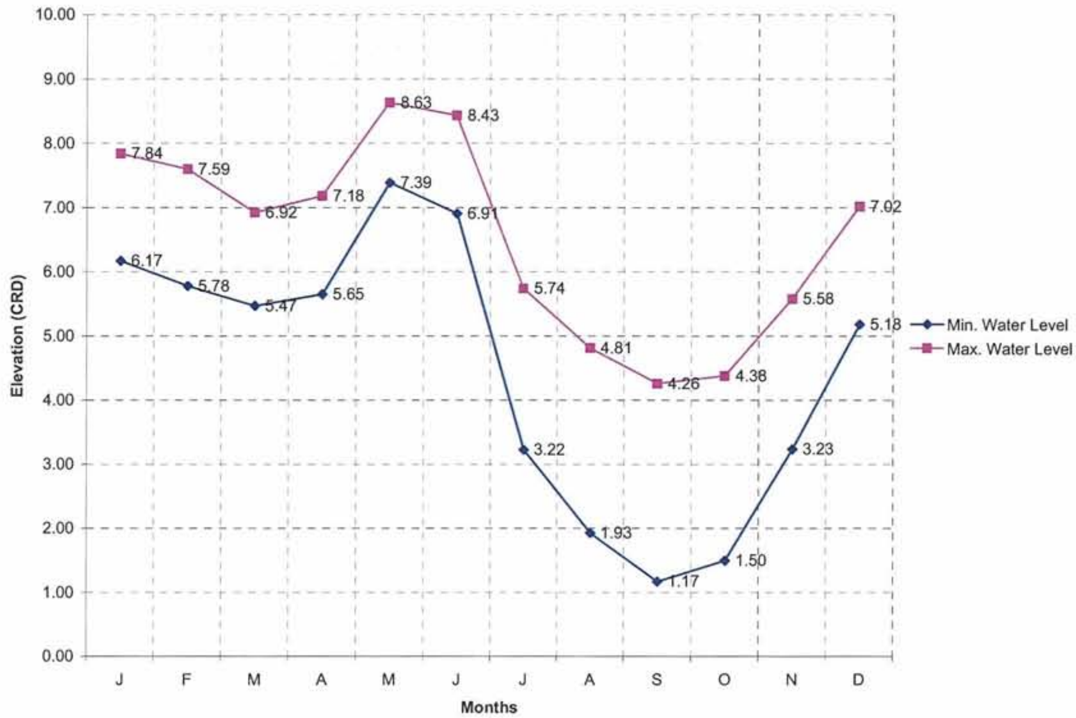
Two key factors must be evaluated in order to set a rational vertical navigation clearance: the water level of the river at any given time and the vertical clearance requirements of the vessels that frequently pass under the bridge.

4.2.2.3 *Water Level*

The U.S. Army Corps of Engineers (USACE) has a Columbia River recording station at Vancouver and records the water level several times each day. Both the minimum and maximum recorded daily water levels are available.

From this data, a 20-year sampling (1987-2006) was taken and Exhibit 4-5 was developed, which depicts the average monthly minimum and maximum water levels over this time period.

Exhibit 4-5. USACE Columbia River at Vancouver Water Level Data (1987-2006)



4.2.2.4 *Vessel Requirements*

A previous study was conducted that provides information on the types of vessels that travel through this portion of the Columbia River, their clearance requirements and their frequency of travel. Exhibit 4-6 shows the finding of the study.

Both factors (Columbia River water levels and the vessel vertical clearance requirements) were thoroughly evaluated before determining the vertical navigation clearance for new bridge proposals.

Exhibit 4-6. Existing Columbia River Navigation Channels

Vessel Type	Clearance Requirement	Approximate Annual Frequency
Tugs and Tows	49 feet to 58 feet	> 500 trips
Sailboats/Recreation	76 feet to 88 feet	24 trips
Marine Contractors	100 feet to 110 feet	Infrequent
Marine Industrial	65 feet	6 trips
Cruise/Passenger	50 feet to 60 feet	25 trips

Within the 300 foot horizontal navigation clearance, a vertical dimension of 95 feet (minimum) was established from 0.00 CRD to the soffit (bottom) of the bridge. The term "minimum" for the vertical dimension value refers to the fact that the soffits of proposed bridges are not flat, but rather, has a haunch. This haunch provides some additional vertical clearance toward the mid-point of the bridge span. The additional vertical clearance can be utilized by reducing the horizontal navigation clearance. Varying vertical clearances associated with smaller horizontal clearances will be discussed in a later section.

5. Long-Term Effects

The I-5 CRC project will have significant long-term effects on navigation of the Columbia River. However, the I-5 CRC project will have minimal long-term effect on navigation North Portland Harbor. The following sections discuss the long-term navigation effects associated with the I-5 CRC project.

5.1 How is this Section Organized?

This chapter describes the long-term impacts that would be expected from the project alternatives and options. We first describe impacts at the larger scale, including the region and corridor. We then focus on impacts that would occur with specific options in each of the corridor's segments. This two part approach helps to inform the range of questions that need to be answered in order to make the key decisions for this proposed project, including: What are the impacts of the different alternatives and options at the regional or system level, and what are their impacts at the local, neighborhood, property and individual resource level. It addresses both direct and indirect long-term impacts.

5.2 Regional and System-wide Impacts

This section describes the impacts from a range of system-wide combinations of highway, river crossing, transit alternatives and options. These system-wide combinations were constructed to represent the range of project choices that most affect system-wide performance, impacts and costs.

5.2.1 No-Build Alternative

5.2.1.1 *North Portland Harbor*

The existing North Portland Harbor Bridge has been in service for nearly 23 years and spans over North Portland Harbor, carrying I-5. No functional or operational deficiencies have been identified for this bridge.

The No Build Alternative would involve continued maintenance for this bridge. This Alternative would not change the existing navigational clearance envelope or any limitations experienced by vessel traffic today. Under normal conditions, there are no apparent adverse impacts to navigation from the No Build Alternative.

A catastrophic event could create an adverse impact to navigation. A seismic evaluation has not been performed on the existing North Portland Harbor Bridge. However, due to the close proximity of this structure with the Interstate Bridges, it is possible that this structure is also founded on highly liquefiable soils. If this were the case, a major seismic event could liquefy the soils and collapse a span into the navigation channel, disrupting river navigation for an unspecified amount of time.

5.2.1.2 *Columbia River Bridge*

The No Build Alternative involves continued maintenance and normal operation of the existing Interstate Bridges. This Alternative does not change the navigational restrictions nor does it adversely or affect the current navigation path through the Interstate Bridges and the BNSF Railroad Bridge.

Although the No Build Alternative does not adversely affect navigational safety, it does not improve the current situation either. As previously mentioned, travel delays from lift span restriction periods are avoided by vessel pilots choosing to use the Barge Channel or the Alternate Barge Channel under the Interstate Bridges. These routes require traversing an "S" curve between the Interstate Bridges and the downstream BNSF Railroad Bridge's swing span. Although there is not a significant accident history for these "S" curve routes, navigation safety is compromised somewhat. The lack of significant accident history is possibly attributed more to the experience of the barge pilots than the ease of traversing the route.

5.2.1.3 *Catastrophic Event Considerations*

It is important to note that key components of the existing bridges are considered vulnerable to severe damage and/or collapse in a major seismic event.

In August 2006, the CRC Project Team convened a panel of seismic bridge design experts to qualitatively assess the vulnerability of the existing Interstate Bridges in a major seismic event. A critical issue discussed was the determination (through geotechnical testing) that the bridges are founded on soil that could liquefy in a major seismic event. This situation would render the existing foundations ineffective in resisting seismic forces.

The "No Build" scenario coupled with a major seismic event could result in the bridges sustaining severe damage (including collapse). If a seismic event were to cause spans to collapse, they could collapse in one or several of the navigation channels and disrupt river navigation for an unspecified amount of time.

5.2.2 Replacement Crossing

5.2.2.1 *North Portland Harbor*

The existing North Portland Harbor Bridge is proposed to be replaced with four new bridges; one carrying mainline I-5, two carrying ramps, and one combined transit and pedestrian bridge. The mode of transit used (LRT or BRT) will not influence how a replacement bridge affects navigation.

The proposed North Portland Harbor navigation vertical clearance envelope will meet or exceed the existing clearance envelope. There are no apparent adverse long-term effects to vertical clearance.

Proposed bridge piers are spaced 275 feet apart over the navigation channel and exceeding the current navigation horizontal clearance of 215 feet. Vessels traveling further down stream are restricted by the BNSF Railroad Bridge swing span opening, which appears to be less than 200 feet wide. The 275 foot horizontal clearance is therefore adequate to meet the needs of the vessels traveling this portion of the river. There are no apparent adverse impacts from the horizontal clearance.

For the four proposed bridges, the length in which vessels must navigate through clearance envelopes, under bridges, is a longer distance than the current situation. Considering the predominant vessel type (recreational vessels) and the slow speeds (No wake zone, for the nearby floating homes), there are no apparent adverse impacts to navigation from this longer trip through the clearance envelopes.

The navigation channel and associated clearances will be improved over the existing condition. There will be no long-term adverse effect to navigation resulting from the I-5 CRC project.

5.2.2.2 *Columbia River*

The following sections discuss the navigation impacts of the Replacement bridges over the Columbia River.

5.2.2.2.1 Vertical Clearance

The replacement bridge provides a new primary navigation channel. Exhibit 5-1 shows the minimum bridge soffit elevations (CRD) for various horizontal navigation clearances.

Exhibit 5-1. Proposed Replacement Columbia River Bridge Clearances

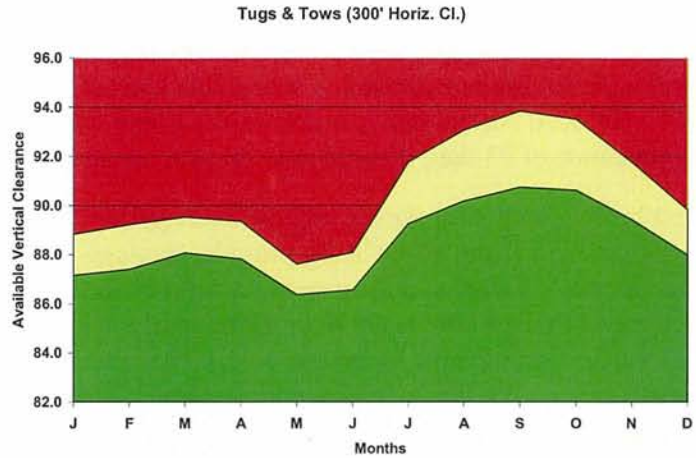
	Navigation Clearances			
Clearance Width	50 feet	100 feet	200 feet	300 feet
Soffit Elevation (CRD)	102 feet	102 feet	100 feet	95 feet

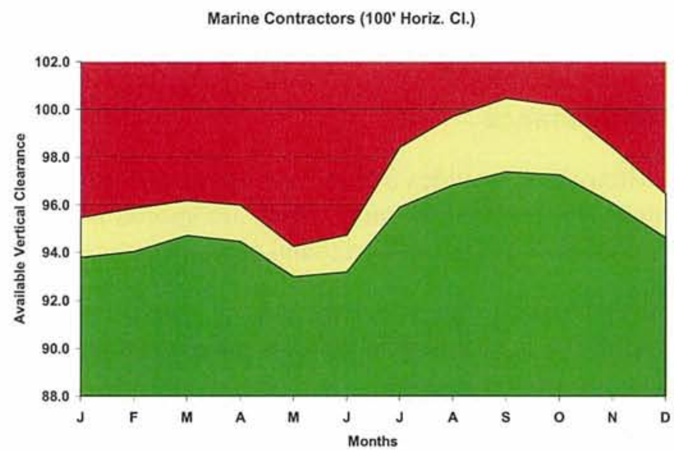
Potential impact that the bridge soffit elevation has on three vessel groups were evaluated, these groups include: Tugs and Tows (requires 60 feet vertical x 300 feet horizontal clearance envelope), high mast sailboats (requires 88 feet vertical x 50 feet horizontal clearance envelope), and Marine Contractors (requires 110 feet vertical x 100 feet horizontal clearance envelope).

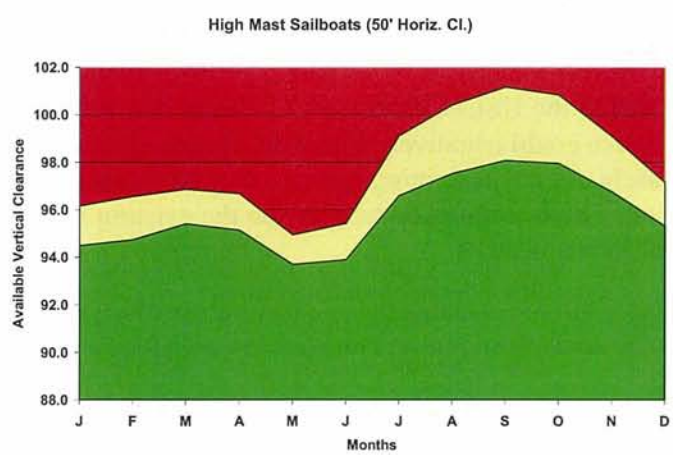
Exhibit 5-2 shows the available vertical clearance for each of the three vessel groups described above. The green zone represents vertical clearances available at the average maximum water level. The red zones indicate that the clearance is not available and the yellow band indicates the range of what may or may not be available due to variation in water elevation. From these graphs the following observations were made;

- Tugs and Tows, with a 60 feet vertical clearance requirement, are well within the Green zone and can pass under the bridge during all months of the year.
- High mast sailboats, with an 88 feet vertical clearance requirement can pass under the bridge during all months of the year.
- Marine Contractors, with a 110 feet vertical clearance requirement cannot pass under the bridge without partial disassembly of their loads.

Exhibit 5-2. Proposed Replacement Alignment Clearances for 300 feet width (top), 100 feet width (center), and 50 feet width (bottom)







Cranes typically used by marine contractors may not be able to pass under the bridge year round. However, the Boat Survey indicated that Marine Contractor vessels travel under the Interstate Bridges infrequently and, in the future, it may be possible for them to lower or disassemble crane gantries, reducing their height meet clearances. This same vessel may be able to pass under the bridge, during a mid-June through mid-November time period, if a 100 feet wide navigation channel is acceptable and reduce the required vertical clearance to 100 feet. Additionally, if this vessel's load was dismantled such that it only required a clearance of 93 feet, it could pass all year around.

A new replacement bridge, with a minimum proposed navigation clearance envelope of 300 feet wide by 95 feet high (from 0.00 CRD), provides passage for nearly all vessels traveling under the Interstate Bridges, during most portions of the year. Only Marine Contractors, which travel this portion of the river infrequently, may have vertical height requirements greater than the available clearance. Interviews with some Marine Contractors suggest there is a possibility they can disassemble their equipment, at a cost, such that they are able to meet the available vertical clearance. Other marine contractors have said that they cannot dismantle their loads.

Based on the navigation clearances established for this project and the preceding discussion, there are no apparent significant adverse impacts from the vertical clearance.

5.2.2.2.2 Horizontal Clearance

The Replacement Alternative provides a span over the new Primary Channel with a clear span of approximately 500 feet and the piers which are spaced wide enough to accommodate the minimum navigation horizontal clearance envelope of 300 feet.

Similar to the Glenn Jackson Bridge, which provides a span of 445 feet for a horizontal navigation clearance of 300 feet; this span width is adequate to meet the needs of all vessels traveling this portion of the river.

Based on the navigation clearances established for this project and the preceding discussion, there are no apparent significant adverse impacts from the vertical clearance.

5.2.2.2.3 Pier Locations

Testimonials provided to the USCG, expressed a concern that pier locations for a Replacement alternative could negatively affect the already difficult "S" curve maneuver for downbound vessels. As the permitting agency, they have stated that piers for all adjacent new structures must align with the piers on the existing I-5 Interstate Bridges and North Portland Harbor bridges.

Impacts to the vessel route of permanent pier locations are discussed below while temporary impacts for navigation during construction are addressed in a later section.

The Replacement Alternative provides a new Primary channel that is positioned between the existing Primary and Barge channels (see Exhibit 5-3). Although further toward the middle of the river, due to a slight bend in the river, this new position improves the alignment with the downstream BNSF Railroad bridge swing span and eases the difficulty of the "S" maneuver. Additionally, vessels can pass under the span directly north, which is the approximate location of the existing Primary channel.

The piers flanking the new Primary channel are oriented in a radial manner with the alignment of the curved bridge. This orientation reduces the potential for pier-vessel conflict.

In summary, the proposed pier locations ease the difficulty of the "S" maneuver. As such, there is no apparent adverse impact to the route that vessel pilots must take to traverse this portion of the Columbia River.

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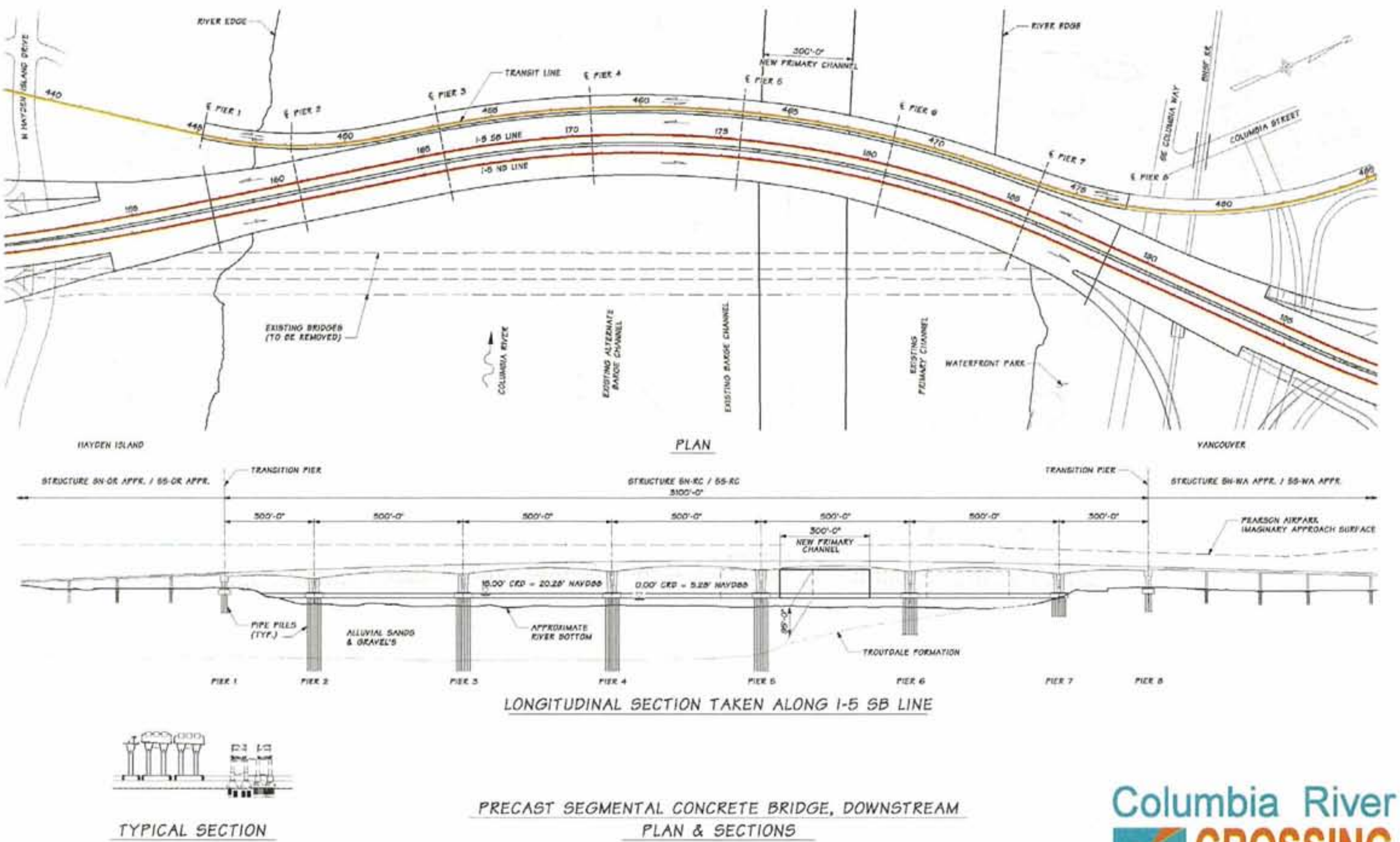
PRELIMINARY

Exhibit 5-3. Proposed Replacement Alternative Pier Locations and Navigation Channels



Columbia River CROSSING

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5.2.2.2.4 Navigation Safety Impact

Features of the replacement bridge improve navigation safety by:

- Reducing the number of piers in the water. The alternative reduces the number of piers (obstacles) in the water from nine to a maximum of six.
- Simplifying the decision making process for vessel pilots. Today, vessel operators have three possible routes under the Interstate Bridges (Primary, Barge and Alternate Barge Channels). The route choice is made only after evaluating many factors, including the gross weight and dimensions of his vessel, river water elevation, and river velocity. The proposed fixed span bridge offers one primary navigation channel which (as stated above) meets the clearance envelope needs of nearly all vessels. Navigation safety will be improved by making the vessel pilot's decision on which path to traverse less dependent on the river elevation at the time.
- Eliminating the lift span. Navigation safety is improved by eliminating the dependency on lift span operations and the navigational constraint of lift span restriction periods.
- Realigning the navigation channel. Navigation safety is further enhanced by locating the primary navigation channel in better alignment with the downstream BNSF Railroad Bridge swing span than the Barge and Alternate Barge Channel routes. Relocating the primary navigation channel to reduce the "S" curve path will improve navigation safety.

5.2.3 Supplemental Crossing

A supplemental crossing will be downstream of the existing Interstate Bridges.

5.2.3.1 *Vertical Clearance*

A supplemental bridge maintains the three existing navigation channels. The piers supporting the supplemental bridge's 600 foot spans line up with existing navigation channels. Exhibit 5-4 shows the supplemental alternative's vertical clearances, above CRD, for various channel widths.

Exhibit 5-4. Proposed Supplemental Alignment Columbia River Bridge Clearances

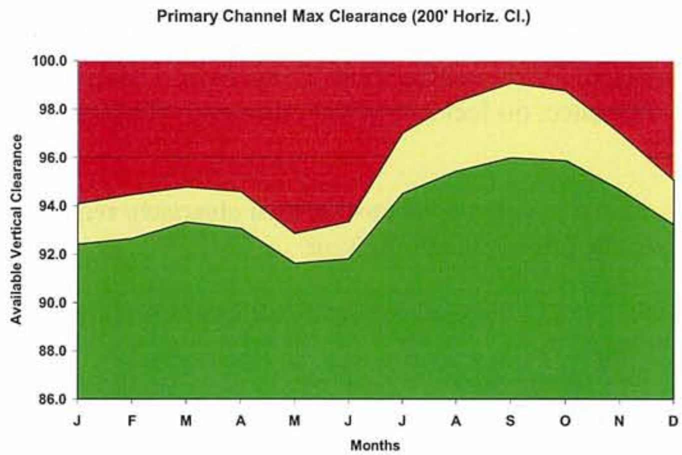
	Navigation Clearances			
Clearance Width	50 feet	100 feet	200 feet	300 feet
Soffit Elevation (CRD)	107 feet	106 feet	100 feet	NA

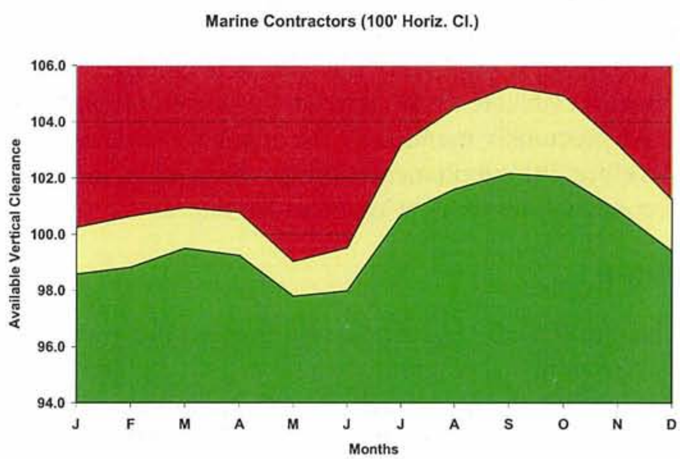
It is important to note that the supplemental alternative appears to have a greater available clearance than the replacement alternatives, even though the supplemental has longer spans. This is slightly misleading. Further investigation has shown that the roadway design of the supplemental alternative is approximately four feet higher than the replacement alternatives.

Potential effects that the bridge soffit elevation has on three vessel groups were evaluated, these groups include: Tugs and Tows (requires 60 feet vertical x 300 feet horizontal clearance envelope), high mast sailboats (requires 88 feet vertical x 50 feet horizontal clearance envelope), and Marine Contractors (requires 110 feet vertical x 100 feet horizontal clearance envelope).

Exhibit 5-5 shows the available vertical clearance through the primary channel, for each of the three vessel groups described above. The green zone represents vertical clearances available at the average maximum water level. The red zones indicate that the clearance is not available and the yellow band indicates the range of what may or may not be available due to variation in water elevation. As indicated in Exhibit 5-5, the maximum horizontal clearance available through the primary channel is approximately 200 feet as, constrained by the existing Interstates Bridges' retrofitted piers, so that was the maximum width investigated for the supplemental alternative. The vertical clearance is dictated by the soffit of the supplemental bridge.

Exhibit 5-5. Proposed Supplemental Alignment Clearances for 200 feet width (top), 100 feet width (center), and 50 feet width (bottom)





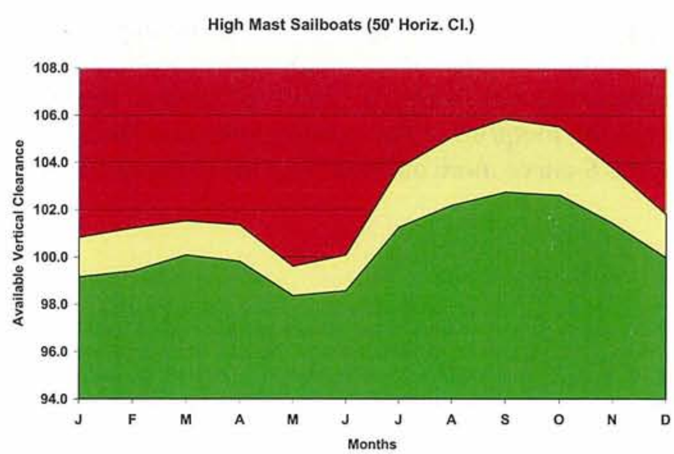


Exhibit 5-5 shows the available vertical clearance for each of the three vessel groups described above. The Green zone represents vertical clearances available at the average maximum water level. From these graphs the following observations were made;

- Tugs and Tows only have an available horizontal width of 200 feet, instead of the 300 feet available for the replacement alternatives. Using the reduced 200 feet horizontal clearance, 60 feet of vertical clearance will be available at all times of year.
- High mast sailboats, with an 88 foot vertical clearance requirement can pass under the bridge during all months of the year.
- Marine Contractors, with a 110 foot vertical clearance requirement cannot pass under the bridge.

5.2.3.2 *Horizontal Clearance*

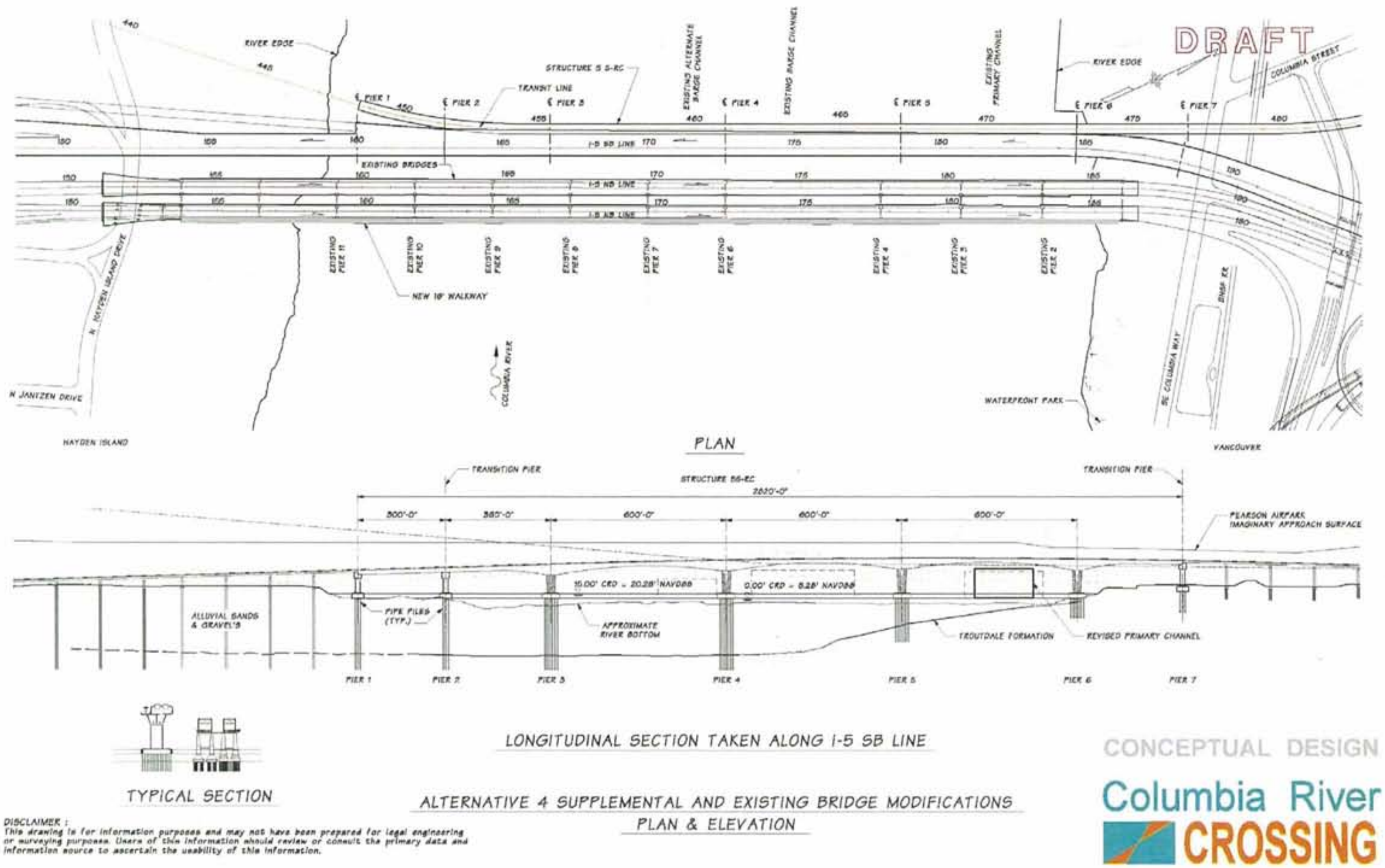
A Supplemental Bridge Alternative provides a span over each of the existing navigation channels. While the spans of the supplemental bridge will be approximately 600 feet, the navigation channels will be constrained by the existing Interstate bridge piers. The existing horizontal clearance available for navigation is 263 feet. The existing horizontal clearance may be further reduced, resulting from the seismic foundation retrofit of the Interstate Bridges. As preciously mentioned, the available horizontal clearance will be about 200 feet. Therefore, the supplemental bridge alternative, including a seismic retrofit will adversely affect navigation on the Columbia River.

5.2.3.3 *Pier Locations*

Testimonials provided to the USCG, expressed a concern that pier locations for a supplemental downstream bridge alignment could negatively affect the already difficult "S" curve maneuver for downbound vessels. As the permitting agency, they have stated that piers for all adjacent new structures must align with the piers on the existing I-5 Interstate Bridges.

The supplemental bridge alternative would continue to use the existing navigation channels (see Exhibit 5-6). Piers for the new supplemental bridge would be placed outside of the existing navigation channels. However, seismic retrofit of the existing bridge would increase the footprint of the existing Interstate Bridges' piers, making navigation through the S-curve more difficult than the existing condition.

Exhibit 5-6. Proposed Supplemental Alternative Pier Locations and Navigation Channels



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5.2.3.4 *Navigation Safety Impact*

Features of the supplemental bridge adversely affect navigation on the Columbia River by:

- Increasing the number of piers in the water. The supplemental bridge's piers would be clear on the existing navigation channel. This alternative will reuse the existing navigation channels, with all associated hazards, plus add piers for the supplemental bridge.
- Seismic retrofit of the existing piers will increase the footprint of the piers and encroach into the existing navigation channels, making navigation worse.
- The lift spans would still be required to use the primary channel and may be increasingly used due to increased difficulty of maneuvering the "S"-curve through narrower navigation channels.

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6. Temporary Effects

6.1 Introduction

The following section discusses likely construction sequences that may minimize adverse effects on navigation on North Portland Harbor and Columbia River during construction.

The discussion below presents a possible range of effects on navigation. Actual construction methods may vary from what is described below, and result in different effects on navigation. The USCG prefers the continuous passage of tugs and tows throughout the construction process. Due to the possibility of alternate construction staging being used, the USCG will separately evaluate construction operations for their effects on navigation.

6.2 Regional and System-wide Impacts

6.2.1 North Portland Harbor

6.2.1.1 *All Alternatives*

It is likely that the bridge will consist of structure type that can clear span over the navigation channel and match or exceed, in height, the existing vertical clearance. Short duration in-water work windows and constructability issues suggest that the new North Portland Harbor Bridge would, most likely, incorporate bridge elements that use prefabricated superstructure elements such as steel girders or precast segmental girders. These types of construction would eliminate the need for extensive supports in the slough. However, some temporary restrictions may be necessary due to barges and cranes used to lift bridge segments into place. Since extensive temporary supports are not likely, the navigation clearance will not be significantly reduced from today's clearance envelope, therefore navigation will not be adversely affected.

6.2.2 Columbia River

6.2.2.1 *Replacement Alternatives*

Replacement bridges over the Columbia River must be constructed in stages because they occupy some of the same area the existing bridge occupies. Over the existing navigation channel, the pier locations for the new bridge will be further apart than the existing bridges. Although vessels will navigate, temporarily, through a longer clearance envelope, it is not anticipated that this will create an adverse impact to navigation or safety levels.

The impact to navigation during the construction of the bridges is also of key interest. Due an anticipated length of construction of several years, it is imperative to accommodate frequent users, such as Tugs and Tows, during construction. The USCG has stated that, if necessary, it may be possible to temporarily restrict infrequent or recreational vessels.

During construction the height and width of the navigation envelope will be reduced. Reductions will be due to construction equipment and pier placement prior to removal of the existing Interstate Bridges. A temporary construction navigation envelope of 75 feet (vertical) by 200 feet (horizontal) may be provided at all times, which meets the vessel clearance needs of the Tugs and Tows. The length of the navigation channel underneath structures will temporarily increase when the new Columbia River Bridge is under construction and the existing Interstate Bridges are still in use. A potential construction staging sequence is presented in Section 9 that maintains the required temporary construction clearance envelope. The replacement bridges do not overlap the existing bridges adjacent piers, enabling the piers of adjacent bridges to be construction together, reducing construction time.

6.2.2.2 *Supplemental Alternative*

Similar to the replacement alternatives, a supplemental alternative will need to be constructed in stages. Navigation channels will be closed for periods of time and will be subject to reductions in available clearance.

Unlike the replacement alternatives, the supplemental alternative will have periods of time when the maximum clearance will not be available to vessels. This will occur when seismic rehabilitation work is being done on the existing bridges. During rehabilitation of foundations adjacent to the lift spans, the lift span towers, and the lift spans themselves, it may not be possible to access or operate the lift spans.

Due to the length of construction and the possibility of significantly reduced clearance because of an inoperable lift span, the supplemental will have greater temporary effects on navigation than the replacement alternatives.

7. Cumulative Effects

7.1 Introduction

Several cumulative effects resulting from the various I-5 CRC alternatives are possible. The following section is a brief presentation of these cumulative effects.

7.2 Cumulative System-wide and Regional Effects

The supplemental alternative has the greatest potential for cumulative effects. Previous discussions have illustrated that the supplemental alternative will adversely affect navigation on the Columbia River. If navigational safety becomes worse, it may prompt the USCG to remove lift restrictions for the existing Interstate Bridges. Removal of the lift restrictions could cause significant congestion and delay to northbound traffic.

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8. Mitigation for Long-Term Effects

8.1 Introduction

Long-term effects vary significantly depending upon the alternative. A replacement alternative will improve navigation conditions and accommodate almost all vessels which use the Columbia River. A supplemental alternative will adversely affect navigation and require mitigation. The section below describes the mitigation required for each alternative.

8.2 Mitigation Common to All Build Alternatives

8.2.1 North Portland Harbor

8.2.1.1 *All Alternatives*

The minimum navigation clearance envelope for any new crossings of North Portland Harbor will match this existing minimum vertical navigation clearance and exceed the existing horizontal clearance. The existing horizontal clearance is 215 feet, the proposed clearance will be approximately 275 feet. Given the proposed clearance, a new bridge over North Portland Harbor will beneficially affect navigation by opening the channel more than the existing condition.

North Portland Harbor bridges may be required to have navigation aids such as vertical clearance gauges, lighting, or other navigation aids, as determined by the USCG.

8.2.2 Columbia River Bridge

8.2.2.1 *Replacement Alternatives*

A Columbia River Bridge replacing the existing Interstate Bridges will reduce the maximum available horizontal clearance through the primary channel from 179 feet to approximately 102 feet using a 50 foot horizontal envelope. The Replacement will provide a minimum 95 foot vertical clearance with a 300 feet wide horizontal envelope. The maximum clearance of the existing bridges with the draw spans in the down position is 40 feet. The proposed clearance will be fixed, not subject to lift restrictions, and accommodate all recreational and commercial vessels. Infrequent trips of marine contractor's cranes will not be accommodated. Their cranes or cargo may be broken down, at a cost, to meet proposed clearances.

Reduced clearances resulting from a replacement bridge will be mitigated by significantly improved navigational safety. The need for pilots to use the "S" curve will be eliminated. The more direct route through the primary channel, where the existing lift span is, will be available for use at all times without restriction.

Replacement Columbia River bridges may be required to have navigation aids such as vertical clearance gauges, lighting, or other navigation aids, as determined by the USCG.

8.2.2.2 *Supplemental Alternatives*

The supplemental alternatives would adversely affect navigation on the Columbia River. Horizontal clearances will be reduced from what currently exists. Furthermore, vessels will have to navigate greater distance under both the Interstate Bridges and supplemental bridge before starting the "S" curve. This will increase the difficulty of the "S" curve maneuver, which may discourage vessels from navigating the "S" curve, and increase use of the lift span. Increased use of the lift span may prompt a repeal of the current lift restrictions to mitigate decreased navigational safety. The USCG has already stated that if navigation conditions were adversely affected as a result of the I-5 CRC project, they may ask for lift restrictions to be removed.

The supplemental and existing Interstate Bridges may be required to have navigation aids such as vertical clearance gauges, lighting, or other navigation aids, as determined by the USCG.

9. Mitigation for Temporary Effects

9.1 Introduction

Mitigation for temporary effects on navigation will be addressed, in large part, by the construction methods and staging. The following sections describe several of many possible construction staging schemes that could be used to construct the bridges while maintaining sufficient clearance to minimize adverse effects on navigation.

9.2 Mitigation Common to All Build Alternatives

9.2.1 North Portland Harbor Bridge

All Alternatives and Alignments have similar temporary effects to navigation on North Portland Harbor.

Construction staging schemes can be devised that minimize adverse effects to navigation on North Portland Harbor. However, construction activities will temporarily reduce available clearances. It will be essential to communicate restrictions or temporary closures of the navigation channel to the surrounding homes and moorages as these are the primary users of North Portland Harbor at this crossing.

9.2.2 Replacement Columbia River Bridge

A construction staging scheme can be developed in which it may be possible to provide a 200 feet wide and 75 feet tall navigation at all times, which meets the vessel clearance needs of the Tugs and Tows.

The construction staging for the replacement alternative generally is as follows:

Phase I - Construct all new Columbia River Bridges (NB, SB, and HCT) to the west of the existing bridges. Exhibit 9-1 illustrates the construction sequence.

Stage 1- Construct Piers 2, 3, 4 for all bridges

- Existing Primary Channel- In service, no navigation encroachment
- Existing Barge Channel – In service, no navigation encroachment
- Existing Alt. Barge Channel- Out of service due to adjacent pier construction

The Alternate Barge Channel is out of service due to the adjacent construction of Pier 4. This may cause some inconvenience, however both existing Primary and Barge Channels are in full service. The impact to vessel navigation is considered minimal.

Stage 2- Construct Piers 6, 7, Spans at Piers 2,3,4,7 for all bridges

- Existing Primary Channel- In service, some navigation encroachment
- Existing Barge Channel – In service, no navigation encroachment

- Existing Alt. Barge Channel- In service, some navigation encroachment

Both the existing Primary and Alternate Barge channels have construction activity overhead and vessels may experience some inconvenience. With the Barge channel in full service, the impact to vessel navigation is considered minimal.

Stage 3- Construct the remainder of the piers and spans: Pier 5, Spans at Piers 5, 6 for all bridges

- Existing Primary Channel- In service, some navigation encroachment
- Existing Barge Channel – Out of service, significant navigation encroachment
- Existing Alt. Barge Channel- In service. Existing piers are in line with new Pier 4, but vessels should be angling away from Pier 4 as they start to align with the BNSF Railroad swing span.

Both the existing Primary and Alternate Barge channels are in service. The existing Primary channel has some overhead construction activity, but it is not anticipated to interrupt service. The construction of Pier 5 eliminates the use of the Barge channel. Vessels that cannot (or choose not to) use the Alternate Barge channel may experience some delays, as the lift span restriction periods are still present.

At the conclusion of Stage 3, all of the Columbia River Bridges are fully constructed.

Phase II - Traffic switched to new bridges, demolish and remove existing bridges.

Stage 4 - Demolition and removal of existing Interstate Bridge piers between new Piers 5 and 6.

- Until the existing piers between the new Piers 5 and 6 are completely removed, the impact to vessel navigation is the same as construction Stage 3.
- Once the existing piers between the new Piers 5 and 6 are removed, the new Primary Channel is in full service and the existing channels can be removed from "official" service.

In summary, the locations of the proposed piers cause no apparent significant adverse impact to the route that vessel pilots must take to traverse this portion of the Columbia River during the construction of the permanent bridges. This is possible because all of the in-water work could be completed at once without complicated staging.

In addition to construction staging, communication of closures and clearance restrictions will users will be critical reduce impacts on users.

Additional tugs may be needed to assist vessels through areas of reduced clearance, especially during times of high water.

9.2.2.1 *Supplemental Alternative*

As discussed previously, this alternative has the greatest potential for temporary construction impacts. The greatest of these impacts will be during the rehabilitation of the lift span and foundation surrounding the lift span. During this time the lift span will not be operable. When the lift span is fixed, the maximum available clearance would be 69 feet, through the existing Barge Channel.

Effective communication with the Columbia River users will be critical to ensure minimal impacts to vessels. Assist tugs may also be required, especially during high water periods, to help vessels safely navigation through the construction zone, around equipment and through areas of reduced clearance.

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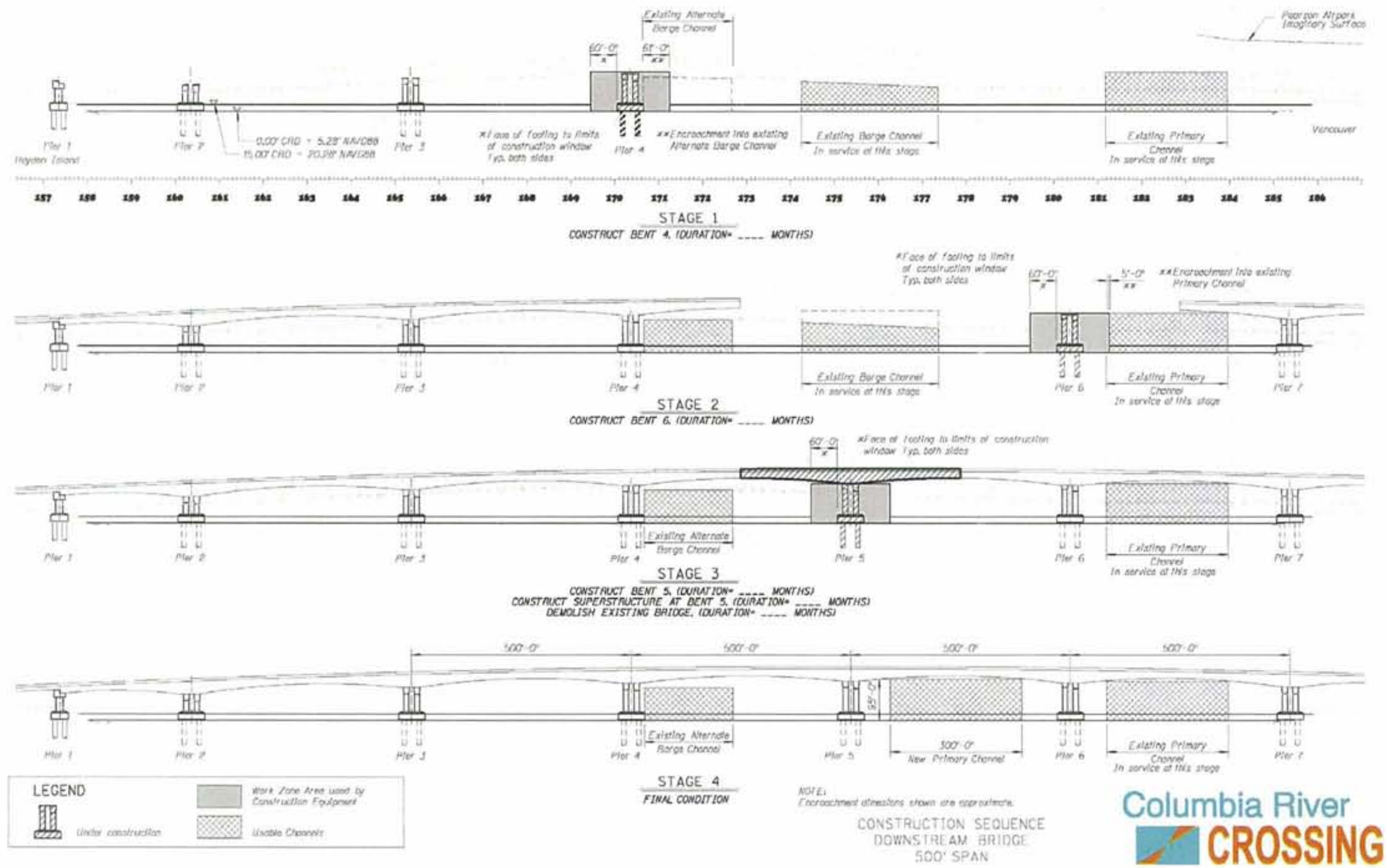
Exhibit 9-1. Proposed Replacement Columbia River Bridge Construction Sequence



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11. Permits and Approvals

11.1 Federal

The Federally Navigable Waterways designation of the Columbia River and North Portland Harbor signifies that all construction or alteration of bridges crossing these waterways must first be approved by the 13th Coast Guard District, Aids to Navigation and Waterway Management Branch, Seattle, WA.

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Columbia River CROSSING

Memorandum

January 14, 2011

TO:	Readers of the CRC Aviation Technical Report
FROM:	CRC Project Team
SUBJECT:	Update to the Aviation Technical Report since the publication of the Draft Environmental Impact Statement (EIS)
COPY:	Project Files

In 2008, the CRC Draft Environmental Impact Statement was published and included in its appendices the Aviation Technical Report and the Aviation Technical Report, Transit in a Box Supplement (TIAB Supplement). Most of the information presented in these Draft EIS Reports is still applicable to and accurate for the alternatives analyzed in the Final EIS. The purpose of this memorandum is to provide a brief update to the Draft EIS Technical Report and TIAB Supplement, highlighting any new information that has been made available since the publication of these reports.

New Information Developed Since the Publication of the Technical Report

The description of alternatives in the Aviation Technical Report has not been updated to incorporate the adoption of the Locally Preferred Alternative (LPA). The following describes the primary transportation improvements included in the LPA:

- The new river crossing over the Columbia River and the I-5 highway improvements, including seven interchanges, north and south of the river.
- 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 changes, and expansion of a light rail transit maintenance facility.
- Bicycle and pedestrian improvements throughout the project corridor.
- A new toll on motorists using the river crossing.
- Transportation demand and system management measures to be implemented with the project.

For a more detailed description of the LPA, please see Chapter 2 of the Final EIS.

Alternatives Analyzed in the Technical Report

The existing bridge lift towers penetrate Pearson Field airspace, causing an obstruction to aviation. The existing bridge truss structures have historically fostered bird populations, creating a hazard to air traffic.

The range of alternatives evaluated in the Aviation Technical Report included No-Build, two supplemental bridge options (Alternatives 4 and 5), and two replacement bridge options (Alternatives 2 and 3). Both river crossing alternatives and capacities would have no known effect on aviation at Portland International Airport.

The No-Build and the supplemental bridge options would adversely affect aviation because the existing bridge lift towers would still penetrate Pearson Field airspace. Keeping the existing bridge and building a supplemental bridge would maintain or increase bird populations compared with the existing conditions.

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The replacement bridge options would improve air navigation due to the removal of the existing bridges and associated lift towers. The removal of the lift towers would decrease the penetration into Pearson Field airspace. Removal of the truss structures would reduce bird nesting areas near the runway. Replacement bridges could be designed to prevent supporting bird populations.

Information Specific to the LPA

The LPA, as adopted, is a refinement of Alternative 3, which includes downstream replacement bridges and light rail. The LPA is expected to beneficially affect aviation due to the removal of the existing bridges. If the existing bridges are removed, the I-5 NB to SR 14 ramp would penetrate Pearson Field's airspace, though it would still be a significant improvement compared to the lift spans on the existing bridges. The other physical components of the LPA--light rail extension, other interchanges, and bicycle and pedestrian improvements—are not expected to have an effect on aviation. The phased construction options and LPA Options A and B would not cause different impacts than those described in the Aviation Technical Report and TIAB Supplement.

Impacts from temporary effects will be similar to that described in the Aviation Technical Report and TIAB Supplement.

Mitigation of long-term and temporary effects will be similar to that described in the Aviation Technical Report and TIAB Supplement.

INTERSTATE 5 COLUMBIA RIVER CROSSING

Aviation Technical Report

Columbia River CROSSING

May 2008

Aviation Technical Report Transit in a Box Supplement

This narrative is a supplement to the Aviation Technical Report. It addresses the Transit in a Box (TIAB) design option's temporary and long-term effects on aviation at Pearson Field and Portland International Airport.

Description of Transit in a Box

In the TIAB design option, I-5 uses the same alignment as the downstream replacement alternative with several modifications. The HCT would be placed inside the box girder of the southbound bridge and a multi-use path would be suspended beneath either the east overhang of the northbound bridge or the west overhang of the southbound bridge, thus eliminating the need for a third HCT/MUP bridge.

In order to accommodate the HCT inside the box girder, some major modifications must be made to the southbound bridge.

- The box girder depth must be increased ten feet from approximately 12.5 feet to 22.5 feet.
- The profile of the southbound highway alignment must be raised five feet to offset some of the increased depth and provide adequate clearance over the BNSF Railroad in Washington.

As with all of the CRC project alternatives, there will be no effects to aviation at Portland International Airport.

Temporary Effects

Temporary effects due to the TIAB design option will be similar to that described in the Aviation Technical Report for the replacement alternatives. The additional five-foot increase in height may slightly increase the height of construction equipment obstructing Pearson Field's obstacle clearance surface (OCS) for westbound departure. However, due to the shorter construction time, the duration of temporary obstructions will also be shorter than the replacement or supplemental alternatives.

As with the replacement alternative described in the Aviation Technical Report, the greatest obstruction would likely be activities associated with the demolition or deconstruction of the existing Interstate Bridge's lift span towers.

Temporary effects from wildlife, dust, emissions, or electronic interference are not anticipated to be significantly different from those described in the Aviation Technical Report for the replacement alternatives.

Long-Term Effects

The southbound alignment is raised five feet in the TIAB design option, when compared to the downstream replacement alternative. The raised alignment will obstruct Pearson Field's OCS for westbound departure to a slightly greater degree than the downstream replacement alternative. It is also important to note that if LRT were selected as the HCT mode, then the TIAB would eliminate the overhead catenary system from the deck. However, as with the replacement alternatives, the greatest obstruction to the OCS for westbound departure will not be a consequence of the bridge type or alignment, but instead result from ramps that comprise the SR-14 interchange.

Long-term effects from wildlife, dust, emissions, or electronic interference are not anticipated to be significantly different from those described in the Aviation Technical Report for the replacement alternatives.

Mitigation of Temporary Effects

Mitigation of temporary effects will be identical to those described in the Aviation Technical Report.

Mitigation of Long-Term Effects

Mitigation of long-term effects associated with permanent construction will be identical to that described in the Aviation Technical Report.

Title VI

The Columbia River Crossing project team ensures full compliance with Title VI of the Civil Rights Act of 1964 by prohibiting discrimination against any person on the basis of race, color, national origin or sex in the provision of benefits and services resulting from its federally assisted programs and activities.

Americans with Disabilities Act (ADA) Information

If you would like copies of this document in an alternative format, please call the Columbia River Crossing project office at (360) 737-2726 or (503) 256-2726. Persons who are deaf or hard of hearing may contact CRC using Telecommunications Relay Service by dialing 7-1-1.

¿Habla usted español? La informacion en esta publicación se puede traducir para usted. Para solicitar los servicios de traducción favor de llamar al (503) 731-3490.

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Cover Sheet

Interstate 5 Columbia River Crossing

Aviation Technical Report:

Submitted By:

Matt Deml

Parsons Brinckerhoff

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ACRONYMS

Acronym	Description
ADA	Americans with Disabilities Act
ADT	Average Daily Traffic
API	Area of Potential Impact
AQMA	Air Quality Management Area
BMP	Best Management Practice
BNSF	Burlington Northern Santa Fe Railroad
BPA	Bonneville Power Administration
BRT	Bus Rapid Transit
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
ft	feet/foot
HUC	Hydrological Unit Code
LRT	Light Rail Transit
NEPA	National Environmental Policy Act
ROW	right-of-way
TDM	Transportation Demand Management
WRD	Oregon Department of Water Resources
WSDOT	Washington State Department of Transportation

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1. Summary

1.1 Introduction

The CRC project is looking at ways to improve the I-5 bridge to benefit the motorists, transit users, cyclists, and pedestrians who depend on it. However, other forms of transportation are also affected by the crossing. Air traffic to and from nearby airports must avoid tall structures such as the bridge lift towers.

When proposing changes to the river crossing, it is important to consider the beneficial or adverse effects to aviation and navigation as well as transportation on the bridge. One goal of the CRC project is to minimize hazards to Columbia River navigation and air navigation from Pearson Field. However, these efforts conflict, as recommended clear heights for river navigation overlap with recommended clear airspace for Pearson Field. Some obstruction of river and air traffic is inevitable, but the project has worked to balance the two interests fairly.

1.2 Description of the Alternatives

The alternatives being considered for the CRC project consist of a diverse range of highway, transit and other transportation choices. Some of these choices – such as the number of traffic lanes across the river – could affect transportation performance and impacts throughout the bridge influence area or beyond. These are referred to as "system-level choices." Other choices – such as whether to run high-capacity transit (HCT) on Washington Street or Washington and Broadway Streets – have little impact beyond the area immediately surrounding that proposed change and no measurable effect on regional impacts or performance. These are called "segment-level choices." This report discusses the impacts from both system- and segment-level choices, as well as "full alternatives." The full alternatives combine system-level and segment-level choices for highway, transit, pedestrian, and bicycle transportation. They are representative examples of how project elements may be combined. Other combinations of specific elements are possible. Analyzing the full alternatives allows us to understand the combined performance and impacts that would result from multimodal improvements spanning the bridge influence area.

Following are brief descriptions of the alternatives being evaluated in this report, which include:

- System-level choices,
- Segment-level choices, and
- Full alternatives.

1.2.1 System-Level Choices

System-level choices have potentially broad influence on the magnitude and type of benefits and impacts produced by this project. These options may influence physical or operational characteristics throughout the project area and can affect transportation and other elements outside the project corridor as well. The system-level choices include:

- River crossing type (replacement or supplemental)
- High-capacity transit mode (bus rapid transit or light rail transit)
- Tolling (no toll, I-5 only, I-5 and I-205, standard toll, higher toll)

This report compares replacement and supplemental river crossing options. A replacement river crossing would remove the existing highway bridge structures across the Columbia River and replace them with three new parallel structures – one for I-5 northbound traffic, another for I-5 southbound traffic, and a third for HCT, bicycles, and pedestrians. A supplemental river crossing would build a new bridge span downstream of the existing I-5 bridge. The new supplemental bridge would carry southbound I-5 traffic and HCT, while the existing I-5 bridge would carry northbound I-5 traffic, bicycles, and pedestrians. The replacement crossing would include three through-lanes and two auxiliary lanes for I-5 traffic in each direction. The supplemental crossing would include three through-lanes and one auxiliary lane in each direction.

Two types of HCT are being considered – bus rapid transit and light rail transit. Both would operate in an exclusive right-of-way through the project area, and are being evaluated for the same alignments and station locations. The HCT mode – LRT or BRT – is evaluated as a system-level choice. Alignment options and station locations are discussed as segment-level choices. BRT would use 60-foot or 80-foot long articulated buses in lanes separated from other traffic. LRT would use one- and two-car trains in an extension of the MAX line that currently ends at the Expo Center in Portland.

Under the efficient operating scenario, LRT trains would run at approximately 7.5 minute headways during the peak periods. BRT would run at headways between 2.5 and 10 minutes depending on the location in the corridor. BRT would need to run at more frequent headways to match the passenger-carrying capacity of the LRT trains. This report also evaluates performance and impacts for an increased operations scenario that would double the number of BRT vehicles or the number of LRT trains during the peak periods.

1.2.2 Segment-Level Choices

1.2.2.1 *Transit Alignments*

The transit alignment choices are organized into three corridor segments. Within each segment the alignment choices can be selected relatively independently of the choices in the other segments. These alignment variations generally do not affect overall system performance but could have important differences in the impacts and benefits that occur in each segment. The three segments are:

- Segment A1 – Delta Park to South Vancouver
- Segment A2 – South Vancouver to Mill Plain District
- Segment B – Mill Plain District to North Vancouver

In Segment A1 there are two general transit alignment options - offset from, or adjacent to, I-5. An offset HCT guideway would place HCT approximately 450 to 650 feet west of I-5 on Hayden Island. An adjacent HCT guideway across Hayden Island would locate HCT immediately west of I-5. The alignment of I-5, and thus the alignment of an adjacent HCT guideway, on Hayden Island would vary slightly depending upon the river crossing and highway alignment, whereas an offset HCT guideway would retain the same station location regardless of the I-5 bridge alignment.

HCT would touch down in downtown Vancouver at Sixth Street and Washington Street with a replacement river crossing. A supplemental crossing would push the touch down location north to Seventh Street. Once in downtown Vancouver, there are two alignment options for HCT – a two-way guideway on Washington Street or a couplet design that would place southbound HCT on Washington Street and northbound HCT on Broadway. Both options would have stations at Seventh Street, 12th Street, and at the Mill Plain Transit Center between 15th and 16th Streets.

From downtown Vancouver, HCT could either continue north on local streets or turn east and then north adjacent to I-5. Continuing north on local streets, HCT could either use a two-way guideway on Broadway or a couplet on Main Street and Broadway. At 29th Street, both of these options would merge to a two-way guideway on Main Street and end at the Lincoln Park and Ride located at the current WSDOT maintenance facility. Once out of downtown Vancouver, transit has two options if connecting to an I-5 alignment: head east on 16th Street and then through a new tunnel under I-5, or head east on McLoughlin Street and then through the existing underpass beneath I-5. With either option HCT would connect with the Clark College Park and Ride on the east side of I-5, then head north along I-5 to about SR 500 where it would cross back over I-5 to end at the Kiggins Bowl Park and Ride.

There is also an option, referred to as the minimum operable segments (MOS), which would end the HCT line at either the Mill Plain station or Clark College. The MOS options provide a lower cost, lower performance alternative in the event that the full-length HCT lines could not be funded in a single phase of construction and financing.

1.2.2.2 *Highway and Bridge Alignments*

This analysis divides the highway and bridge options into two corridor segments, including:

- Segment A – Delta Park to Mill Plain District
- Segment B – Mill Plain District to North Vancouver

Segment A has several independent highway and bridge alignment options. Differences in highway alignment in Segment B are caused by transit alignment, and are not treated as independent options.

There are two options for the replacement crossing – it could be located either upstream or downstream of the existing I-5 bridge. At the SR 14 interchange there are two basic configurations being considered. A traditional configuration would use ramps looping around both sides of the mainline to provide direct connection between I-5 and SR 14. A less traditional design could reduce right-of-way requirements by using a "left loop" that would stack both ramps on the west side of the I-5 mainline.

1.2.3 Full Alternatives

Full alternatives represent combinations of system-level and segment-level options. These alternatives have been assembled to represent the range of possibilities and total impacts at the project and regional level. Packaging different configurations of highway, transit, river crossing, tolling and other improvements into full alternatives allows project staff to evaluate comprehensive traffic and transit performance, environmental impacts and costs.

Exhibit 1-1 summarizes how the options discussed above have been packaged into representative full alternatives.

Exhibit 1-1. Full Alternatives

	Packaged Options				
Full Alternative	River Crossing Type	HCT Mode	Northern Transit Alignment	TDM/TSM Type	Tolling Method[a]
1	Existing	None	N/A	Existing	None
2	Replacement	BRT	I-5	Aggressive	Standard Rate
3	Replacement	LRT	I-5	Aggressive	Two options[b]
4	Supplemental	BRT	Vancouver	Very Aggressive	Higher rate
5	Supplemental	LRT	Vancouver	Very Aggressive	Higher rate

a In addition to different tolling rates, this report evaluates options that would toll only the I-5 river crossing and options that would toll both the I-5 and the I-205 crossings.
b Alternative 3 is evaluated with two different tolling scenarios, tolling and non-tolling.

Modeling software used to assess alternatives' performance does not distinguish between smaller details, such as most segment-level transit alignments. However, the geographic difference between the Vancouver and I-5 transit alignments is significant enough to warrant including this variable in the model. All alternatives include Transportation Demand Management (TDM) and Transportation System Management (TSM) measures designed to improve efficient use of the transportation network and encourage alternative transportation options to commuters such as carpools, flexible work hours, and telecommuting. Alternatives 4 and 5 assume higher funding levels for some of these measures.

Alternative 1: The National Environmental Policy Act (NEPA) requires the evaluation of a No-Build or "No Action" alternative for comparison with the build alternatives. The No-Build analysis includes the same 2030 population and employment projections and the same reasonably foreseeable projects assumed in the build alternatives. It does not include any of the I-5 CRC related improvements. It provides a baseline for comparing the build alternatives, and for understanding what will happen without construction of the I-5 CRC project.

Alternative 2: This alternative would replace the existing I-5 bridge with three new bridge structures downstream of the existing bridge. These new bridge structures would carry Interstate traffic, BRT, bicycles, and pedestrians. There would be three through-lanes and two auxiliary lanes for I-5 traffic in each direction. Transit would include a BRT system that would operate in an exclusive guideway from Kiggins Bowl in Vancouver to the Expo Center station in Portland. Express bus service and local and feeder bus service would increase to serve the added transit capacity. BRT buses would turn around at the existing Expo Station in Portland, where riders could transfer to the MAX Yellow Line.

Alternative 3: This is similar to Alternative 2 except that LRT would be used instead of BRT. This alternative is analyzed both with a toll collected from vehicles crossing the Columbia River on the new I-5 bridge, and with no toll. LRT would use the same transit alignment and station locations. Transit operations, such as headways, would differ, and LRT would connect with the existing MAX Yellow Line without requiring riders to transfer.

Alternative 4: This alternative would retain the existing I-5 bridge structures for northbound Interstate traffic, bicycles, and pedestrians. A new crossing would carry southbound Interstate traffic and BRT. The existing I-5 bridges would be re-striped to provide two lanes on each structure and allow for an outside safety shoulder for disabled vehicles. A new, wider bicycle and pedestrian facility would be cantilevered from the eastern side of the existing northbound (eastern) bridge. A new downstream supplemental bridge would carry four southbound I-5 lanes (three through-lanes and one auxiliary lane) and BRT. BRT buses would turn around at the existing Expo Station in Portland, where riders could transfer to the MAX Yellow Line. Compared to Alternative 2, increased transit service would provide more frequent service. Express bus service and local and feeder bus service would increase to serve the added transit capacity.

Alternative 5: This is similar to Alternative 4 except that LRT would be used instead of BRT. LRT would have the same alignment options, and similar station locations and requirements. LRT service would be more frequent (approximately 3.5 minute headways during the peak period) compared to 7.5 minutes with Alternative 3. LRT would connect with the existing MAX Yellow Line without requiring riders to transfer.

1.3 Long-Term Effects

Long-term effects to aviation were evaluated using a combination of federal regulations and Federal Aviation Administration (FAA) procedures. The following list highlights the regulations used to evaluate long-term effects.

- Federal Aviation Regulation (FAR) 14 Code of Federal Regulations (CFR) Part 77 surfaces – these surfaces, sometimes called the imaginary surfaces, are used to evaluate all obstructions around an airport that may be hazardous to aviation at that facility.
- United States Standard for Terminal Instrument Procedures (TERPS) Obstacle Clearance Surfaces (OCS) – One of the OCS surfaces involves obstacle

clearances for aircraft departing a runway using Instrument Flight Rules (IFR) procedures. This surface, sometimes called the departure surface, is used to determine instrument departure procedures, including calculation of climb gradients and identification of potentially hazardous obstructions.

- One engine operative (OEI) obstacle identification surface – This surface is similar to the OCS departure surface. It is used only at airports that support air carrier operations. For the purposes of the I-5 CRC project this surface only applies to Portland International Airport. The OEI has a shallower, more stringent, slope than the OCS to account for aircraft engine failure at takeoff.

Other criteria used for evaluation of effects to aviation include dust or emissions that may limit visibility, electronic interference to communication and navigation systems, lights or glare that may affect visibility, and fostering of wildlife that may increase the probability of aircraft strikes.

1.3.1 System-wide Effects

The long-term effects to both facilities are summarized below.

Portland International Airport (PDX)

None of the alternatives under consideration by the Columbia River Crossing Project will have long-term effects on aviation activities at PDX. PDX is located approximately three miles southeast of the I-5 CRC project. At the project location, the most critical surface is above the existing interstate bridge tower and any alternative under consideration by the I-5 CRC project.

Pearson Field (VUO)

Aviation operations into and out of Pearson Field will be improved for the replacement alternatives. The degree of improvement is dependent on the associated profile, superstructure section, signing, lighting, and configuration of the SR 14 interchange that the replacement uses. The replacement alternative and bridge types proposed will obstruct the Pearson Field Obstacle Clearance Surface, but to a lesser degree than the existing Interstate Bridges. Long-term effects on aviation at Pearson Field are not necessarily due to the river crossing structure type. The greatest effects, for the structure types and alignments analyzed are due to ramps within the SR 14 interchange.

Neither The alternative nor any proposed bridge types obstruct the Part 77 imaginary surfaces, assuming careful placement of luminaries and sign bridges. This is a benefit over the existing Interstate Bridges, which currently penetrate the Part 77 imaginary surfaces. The replacement alternative, and bridge types make an improvement when compared with existing conditions.

Supplemental alternatives, in which a new bridge would be constructed and the existing interstate bridges would be reused, will adversely affect aviation at Pearson Field. The existing I-5 Interstate Bridges penetrate Pearson's Part 77 imaginary surfaces. Airspace affected by the existing Interstate Bridges will be further restricted by the supplemental bridge used for southbound I-5 traffic. A proposed southbound I-5 structure would not affect the Part 77 surfaces, but it would further constrict the westbound departure OCS.

Perhaps the most significant long-term concern to aviation at Pearson Field will be wildlife hazard management. Large bird populations at the end of the runway increase the probability of an aircraft striking one of the birds.

The existing Interstate Bridges truss structures have historically fostered bird populations, creating a hazard to aviation at Pearson Field. Recently, sound canons have been used to reduce the bird populations on the existing Interstate Bridges. Replacement bridges could be designed to prevent supporting bird populations, thereby reducing the hazard to aviation. Keeping the existing bridge and building a supplemental would maintain or increase bird populations compared with the existing conditions.

Open stormwater ponds holding water for more than 48-hours within the wildlife hazard zone can create bird habitat that, in turn, can lead to an aviation hazard. Such ponds are anticipated within the wildlife hazard zone, but proposed open ponds in and around the SR 14 Interchange are particularly hazardous because they are close to the end of Pearson Field's runway. All alternatives will have similar effects with regard to stormwater ponds.

Dust, emissions, or electronic interference that could affect navigation are not anticipated to change from the existing conditions and will not create hazardous conditions for aviation at Pearson Field. This is anticipated to be true for all alternatives.

1.3.1.1 *River Crossing Alternative and Capacity: How does the Supplemental 8-lane crossing compare to the Replacement 10-lane crossing?*

The supplemental 8-lane crossing will maintain or adversely affect aviation activities at Pearson Field when compared with the No Build alternative. The towers on the existing Interstate Bridge's lift spans will remain the prominent feature obstructing airspace. A supplemental bridge could further constrict Pearson Field's airspace, most notably the airspace above the I-5 interchange with SR 14.

Replacement bridges could beneficially affect aviation at Pearson Field. Removal of the existing Interstate Bridges would eliminate obstructions into the Part 77 surfaces. The replacement bridges would not penetrate the Part 77 surfaces. Therefore, the replacement 10-lane crossing alternative would have a beneficial effect on aviation at Pearson field.

Both river crossing alternatives and capacities would have no known effect on aviation at PDX.

1.3.1.2 *Transit Mode: How does BRT compare to LRT?*

There are no effects, as the overhead catenary system for LRT can fit within the 28.5 ft envelope used in this study.

1.4 Temporary Effects

Temporary effects on aviation will result from construction of new Columbia River Bridges, construction of the SR 14 Interchange, and deconstruction or rehabilitation of the existing Interstate Bridges. All temporary effects will be due to construction equipment extending higher than the proposed Columbia River Bridge and existing Interstate Bridges, especially cranes.

The temporary effects to both airports are summarized below.

1.4.1 Portland International Airport (PDX)

The Columbia River Crossing Project will likely not have any temporary effects on aviation activities at PDX.

1.4.2 Pearson Field (VUO)

Short-term effects will be dependent on techniques and equipment required to construct structures, interchanges, and deconstruct the existing bridge. These effects will be present throughout the anticipated three to six year construction project. Cranes used in deconstruction or rehabilitation of the existing bridges and construction of a replacement or supplemental bridge would likely obstruct the Part 77 imaginary surfaces and westbound departure surface more than the existing condition. Construction of the SR 14 interchange may also penetrate the Part 77 surfaces in addition to the westbound departure surface. Temporary obstructions in the SR 14 interchange area will likely be greater than what currently exists. Stockpiling or surcharging of soil, if required, could also further obstruct aviation surfaces compared with the existing condition.

The duration of the temporary effects may be longer with a supplemental alternative, while the replacement could have shortest duration of temporary effects. The seismic retrofit of the existing Interstate Bridges for a supplemental alternative may require cranes that penetrate the Part 77 surfaces for a longer time than the downstream supplemental alternative.

Construction dust or emissions from construction equipment could pose a short-term hazard to aviation by reducing visibility at the end of runway.

Electronic equipment may also cause interference with radio communications.

Temporary stormwater ponds around the SR 14 interchange construction area may also provide a place for birds to land and congregate increasing the potential for an aircraft strike.

1.5 Mitigation

Since PDX will be unaffected by the I-5 Columbia River Crossing (CRC) project, all of the mitigation measures presented below only apply to Pearson Field.

1.5.1 Mitigation of Long-Term Effects

Form 7460-1 (Appendix A) and supporting documentation must be submitted to the FAA, initiating an aeronautical review of the proposed construction. The FAA will thoroughly review proposed construction and its effects on aviation into and out of Pearson Field and PDX. The outcome of the aeronautical review will be a finding of either "No Hazard to Aviation" or "Hazard to Aviation". The FAA will also determine what obstacle marking is appropriate and where to place the obstacle marking. All proposed construction obstructing FAA surfaces must comply with FAA standards for marking obstructions.

No long-term effects are anticipated from dust, emissions, or electronic interference.

As previously mentioned, open stormwater ponds near the airport can lead to increased bird populations, thus increasing the probability of an aircraft striking a bird. Birds can be discouraged from landing on these ponds by many different methods including placing wire mesh over ponds or planting special vegetation to conceal open water.

1.5.2 Mitigation of Short-Term Effects

Any temporary obstructions by cranes, stockpiles, or other construction related equipment must also submit Form 7460-1 to the FAA, initiating and aeronautical review. This submission is required in addition to the process required for permanent structures. Temporary obstruction markings must also comply with FAA standards. This may include, but is not limited to flagging equipment and placing obstruction-warning lights on equipment as required by the FAA.

Dust on the construction site may be controlled by means of watering or other methods that ensure dust does not rise and create a hazard to aviation. Emissions from construction related equipment must also be controlled so that visibility is not reduced.

Temporary stormwater ponds will likely be used within or near the SR 14 Interchange. Wire mesh or other measures may be taken to prevent birds from landing on temporary stormwater ponds near Pearson Field.

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2. Methods

2.1 Introduction

The purpose of this technical report is to identify potential effects the I-5 CRC project could have on aviation activities and Pearson Field and Portland International Airport. Several alignments, bridge types, and interchange configurations were investigated to determine the worst-case effects on aviation at both airports.

FAA surfaces, described in section 2.3, and any other conditions including dust, emissions, electronic interference, and wildlife that may affect aviation were investigated. Potential mitigation measures, if any reasonable measures exist, are presented for undesirable conditions. This project has assumed that impacts in which the Part 77 surfaces or westbound departure surfaces are further compromised when compared to the existing condition will be considered significant.

2.2 Study Area

The analysis area was limited to the primary Area of Potential Impact (API). Further, it was limited to the portion of the API associated with the Columbia River Bridge and SR 14 Interchange for Pearson Field and from the Marine Drive Interchange to the SR 14 Interchange for PDX. Exhibits 2-1 and 2-2 show the portion of the API used for analysis of I-5 CRC project effects on aviation at Pearson Field and PDX.

Effects on aviation were not sensitive to the mode of high capacity transit used, which is the primary differentiator between the I-5 CRC project transit alternatives defined in Section 1.1. Overhead catenary systems used for LRT can fit within the envelopes used for this analysis, which will be described in a later section. Effects to aviation varied by alternative, alignment, and bridge structure type, but they are not sensitive to the mode of high capacity transit.

One replacement and one supplemental bridge were evaluated. Two general bridge types were evaluated for each of the alignments; bridges with all structure beneath the roadway surface such as a deck-arch or concrete segmental bridge, and an extradosed bridge with structure above the roadway surface. Each of the I-5 CRC project alternatives, in conjunction with the various bridge types, was investigated to determine beneficial and adverse effects on aviation.

Exhibit 2-1. Portion of the API Affecting Aviation at Pearson Field

Exhibit 2-2. Portion of the API Affecting Aviation at PDX

Pearson Field (VUO)

Operations at Pearson Field are comprised primarily of piston engine aircraft. Pearson Field is a B-1 small aircraft (weighing 10,000 lbs or less) general aviation airport. There are no plans for future expansion of Pearson Field's facilities or for larger or different types of aircraft to use the airport. Therefore, analysis was based on the Pearson Field as it currently operates.

Portland International Airport (PDX)

PDX was investigated to determine what conditions will exist in the foreseeable future. Plans at PDX include extension of runway 10R-28L and the addition of a future runway south of 10R-28L. All analysis is based on the currently planned build-out of PDX including the runway extensions and additions.

2.3 Effects Guidelines

The following list contains applicable regulatory procedures and guidelines from the FAA, City of Vancouver, and City of Portland. Below each document is a brief description of applicable portions of the document used for this study.

Advisory Circular (AC) 70/7460-2K Proposed Construction or Alteration of Objects that May Affect Navigable Airspace and FAR 14 CFR Part 77 Imaginary Surfaces

FAR Part 77 is the standard by which obstructions in navigable airspace are determined. Any object that penetrates the Part 77 surfaces may be deemed a hazard to aviation. This document establishes standards for determining obstructions in navigable airspace, sets forth the requirements for notice to the FAA of proposed construction or alteration, provides for aeronautical studies of obstructions to air navigation to determine their effect on the safe and efficient use of airspace, and provides for public hearings on the hazardous effect of proposed construction or alteration on air navigation.

Pearson Field is categorized as a general utility runway, therefore the Part 77 surfaces were constructed using a 20:1 approach slope, starting at the end of runway, with a horizontal surface 150 feet above the Pearson Field NAVD88 elevation of 33.47 ft.

United States Standard for Terminal Instrument Procedures (TERPS) Departure Procedure Construction.

TERPS describes how to construct the departure OCS and outlines how to develop departure procedures and calculate climb gradients when an obstacle penetrates the OCS. The OCS for departures is defined as a 40:1 slope beginning at the end of runway. Any object penetrating this obstacle clearance surface must be evaluated. If the OCS is penetrated, then specific departure procedures can usually be developed for that runway. Such procedures include departure routes and climb gradients. Climb gradients greater than 200 ft/Nautical Mile (NM) need to be noted, and climb gradients greater than 500 ft/NM need special consideration from the Flight Standards Service. Climb gradients and departure procedures are developed by the Flight Standards Service.

AC 150/5300-13 Airport Design

AC 150/5300-13 encompasses all airport design procedures. FAR 14 CFR Part 77 and TERPS are both referenced by this document. Change 10 of this document supplements TERPS, stating that beginning January 1, 2008 any runway supporting air carrier operations will require all objects to be evaluated using a one-engine inoperative (OEI) obstacle identification surface defined by a 62.5:1 slope extending from the departure end of runway (DER). This slope allows for commercial aircraft engine failure during departure. Pearson Field does not support air carriers and therefore the OEI obstacle identification surface is not applicable. However, effects on PDX were evaluated using this more stringent criterion.

AC 150/5200-33A Hazardous Wildlife Attractants on or Near Airports

Creating features or habitat which foster birds or other wildlife populations may create a hazard for aviation, increasing the likelihood that aircraft will strike wildlife. This advisory circular establishes a zone, 5,000' from the centerline and runway ends, in which hazardous wildlife attractant should be mitigated, identifies land uses that could promote wildlife populations, and suggests possible mitigation measures for some wildlife attractants. The hazardous wildlife exclusion zone is shown in Exhibit 2-3. It shows that the wildlife exclusion zone is large, extending well beyond the limits of the I-5 CRC project. The areas of primary interest for this project are the bridges and the area in and around the I-5 and SR 14 interchange. These areas are especially sensitive because they are so close to the end of Pearson Field's runway.

Exhibit 2-3. Pearson Field Hazardous Wildlife Exclusion Zone

7284

City of Portland Code (CPC). 2002. "Aircraft Landing Zone." CPC 33.400, as amended. Portland, OR.

The City of Portland restricts the allowable height of structures and vegetation within the FAR Part 77 imaginary surfaces established by the FAA for Portland International Airport. These surfaces define where aircraft generally approach and depart the airport. Exceptions to these restrictions may be approved by the FAA in consultation with the Port of Portland.

City of Vancouver – Vancouver Municipal Code (VMC). 2002. "Vision & Airport Height Overlay District". VMC 20.560, as amended. Vancouver, WA.

The City of Vancouver prohibits development within the Vision & Airport Height Overlay District that could interfere with aircraft operations at Pearson Field. This includes structures that produce light and glare and vertical intrusions into aircraft flight paths.

2.4 Analysis Methods

Potential cumulative effects from this project are evaluated in the Cumulative Effects Technical Report. Please refer to this for an evaluation of possible cumulative effects.

The analysis done for this report and values obtained should not be used for aviation purposes. Values presented in this report are used for comparison and discussion of the CRC project alternatives only. Values presented are not the result of a formal FAA aeronautical study and are not intended to replace the formal FAA Form 7460-1 process.

Profiles and sections of the CRC alternatives were created showing the westbound departure surface and Part 77 imaginary surfaces from both Pearson Field and PDX. FAA AC 70/7460-2K requires that a minimum 17 ft envelope above the roadway surface be created to account for vehicle height. However, other fixed objects such as signs, sign bridges, and luminaries must be accounted for. The envelope used for this analysis was constructed using the required WSDOT bridge clearance of 16.5 ft and adding an additional 12 ft to account for other fixed objects above the 17 ft envelope required for traffic. This results in a design envelope height of 28.5 ft. While this is more stringent than what is required by the FAA, it more accurately represents anticipated conditions on the Columbia River Bridge and SR 14 Interchange.

The 28.5 ft envelope was superimposed onto the section and profiles for all alternatives. In any place where the westbound departure surface was penetrated by the envelope, a climb gradient was calculated from the high point to the end of runway in accordance with procedures defined in TERPS. The maximum climb gradient was reported for each alignment or feature that penetrated the westbound departure surface. If an object or envelope obstructs the Part 77 surfaces, the point and penetration height was recorded.

A review of likely structure types, surface features, and drainage systems was conducted to identify any potential environments that may foster birds or other wildlife. Possible construction methods and staging were investigated for any short-term effects on aviation.

2.4.1 Pearson Field

A preliminary aeronautical study was performed on three alternatives by the FAA in which they stated that the existing departure gradient is 650 ft/NM. If the existing Interstate Bridges were removed, the controlling gradient would be 269 ft/NM due to existing transmission towers on the west end of Hayden Island. If the existing I-5 bridges are removed, the transmission towers on Hayden Island will be the controlling feature. In order for the any CRC project bridges or features not to be a controlling feature, the climb gradient to any new features must be below 269 ft/NM.

2.4.2 Portland International Airport

The OEI obstacle identification surface used for analysis was derived using the extended runway 10R-28L and the future runway. An OEI obstacle identification surface was constructed using a 62.5:1 slope from the end of each runway, in accordance with FAA AC 150/5300-13. The OEI is the lowest, most critical surface from PDX in the API. If there is no penetration of this surface by the CRC project, then the Part 77 surface will also not be affected.

3. Coordination

Several meetings were held with CRC project staff, FAA, Pearson Field Airport Manager, Vancouver Aviation Advisory Committee, and WSDOT Aviation Division to introduce CRC project concepts, identify concerns and conduct a preliminary review of some conceptual level alternatives. These meeting were held on November 7, 2005, December 9, 2005, and a teleconference on July 25, 2006. The subject of these meetings centered on discussion of applicable standards and general discussion of what options and what concept would be more or less likely to constitute a hazard to aviation.

In a meeting May 8, 2007 meeting with the FAA, the question was asked, "how high can the structure go?" The FAA stated that they would not say how high. They reaffirmed FAA procedure in stating that once a proposal is submitted the FAA aeronautical review will issue a finding of "hazard to aviation" or "no hazard to aviation". The FAA also stated that they would prefer not to have decorative features above the deck; they prefer open space above the deck. They also noted that it is ultimately up to the community to determine the preferable mode of transportation and service to Pearson may be affected if proposed improvements are not safe for aviation. The FAA noted that the project needs to consider crane heights during construction.

Once a locally preferred alternative (LPA) is identified, FAA Form 7460 can be submitted to the FAA. This form initiates the formal FAA aeronautical review process. FAA will review proposed construction and how it affects the Part 77 imaginary surface. After a period of public comment and communication with stakeholders, FAA will issue either a determination of "no hazard to aviation" or "hazard to aviation". These determinations are not a rejection or approval of the project. FAA may also require obstructions to be marked.

FAA will also conduct a review of the 40:1 westbound departure surface for Pearson Field and the 62.5:1 OIS for PDX. Flight rules can then be adjusted to address air navigation concerns for changes including removal of the existing bridges and new obstacles created by the I-5 CRC project.

At the May 8, 2007 meeting, the FAA agreed to perform another conceptual review of CRC alternatives. The I-5 CRC project will submit conceptual plans to the FAA in August 2007. Future meetings will discuss the findings of this second round of preliminary reviews.

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4. Affected Environment

4.1 Introduction

The I-5 CRC project has the potential to affect aviation activities at Portland International Airport and Pearson Field. The following section provides a brief description of the existing conditions at both facilities.

4.2 Regional Conditions

4.2.1 Pearson Field

The lift span tower on the existing Interstate Bridges currently penetrate 98 ft into the Part 77 imaginary surface 20:1 slope and 70 ft above the horizontal surface.

A preliminary aeronautical study was performed by the FAA in which they determined that the existing departure gradient is 650 ft/NM due to the lift-span towers on the existing Interstate Bridges. If the existing Interstate Bridges were removed, the controlling gradient would be 269 ft/NM due to existing transmission towers on the west end of Hayden Island.

The Land Bridge is currently under construction. Crossing over SR 14 at the end of the Pearson Field runway, the Land Bridge is a pedestrian structure that will connect Historic Fort Vancouver to the Columbia River waterfront. This structure does not penetrate the Part 77 imaginary surface, but the structure does penetrate Pearson Field's westbound departure surface.

4.2.2 Portland International Airport

Both the Part 77 imaginary surface and 62.5:1 OEI obstacle identification surface are unaffected by any existing feature within the API.

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5. Long-Term Effects

The aviation related areas affected by the CRC project are Pearson Field and PDX. Long-term effects for each of those areas are presented below.

5.1 Regional and System-wide Impacts

5.1.1 No Build

Pearson Field would continue to use the current arrival and departure procedures in the No-Build Alternative. The lift span towers of the existing Interstate Bridges have historically been an aviation hazard. Therefore, the "No-Build" alternative would neither beneficially nor adversely affect aviation now and for the near future. The status quo of the historical hazard to aviation would be maintained.

The existing Interstate Bridges do not affect aviation at PDX. Therefore, the No-Build Alternative would not affect aviation at PDX.

5.1.2 Replacement Crossing

5.1.2.1 *Pearson Field*

Exhibit 5-1 summarizes how a replacement bridge would affect Pearson Field's aviation surfaces. If an obstruction into the FAR 14 CFR Part 77 imaginary surfaces were identified, then the depth of the penetration was identified along with what object is causing the obstruction. Likewise, if the westbound departure OCS is obstructed then a new climb gradient to the obstruction is calculated and the object causing the obstruction is identified.

Exhibit 5-1. Long-Term Effects on Pearson Field Aviation Surfaces

	Replacement Alignment	
Aviation Surface	**Concrete Segmental or Arch**	**Extradosed**
FAR 14 CFR Part 77 Imaginary Surfaces	No obstructions identified	No obstructions identified
TERPS Obstacle Clearance Surface (OCS) for westbound departure procedure	275 ft/NM climb gradient due to 28.5 ft tall envelope on I-5 NB to C St. ramp[1]	275 ft/NM climb gradient due to 28.5 ft tall envelope on I-5 NB to C St. ramp[1]

1 – Obstruction or climb gradient not dependent on bridge structure type.

5.1.2.2 *Columbia River Bridge*

The goal of the proposed alignments and structures is to minimize effects to both Columbia River navigation and air navigation from Pearson Field. However, the river navigation envelope for the Columbia River and the westbound departure OCS for

Pearson Field overlap. In order to maintain equity between the two interests, portions of both the maritime and aviation envelopes were used for the bridge and roadway. Therefore, obstruction of the westbound departure OCS is unavoidable by any bridge type or alignment alternative. All proposed I-5 CRC project replacement will penetrate the Pearson Field westbound departure OCS.

While obstruction of the westbound departure OCS is inevitable, analysis has shown that it is possible to avoid penetrating the Part 77 imaginary surfaces. Exhibit 5-2 shows clearances from the roadway deck of 55 ft and 54 ft for the replacement. These clearances represent alignments constructed using a concrete segmental or arch bridge. An extradosed bridge would allow the deck to be lowered approximately ten feet because it has a shallower superstructure depth for the same span. This would allow 64 ft of clearance available for the replacement structures. These clearances can accommodate the estimated 60 ft tall extradosed towers. See Exhibit 5-2.

It is important to note that cables used above the roadway surface on the extradosed structure type are a potential aviation hazard. Cables may not be easily seen be pilots, creating an "invisible wall". This hazard is only present on the extradosed structure type.

The concrete segmental or arch bridge has less impact than the extradosed bridge type and all replacement bridge alternatives under consideration have less impact than the No-Build condition.

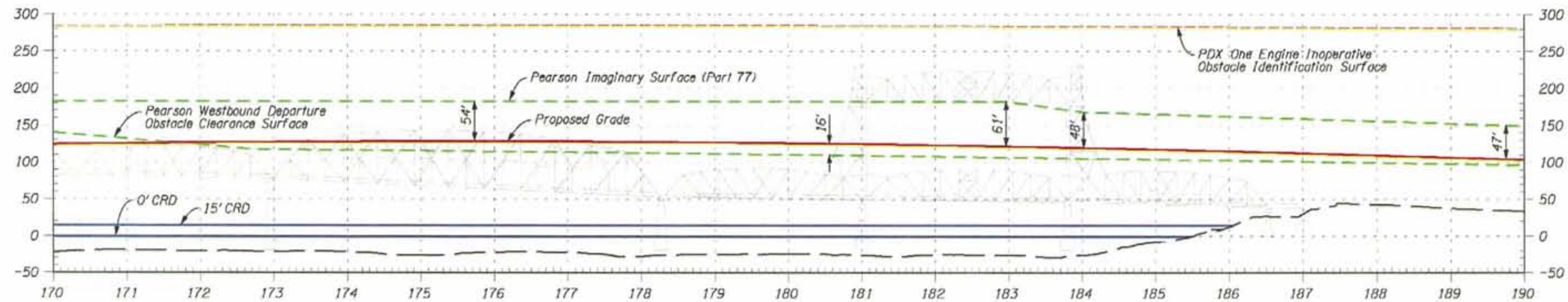
5.1.2.3 *SR 14 Interchange*

If sign bridges and luminaries are excluded from the obstructed areas, then the 16.5 ft FAA required vehicle envelope would not penetrate the Part 77 surfaces.

SR 14 ramps transitioning to and from the I-5 mainlines structure penetrated the westbound departure OCS. This is due, in part, because all ramps must maintain clearance over the BNSF railroad lines before beginning their decent. The most stringent climb gradient from Pearson Field due to the replacement alternative is 275 ft/NM resulting from the I-5 NB to SR 14 ramp. Both of the I-5 CRC project alignments would be a significant improvement over the 650 ft/NM climb gradient due the lift towers of the existing Interstate Bridges. However, the climb gradients to features in the replacement alternative would be the controlling climb gradient. Both gradients will exceed the 269 ft/NM resulting from existing transmission towers on Hayden Island.

PRELIMINARY

Exhibit 5-2. Clearances from Roadway to Aviation Surfaces for the Replacement Alternative.



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5.1.2.4 *Wildlife*

Wildlife in and around airports is a hazard to aviation. In fact, wildlife hazards may be the most significant long-term concern to aviation at Pearson Field. Aircraft striking wildlife can cause significant damage to an airplane and even loss of life. The I-5 CRC project may create habitat that attracts birds near Pearson Field, increasing the probability of a wildlife strike. The open truss framing of the existing Interstate Bridges have historically fostered bird roosting and nesting. Recently, ODOT has been using sound cannons to reduce the numbers of birds on the structures. All structure types currently under consideration will reduce the areas on which birds can land and roost when compared to the existing Interstate Bridges.

Stormwater ponds are likely within or near the SR 14 Interchange. Open water has the potential for attracting birds and thereby increasing the likelihood of an aircraft strike. Exhibit 2-3 shows the hazardous wildlife exclusion zone for Pearson Field as defined by FAA AC 150/5200-33A. All I-5 CRC stormwater ponds within the hazardous wildlife exclusion zone must be addressed, but those near the SR 14 Interchange are close to the Pearson Field runway and have the potential for creating the greatest aviation hazard.

5.1.2.5 *Other Aspects Affecting Aviation*

Long-term emissions, dust, or electronic interference resulting from the CRC project is not expected in affect aviation.

5.1.2.6 *Portland International Airport*

Neither of the replacement alternatives will have long-term effects on aviation activities at PDX. PDX is located approximately three miles southeast of the I-5 CRC project. At the project location, the critical OEI obstacle identification surface is approximately at elevation 275 ft. The elevation of the top of the existing Interstate Bridge lift span towers are approximately 240 ft. Since the replacement alternatives are shorter than the existing Interstate Bridges, they will have no long-term effects on aviation at PDX.

5.1.3 Supplemental Crossing

5.1.3.1 *Pearson Field*

Exhibit 5-4 summarizes how a supplemental bridge would affect Pearson Field's aviation surfaces. If an obstruction into the FAR 14 CFR Part 77 imaginary surfaces was identified, then the depth of the penetration was identified along with what object is causing the obstruction. Likewise, if the westbound departure OCS is obstructed then a new climb gradient to the obstruction is calculated and the object causing the obstruction is identified.

Exhibit 5-3. Long-Term Effects on Pearson Field Aviation Surfaces

	Supplemental Alternative	
Aviation Surface	**Concrete Segmental**	**Existing Interstate Bridges**
FAR 14 CFR Part 77 Imaginary Surfaces	No obstructions identified	Lift span towers penetrate 67 ft into surface
TERPS Obstacle Clearance Surface (OCS) for westbound departure procedure	280 ft/NM climb gradient due to 28.5 ft tall envelope on I-5 NB to C St. ramp[1]	650 ft/NM climb gradient due to existing lift span tower

1 – Obstruction or climb gradient not dependent on bridge structure type.

5.1.3.2 *Columbia River Bridge*

As previously mentioned, the alignments were developed to minimize adverse effects to both the navigation and aviation surface. Similar to the replacement bridge alternative the supplemental bridge will penetrate the Pearson Field OCS. However, the existing I-5 Interstate bridges will remain a greater obstruction into the westbound departure OCS and obstruct the Pearson Field's Part 77 surfaces.

Exhibit 5-5 shows a 55 ft clearance from the roadway deck of the supplemental bridge. This clearance is based on the deck elevation of a concrete segmental bridge. (The 600 ft span is required for navigation purposes in a supplemental scenario.) This would allow 36 ft of clearance available above the supplemental structure's deck.

Analysis has shown that it is possible to construct a supplemental bridge that does not penetrate the Part 77 imaginary surfaces. While a supplemental bridge does not penetrate the Part 77 imaginary surfaces, the existing I-5 Interstate Bridges penetrates 67 ft into the Part 77 imaginary surfaces.

Retaining the existing I-5 Interstate Bridges and constructing a supplemental bridge would further restrict an already congested area for aviation. In addition to the existing Part 77 surfaces' penetrations from the existing Interstate Bridges, the supplemental bridge would further restrict the airspace above the SR 14 interchange.

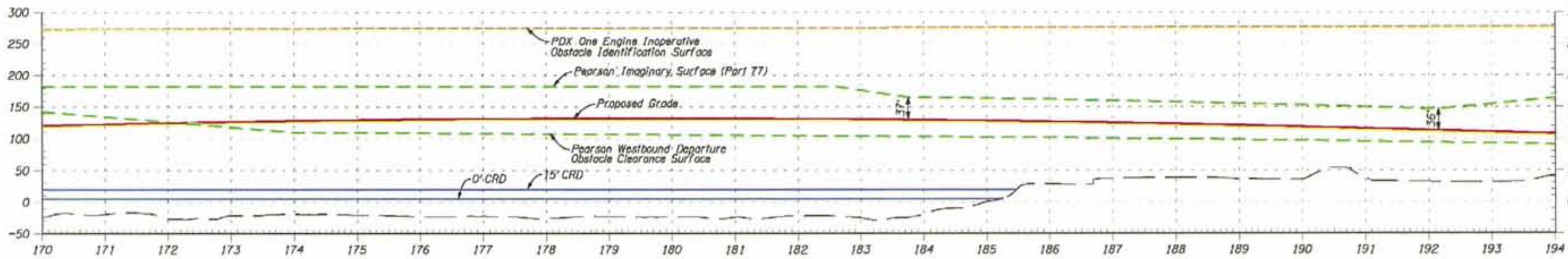
The supplemental bridge option adversely affects aviation, creating a situation worse than both the "No-Build" and replacement alternatives.

5.1.3.3 *SR 14 Interchange*

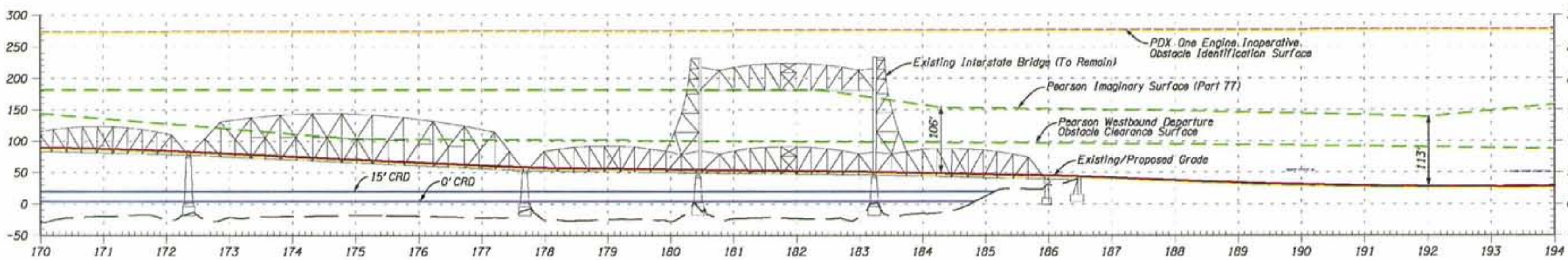
None of the ramps in the SR 14 interchange penetrate Pearson Field's Part 77 surfaces.

Overall, the supplemental alternative has a greater adverse effect on aviation at Pearson Field when compared to either of the replacement alternatives.

Exhibit 5-4. Supplemental Alternative Profiles



(a) I-5 SB Supplemental Bridge Profile



(b) I-5 NB Interstate Bridge Profile, Reused in Supplemental Alternative

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5.1.3.4 *Wildlife*

Wildlife in and around airports is a hazard to aviation. Aircraft striking wildlife can cause significant damage to an airplane and even loss of life. The I-5 CRC project may create habitat that attracts birds near Pearson Field, increasing the probability of a wildlife strike. The open truss framing of the existing Interstate Bridges have historically fostered bird roosting and nesting. Recently, ODOT has been using sound cannons to reduce the numbers of birds on the structures. Since the supplemental option will retain the existing Interstate Bridges in addition to constructing a supplemental, the available areas for birds to roost will be increased over both the No-Build and the replacement alternatives.

Stormwater ponds are likely within or near the SR 14 Interchange. Open water has the potential for attracting birds. Exhibit 2-3 shows the hazardous wildlife exclusion zone for Pearson Field as defined by FAA AC 150/5200-33A. All I-5 CRC stormwater ponds within the hazardous wildlife exclusion zone must be addressed, but stormwater ponds near the SR 14 Interchange are close to the Pearson Field runway and have the potential for creating the greatest aviation hazard. Potential wildlife hazards resulting from the supplemental alternative will be similar to hazards from the replacement alternative.

5.1.3.5 *Other Aspects Affecting Aviation*

As with the replacement alternatives, there will be no long-term emissions, dust, or electronic interference affecting aviation, resulting from the supplemental alternative.

5.1.3.6 *Portland International Airport*

The supplemental alternative will not have any long-term effects on aviation activities at PDX. PDX is located approximately three miles southeast of the I-5 CRC project. At the project location, the critical OEI obstacle identification surface is approximately at elevation 275 ft. The elevation of the top of the existing Interstate Bridge lift span towers are approximately 240 ft. Since the highest point in the supplemental alternative will continue to be the Interstate Bridges, the alternative will have no long-term effects on aviation at PDX.

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6. Temporary Effects

6.1 Introduction

The aviation related areas affected by the I-5 CRC project are Pearson Field and PDX. The temporary effects for each of those areas with regard to each alternative are presented below.

Temporary effects will be due to cranes and other construction equipment, temporary facilities, and construction methods. The degree to which aviation will be affected depends on the bridge type and construction methods employed for that bridge type. The following sections are a summary of some of the potential temporary effects.

6.2 Regional and System-wide Impacts

6.3 Pearson Field

6.3.1 Impacts Common to All Alternatives

Temporary effects on aviation due to a replacement bridge will depend, in large part, on techniques and equipment required to construct proposed structures, interchanges and deconstruct the existing bridges. The greatest effect could result from methods used to deconstruct or rehabilitate the existing Interstate Bridges' towers. The equipment required for these activities would likely be the tallest required for the I-5 CRC project. Cranes used for work on the existing Interstate Bridges would need to be taller than those towers, and would temporarily affect the Pearson surfaces greater than the existing condition. The actual degree of additional intrusion into the Part 77 surfaces and westbound departure OCS will depend on the actual deconstruction or rehabilitation methods used and associated crane(s).

Construction of the SR 14 will also penetrate the Part 77 surfaces and westbound departure OCS. Temporary storage of fill, cranes, or other construction related materials and equipment might also temporarily pierce the aviation surfaces. As with Columbia River Bridge construction, the actual degree of penetration will depend on the equipment and construction methods used. Short-term obstructions in the SR 14 interchange area could be significantly greater than what currently exists.

Construction dust or emissions from construction equipment could pose a short-term hazard to aviation by reducing visibility at the end of runway. Dust could result from wind disturbing uncovered fills or open excavations. Unimproved construction roads could also stir up dust, impairing visibility.

Electronic interference with aviation related instruments and communications is not anticipated as a result of the CRC project.

Temporary stormwater ponds that fall within the limits of the hazardous wildlife exclusion zone, especially near the SR 14 interchange, may provide a place for birds to land and congregate increasing the potential for aircraft to strike a bird.

6.3.2 Impacts Unique to River Crossing Alternatives

Temporary effects on aviation due to a supplemental bridge will be similar to what was described for a replacement bridge, except the duration of the obstruction will be longer. The increase in duration will be due to seismic rehabilitation and retrofit of the existing Interstate Bridges, which might require taller cranes for longer periods when compared to a downstream replacement alternative.

6.4 Portland International Airport

Construction activities are not anticipated to affect the aviation surfaces at PDX. At the project location, the critical OEI obstacle identification surface is approximately at elevation 275 ft. The elevation of the top of the existing Interstate Bridge lift span towers is approximately 240 ft, leaving approximately 35 ft above the towers available for cranes. Cranes used for deconstruction or rehabilitation of the Interstate Bridges will likely fit within this 35 ft clearance and have little or no obstruction of the OEI obstacle identification surface.

It is important to note that the PDX Part 77 surface is at approximately 380 ft in the vicinity of the Interstate Bridges' lifts pan towers. This leaves approximately 140 ft between the top of the lift span towers and the PDX Part 77 surface. Therefore, the I-5 CRC project will not affect the PDX Part 77 surfaces.

All potential construction related effects will be evaluated by the FAA upon submission of Form 7460-1 for construction activities.

7. Mitigation for Long-Term Effects

7.1 Introduction

Long-term effects resulting from the mid-level replacement bridge options improve conditions for aviation at Pearson Field. The supplemental alternative will have adverse long-term effects on aviation at Pearson Field. Effects from all alternatives, whether beneficial for adverse, will require FAA review.

Mitigation measures for each of the I-5 CRC project alternatives are presented below.

7.2 Mitigation Common to All Build Alternatives

Many of the long-term effect are similar among all of the I-5 CRC alternatives. Furthermore, the mitigation for these effects will also be similar.

All I-5 CRC project replacement alternatives obstruct the westbound departure OCS. Preliminary climb gradients previously listed show the final long-term conditions will be improved over "No-Build" condition. New construction and removal of the existing Interstate Bridges will result in a review of the departure procedures from Pearson Field. The FAA may issue new approach and departure procedures for Pearson Field.

The towers of the existing Interstate Bridges in the supplemental alternative penetrate the Part 77 imaginary surfaces. The replacement bridge does not penetrate the Part 77 surfaces. For all cases, the FAA will conduct an aeronautical review upon submission of FAA Form 7460-1. The FAA will issue a finding of "hazard to aviation" or "no hazard to aviation" upon completion of the aeronautical review. In addition, the FAA will have requirements for marking obstacles, this will likely include marking according to FAA AC 70/7460-1K "Obstruction Marking and Lighting" using equipment specified in AC 150/5345-43E "Specification for Obstruction Lighting Equipment". The FAA encourages sponsors to be familiar with the various types of marking systems available and suggest what type of system they would prefer.

Proposed roadway or accent lighting on the bridge and surrounding interchanges should be designed to limit light or glare that could affect aviation at Pearson field or PDX. If an extradosed structure were to be used, special attention would be needed for lighting and marking cables, making them easily visible to pilots. If the mode of HCT chosen requires the use of overhead catenary cables, then these cables may be designed to be shorter than surrounding luminaries, or otherwise accented to make them visible to pilots.

No long-term dust, emissions, or electronic interference associated with the project are anticipated beyond what is already present. Disturbed soils will be re-seeded upon completion of construction and appropriate dust control measures taken. Otherwise, no mitigation measures will be necessary for emissions or electronic interference.

Permanent stormwater ponds will likely be incorporated into the SR 14 interchange. In order to prevent birds from congregating on the open water of a pond several mitigation measures are available. Mitigation measures could include placing wire mesh over the water to prevent birds from landing, or using selective plantings within ponds to conceal open water when they are full.

Proposed structures and features of the project will incorporate designs that minimize locations for birds to roost or nest, resulting in an improvement over the "No-Build" condition. This is expected to have no effect or slightly decrease bird populations, near Pearson Field, compared to the No Build option.

8. Mitigation for Temporary Effects

8.1 Introduction

Temporary effects will result from deconstruction or rehabilitation and construction activities in the area of the Columbia River Bridge and the SR 14 Interchange. Mitigation of temporary hazards to aviation will be required in these areas only.

8.2 Mitigation Common to All Build Alternatives

All construction activities must adhere to FAA Advisory Circular AC 70/7460-1 "Obstruction Marking and Lighting". FAA From 7460-1 must be submitted to the FAA for all cranes or other construction related equipment that will potentially penetrate the Part 77 imaginary surfaces. Submission of Form 7460-1 will initiate an aeronautical review of the proposed temporary effects construction equipment and activates will have on aviation at Pearson Field. The aeronautical review will take approximately 90 days. The result of the study will be a finding of "hazard to aviation" or "no hazard to aviation" due to the proposed activities. In addition, the FAA will identify requirements for marking obstructions.

The Form 7460-1 process described above is in addition the Form 7460-1 procedure required for permanent structures, as will be discussed in Section 9.

Aviation at Pearson Field will be temporarily affected by all I-5 CRC project alternatives. The primary difference between the alternatives will be the duration of the temporary effects. Temporary effects will likely last longer for the supplemental alternatives. Therefore, the replacement alternative will likely have the shortest duration of temporary obstructions to aviation.

Construction in the SR 14 area has the potential to stir up dust that may impair visibility. Dust control measures such as watering exposed soil and using gravel surfacing on temporary construction roads can effectively mitigate dust.

Any electronic devices communication related or otherwise cannot interfere with equipment required for air navigation and communication.

Temporary stormwater ponds may be used during construction. Wire mesh or other deterrents may be placed over the top of stormwater ponds to prevent birds from landing on open water.

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10. Permits and Approvals

10.1 Federal

FAA From 7460-1 Notice of Proposed Construction or Alteration (See Appendix A)

Notice must be filed as early as possible in the planning stage but no less than 90 days before construction will begin. FAA will not issue a determination for conceptual plans.

The FAA will acknowledge receipt. FAA will likely initiate an aeronautical study, during which comment will be received from agencies, organizations, or others with known aeronautical interests.

FAA will issue a determination of either "Hazard to Air Navigation" or "No Hazard to Air Navigation". The determination is not an approval or disapproval of the project. The determination is based on the projected impact of the project on safe and efficient use of navigable airspace. FAA usually recommends marking for any obstruction that is greater than 200 ft above ground level or penetrated the Part 77 surface.

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Columbia River CROSSING

Memorandum

January 14, 2011

TO: Readers of the CRC Electromagnetic Fields (EMF) Technical Report

FROM: CRC Project Team

SUBJECT: Update to the EMF Technical Report since the publication of the Draft Environmental Impact Statement (EIS)

COPY: Project Files

Most of the information presented in the Draft EIS CRC Electromagnetic Fields Technical Report (EMF Technical Report) produced for the Draft EIS is still pertinent to the alternatives analyzed in the Final EIS. The purpose of this memorandum is to provide a brief update to the Draft EIS Technical Report, highlighting any new information that has been made available since the publication of the Draft EIS. Additionally, this memorandum summarizes the main points of the Draft EIS Technical Report so that the reader does not have to refer to the report unless more detail is desired.

Introduction

Electromagnetic fields (EMF) are radiated energy that is produced by many natural and human-made sources. Natural sources produce an ambient level of EMF of approximately 500 milligauss (mG). Human-made sources, such as cell phones, microwaves, and light rail transit systems also produce EMF. Both electric and magnetic field strength decrease with distance from the source. Electric fields are greatly reduced by walls and objects. However, magnetic fields can pass through objects, so it is magnetic fields which are generally the radiation of concern when evaluating EMF. There has been concern in the general public on the effects of exposure to EMF. However, studies in the health and medical community have proven inconclusive on the effects of EMF on human health.

Regulation

While there are no federal laws that limit exposure to EMF, two organizations have developed voluntary occupational guidelines. The organizations, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the American Conference of Governmental Industrial Hygienists (ACGIH), set guidelines for exposure which are outlined in the EMF Technical Report. The ICNIRP guideline for the general public is 833mG for exposure to magnetic fields and 4.2 kV/m for exposure to electric fields. Washington State has no standards related to EMF exposure. Oregon has a standard of 9 kV/m within the right-of-way of an electrical transmission line. The Oregon Energy Facilities Siting Council (Oregon Department of Energy) has a "prudent avoidance policy" safety standard.

Effects

Despite the lack of regulations on EMF exposure or conclusive evidence that EMF affects human health, it is prudent to analyze the effects of the LPA on users of the light rail system and the general public. The light rail extension is the aspect of the LPA which has the highest potential to increase EMF levels because it would add a 750-volt DC overhead system along the track alignment to deliver power to the cars and would utilize substations along the alignment.

360/737-2726 503/256-2726 WWW.COLUMBIARIVERCROSSING.ORG 700 WASHINGTON STREET, SUITE 300, VANCOUVER, WA 98660

The light rail extension proposed with this project would extend the existing MAX LRT system, and would bring similar EMF levels to the new parts of the line. As described in the EMF Technical Report, magnetic field strength diminishes with distance from the MAX light rail track. At 10 meters from the MAX light rail tracks, the highest measured value was 167 mG, well below the ICNIRP guidelines for the general public. At 30 meters the strength had been reduced to 13.3 mG.

According to the Federal Railroad Administration, strong magnetic fields are not associated with the operation of light rail trains. The major light rail sources that generate magnetic fields are associated with the traction power and the control equipment under the vehicle's floor.

The EMF Technical Report demonstrated that EMF emissions were very low within the light rail vehicles used in the existing MAX system, fluctuating from 0.38 to 8.13 mG measured at approximate seat height.

DC magnetic fields were measured at stations and power substations during a site visit and found to range from 107 to 601 mG at substations (measured at the perimeter of the buildings that enclosed the substations) and from 47 to 551 mG at transit stations. The field intensities at the stations and substations were below the general public exposure standards.

It is anticipated that future levels of EMF along the proposed light rail line will be very similar to those produced in the current light rail system, since the elements of the system such as power levels, substation ratings, and facility and system design would not change. EMF would be generated from these sources during operation and the public (internal receptors) would be exposed to EMF along the light rail tracks, near substations, at station stops, and in the light rail cars. Because the current levels of EMF are not considered excessive and fall below the ICNIRP exposure standards there would be no expected adverse risk to human health.

External receptors located at greater distances from the MAX electrical system than passengers or MAX workers would also receive some exposure to EMF from the MAX line. However, because field strengths decrease rapidly with distance and generated field intensities are below the ICNIRP exposure standards, there would be no expected effect on the health of external receptors.

New information

Since publication of the DEIS, the location of substations has been refined. Though EMF levels are below the exposure guidelines at the perimeter of the substation buildings, the land uses around the substations were examined to determine if any sensitive uses are located nearby. Since health effects from EMF exposure are still unknown it is prudent to limit extended exposure to children, the elderly and the infirm. Exhibit 1 illustrates the site locations of the three proposed substations and the adjacent land uses. No schools, daycare facilities, hospitals, or senior housing are located within 30 meters of a proposed substation. The substation near Clark College is located adjacent to a multi-use athletic field and across the street from the Marshall Community Center. However, the nature of athletic field and community center use is sporadic, so extended EMF exposure is not likely. Since LPA Option A and Option B does not affect transit alignment, there would be no difference in EMF impacts between the two options.

Conclusion

The levels of anticipated EMF produced by the proposed light rail extension would be low and below the exposure guidelines for either the workplace or general public. Mitigation would not be necessary. The power substations have been designed and sited to minimize exposure to users of the system, the general public, and sensitive users.

PRELIMINARY

N W E S

- Substation
- 30 Meter Buffer
- Tax Lot Boundary

Existing Land Use Type

- Residentail
- Commercial
- Mixed Use
- Industrial
- Parks, Recreation and Civic
- Unused/Right-of-Way
- Vacant
- Unknown

Exhibit 1. Light Rail Substations and Exisiting Land Uses

Columbia River CROSSING

INTERSTATE 5 COLUMBIA RIVER CROSSING

Electromagnetic Fields (EMF) Technical Report

Columbia River CROSSING

May 2008

Title VI

The Columbia River Crossing project team ensures full compliance with Title VI of the Civil Rights Act of 1964 by prohibiting discrimination against any person on the basis of race, color, national origin or sex in the provision of benefits and services resulting from its federally assisted programs and activities.

Americans with Disabilities Act (ADA) Information

If you would like copies of this document in an alternative format, please call the Columbia River Crossing project office at (360) 737-2726 or (503) 256-2726. Persons who are deaf or hard of hearing may contact CRC using Telecommunications Relay Service by dialing 7-1-1.

¿Habla usted español? La informacion en esta publicación se puede traducir para usted. Para solicitar los servicios de traducción favor de llamar al (503) 731-3490.

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Cover Sheet

Interstate 5 Columbia River Crossing

Electromagnetic Fields (EMF) Technical Report:

Submitted By:

Gary Maynard

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TABLE OF CONTENTS

List of Exhibits

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ACRONYMS

Acronym	Description
AC	Alternating Current
ACGIH	American Conference of Government Industrial Hygienists
ADA	Americans with Disabilities Act
CRC	Columbia River Crossing
DC	Direct Current
ELF	Extremely Low Frequency Fields
EMF	Electric and Magnetic Fields
EPA	U.S. Environmental Protection Agency
FCC	Federal Communications Commission
G	Gauss
HCT	High Capacity Transit
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
kHz	Kilohertz
kV	Kilovolt
kV/m	Kilovolts per Meter
LRT	Light Rail Transit
mG	milligauss
MHz	Megahertz
V	Volt
VLF.	Very Low Frequency

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1. Summary

1.1 Introduction

This report assesses the potential for human health impacts from exposure to electromagnetic fields (EMF) during operation of the new high-capacity transit facilities proposed as part of the I-5 Columbia River Crossing (CRC) project. Alternatives 3 and 5 include the potential extension of the TriMet MAX light rail transit (LRT) system from its existing terminus at Delta Park into Vancouver, Washington. Alternatives that include extending the light rail line would result in the generation of EMF and thus could have potential impacts. Alternatives that do not involve extending LRT would not produce any appreciable amounts of EMF above existing levels.

This report relies on measurements of EMF from existing sections of the MAX LRT and available data on similar light rail systems in California. Based on EMF measurements and available data, operation of future segments of the MAX LRT are unlikely to generate sufficiently intense levels of EMF to cause significant exposure risks to human health. The anticipated intensities of electromagnetic fields at locations where humans would be exposed (within and adjacent to the LRT right-of-way, near power substations, or in the light rail vehicles) are considerably below exposure guidelines set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the American Conference of Governmental Industrial Hygienists (ACGIH).

1.2 Description of the Alternatives

The alternatives being considered for the CRC project consist of a diverse range of highway, transit and other transportation choices. Some of these choices – such as the number of traffic lanes across the river – could affect transportation performance and impacts throughout the bridge influence area or beyond. These are referred to as "system-level choices." Other choices – such as whether to run high-capacity transit (HCT) on Washington Street or Washington and Broadway Streets – have little impact beyond the area immediately surrounding that proposed change and no measurable effect on regional impacts or performance. These are called "segment-level choices." This report discusses the impacts from both system- and segment-level choices, as well as "full alternatives." The full alternatives combine system-level and segment-level choices for highway, transit, pedestrian, and bicycle transportation. They are representative examples of how project elements may be combined. Other combinations of specific elements are possible. Analyzing the full alternatives allows us to understand the combined performance and impacts that would result from multimodal improvements spanning the bridge influence area.

Following are brief descriptions of the alternatives being evaluated in this report, which include:

- System-level choices,
- Segment-level choices, and
- Full alternatives.

1.2.1 System-Level Choices

System-level choices have potentially broad influence on the magnitude and type of benefits and impacts produced by this project. These options may influence physical or operational characteristics throughout the project area and can affect transportation and other elements outside the project corridor as well. The system-level choices include:

- River crossing type (replacement or supplemental)
- High-capacity transit mode (bus rapid transit or light rail transit)
- Tolling (no toll, I-5 only, I-5 and I-205, standard toll, higher toll)

This report compares replacement and supplemental river crossing options. A replacement river crossing would remove the existing highway bridge structures across the Columbia River and replace them with three new parallel structures – one for I-5 northbound traffic, another for I-5 southbound traffic, and a third for HCT, bicycles, and pedestrians. A supplemental river crossing would build a new bridge span downstream of the existing I-5 bridge. The new supplemental bridge would carry southbound I-5 traffic and HCT, while the existing I-5 bridge would carry northbound I-5 traffic, bicycles, and pedestrians. The replacement crossing would include three through-lanes and two auxiliary lanes for I-5 traffic in each direction. The supplemental crossing would include three through-lanes and one auxiliary lane in each direction.

Two types of HCT are being considered – bus rapid transit and light rail transit. Both would operate in an exclusive right-of-way through the project area, and are being evaluated for the same alignments and station locations. The HCT mode – LRT or BRT – is evaluated as a system-level choice. Alignment options and station locations are discussed as segment-level choices. BRT would use 60-foot or 80-foot long articulated buses in lanes separated from other traffic. LRT would use one- and two-car trains in an extension of the MAX line that currently ends at the Expo Center in Portland.

Under the efficient operating scenario, LRT trains would run at approximately 7.5 minute headways during the peak periods. BRT would run at headways between 2.5 and 10 minutes depending on the location in the corridor. BRT would need to run at more frequent headways to match the passenger-carrying capacity of the LRT trains. This report also evaluates performance and impacts for an increased operations scenario that would double the number of BRT vehicles or the number of LRT trains during the peak periods.

1.2.2 Segment-Level Choices

See Exhibit 1-1 for a map of the project area and segment boundaries.

PRELIMINARY

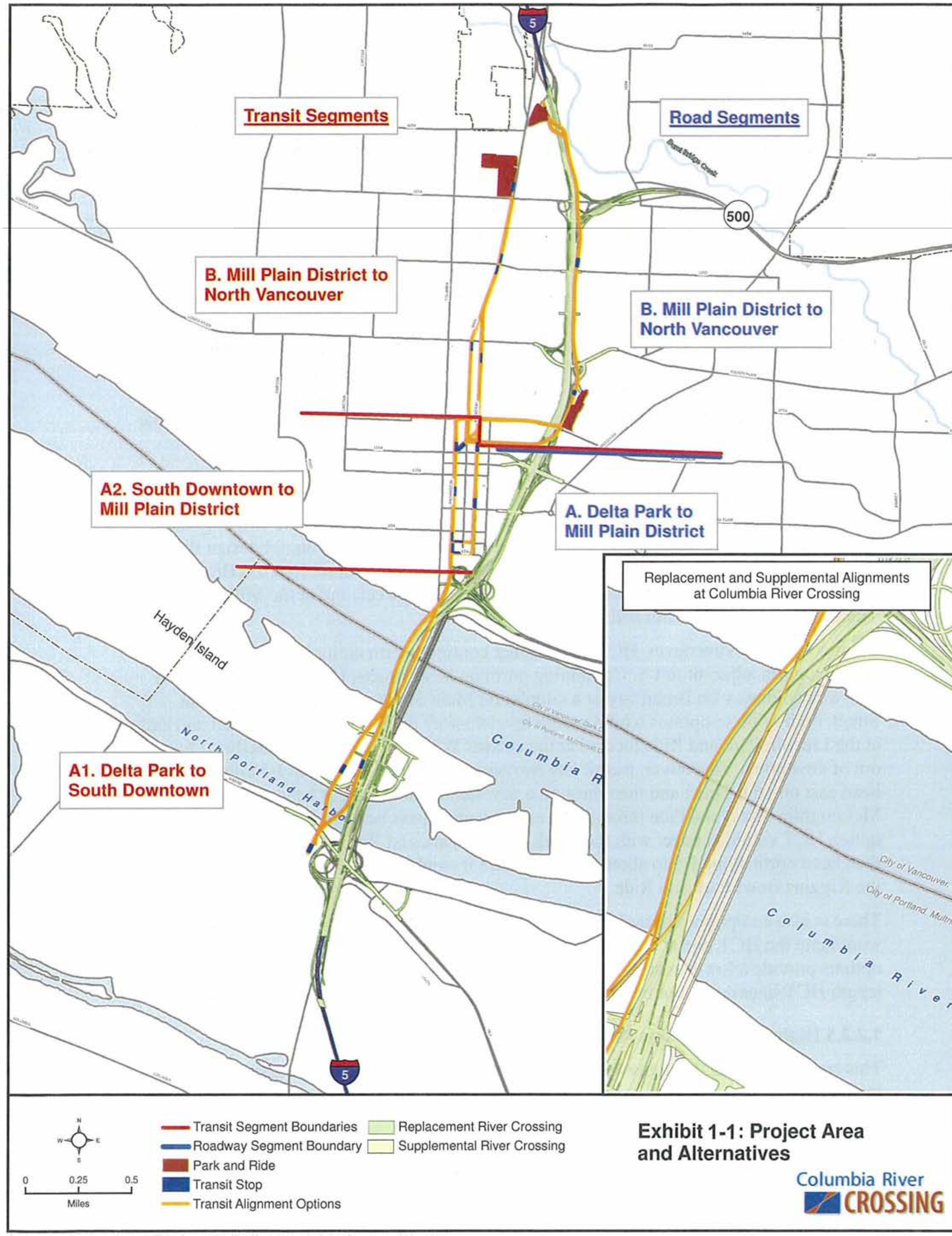

Exhibit 1-1: Project Area and Alternatives

Columbia River CROSSING

The transit alignment choices are organized into three corridor segments. Within each segment the alignment choices can be selected relatively independently of the choices in the other segments. These alignment variations generally do not affect overall system performance but could have important differences in the impacts and benefits that occur in each segment. The three segments are:

- Segment A1 – Delta Park to South Vancouver
- Segment A2 – South Vancouver to Mill Plain District
- Segment B – Mill Plain District to North Vancouver

In Segment A1 there are two general transit alignment options - offset from, or adjacent to, I-5. An offset HCT guideway would place HCT approximately 450 to 650 feet west of I-5 on Hayden Island. An adjacent HCT guideway across Hayden Island would locate HCT immediately west of I-5. The alignment of I-5, and thus the alignment of an adjacent HCT guideway, on Hayden Island would vary slightly depending upon the river crossing and highway alignment, whereas an offset HCT guideway would retain the same station location regardless of the I-5 bridge alignment.

HCT would touch down in downtown Vancouver at Sixth Street and Washington Street with a replacement river crossing. A supplemental crossing would push the touch down location north to Seventh Street. Once in downtown Vancouver, there are two alignment options for HCT – a two-way guideway on Washington Street or a couplet design that would place southbound HCT on Washington Street and northbound HCT on Broadway. Both options would have stations at Seventh Street, 12th Street, and at the Mill Plain Transit Center between 15th and 16th Streets.

From downtown Vancouver, HCT could either continue north on local streets or turn east and then north adjacent to I-5. Continuing north on local streets, HCT could either use a two-way guideway on Broadway or a couplet on Main Street and Broadway. At 29th Street, both of these options would merge to a two-way guideway on Main Street and end at the Lincoln Park and Ride located at the current WSDOT maintenance facility. Once out of downtown Vancouver, transit has two options if connecting to an I-5 alignment: head east on 16th Street and then through a new tunnel under I-5, or head east on McLoughlin Street and then through the existing underpass beneath I-5. With either option HCT would connect with the Clark College Park and Ride on the east side of I-5, then head north along I-5 to about SR 500 where it would cross back over I-5 to end at the Kiggins Bowl Park and Ride.

There is also an option, referred to as the minimum operable segments (MOS), which would end the HCT line at either the Mill Plain station or Clark College. The MOS options provide a lower cost, lower performance alternative in the event that the full-length HCT lines could not be funded in a single phase of construction and financing.

1.2.2.1 Highway and Bridge Alignments

This analysis divides the highway and bridge options into two corridor segments, including:

- Segment A – Delta Park to Mill Plain District
- Segment B – Mill Plain District to North Vancouver

Segment A has several independent highway and bridge alignment options. Differences in highway alignment in Segment B are caused by transit alignment, and are not treated as independent options.

The replacement crossing would be located slightly downstream of the existing I-5 bridge. At the SR 14 interchange there are two basic configurations being considered. A traditional configuration would use ramps looping around both sides of the mainline to provide direct connection between I-5 and SR 14. A less traditional design could reduce right-of-way requirements by using a "left loop" that would stack both ramps on the west side of the I-5 mainline.

1.2.3 Full Alternatives

Full alternatives represent combinations of system-level and segment-level options. These alternatives have been assembled to represent the range of possibilities and total impacts at the project and regional level. Packaging different configurations of highway, transit, river crossing, tolling and other improvements into full alternatives allows project staff to evaluate comprehensive traffic and transit performance, environmental impacts and costs.

Exhibit 1-2 summarizes how the options discussed above have been packaged into representative full alternatives.

Exhibit 1-2. Full Alternatives

	Packaged Options				
Full Alternative	River Crossing Type	HCT Mode	Northern Transit Alignment	TDM/TSM Type	Tolling Method[a]
1	Existing	None	N/A	Existing	None
2	Replacement	BRT	I-5	Aggressive	Standard Rate
3	Replacement	LRT	I-5	Aggressive	Two options[b]
4	Supplemental	BRT	Vancouver	Very Aggressive	Higher rate
5	Supplemental	LRT	Vancouver	Very Aggressive	Higher rate

[a] In addition to different tolling rates, this report evaluates options that would toll only the I-5 river crossing and options that would toll both the I-5 and the I-205 crossings.

[b] Alternative 3 is evaluated with two different tolling scenarios, tolling and non-tolling.

Modeling software used to assess alternatives' performance does not distinguish between smaller details, such as most segment-level transit alignments. However, the geographic difference between the Vancouver and I-5 transit alignments is significant enough to warrant including this variable in the model. All alternatives include Transportation Demand Management (TDM) and Transportation System Management (TSM) measures designed to improve efficient use of the transportation network and encourage alternative transportation options to commuters such as carpools, flexible work hours, and telecommuting. Alternatives 4 and 5 assume higher funding levels for some of these measures.

Alternative 1: The National Environmental Policy Act (NEPA) requires the evaluation of a No-Build or "No Action" alternative for comparison with the build alternatives. The No-Build analysis includes the same 2030 population and employment projections and the same reasonably foreseeable projects assumed in the build alternatives. It does not include any of the I-5 CRC related improvements. It provides a baseline for comparing the build alternatives, and for understanding what will happen without construction of the I-5 CRC project.

Alternative 2: This alternative would replace the existing I-5 bridge with three new bridge structures downstream of the existing bridge. These new bridge structures would carry Interstate traffic, BRT, bicycles, and pedestrians. There would be three through-lanes and two auxiliary lanes for I-5 traffic in each direction. Transit would include a BRT system that would operate in an exclusive guideway from Kiggins Bowl in Vancouver to the Expo Center station in Portland. Express bus service and local and feeder bus service would increase to serve the added transit capacity. BRT buses would turn around at the existing Expo Station in Portland, where riders could transfer to the MAX Yellow Line.

Alternative 3: This is similar to Alternative 2 except that LRT would be used instead of BRT. This alternative is analyzed both with a toll collected from vehicles crossing the Columbia River on the new I-5 bridge, and with no toll. LRT would use the same transit alignment and station locations. Transit operations, such as headways, would differ, and LRT would connect with the existing MAX Yellow Line without requiring riders to transfer.

Alternative 4: This alternative would retain the existing I-5 bridge structures for northbound Interstate traffic, bicycles, and pedestrians. A new crossing would carry southbound Interstate traffic and BRT. The existing I-5 bridges would be re-striped to provide two lanes on each structure and allow for an outside safety shoulder for disabled vehicles. A new, wider bicycle and pedestrian facility would be cantilevered from the eastern side of the existing northbound (eastern) bridge. A new downstream supplemental bridge would carry four southbound I-5 lanes (three through-lanes and one auxiliary lane) and BRT. BRT buses would turn around at the existing Expo Station in Portland, where riders could transfer to the MAX Yellow Line. Compared to Alternative 2, increased transit service would provide more frequent service. Express bus service and local and feeder bus service would increase to serve the added transit capacity.

Alternative 5: This is similar to Alternative 4 except that LRT would be used instead of BRT. LRT would have the same alignment options, and similar station locations and requirements. LRT service would be more frequent (approximately 3.5 minute headways during the peak period) compared to 7.5 minutes with Alternative 3. LRT would connect with the existing MAX Yellow Line without requiring riders to transfer.

1.3 Summary of Impacts

Under the No-Build Alternative there would be no construction of a high-capacity transit line into Washington. Thus, there would be no potential for an increased risk of EMF exposures to the general public.

There would be no EMF-related impacts related to the highway alignment options. The CRC light rail options (Alternatives 3 and 5) would extend the existing MAX system, and would bring similar EMF levels to the new parts of the line. Where people could be exposed (within and near the light rail right-of-way, near power substations, or in the light rail vehicles) EMF emissions would be considerably below exposure guidelines set by the International Commission on Non-Ionizing Radiation Protection and the American Conference of Governmental Industrial Hygienists. While the light rail option would generate higher EMF intensities than bus rapid transit, none of the options or alternatives would pose significant EMF exposure risks to human health.

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2. Methods

2.1 Introduction

Potential cumulative effects from this project are evaluated in the Cumulative Effects Technical Report. Please refer to this report for an evaluation of possible cumulative effects.

The methods used in this report relied primarily on existing literature sources and field measurements of EMF. The following supplied information for this report:

- Literature on the TriMet light rail system, which included EMF measurements conducted for use in the Central Link EIS for Sound Transit in Seattle.
- Literature on electromagnetic field measurements of light rail systems similar to the TriMet system, such as the Santa Clara Valley Transit System in San Francisco and the Regional Rail Transit system in Sacramento.
- Literature on potential health effects from exposure to electromagnetic fields.

Data and measurements from the TriMet rail system and similar rail systems were used in comparison to exposure standards for electromagnetic fields as the basis for the assessment of probably human health impacts.

2.2 Effects Guidelines

There are no federal laws that limit exposure to EMF. Several agencies had been considering developing standards such as the U.S. Food and Drug Administration, U.S. Department of Defense, and the EPA. The Federal Communications Commission (FCC) has recently adopted and enforces limits for exposure in the workplace and out in public areas for radiofrequency radiation from AM, FM television and wireless sources (47 CFR 1.1307(b)).

Two organizations have developed voluntary occupational guidelines for EMF exposure. The guidelines are intended to prevent EMF effects such as nerve stimulation or inducing currents in cells (these effects have been shown to occur in higher frequency EMF than typically occurs in residences or occupations). These organizations include the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in association with the World Health Organization and the American Conference of Governmental Industrial Hygienists (ACGIH). Exhibit 2-1 shows the exposure guidelines for the typical power frequency (60 Hz) that have been developed by ICNIRP and ACGIH. The values shown in the table may be exceeded for several minutes.

Exhibit 2-1. Exposure Guidelines for Power Frequency (60 Hz) EMF

Exposure at 60 Hz	Electric Field (kV/m)	Magnetic Field (mG)
International Commission on Non-Ionizing Radiation Protection		
Occupational	8.3	4,200
General Public	4.2	833
American Conference of Governmental Industrial Hygienists		
Occupational Exposure Should not Exceed	25	10,000
Prudence Dictates Use of Protective Clothing Above this Level	15	---
Exposure of Workers with Cardiac Pacemakers Should not Exceed this Level	1	1,000

Source: ICNIRP and ACGIH.

Washington State has no standards relating to EMF exposure. Oregon does have a standard for electric field exposure. The electrical field exposure standard for Oregon is 9 kV/m within the right-of-way of an electrical transmission line.

The Oregon Energy Facilities Siting Council (Oregon Department of Energy) has a "prudent avoidance policy" safety standard. Many utility companies have adopted this policy. A prudent avoidance policy is the exercising of sound judgments and caution in dealing with EMF. For example, limiting or avoiding exposure to EMF particularly in the workplace. This type of policy arose based on the absence of absolute scientific proof that EMF affects human health (e.g., causes cancer).

3. Coordination

Coordination is not applicable to this technical report.

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4. Affected Environment

4.1 Introduction to EMF

Electric and magnetic fields are an invisible force of radiated energy that is produced by many natural and man-made sources. Natural sources include the earth itself, which generates a weak magnetic field from currents flowing deep within the magma of the earth's core (the intensity of this DC magnetic field is approximately 500 milligauss [mG]). Air turbulence and other atmospheric activity such as lightning can also create electric fields (WHO 2005). Human sources of EMF are generally produced by electrical systems such as wireless telecommunications (including cell phones), electric motors, electronics, power transmission and distribution lines, and other electrically powered equipment.

Scientists have classified EMF into an electromagnetic spectrum based on the wavelength and frequency of the various forms of radiation (expressed in hertz—Hz—or the number of wave cycles per second). The spectrum ranges from direct current (zero Hz) and extremely low frequency (ELF) radiation (3 to 3,000 Hz) to radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, x-rays and gamma rays (10^{20} to 10^{22} Hz). Some types of operations can generate electromagnetic energy in many frequencies simultaneously such as welding which produces energy in the ultraviolet, visible, infrared, radiowave, and ELF range. The typical power frequency used in the United States (such as in electrical transmission and distribution lines and residential wiring) is in the ELF range and is 60 Hz. EMF from electrical systems in the ELF range will be the focus of analysis for the purposes of this report.

In a typical situation that involves electrical wiring, an electrical field is generated. For example, a lamp or microwave oven that is plugged into a wall socket but turned off will generate an electrical field from the voltage in the line. The voltage can be thought of as "electrical pressure" in the line or the potential to do work, which is measured in volts (V) or kilovolts (kV). The electrical field produced by the voltage is measured in volts per meter (V/m). Once the lamp or oven is turned on it creates an electrical current through the line. This electrical current produces a magnetic field in addition to the electrical field. Magnetic fields are measured in units of gauss (G) (or tesla). Since most magnetic field exposure involves a fraction of a gauss, EMF exposure is typically measured in milligauss (1/1,000th of a gauss).

Electrical systems can be either direct current (DC) or alternating current (AC). Direct current is defined as the unidirectional flow or movement of the electric charge through a line. The intensity of the current can vary with time, but the general direction of movement stays the same at all times.

The electricity in residences and power lines is alternating current (AC). Alternating current does not move in one direction, but instead moves back and forth. The power frequency used in the United States alternates back and forth 60 times per second. This frequency is measured in Hertz (Hz), thus the typical frequency for electricity within a line (such as in household wiring or high voltage power transmission lines) is 60 Hz. Power line AC can be converted to DC by means of a power supply consisting of a transformer, a rectifier (which prevents the flow of current from reversing), and a filter (DC is used to power the MAX light rail system in Portland).

Electric and magnetic fields are stronger closer to the source and decrease with distance. For example, the electrical field directly beneath a 115 kV (kilovolt) power line is approximately 1.0 kV/m and the magnetic field is approximately 35 mG. At 50 feet, the electrical field is approximately 0.4 kV/m and the magnetic field is approximately 7 mG. Similarly, at 100 and 200 feet, the electrical field is approximately 0.07 kV/m and 0.01 kV/m, and the magnetic field is approximately 2 mG and 0.5 mG, respectively.

Research indicates electrical fields can be greatly reduced by the walls of homes (electric fields in homes are generated almost entirely by household wiring and appliances). However, magnetic fields are not blocked by most materials and can enter homes from nearby power lines. Magnetic fields in homes are also commonly caused by the electrical appliances and wiring within a home. These internal sources of magnetic fields can extend into rooms other than where the source is located. For example, if an electrical appliance is located near a wall, its magnetic field will extend into the room on the other side of the wall.

Electrical and magnetic fields that occur in the same place can add to or subtract from the strength of the field. For example, if there are two separate 60 Hz sources located at the same place and each has a field strength of 4 volts per meter (V/m); and if they are alternating in strength and direction together at 60 Hz (i.e., they are exactly in phase), then the electrical field will be 8 V/m. If the two fields are exactly out of phase then the field will measure 0 V/m. Because of this property, power companies frequently situate their high voltage lines in close proximity and operate them at different phases to help cancel out their electric and magnetic fields.

Exhibit 4-1 shows some typical ranges of electric and magnetic fields at the surface of the human body from power lines (directly beneath the power line) and next to an appliance (at a distance of 6 inches).

Exhibit 4-1. Approximate Strength of Average Electric and Magnetic Fields at the Surface of the Body Produced by Common Sources of 60 Hertz Fields

Power Source	Electrical Field (kV)	Magnetic Field (mG)
500 kV Electricity Transmission Line	0.9–7.5	20–800
Electrical Distribution Line	0.009–0.12	0.6–30
Electric Blanket	0.1–3.0	5–100
Shaver	0.05–1.0	100–1,500
Toaster	0.005–0.09	5–20
Microwave		100–300
Average Household Background Level	0.002–0.02	0.2–9
Copy Machine		4–200
Fax Machine		4–9
PC Video Display Terminal		7–20

Source: Department of Engineering and Public Policy, Carnegie Mellon University & Bonneville Power Administration.

4.2 Regional Conditions

The existing EMF environment in the API varies depending on location, as EMF levels are site and time-specific. The main sources of EMF considered in this report are the electrical lines associated with the TriMet MAX light rail system. The following discussion describes the MAX system.

MAX is served by two local utilities with three-phase AC electricity at 12.5 to 13.8 kV (Porter and Helig 2003). There is a system in place to regulate the electrical load so that loads throughout the system are balanced. The substations convert AC power into DC power for the overhead lines. The traction power substations for the Interstate MAX substations are rated at 1 MW. The other MAX line substations are rated at 750 kW. Substations along the alignments convert high voltage AC power from the public supply system to the 750-volt DC system used to power the trains. Substations are located approximately one mile apart.

The MAX light rail line uses a 750-volt DC overhead system to deliver power to the cars. The overhead system (catenary) is made up of either a single or dual wire. In the API, the catenary system is a dual wire (messenger and contact wire). Other elements of the light rail system use either AC or DC electricity for power. These include electricity for lights, signals, and switches along the alignment.

Generally, strong magnetic fields are not associated with the operation of light rail trains. The major LRT sources that generate magnetic fields are associated with the traction power and the control equipment under the vehicle's floor (Federal Railroad Administration 1993).

For the purposes of a study of EMF for the Sound Transit Link LRT project in Seattle, measurements were taken of the TriMet MAX system to help evaluate possible EMF effects from the new light rail line (Edelson and Holmstrom 1998). DC magnetic fields were measured at distances of 10, 20, and 30 meters (approximately 32, 65, and 98 feet, respectively) from the MAX light rail track. The results are shown in the Exhibit 4-2 and reflect measurements taken at an open field location with a DC magnetometer.

Exhibit 4-2. Magnetic Field Strength at Distance from MAX Light Rail Tracks (mG)

	10 Meters	20 Meters	30 Meters
Horizontal	167	44.6	13.3
Vertical	17.8	8.22	3.43

Source: Edelson and Holmstrom 1998.

As shown in the table, the DC magnetic field diminishes with distance from the track. The highest value was 167 mG at 32 feet from the track. These values are well below the ICNIRP standard of 833 mG for general public exposure to magnetic fields.

DC magnetic fields were measured at stations and substations during a recent site visit and found to range from 107 to 601 mG at substations (measured at the perimeter of the buildings that enclosed the Delta Park and Killingsworth substations). DC field intensities ranged from 47 to 551 mG at stations (Delta Park and Killingsworth). Similar to the DC magnetic field measurements conducted in 1998, the field intensities at the stations and substations were below the general public exposure standards.

AC magnetic field measurements were also made at rail stops and substations during the field visit. The AC magnetic field levels at light rail station stops (Delta Park and Killingsworth) fluctuated depending on the movement of the light rail cars (higher values were associated with the cars accelerating) and ranged from 0.76 to 12.77 mG at a distance of 3 feet from the track. The levels of the AC magnetic fields at the substations ranged from almost zero to 2.86 mG (measured at the perimeter of the buildings that enclosed the Delta Park and Killingsworth substations).

Measurements of AC and DC magnetic fields conducted at 20 feet from the Killingsworth station showed the predicted decrease in field strengths as AC fields ranged from 0.76 to 1.47 mG and DC fields ranged from 86 to 199 mG.

Measurements of EMF at other light rail systems have produced similar results. For example the Vascona Corridor for the Santa Clara Valley, California light rail system measured magnetic field strength at four light rail stations and one substation in 1999 (Santa Clara Valley Transportation Authority 2005) with the following results:

- At a distance of 20-30 feet from the closest track, DC magnetic fields were typically within a few hundred mG of the Earth's ambient DC field (approximately 500 mG).
- Measured AC magnetic fields were typically 5 mG or less within 10 feet of the tracks and 2 mG or less at 20 feet from the track
- At the perimeter of substations, DC magnetic field levels ranged from 194-921 mG. AC magnetic fields ranged from 0.3 mG to 31.3 mG. (The higher levels at the substation were thought to be caused by the location of underground electrical feeder cables.)

The existing levels of AC and DC magnetic fields from MAX are largely isolated in the TriMet owned right-of-way because field intensities are relatively low and decrease quickly with distance from the track (and overhead catenary lines). This is also true of the substations. Thus, it is unlikely that there have been any exposures at adjacent residences located along the light rail line or near substations that would be a cause for concern since they do not exceed the ICNIRP exposure standards.

The general public and train operators are also currently exposed to EMF at station stops and in the light rail cars themselves. AC magnetic field measurements were taken in the light rail cars during a recent site visit (between the Delta Park and Killingsworth stations) and found to fluctuate from approximately 0.38 to 8.13 mG at a height of approximately 20 inches from the floor (approximate seat height). Thus, EMF emissions were also very low within the light rail vehicles.

To provide some perspective to the potential exposures of EMF from light rail, this section presents the results of a survey conducted for the EMF Rapid Program (a program conducted under the National Institutes of Health). The purpose of the 1997 survey was to characterize personal magnetic field exposure in the general population (Enertech Consultants 1998). Slightly over 1,000 people participated in the survey of exposure over a 24-hour period. The results indicated approximately 14 percent of the general population is exposed to a 24-hour average magnetic field strength exceeding 2 mG. About 25 percent of the people spent more than one hour at fields greater than 4 mG, and 9 percent spend more than one hour at fields greater than 8 mG. Approximately 1.6 percent of people experience at least one gauss (1,000 mG) during a 24-hour period.

Compared to the study above, the typical time that people would be riding the MAX system and would be exposed to its magnetic fields is very low, and when averaged over a 24-hour period would amount to an insignificant exposure from this source of EMF.

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5. Long-Term and Temporary Effects

5.1 Potential Human Health Effects of EMF

No excessive EMF emissions would occur during construction

It is uncertain whether 60 Hz fields pose health risks. Scientists have found that electric and magnetic fields produce biological effects on humans and animals such as changes in the cell growth rates and intercellular communication (American Medical Association 1994). However, scientists do not agree on EMF's potential health effects because the available evidence is fragmentary, complex, and often inconclusive. The problem has been exacerbated by less careful studies, which have produced results that are contradictory to other studies (NIEHS 1991 and 2002).

Three kinds of studies have been done on EMF. These include: 1) laboratory studies that expose single or groups of cells and organs to EMF under a variety of conditions and look for effects; 2) laboratory studies that expose animals or humans to EMF and look for effects; and 3) epidemiological studies of varying human population groups which look for an association between EMF and diseases.

Researchers in the laboratory have studied the effects of EMF on isolated tissue and cells. These studies have indicated changes in cell growth rates, intercellular communication, movement of calcium ions and levels of various enzymes. The scientific community however, does not agree on the biological significance of these results. While changes from EMF have been shown to occur, it is uncertain what effect these changes have on human health or the incidence of diseases.

Laboratory studies have also found several effects from EMF on animals. Effects attributed to these fields include changes in behavior and activity, biological rhythms, some hormone levels, bone fracture healing, response to drugs and learning abilities. These effects have been small and required special conditions in the laboratory to achieve. For example, in some cases for changes to take place, very strong fields were needed, while in other studies, changes only occurred under certain field frequencies.

Epidemiological studies involve research on the statistical occurrence and possible causes of disease in human populations. These studies have resulted in conflicting conclusions. Some studies have found an association with cancer and certain types of power lines. Associations have been found for both increased occurrences of cancer and decreased occurrences of cancer for those living in proximity to power lines. Other studies have concluded that there is no association whatsoever.

Overall, the biological and epidemiological results suggest that there may be a link between EMF and certain diseases, however at this time no cause and effect relationship has been established. The most widely accepted consensus concerning the effects of EMF on human health is that more research is needed.

5.2 Impacts from Full Alternatives

This section describes the impacts from five full alternatives including the No-Build Alternative. These are combinations of highway, river crossing, transit and pedestrian/bicycle alternatives and options covering all of the CRC segments. They represent the range of system-level choices that most affect overall performance, impacts and costs. The full alternatives are most useful for understanding the regional impacts, performance and total costs associated with the CRC project.

5.2.1 No-Build Alternative (Alternative 1)

Under the No-Build Alternative there would be no construction of a high-capacity transit line into Washington. Thus, there would be no potential for an increased risk of EMF exposures to the general public.

5.2.2 Replacement Crossing with BRT and I-5 Standard Toll (Alternative 2)

There would be no appreciable amounts of EMF generated by this alternative and thus there would be no increased risk of EMF exposures to the general public.

5.2.3 Replacement Crossing with LRT and I-5 Standard Toll (Alternative 3 Toll)

The LRT system would be extended under this alternative, which would result in the operation of electrical power sources of AC and DC magnetic fields, particularly the overhead catenary lines and power substations. EMF would be generated from these sources during operation and the public (internal receptors) would be exposed to EMF along the light rail tracks, near substations, at station stops, and in the light rail cars.

It is anticipated that future levels of EMF along the extended LRT line will be identical to those produced in the current light rail system, since the elements of the system such as power levels, substation ratings, and facility and system design would not change. Because the current levels of EMF are not considered excessive and fall below the ICNIRP exposure standards there would be no expected adverse risk to human health.

External receptors located at greater distances from the MAX electrical system than passengers or MAX workers would also receive some exposure to EMF from the MAX line. However, because field strengths decrease rapidly with distance and generated field intensities are below the ICNIRP exposure standards, there would be no expected effect on the health of external receptors.

5.2.4 Replacement Crossing with LRT and No Toll (Alternative 3 No-Toll)

The potential impacts from EMF would be the identical to those described under Alternative 3.

5.2.5 Supplemental Crossing with BRT and I-5 Higher Toll (Alternative 4)

There would be no appreciable amounts of EMF generated by this alternative and thus there would be no increased risk of EMF exposures to the general public.

5.2.6 Supplemental Crossing with LRT and I-5 Higher Toll (Alternative 5)

The potential impacts from EMF would be identical to those described under Alternative 3.

5.3 Impacts from Segment-level Options

There would be no EMF-related impacts related to the highway alignment options.

The only difference between the transit alignment options for LRT is that EMF emissions would occur in one place or the other. There would be no difference in the field intensities generated by the LRT. However, because the EMF levels are low and decrease rapidly with distance there would be no expected adverse health effects from EMF exposure (see Section 5.2.2).

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6. Mitigation for Long-Term Effects

The levels of anticipated EMF would be low and under the exposure standards for either the workplace or general public. Thus, mitigation would not be necessary.

The design and location of facilities can help to reduce the intensity of magnetic fields and exposure of the public to EMF. Some examples include ensuring that all electrical equipment is operated with a good ground system and that proper shielding is provided for all electrical lines. Where electrical lines are located in close proximity, the frequency of electrical lines can be phased to cancel out the magnetic or electrical fields.

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7. Permits and Approvals

No permits or approvals associated with EMF-related impacts are required for any of the alternatives.

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PRELIMINARY

Interstate 5 Columbia River Crossing

Traffic Technical Report for the Final Environmental Impact Statement

Columbia River CROSSING

January 2011

Title VI

The Columbia River Crossing project team ensures full compliance with Title VI of the Civil Rights Act of 1964 by prohibiting discrimination against any person on the basis of race, color, national origin or sex in the provision of benefits and services resulting from its federally assisted programs and activities. For questions regarding WSDOT's Title VI Program, you may contact the Department's Title VI Coordinator at (360) 705-7098. For questions regarding ODOT's Title VI Program, you may contact the Department's Civil Rights Office at (503) 986-4350.

Americans with Disabilities Act (ADA) Information

If you would like copies of this document in an alternative format, please call the Columbia River Crossing (CRC) project office at (360) 737-2726 or (503) 256-2726. Persons who are deaf or hard of hearing may contact the CRC project through the Telecommunications Relay Service by dialing 7-1-1.

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Cover Sheet

Interstate 5 Columbia River Crossing

DRAFT - Traffic Technical Report for the Final Environmental Impact Statement:

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List of Exhibits

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ACRONYMS

Acronym	Description
ADA	Americans with Disabilities Act
ADT	Average Daily Traffic
APM	Analysis Procedures Manual
BNSF	Burlington Northern Santa Fe Railroad
CAGR	Compound Annual Growth Rate
CBD	Central Business District
CD	Collector/distributor
CRC	Columbia River Crossing
C-TRAN	Clark County Public Transit Benefit Area Authority
CTR	Commute Trip Reduction (Washington)
DEIS	Draft Environmental Impact Statement
DOT	U.S. Department of Transportation
ECO	Employee Commute Options (Oregon)
FEIS	Final Environmental Impact Statement
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HAC	High Accident Corridor
HAL	High Accident Location
HDM	Highway Design Manual
HOV	High Occupancy Vehicle
ICU	Intersection Capacity Utilization
LPA	Locally Preferred Alternative
LOS	Level-of-Service
LRT	Light Rail Transit
LRV	Light Rail Vehicle
MAX	Metropolitan Area Express
Metro	Metropolitan Service District
MPO	Metropolitan Planning Organization
MTP	Metropolitan Transportation Plan
MVMT	Million Vehicle Miles Traveled
ODOT	Oregon Department of Transportation
OHP	Oregon Highway Plan
ORT	Open Road Tolling
OTC	Oregon Transportation Commission
PDO	Property Damage Only
PBOT	Portland Bureau of Transportation
ROD	Record of Decision
RTC	Regional Transportation Council
RTP	Regional Transportation Plan
RTPO	Regional Transportation Planning Organization
SPIS	Safety Priority Index System
SPUI	Single Point Urban Interchange
SR	State Route
TDM	Transportation Demand Management
TPAC	Transportation Policy Alternatives Committee
TriMet	Tri-County Metropolitan Transportation District
TSM	Transportation System Management
TSP	Transportation System Plan
UP	Union Pacific Corporation

Acronym	Description
V/C	Volume-to-Capacity Ratio
VCCV	Vancouver Central City Vision
WSDOT	Washington Department of Transportation
WTC	Washington Transportation Commission

1. Project Purpose and Need

1.1 Project Description

The Columbia River Crossing (CRC) project is a bridge, transit, and highway improvement project for Interstate 5 between the states of Washington and Oregon. It is co-sponsored by the Oregon Department of Transportation (ODOT) and the Washington Department of Transportation (WSDOT) and is focused on addressing the congestion, mobility, and safety issues on I-5 between State Route 500 in Vancouver, Washington and Columbia Boulevard in Portland, Oregon.

This five-mile segment of I-5, referred to as the Bridge Influence Area or project area, includes seven interchanges. Interstate 5 in the Bridge Influence Area sustains recurrent congestion during the morning, midday and evening periods. The I-5 bridge is one of only two major interstate highway river crossings providing connectivity and mobility between Washington and Oregon in the Portland-Vancouver metropolitan region.

1.2 Project Purpose and Need

The purpose of the proposed action is to improve I-5 corridor mobility by addressing present and future travel demand and mobility needs in the CRC project area. Relative to the No-Build Alternative, the proposed action is intended to achieve the following objectives:

a) Improve travel safety and traffic operations on the Interstate 5 crossing's bridges and associated interchanges;

b) Improve connectivity, reliability, travel times, and operations of public transportation modal alternatives in the Bridge Influence Area;

c) Improve highway freight mobility and address interstate travel and commerce needs in the Bridge Influence Area;

d) Improve pedestrian and bicycle infrastructure and connections to regional trail networks; and

e) Improve the Interstate 5 river crossing's structural integrity.

The specific needs to be addressed by the proposed action include:

Growing Travel Demand and Congestion: Existing travel demand exceeds capacity in the CRC area on I-5 and associated interchanges. This corridor experiences heavy congestion and delay lasting two to five hours during both the morning and afternoon/evening peak travel periods and when traffic crashes, vehicle breakdowns, or bridge-lifts occur. Due to excess travel demand and congestion in the I-5 bridge corridor, many trips take the longer, alternative I-205 route across the river. Spillover traffic from

I-5 onto parallel arterials, such as Martin Luther King, Jr. Boulevard and Interstate Avenue increases local congestion. The two crossings currently carry over 280,000 trips across the Columbia River daily. Daily traffic demand over the I-5 crossing is projected to increase by 40 percent during the next 25 years, with stop-and-go conditions increasing to at least 15 hours each day if no improvements are made.

Impaired freight movement: I-5 is part of the National Truck Network and the most important freight highway on the West Coast. I-5 links international, national, and regional markets in Canada, Mexico, and the Pacific Rim with destinations throughout the western United States. In the center of the project area, I-5 intersects with the Columbia River's deep water shipping and barging channels as well as two transcontinental railroad mainlines. The I-5 crossing provides direct and important highway connections to the Port of Vancouver and Port of Portland facilities located on the Columbia River as well as the majority of the area's freight consolidation facilities and distribution terminals. Freight volumes moved by truck to and from the area are projected to more than double over the next 25 years. Vehicle-hours of delay on truck routes in the Portland-Vancouver area are projected to increase by more than 90 percent over the next 25 years. Growing demand and congestion will result in increasing delay, costs and uncertainty for all businesses that rely on this corridor for freight movement.

Limited public transportation operation, connectivity, and reliability: Due to limited public transportation options, a number of transportation markets are not well served. The key transit markets include trips between the Portland Central City and the City of Vancouver and Clark County, trips between North/Northeast Portland and the City of Vancouver and Clark County, and trips connecting the City of Vancouver and Clark County with the regional transit system in Oregon. Congestion in the corridor adversely impacts public transportation service reliability and travel speed. Southbound bus travel times across the bridge are currently up to three times longer during parts of the morning peak compared to off peak. Travel times for public transit using general-purpose lanes on I-5 are expected to increase substantially by 2030.

Safety and Vulnerability to Incidents: The I-5 river crossing and its approach sections experience crash rates over twice that of statewide averages for comparable facilities. Incident evaluations generally attribute these crashes to traffic congestion and weaving movements associated with closely spaced interchanges. Without breakdown lanes or shoulders, even minor traffic crashes or stalls cause severe delay or more serious accidents.

Substandard bicycle and pedestrian facilities: The bike/pedestrian facilities, which consist of shared sidewalks on the I-5 bridges, are generally no wider than four feet, narrower than the 14-foot standard, and are located extremely close to traffic lanes, thus impacting safety for pedestrians and bicyclists. Pedestrian and bicycle connectivity are poor in the Bridge Influence Area.

Seismic vulnerability: The existing I-5 bridges are located in a seismically active zone. They do not meet current seismic standards and are vulnerable to failure in an earthquake.

1.3 Project Vision and Values

The CRC project is being developed through an inclusive and collaborative process that builds upon the previous work of the I-5 Trade and Transportation Partnership. It seeks to deliver a financially feasible solution that sustains and stimulates a healthy community by addressing its mobility and transportation needs, strengthening the economy, protecting natural resources, and enhancing quality of life.

The CRC project should reach this vision through:

1.3.1 Mobility, Reliability, and Accessibility

- Ensuring mobility, reliability, and accessibility for all users, recognizing the requirements of local, intra-regional, and interstate movement now and in the future.

1.3.2 Modal Choice

- Providing attractive opportunities to use transit, bicycle, and pedestrian modes for travel across the I-5 bridge.

1.3.3 Safety

- Ensuring safety for vehicles (trucks, autos, emergency, and transit), pedestrians, bicyclists, river users, and air traffic at the crossing.

1.3.4 Community Livability

- Enhancing community livability. This would be done through:
  - Support of a healthy and vibrant land use mix of residential, commercial, industrial, recreational, cultural, and historic areas.
  - Consideration of air quality; aesthetic quality that achieves a regional landmark; community cohesion and avoidance of disruption; impacts of noise, light, and glare; and parks, historic resources, and cultural resources.

1.3.5 Freight Mobility

- Supporting a sound regional economy by addressing the need to move freight efficiently and reliably through the I-5 Bridge Influence Area and allow for river navigational needs.

1.3.6 Natural Resource Stewardship

- Respecting and protecting natural resources including fish, fish and wildlife habitat, and water quality.

1.3.7 Distribution of Impacts and Benefits

- Ensuring the fair distribution of benefits and adverse effects of the project for the region, communities, and neighborhoods adjacent to the project area.

1.3.8 Cost Effectiveness

- Ensuring cost effectiveness in design, construction, maintenance, and operation.

1.3.9 Financial Feasibility

- Ensuring a reliable funding plan for the project.

2. Description of Alternatives

This technical report evaluates the CRC project's locally preferred alternative (LPA) and the No-Build Alternative. The LPA includes two design options: The preferred option, LPA Option A, which includes local vehicular access between Marine Drive and Hayden Island on an arterial bridge; and LPA Option B, which does not have arterial lanes on the light rail/multi-use path bridge, but instead provides direct access between Marine Drive and Hayden Island with collector-distributor (CD) lanes on the two new bridges that would be built adjacent to I-5. In addition to the design options, if funding availability does not allow the entire LPA to be constructed in one phase, some roadway elements of the project would be deferred to a future date. This technical report identifies several elements that could be deferred, and refers to that possible initial investment as LPA with highway phasing. The LPA with highway phasing option would build most of the LPA in the first phase, but would defer construction of specific elements of the project. The LPA and the No-Build Alternative are described in this section.

2.1.1 Adoption of a Locally Preferred Alternative

Following the publication of the Draft Environmental Impact Statement (DEIS) on May 2, 2008, the project actively solicited public and stakeholder feedback on the DEIS during a 60-day comment period. During this time, the project received over 1,600 public comments.

During and following the public comment period, the elected and appointed boards and councils of the local agencies sponsoring the CRC project held hearings and workshops to gather further public input on and discuss the DEIS alternatives as part of their efforts to determine and adopt a locally preferred alternative. The LPA represents the alternative preferred by the local and regional agencies sponsoring the CRC project. Local agency-elected boards and councils determined their preference based on the results of the evaluation in the DEIS and on the public and agency comments received both before and following its publication.

In the summer of 2008, the local agencies sponsoring the CRC project adopted the following key elements of CRC as the LPA:

- A replacement bridge as the preferred river crossing,
- Light rail as the preferred high-capacity transit mode, and
- Clark College as the preferred northern terminus for the light rail extension.

The preferences for a replacement crossing and for light rail transit were identified by all six local agencies. Only the agencies in Vancouver – the Clark County Public Transit Benefit Area Authority (C-TRAN), the City of Vancouver, and the Regional Transportation Council (RTC) – preferred the Vancouver light rail terminus. The adoption of the LPA by these local agencies does not represent a formal decision by the federal agencies leading this project – the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) – or any federal funding commitment. A formal decision by FHWA and FTA about whether and how this project should be constructed will follow the FEIS in a Record of Decision (ROD).

2.1.2 Description of the LPA

The LPA includes an array of transportation improvements, which are described below. When the LPA differs between Option A and Option B, it is described in the associated section. For a more detailed description of the LPA, including graphics, please see Chapter 2 of the FEIS.

2.1.2.1 Multimodal River Crossing

Columbia River Bridges

The parallel bridges that form the existing I-5 crossing over the Columbia River would be replaced by two new parallel bridges. The eastern structure would accommodate northbound highway traffic on the bridge deck, with a bicycle and pedestrian path underneath; the western structure would carry southbound traffic, with a two-way light rail guideway below. Whereas the existing bridges have only three lanes each with virtually no shoulders, each of the new bridges would be wide enough to accommodate three through-lanes and two add/drop lanes. Lanes and shoulders would be built to full design standards.

The new bridges would be high enough to provide approximately 95 feet of vertical clearance for river traffic beneath, but not so high as to impede the take-offs and landings by aircraft using Pearson Field or Portland International Airport to the east. The new bridge structures over the Columbia River would not include lift spans, and both of the new bridges would each be supported by six piers in the water and two piers on land.

North Portland Harbor Bridges

The existing highway structures over North Portland Harbor would not be replaced; instead, they would be retained to accommodate all mainline I-5 traffic. As discussed at the beginning of this chapter, two design options have emerged for the Hayden Island and Marine Drive interchanges. The preferred option, LPA Option A, includes local vehicular access between Marine Drive and Hayden Island on an arterial bridge. LPA Option B does not have arterial lanes on the light rail/multi-use path bridge, but instead provides direct access between Marine Drive and the island with collector-distributor lanes on the two new bridges that would be built adjacent to I-5.

LPA Option A: Four new, narrower parallel structures would be built across the waterway, three on the west side and one on the east side of the existing North Portland Harbor bridges. Three of the new structures would carry on- and off-ramps to mainline I-5. Two structures west of the existing bridges would carry traffic merging onto or exiting off of I-5 southbound. The new structure on the east side of I-5 would serve as an on-ramp for traffic merging onto I-5 northbound.

The fourth new structure would be built slightly farther west and would include a two-lane arterial bridge for local traffic to and from Hayden Island, light rail transit, and a multi-use path for pedestrians and bicyclists. All of the new structures would have at least as much vertical clearance over the river as the existing North Portland Harbor bridges.

LPA Option B: This option would build the same number of structures over North Portland Harbor as Option A, although the locations and functions on those bridges would differ, as described below. The existing bridge over North Portland Harbor would be widened and would receive seismic upgrades.LPA Option B does not have arterial lanes on the light rail/multi-use path bridge. Direct access between Marine Drive and the island would be provided with collector-distributor lanes. The structures adjacent to the highway bridge would carry traffic merging onto or exiting off of mainline I-5 between the Marine Drive and Hayden Island interchanges.

2.1.2.2 Interchange Improvements

The LPA includes improvements to seven interchanges along a 5-mile segment of I-5 between Victory Boulevard in Portland and SR 500 in Vancouver. These improvements include some reconfiguration of adjacent local streets to complement the new interchange designs, as well as new facilities for bicyclists and pedestrians along this corridor.

Victory Boulevard Interchange

The southern extent of the I-5 project improvements would be two ramps associated with the Victory Boulevard interchange in Portland. The Marine Drive to I-5 southbound on-ramp would be braided over the I-5 southbound to the Victory Boulevard/Denver Avenue off-ramp. The other ramp improvement would lengthen the merge distance for northbound traffic entering I-5 from Denver Avenue. The current merging ramp would be extended to become an add/drop (auxiliary) lane which would continue across the river crossing.

***Potential phased construction option*:** The aforementioned southbound ramp improvements to the Victory Boulevard interchange may not be included with the CRC project. Instead, the existing connections between I-5 southbound and Victory Boulevard could be retained. The braided ramp connection could be constructed separately in the future as funding becomes available.

Marine Drive Interchange

All movements within this interchange would be reconfigured to reduce congestion for motorists entering and exiting I-5 at this location. The interchange configuration would be a single-point urban interchange (SPUI) with a flyover ramp serving the east to north movement. With this configuration, three legs of the interchange would converge at a point on Marine Drive, over the I-5 mainline. This configuration would allow the highest volume movements to move freely without being impeded by stop signs or traffic lights.

The Marine Drive eastbound to I-5 northbound flyover ramp would provide motorists with access to I-5 northbound without stopping. Motorists from Marine Drive eastbound would access I-5 southbound without stopping. Motorists traveling on Martin Luther

King Jr. Boulevard westbound to I-5 northbound would access I-5 without stopping at the intersection.

The new interchange configuration changes the westbound Marine Drive and westbound Vancouver Way connections to Martin Luther King Jr. Boulevard and to northbound I-5. These two streets would access westbound Martin Luther King Jr. Boulevard farther east. Martin Luther King Jr. Boulevard would have a new direct connection to I-5 northbound.

In the new configuration, the connections from Vancouver Way and Marine Drive would be served, improving the existing connection to Martin Luther King Jr. Boulevard east of the interchange. The improvements to this connection would allow traffic to turn right from Vancouver Way and accelerate onto Martin Luther King Jr. Boulevard. On the south side of Martin Luther King Jr. Boulevard, the existing loop connection would be replaced with a new connection farther east.

A new multi-use path would extend from the Bridgeton neighborhood to the existing Expo Center light rail station and from the station to Hayden Island along the new light rail line over North Portland Harbor.

LPA Option A: Local traffic between Martin Luther King Jr. Boulevard/Marine Drive and Hayden Island would travel via an arterial bridge over North Portland Harbor. There would be some variation in the alignment of local streets in the area of the interchange between Option A and Option B. The most prominent differences are the alignments of Vancouver Way and Union Court.

LPA Option B: With this design option, there would be no arterial traffic lanes on the light rail/multi-use path bridge over North Portland Harbor. Instead, vehicles traveling between Martin Luther King Jr. Boulevard/ Marine Drive and Hayden Island would travel on the collector-distributor bridges that would parallel each side of I-5 over North Portland Harbor. Traffic would not need to merge onto mainline I-5 to travel between the island and Martin Luther King Jr. Boulevard/Marine Drive.

***Potential phased construction option*:** The aforementioned flyover ramp could be deferred and not constructed as part of the CRC project. In this case, rather than providing a direct eastbound Marine Drive to I-5 northbound connection by a flyover ramp, the project improvements to the interchange would instead provide this connection through the signal-controlled SPUI. The flyover ramp could be constructed separately in the future as funding becomes available.

Hayden Island Interchange

All movements for this interchange would be reconfigured. The new configuration would be a split tight diamond interchange. Ramps parallel to the highway would be built, lengthening the ramps and improving merging speeds. Improvements to Jantzen Drive and Hayden Island Drive would include additional through, left-turn, and right-turn lanes. A new local road, Tomahawk Island Drive, would travel east-west through the middle of Hayden Island and under the I-5 interchange, improving connectivity across I-5 on the island. Additionally, a new multi-use path would be provided along the elevated light rail line on the west side of the Hayden Island interchange.

LPA Option A: A proposed arterial bridge with two lanes of traffic, one in each direction, would allow vehicles to travel between Martin Luther King Jr. Boulevard/ Marine Drive and Hayden Island without accessing I-5.

LPA Option B: With this design option there would be no arterial traffic lanes on the light rail/multi-use path bridge over North Portland Harbor. Instead, vehicles traveling between Martin Luther King Jr. Boulevard/Marine Drive and Hayden Island would travel on the collector-distributor bridges that parallel each side of I-5 over North Portland Harbor.

SR 14 Interchange

The function of this interchange would remain largely the same. Direct connections between I-5 and SR 14 would be rebuilt. Access to and from downtown Vancouver would be provided as it is today, but the connection points would be relocated. Downtown Vancouver I-5 access to and from the south would be at C Street rather than Washington Street, while downtown connections to and from SR 14 would be made by way of Columbia Street at 4th Street.

The multi-use bicycle and pedestrian path in the northbound (eastern) I-5 bridge would exit the structure at the SR 14 interchange, and then loop down to connect into Columbia Way.

Mill Plain Interchange

This interchange would be reconfigured into a SPUI. The existing "diamond" configuration requires two traffic signals to move vehicles through the interchange. The SPUI would use one efficient intersection and allow opposing left turns simultaneously. This would improve the capacity of the interchange by reducing delay for traffic entering or exiting the highway.

This interchange would also receive several improvements for bicyclists and pedestrians. These include bike lanes and sidewalks, clear delineation and signing, short perpendicular crossings at the ramp terminals, and ramp orientations that would make pedestrians highly visible.

Fourth Plain Interchange

The improvements to this interchange would be made to better accommodate freight mobility and access to the new park-and-ride facility at Clark College. Northbound I-5 traffic exiting to Fourth Plain would continue to use the off-ramp just north of the SR 14 interchange. The southbound I-5 exit to Fourth Plain would be braided with the SR 500 connection to I-5, which would eliminate the non-standard weave between the SR 500 connection and the off-ramp to Fourth Plain as well as the westbound SR 500 to Fourth Plain Boulevard connection.

Additionally, several improvements would be made to provide better bicycle and pedestrian mobility and accessibility, including bike lanes, neighborhood connections, and access to the park-and-ride facility.

SR 500 Interchange

Improvements would be made to the SR 500 interchange to add direct connections to and from I-5. On- and off-ramps would be built to directly connect SR 500 and I-5 to and from the north, connections that are currently made by way of 39th Street. I-5 southbound traffic would connect to SR 500 via a new tunnel underneath I-5. SR 500 eastbound traffic would connect to I-5 northbound on a new on-ramp. The 39th Street connections with I-5 to and from the north would be eliminated. Travelers would instead use the connections at Main Street to connect to and from 39th Street.

Additionally, several improvements would be made to provide better bicycle and pedestrian mobility and accessibility, including sidewalks on both sides of 39th Street, bike lanes, and neighborhood connections.

Potential phased construction option: The northern half of the existing SR 500 interchange would be retained, rather than building new connections between I-5 southbound to SR 500 eastbound and from SR 500 westbound to I-5 northbound. The ramps connecting SR 500 and I-5 to and from the north could be constructed separately in the future as funding becomes available.

2.1.2.3 Transit

The primary transit element of the LPA is a 2.9-mile extension of the current Metropolitan Area Express (MAX) Yellow Line light rail from the Expo Center in North Portland, where it currently ends, to Clark College in Vancouver. The transit element would not differ between LPA and LPA with highway phasing. To accommodate and complement this major addition to the region's transit system, a variety of additional improvements are also included in the LPA:

- Three park-and-ride facilities in Vancouver near the new light rail stations.
- Expansion of Tri-County Metropolitan Transportation District's (TriMet's) Ruby Junction light rail maintenance base in Gresham, Oregon.
- Changes to C-TRAN local bus routes.
- Upgrades to the existing light rail crossing over the Willamette River via the Steel Bridge.

Operating Characteristics

Nineteen new light rail vehicles (LRV) would be purchased as part of the CRC project to operate this extension of the MAX Yellow Line. These vehicles would be similar to those currently used by TriMet's MAX system. With the LPA, LRVs in the new guideway and in the existing Yellow Line alignment are planned to operate with 7.5-minute headways during the "peak of the peak" (the two-hour period within the 4-hour morning and afternoon/evening peak periods where demand for transit is the highest) and 15-minute headways during off-peak periods.

Light Rail Alignment and Stations

Oregon Light Rail Alignment and Station

A two-way light rail alignment for northbound and southbound trains would be constructed to extend from the existing Expo Center MAX station over North Portland Harbor to Hayden Island. Immediately north of the Expo Center, the alignment would curve eastward toward I-5, pass beneath Marine Drive, then rise over a flood wall onto a light rail/multi-use path bridge to cross North Portland Harbor. The double-track guideway over Hayden Island would be elevated at approximately the height of the rebuilt mainline of I-5, as would a new station immediately west of I-5. The alignment would extend northward on Hayden Island along the western edge of I-5, until it transitions into the hollow support structure of the new western bridge over the Columbia River.

Downtown Vancouver Light Rail Alignment and Stations

After crossing the Columbia River, the light rail alignment would curve slightly west off of the highway bridge and onto its own smaller structure over the Burlington Northern Santa Fe (BNSF) rail line. The double-track guideway would descend on structure and touch down on Washington Street south of 5th Street, continuing north on Washington Street to 7th Street. The elevation of 5th Street would be raised to allow for an at-grade crossing of the tracks on Washington Street. Between 5th and 7th Streets, the double-track guideway would run down the center of the street. Traffic would not be allowed on Washington between 5th and 6th Streets and would be two-way between 6th and 7th Streets. There would be a station on each side of the street on Washington between 5th and 6th Streets.

At 7th Street, the light rail alignment would form a couplet. The single-track northbound guideway would turn east for two blocks, then turn north onto Broadway Street, while the single-track southbound guideway would continue on Washington Street. Seventh Street will be converted to one-way traffic eastbound between Washington and Broadway with light rail operating on the north side of 7th Street. This couplet would extend north to 17th Street, where the two guideways would join and turn east.

The light rail guideway would run on the east side of Washington Street and the west side of Broadway Street, with one-way traffic southbound on Washington Street and one-way traffic northbound on Broadway Street. On station blocks, the station platform would be on the side of the street at the sidewalk. There would be two stations on the Washington-Broadway couplet, one pair of platforms near Evergreen Boulevard, and one pair near 15th Street.

East-West Light Rail Alignment and Terminus Station

The single-track southbound guideway would run in the center of 17th Street between Washington and Broadway Streets. At Broadway Street, the northbound and southbound alignments of the couplet would become a double-track, center-running guideway traveling east-west on 17th Street. The guideway on 17th Street would run until G Street, then connect with McLoughlin Boulevard and cross under I-5. Both alignments would end at a station east of I-5 on the western boundary of Clark College.

Park-and-Ride Stations

Three park-and-ride stations would be built in Vancouver along the light rail alignment:

- Within the block surrounded by Columbia, Washington, 4th and 5th Streets, with five floors above ground that include space for retail on the first floor and 570 parking stalls.
- Between Broadway and Main Streets next to the stations between 15th and 16th Streets, with space for retail on the first floor, and four floors above ground that include 420 parking stalls.
- At Clark College, just north of the terminus station, with space for retail or C-TRAN services on the first floor, and five floors that include approximately 1,910 parking stalls.

Ruby Junction Maintenance Facility Expansion

The Ruby Junction Maintenance Facility in Gresham, Oregon, would be expanded to accommodate the additional LRVs associated with the CRC project. Improvements include additional storage for LRVs and other maintenance material, expansion of LRV maintenance bays, and expanded parking for additional personnel. A new operations command center would also be required, and would be located at the TriMet Center Street location in Southeast Portland.

Local Bus Route Changes

As part of the CRC project, several C-TRAN bus routes would be changed in order to better complement the new light rail system. Most of these changes would re-route bus lines to downtown Vancouver where riders could transfer to light rail. Express routes, other than those listed below, are expected to continue service between Clark County and downtown Portland. The following table **Exhibit 2-1** shows anticipated future changes to C-TRAN bus routes.

Exhibit 2-1. Proposed C-TRAN Bus Routes Comparison

C-TRAN Bus Route	Route Changes
#4 - Fourth Plain	Route truncated in downtown Vancouver
#41 - Camas / Washougal Limited	Route truncated in downtown Vancouver
#44 - Fourth Plain Limited	Route truncated in downtown Vancouver
#47 - Battle Ground Limited	Route truncated in downtown Vancouver
#105 - I-5 Express	Route truncated in downtown Vancouver
#105S - I-5 Express Shortline	Route eliminated in LPA (The No-Build runs articulated buses between downtown Portland and downtown Vancouver on this route)

Steel Bridge Improvements

Currently, all light rail lines within the regional TriMet MAX system cross over the Willamette River via the Steel Bridge. By 2030, the number of LRVs that cross the Steel Bridge during the 4-hour PM peak period would increase from 152 to 176. To accommodate these additional trains, the project would retrofit the existing rails on the Steel Bridge to increase the allowed light rail speed over the bridge from 10 to 15 mph. To accomplish this, additional work along the Steel Bridge lift spans would be needed.

2.1.2.4 Tolling

Tolling cars and trucks that use the I-5 river crossing is proposed as a method to help fund the CRC project and to encourage the use of alternative modes of transportation. The authority to toll the I-5 crossing is set by federal and state laws. Federal statutes permit a toll-free bridge on an interstate highway to be converted to a tolled facility following the reconstruction or replacement of the bridge. Prior to imposing tolls on I-5, Washington and Oregon Departments of Transportation (WSDOT and ODOT) would have to enter into a toll agreement with U.S. Department of Transportation (DOT). Recently passed state legislation in Washington permits WSDOT to toll I-5 provided that the tolling of the facility is first authorized by the Washington legislature. Once authorized by the legislature, the Washington Transportation Commission (WTC) has the authority to set the toll rates. In Oregon, the Oregon Transportation Commission (OTC) has the authority to toll a facility and to set the toll rate. It is anticipated that prior to tolling I-5, ODOT and WSDOT would enter into a bi-state tolling agreement to establish a cooperative process for setting toll rates and guiding the use of toll revenues.

Tolls would be collected using an electronic toll collection system: toll collection booths would not be required. Instead, motorists could obtain a transponder that would automatically bill the vehicle owner each time the vehicle crossed the bridge, while cars without transponders would be tolled by a license-plate recognition system that would bill the address of the owner registered to that license plate.

The LPA proposes to apply a variable toll on vehicles using the I-5 crossing. Tolls would vary by time of day, with higher rates during peak travel periods and lower rates during off-peak periods. Medium and heavy trucks would be charged a higher toll than passenger vehicles. The traffic-related impact analysis in this FEIS is based on toll rates that, for passenger cars with transponders, would range from $1.00 during the off-peak to $2.00 during the peak travel times (in 2006 dollars).

2.1.2.5 Transportation System and Demand Management Measures

Many well-coordinated transportation demand management (TDM) and transportation system management (TSM) programs are already in place in the Portland-Vancouver Metropolitan region and supported by agencies and adopted plans. In most cases, the impetus for the programs is from state-mandated programs: Oregon's Employee Commute Options (ECO) rule and Washington's Commute Trip Reduction (CTR) law.

The physical and operational elements of the CRC project provide the greatest TDM opportunities by promoting other modes to fulfill more of the travel needs in the project corridor. These include:

- Major new light rail line in exclusive right-of-way, as well as express bus and feeder routes;
- Modern bicycle and pedestrian facilities that accommodate more bicyclists and pedestrians, and improve connectivity, safety, and travel time;
- Park-and-ride lots and garages; and
- A variable toll on the highway crossing.

In addition to these fundamental elements of the project, facilities and equipment would be implemented that could help existing or expanded TSM programs maximize capacity and efficiency of the system. These include:

- Replacement or expanded variable message signs or other traveler information systems in the CRC project area;
- Expanded incident response capabilities;
- Queue jumps or bypass lanes for transit vehicles where multi-lane approaches are provided at ramp signals for entrance ramps;
- Expanded traveler information systems with additional traffic monitoring equipment and cameras, and
- Active traffic management.

2.1.3 LPA Construction

Construction of bridges over the Columbia River is the most substantial element of the project, and this element sets the sequencing for other project components. The main river crossing and immediately adjacent highway improvement elements would account for the majority of the construction activity necessary to complete this project.

2.1.3.1 Construction Activities Sequence and Duration

The following table **Exhibit 2-2** displays the expected duration and major details of each element of the project. Due to construction sequencing requirements, the timeline to complete the initial phase of the LPA with highway phasing is the same as the full LPA.

Exhibit 2-2. Construction Activities and Estimated Duration

Element	Estimated Duration	Details
Columbia River bridges	4 years	• Construction is likely to begin with the bridges. • General sequence includes initial preparation, installation of foundation piles, shaft caps, pier columns, superstructure, and deck.
Hayden Island and SR 14 interchanges	1.5 - 4 years for each interchange	• Both interchanges must be partially constructed before any traffic can be transferred to the new structure. • Each interchange needs to be completed at the same time.
Marine Drive interchange	3 years	• Construction would need to be coordinated with construction of the southbound lanes coming from Vancouver.
Demolition of the existing bridge	1.5 years	• Demolition of the existing bridges can begin only after traffic is rerouted to the new bridges.
Three interchanges north of SR 14	4 years for all three	• Construction of these interchanges could be independent from each other or from the southern half of the project. • More aggressive and costly staging could shorten this timeframe.
Light rail	4 years	• The river crossing for the light rail would be built with the bridges. • Any bridge structure work would be separate from the actual light rail construction activities and must be completed first.
Total construction timeline	6.3 years	• Funding, as well as contractor schedules, regulatory restrictions on in-water work, weather, materials, and equipment, could all influence construction duration. • This is also the same time required to complete the smallest usable segment of roadway – Hayden Island through SR 14 interchanges.

2.1.3.2 Major Staging Sites and Casting Yards

Staging of equipment and materials would occur in many areas along the project corridor throughout construction, generally within existing or newly purchased right-of-way or on nearby vacant parcels. However, at least one large site would be required for construction offices, to stage the larger equipment such as cranes, and to store materials such as rebar and aggregate. Suitable sites must be large and open to provide for heavy machinery and material storage, must have waterfront access for barges (either a slip or a dock capable of handling heavy equipment and material) to convey material to the construction zone, and must have roadway or rail access for landside transportation of materials by truck or train.

Three sites have been identified as possible major staging areas:

1. Port of Vancouver (Parcel 1A) site in Vancouver: This 52-acre site is located along SR 501 and near the Port of Vancouver's Terminal 3 North facility.

2. Red Lion at the Quay hotel site in Vancouver: This site would be partially acquired for construction of the Columbia River Crossing, which would require the demolition of the building on this site, leaving approximately 2.6 acres for possible staging.
3. Vacant Thunderbird hotel site on Hayden Island: This 5.6-acre site is much like the Red Lion hotel site in that a large portion of the parcel is already required for new right-of-way necessary for the LPA.

A casting/staging yard could be required for construction of the over-water bridges if a precast concrete segmental bridge design is used. A casting yard would require access to the river for barges, including either a slip or a dock capable of handling heavy equipment and material; a large area suitable for a concrete batch plant and associated heavy machinery and equipment; and access to a highway and/or railway for delivery of materials.

Two sites have been identified as possible casting/staging yards:

1. Port of Vancouver Alcoa/Evergreen West site: This 95-acre site was previously home to an aluminum factory and is currently undergoing environmental remediation, which should be completed before construction of the CRC project begins (2012). The western portion of this site is best suited for a casting yard.
2. Sundial site: This 50-acre site is located between Fairview and Troutdale, just north of the Troutdale Airport, and has direct access to the Columbia River. There is an existing barge slip at this location that would not have to undergo substantial improvements.

2.1.4 The No-Build Alternative

The No-Build Alternative illustrates how transportation and environmental conditions would likely change by the year 2030 if the CRC project is not built. This alternative makes the same assumptions as the build alternatives regarding population and employment growth through 2030, and also assumes that the same transportation and land use projects in the region would occur as planned. The No-Build Alternative also includes several major land use changes that are planned within the project area, such as the Riverwest development just south of Evergreen Boulevard and west of I-5, the Columbia West Renaissance project along the western waterfront in downtown Vancouver, and redevelopment of the Jantzen Beach shopping center on Hayden Island. All traffic and transit projects within or near the CRC project area that are anticipated to be built by 2030 separately from this project are included in the No-Build and build alternatives. Additionally, the No-Build Alternative assumes bridge repair and continuing maintenance costs to the existing bridge that are not anticipated with the replacement bridge option.

3. Transportation Analysis Methodology

3.1 Study Area

Exhibit 3-1 (illustrated at the end of this chapter) shows the transportation study area for the CRC project. The five-mile segment of I-5 referred to as the Bridge Influence Area includes seven interchanges: State Route 500, Fourth Plain Boulevard, Mill Plain Boulevard, and City Center/State Route 14 in Vancouver; and Hayden Island, Marine Drive, and Interstate Avenue/Victory Boulevard in Portland. The Bridge Influence Area includes the Interstate Bridges and the North Portland Harbor bridge.

A larger, 23-mile-long study area inclusive of the Bridge Influence Area was used for analyzing traffic effects for the CRC project. The longer area was used to provide a more rigorous and inclusive approach to the traffic modeling and analysis. The northern boundary of this corridor is located at the Pioneer Street/SR 501 interchange in Ridgefield, Washington. In total, 11 interchanges are included in the 14-mile-long segment of the study area in Washington. In Oregon, the southern boundary of the 23-mile-long area is the Marquam Bridge, where I-5 crosses the Willamette River near downtown Portland. In total, 12 interchanges are located in the 9-mile-long segment of the study area in Oregon.

To develop an understanding of the possible effects of tolling in conjunction with potential improvements to the bridge, highway and transit networks, a 9-mile segment of I-205 in Washington and Oregon was examined. The segment of highway includes the Glenn Jackson Bridge over the Columbia River. The northern boundary of the I-205 study area is at the SR 500 interchange with I-205 in Vancouver. The southern boundary of the 9-mile corridor is the southernmost interchange of I-84 and I-205 in Portland, near the Gateway area. There are a total of six interchanges included in the study area, three in Washington and three in Oregon.

A number of local street intersections were evaluated. Signalized and unsignalized intersections in Vancouver and Portland were studied to determine the effects of potential improvements to the bridge, highway and transit networks would have on local street operations. The local street operations study included the ramp terminals at the I-5 highway interchanges located within the Bridge Influence Area. For the existing conditions analysis a total of 73 intersections in Vancouver and 25 intersections in Portland were examined; the total includes the I-5 ramp terminals in the project area. The number of intersections increased under the future scenarios.

3.2 Study Periods

The traffic analysis focused on existing conditions (generally in 2005 to 2007) and projected year 2030 conditions. Current traffic volumes within the study area are typically at their highest on weekdays between 6 and 10 a.m. and between 3 and 7 p.m.

This trend is expected to continue into the future. The majority of the traffic performance analyses conducted for this report focuses on these two weekday peak periods, although certain data has been extrapolated to cover a 16-hour period from 5 a.m. to 9 p.m. In addition, some data is presented for a daily (24-hour) period.

Metro's regional travel demand model was used to report existing and future region-wide transportation measures. Metro's model is calibrated to year 2005 conditions and it is used to predict 2030 conditions.

3.3 Data Collection

The foundation of any traffic operations analysis is a clear and thorough understanding of existing conditions through the collection of detailed traffic data. The CRC project area contains a diverse transportation system with a highway system, a network of local area roads, and bicycle and pedestrian systems. The traffic composition within the study area is a very diverse mix with commuters, heavy truck traffic, transit users, local business and residential traffic, and bicycle and pedestrian users.

The traffic data used in this analysis was primarily collected during the fall of 2005. Supplemental data was collected during the summer of 2006 and during the spring and summer of 2007. Data included traffic volumes along the highway and at ramp terminals, local intersection turning movement counts, vehicle classification surveys, travel lane utilization surveys, travel speeds, vehicle occupancy counts, vehicle origin-destination data, and bicycle and pedestrian counts.

The various traffic counts and surveys collected for this study were collected at sites that were identified through discussions with ODOT, WSDOT, City of Vancouver, and City of Portland staff.

3.4 Travel Demand Forecasting Overview

Travel demand models use a market-based approach by considering both the transportation supply and travel demand for producing future mobility characteristics such as roadway traffic volumes and transit ridership.

The two Metropolitan Planning Organizations (MPO) in the Portland-Vancouver metropolitan area are the Metropolitan Service District (Metro), and the Southwest Washington Regional Transportation Council (RTC). Both organizations have travel demand modeling capability and a long history of successfully coordinating their modeling activities. For the purposes of the analysis, it was determined that Metro would lead the modeling effort, supported closely by the RTC. The regional travel model at Metro was expanded to include population and employment forecasts from southwest Washington that were approved by Clark County and its cities.

The regional travel demand model uses a four-step process, shown in **Exhibit 3-2**, which includes the following components:

- **Trip generation** determines the location, magnitude, and purpose of trip-making based on land use and socioeconomic input data.

- **Trip distribution** identifies origin and destination travel patterns by calculating trip lengths and travel times from transportation system attributes.
- In **mode choice**, trips are sorted into the various vehicle, transit, and in some cases, walk and bike modes.
- Through **trip assignment**, routing paths for vehicle and transit trips are determined for several time periods throughout the day.

Several traffic modeling tools were used to forecast travel demands and evaluate traffic operations. These are explained in the following sections.

3.4.1 EMME/2

The EMME/2 transportation modeling software program assigns regional travel demands to a transportation network using an equilibrium assignment. The assignment results in roadway link volumes where no traveler can achieve additional travel time savings by changing routes. The software program itself is used to edit highway networks, analyze data, display and plot results, and import and export data.

The transportation analysis used Metro's regional travel forecasting model to simulate highway and transit option packages to derive transportation performance measures. The highway and transit assignments were done using the EMME/2 software package.

3.4.2 VISUM

VISUM is a comprehensive, flexible software system for transportation planning, travel demand modeling, and network data management. Designed for multimodal analysis, VISUM integrates all relevant modes of transportation (i.e., car, car passenger, truck, bus, train, pedestrians, and bicyclists) into one comprehensive network model while providing a variety of assignment procedures. VISUM provides direct network linkage capabilities to VISSIM (see description below). This linkage facilitates network building and permits the use of dynamic path building (i.e., not fixed routes) in VISSIM.

The region including Metro, RTC, and many agencies in the Portland-Vancouver region are currently transitioning from EMME/2 to the VISUM assignment software. Most of the outputs derived during the Final Environmental Impact Statement (FEIS) analysis were prepared using EMME/2. However, auto assignment information was developed using VISUM for flow bundle analyses and traffic operations work.

3.4.3 VISSIM

VISSIM is a microscopic, behavior-based multi-purpose traffic simulation program. For many engineering disciplines, simulation has become an indispensable instrument for the optimization of complex technical systems. This is especially true for transportation planning and traffic engineering, where simulation is an invaluable and cost-reducing tool.

VISSIM offers a wide variety of urban and highway applications, integrating public and private transportation. The traffic simulation model is able to model complex traffic conditions and is capable of analyzing traffic operations under both uncongested and congested conditions. VISSIM is explained further in Section 3.5.1.

3.4.4 Synchro/SimTraffic

Synchro is a software application for optimizing traffic signal timing and performing intersection capacity analysis. The software optimizes traffic signal splits, offsets, and cycle lengths for individual intersections, an arterial, or a complete network. SimTraffic is a microscopic model that simulates individual vehicles using the roadway network.

As a microscopic model SimTraffic animates traffic flow based on input volumes and signal timing and is able to model congested conditions on arterials, including overcapacity operations at signalized intersections, unbalanced lane utilization and vehicle queue build up, and dissipation over morning and afternoon/evening peak periods. SimTraffic models signalized and unsignalized intersections, and roadway segments with automobiles, trucks, pedestrians, and buses. By basing the traffic analysis on driver behavior (driver reaction to the environment) rather than individual capacities, SimTraffic is able to model arterials as a traffic system, where congestion at one intersection influences operations both upstream and downstream of that intersection.

3.5 Traffic Operations Overview

3.5.1 I-5 and I-205 Operations

Simulation modeling is a useful tool for designing improvements and evaluating operations on a roadway system. Simulation models enable engineers to predict the outcome of a proposed change to the roadway before it is implemented and help evaluate the merits and demerits of design options. Models are set up to predict system responses by calibrating to the model to reflect existing traffic conditions. Calibration is a process of adjusting model parameters so that simulated responses agree with measured field conditions.

Traffic simulation may be macroscopic or microscopic in nature. While macroscopic models describe the traffic process with aggregate quantities, such as flow and density, microscopic models describe the behavior of the individual drivers as they react to their perceived environments. The aggregate response in the latter case is the result of interactions among many driver/vehicle entities. Microscopic models are helpful in capturing the more detailed aspects of the system (e.g., interacting bottlenecks, closely spaced intersections, and unusual lane utilization).

For the study of I-5 operations, VISSIM was selected as the environment for micro-simulation modeling. VISSIM was supplemented by VISUM, a macro-simulation model for providing traffic flow information as mentioned under **Section 3.4**.

VISSIM is the stochastic traffic simulator that uses the psycho-physical driver behavior model. VISSIM combines a perceptual model of the driver with a vehicle model. Every driver with his or her specific behavior characteristics is assigned to a specific vehicle. As a result, driver behavior corresponds to the technical capabilities of a vehicle. The behavior model for the driver involves a classification of reactions in response to the perceived relative speed and distance with respect to the preceding vehicle. Drivers can make the decision to change lanes that can either be forced by a routing requirement, or made by the driver to access a faster-moving lane. Four driving modes are defined: free driving, approaching, following, and braking. In each mode, the driver behaves differently, reacting either to his following distance or trying to match a prescribed target speed.

VISSIM was selected for analysis due to its multimodal modeling capabilities that may include cars, trucks, and buses. Another benefit of using VISSIM is that it can simulate unique operational conditions, high occupancy vehicle (HOV) lanes, toll lanes, exclusive lanes, merging/diverging, and weaving areas. It also has visualization capabilities that make it easier to visualize design options.

3.5.2 Local Street Operations

At signalized intersections, level-of-service (LOS) is a function of control delay, which includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. Both delays and volume-to-capacity (V/C) ratios are calculated for all movements at a signalized intersection since all movements are stopped at some time during the signal cycle. Some movements, particularly side street approaches or left turns onto side streets, may experience longer delays because they receive only a small portion of the green signal time during a signal cycle but their V/C ratio may be relatively low. It is important to examine both factors – delay and V/C ratio – before drawing conclusions about operational performance. A third variable, the intersection capacity utilization (ICU) value was also determined for each intersection. The ICU is the sum of time required to serve all movements at saturation given a reference cycle length, divided by the reference cycle length.

At stop-sign controlled intersections, LOS is also a function of control delay. In addition to calculating delay, the analysis also calculates the V/C ratio for all stopped movements at the intersection. Although delays can sometimes be long for some movements at stop-sign controlled intersections, the V/C ratio may indicate that there is adequate capacity to process the demand for that movement.

Key signal-controlled and stop-sign controlled intersections were evaluated with the Synchro/SimTraffic analysis software package, which uses methodology outlined in the *2000 Highway Capacity Manual* prepared by the Transportation Research Board. **Exhibit 3-3** summarizes the LOS criteria for both signalized and unsignalized intersections based on the manual's criteria. All SimTraffic data presented in this technical report consist of the averaged results across a stochastic, randomized five-seed set of simulation outputs.

The LOS for unsignalized intersections is somewhat different than the criteria used for signalized intersections. The primary reason for this is that drivers expect different levels of performance from different kinds of transportation facilities. In general, the expectation is that a signalized intersection is designed to accommodate higher traffic volumes than an unsignalized intersection. Additionally, several driver behavior considerations combine to make delays at signalized intersections less onerous than at unsignalized intersections. For example, drivers at signalized intersections are able to relax during the red interval, while drivers on the minor street approaches to two-way stop-sign controlled intersections must remain attentive to the task of identifying acceptable gaps and vehicle conflicts. Also, there is often much more variability in the amount of delay experienced by individual drivers at unsignalized intersections than signalized intersections. For these reasons, the total delay threshold for any given LOS is considered to be less for an unsignalized intersection than for a signalized intersection.

The SimTraffic queuing results are reported when the 95th percentile vehicle queue length exceeds the available vehicle storage distance in a left- or right-turn turn lane, or when the vehicle queue length exceeds the distance between two intersections. For left- and right-turn lanes, the 95th percentile queue length is reported. In the case where the 95th percentile queue length exceeds the distance between two intersections, the queue distance reported is limited to the distance between those two intersections. In this situation, the queuing result is accompanied by a note indicating that the vehicle queue extends back into the upstream intersection. Queues for through movements are reported in this manner to allow the 95th percentile queuing distance at the upstream intersection to be attributed only to that intersection.

"Screenlines" are imaginary lines drawn across a series of parallel roadways and are used to evaluate traffic demand changes. This method involves measuring entering and exiting traffic volumes across key north-south and east-west axes. Comparison of screenline volumes yields information regarding the performance of local streets, including increased or decreased traffic volumes resulting from specific actions.

3.5.3 Development of Performance Standards

Local traffic impacts are measured by impacts to intersection LOS, delay, and queuing. WSDOT, ODOT, the City of Vancouver, the City of Portland, RTC and Metro all have definable standards for intersection operations. A description of the development and application of these standards to local street operations is provided below.

3.5.3.1 WSDOT and City of Vancouver Standards

The Washington State Department of Transportation defers to the local MPO or Regional Transportation Planning Organization (RTPO) for LOS thresholds on "Highways of Regional Significance." The RTC has adopted LOS E as the standard for urban state highways. For the purposes of the analysis of local Vancouver street intersections, including ramp terminals, the concurrency standards developed by the City of Vancouver are solely applied. **Exhibit 3-4** summarizes the intersection standards for WSDOT and the City of Vancouver.

The City of Vancouver, in compliance with WSDOT requirements, has identified and recommended LOS standards for all intersections within the city. The description of these standards is provided in the 2003 Vancouver Concurrency Administration Manual. Acceptable signalized intersection operating levels (the average weighted delay for all vehicles entering the intersection) shall not exceed 55 seconds (LOS D), with exception of traffic signals located downtown (south of McLoughlin Boulevard on the west side of I-5). The acceptable intersection operating LOS for downtown is 80 seconds (LOS E). For stop-controlled and other unsignalized intersections, a per-vehicle delay less than 50 seconds (LOS E) is considered acceptable operations by the City of Vancouver.

3.5.3.2 ODOT and City of Portland Standards

The ODOT Analysis Procedures Manual (APM) requires that the performance standards from the Oregon Highway Plan (OHP) be used to analyze existing conditions and No-Build scenarios. The stated V/C standard for ramp terminals in the OHP is 0.85, and is used for evaluation of the existing and No-Build scenarios. In addition to the ramp terminals, ODOT has jurisdiction over Lombard Street, and along Martin Luther King, Jr. Boulevard between the I-5 Marine Drive ramp terminal and Columbia Boulevard. The OHP V/C standard for these intersections is 0.99.

The APM states that the operational performance standards based on the V/C and contained in the Highway Design Manual (HDM) are to be used for the evaluation of all build cases. Interstate-5, for the entire length of the project area, is categorized as an Interstate Highway and Statewide Expressway, is located inside of an Urban Growth Boundary and within an MPO. Therefore, according to Table 10-1 of the HDM, the V/C standard that applies to the ramp terminals in the LPA and LPA with highway phasing scenarios is 0.75. For ramp terminals in the LPA and LPA with highway phasing scenarios that remain unchanged from No-Build, a V/C standard of 0.85 applies. Other intersections that would be constructed in the LPA or LPA with highway phasing, and be under ODOT's jurisdiction, would have a V/C standard between 0.75 and 0.85, depending on the cross-street roadway classification type of the facility. For all other intersections in the study area under ODOT's jurisdiction, a V/C standard of 0.99, as stated in the OHP, will be applied to the build alternatives.

The results from the Synchro/SimTraffic intersection models for the ramp terminals, the intersections along Lombard Street, and the intersections along Martin Luther King Jr. Boulevard are measured against the above standards for both the morning and afternoon/evening peak hours. **Exhibit 3-5** summarizes the intersection standards for ODOT.

For the non-ramp terminal intersections in the Portland, LOS standards from the Portland Bureau of Transportation (PBOT) apply. Like ODOT, PBOT has two tiers of standards – one that is used for the analysis of the No-Build scenario and one for the build scenarios. The level-of-service standard in the PBOT's Transportation System Plan (TSP) states that signalized intersections must meet LOS D in the No-Build scenario. Unsignalized intersections must meet a standard of LOS E. These standards also apply to the build scenarios. However, in the case where intersections in the build scenario do not meet the LOS standard, they are still considered to be performing acceptably if they "do no worse" than the No-Build scenario, consistent with PBOT's usual practice. That is, intersections in the build scenario which fail to meet the LOS D/E standard, but perform better than under the No-Build scenario, meet PBOT's requirements. **Exhibit 3-5** summarizes the intersection standards for the City of Portland.

For purposes of the FEIS, if the project would degrade an intersection's performance to an unacceptable LOS, the project will work with the operating jurisdiction to develop a cost-effective solution to mitigate the intersection performance to the minimum of the peak hour standard. If vehicular queuing blockages occur with both the No-Build Alternative and the project, then the project would be mitigated to No-Build conditions.

If the project causes traffic signal warrants, safety criteria or other criteria to be met, the project would be designed to meet applicable standards and mitigate for the impacts.

3.6 Performance Criteria

Project performance criteria were developed based on CRC's Purpose and Need statement and Vision and Values statement (see **Sections 1.2 and 1.3**). Ten categories of performance criteria were established. Four of the categories relate directly to traffic and safety measures:

- Mobility, reliability, accessibility, congestion reduction and efficiency;
- Modal choice;
- Safety; and
- Regional economy and freight mobility.

The following sections describe specific measures used to evaluate each of the traffic and safety related criterion in the I-5 corridor within the Bridge Influence Area.

3.6.1 Mobility, Reliability, Accessibility, Congestion Reduction and Efficiency

Measures used to evaluate mobility, reliability, accessibility, congestion reduction, and efficiency include:

- Reduction in travel times and delays.
- Reduction in the number of hours of highway congestion.
- Improvement in person throughput of the I-5 river crossing.
- Improvement in vehicle throughput of the I-5 river crossing.

3.6.2 Modal Choice

Measures used to evaluate modal choice include:

- Improvement in pedestrian/bicycle connectivity
- Increase in vehicle occupancy.

3.6.3 Safety

Measures used to evaluate safety include:

- Enhancement in vehicle/freight safety.
- Enhancement in pedestrian/bicycle facilities and safety.

3.6.4 Regional Economy; Freight Mobility

Measures used to evaluate regional economy and freight mobility include:

- Reduction in travel times and delays for vehicle-moved freight.
- Improvement in freight truck throughput of the I-5 river crossing.
- Improvement in vehicle throughput of the I-5 river crossing.

The performance results for each project alternative are summarized in **Section 4. Alternatives Performance Summary**.

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Exhibit 3-1
CRC Traffic Study Area

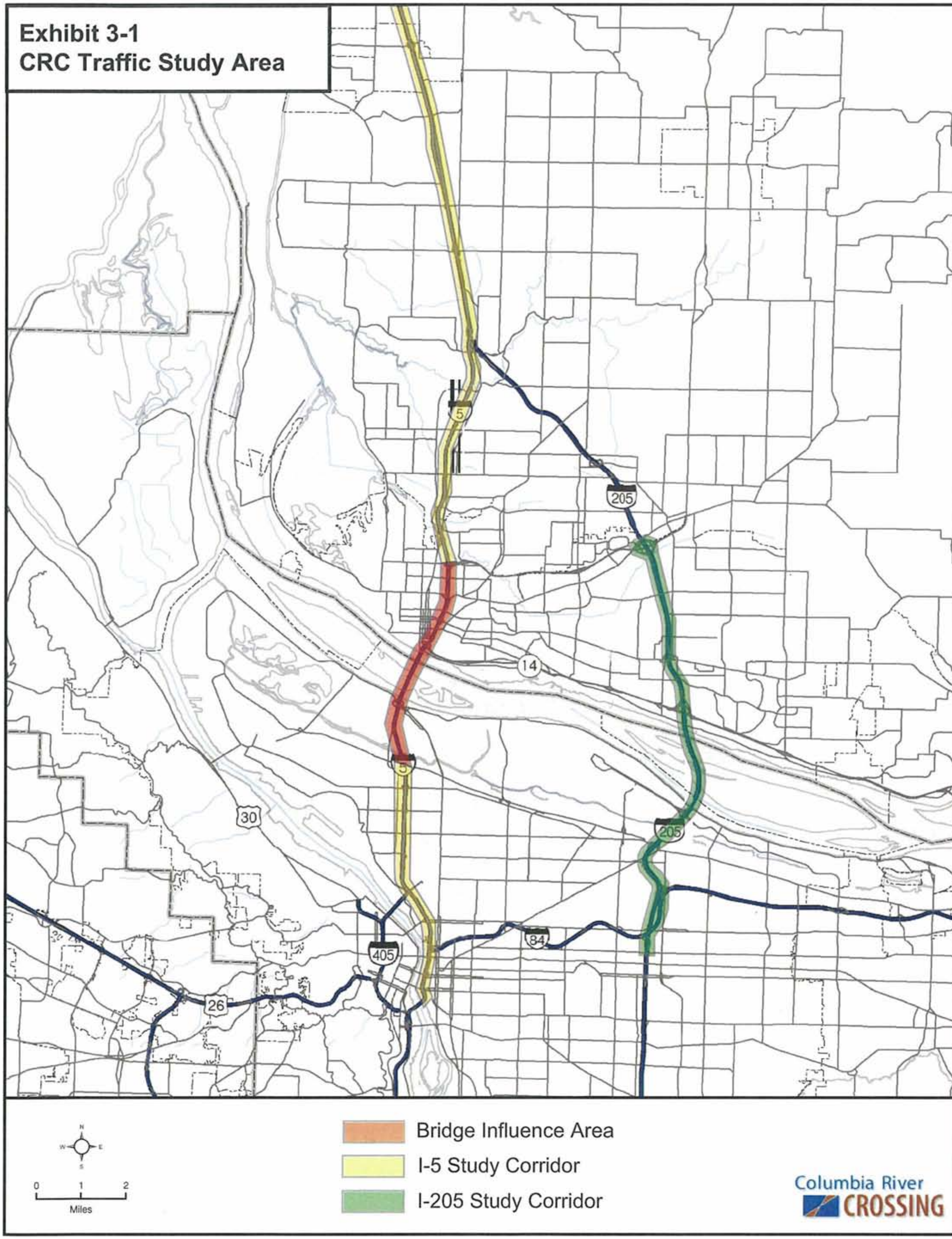
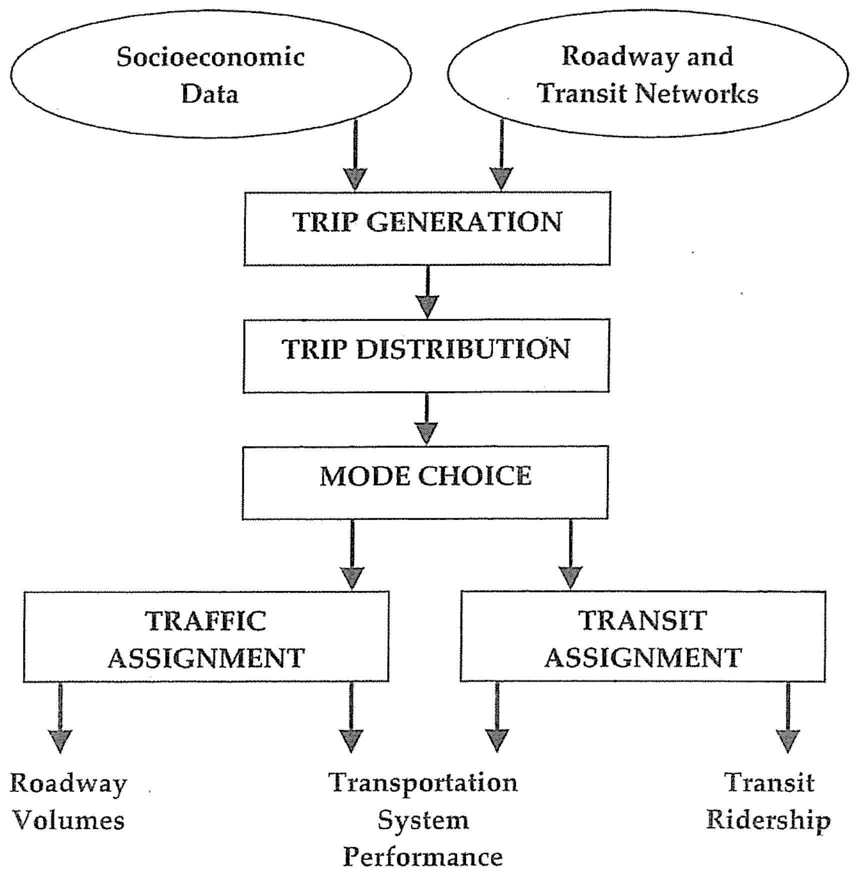


Exhibit 3-2

Multi-Modal Travel Model



The travel demand modeling process estimates trip-making behavior through a four-step process. Various socioeconomic scenarios and transportation alternatives can be forecasted by the model. Roadway traffic volumes, transit ridership, and system performance characteristics are produced by the model's application.

Exhibit 3-3

	Control Delay (seconds/vehicle)	
Level-of-Service	Signalized Intersections	Unsignalized Intersections
A	≤ 10	≤ 10
B	> 10 and ≤ 20	> 10 and ≤ 15
C	> 20 and ≤ 35	> 15 and ≤ 25
D	> 35 and ≤ 55	> 25 and ≤ 35
E	> 55 and ≤ 80	> 35 and ≤ 50
F	> 80	> 50

Note: The LOS criteria are based on control delay, which includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.

Source: Transportation Research Board, Highway Capacity Manual, 2000, p. 16-2 for signalized intersections and p. 17-2 for unsignalized intersections.

Exhibit 3-4

WSDOT and City of Vancouver Intersection Standards				
Jurisdiction	**Method**	**Existing**	**No-Build**	**Build**
WSDOT[1]	n/a	n/a	n/a	n/a
City of Vancouver (signalized)[2]	LOS	E[3] / D[3]	E[3] / D[3]	E[3] / D[3]
City of Vancouver (unsignalized)[2]	LOS	E	E	E

Note 1: By legislation, WSDOT defers to regional and local agencies for standards

Note 2: Based on the 2003 Vancouver Concurrency Administration Manual

Note 3: Downtown Vancouver LOS Standard / Outside downtown Vancouver LOS Standard

Exhibit 3-5

ODOT and City of Portland Intersection Standards				
Jurisdiction	**Method**	**Existing**	**No-Build**	**Build**
ODOT (ramp terminals)	V/C	0.85[1]	0.85[1]	0.75[2] / 0.85[1]
ODOT (street intersections)[3]	V/C	0.99	0.99	0.75 - 0.85[4] / 0.99[5]
City of Portland (signalized)[6]	LOS	D	D	D[7]
City of Portland (unsignalized)[6]	LOS	E	E	E[7]

Note 1: The standard stated in the Oregon Highway Plan (Action 1F1) applies to existing conditions, the No-Build alternative, and ramp terminals that remain unchanged from the No-Build in the LPA and LPA Phase I scenarios

Note 2: The standard stated in the Oregon Highway Design Manual (Table 10-1) applies to the LPA and LPA Phase I scenarios

Note 3: The standards stated in the Oregon Highway Design Manual (Table 7, 2004 update) applies to all scenarios

Note 4: Applies to new ODOT intersections that are not ramp terminals, and is dependant on roadway classification

Note 5: Applies to all intersections along Lombard Street and the intersection of MLK Jr. Boulevard and Columbia Boulevard

Note 6: Based on the Portland Transportation System Plan

Note 7: PDOT also considers Build scenarios to meet standards if they perform no worse than the No-Build

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4. Alternatives Performance Summary

This section presents highway and local street system transportation performance data and compares the data among the various alternatives. Highway performance data address I-5 and I-205 and compares travel demands, effects of congestion, traffic service volumes, travel times, and served versus unserved on-ramp volumes for each alternative. Local street performance data address travel demands across major roadways and intersection service levels for each alternative.

The three sections following this section provide detailed results and analysis of each of the following scenarios: existing conditions, No-Build Alternative, and the LPA. The LPA with highway phasing option is referred to as LPA Phase I in project exhibits.

4.1 I-5 and I-205 Performance

4.1.1 Daily Traffic Levels

Average daily traffic (ADT) volumes represent the average 24-hour weekday volume on a roadway segment. **Exhibit 4-1** summarizes ADT volumes on the I-5 bridge, the I-205 bridge, and the total river crossing.

4.1.2 Travel Demand

Exhibits 4-2 through **4-5** summarize existing and forecast 2030 I-5 travel demand. The four-hour peak period travel demands are shown by direction by alternative for the entire 23-mile corridor from the Marquam Bridge in Portland, Oregon to the Pioneer Street interchange in Ridgefield, Washington. There is little or no difference in travel demand between the LPA with highway phasing option and the LPA scenarios because the differences in the highway and ramp configurations between the two options do not affect travel demand in the corridor.

Existing and forecast 2030 I-205 travel demands are summarized in **Exhibits 4-6** through **4-9**. The two-hour peak period travel demands are summarized by direction by alternative for the nine-mile corridor from the I-84 interchange in Portland, Oregon to the SR 500 interchange in Vancouver, Washington.

4.1.3 Effect of Congestion

Existing and forecast 2030 I-5 southbound and northbound daily hours of congestion are shown in **Exhibits 4-10** and **4-11**, respectively. The numbers of hours during which speeds are less than 30 mph have been summarized for each alternative between 5 a.m. and 9 p.m.

4.1.4 Travel Times

Existing and forecast 2030 southbound I-5 travel times during the two-hour morning peak are summarized for SR 500 to Columbia Boulevard and 179th Street to I-84 in **Exhibit 4-12**. The travel times are summarized for travel time segments by alternative. **Exhibit 4-13** summarizes northbound travel times for Columbia Boulevard to SR 500 and I-84 to 179th Street for the two-hour afternoon/evening peak. The travel times are summarized for both travel time segments by alternative. Additionally, travel times were computed to account for the time it would take to access I-5 southbound from SR 500, Mill Plain and SR 14.

Existing and forecast 2030 southbound I-205 travel times during the two-hour morning peak are summarized for three segments by alternative in **Exhibit 4-14**. The three travel time segments reported include SR 500 to bridge mid-point, bridge mid-point to I-84, and the combined segment from SR 500 to I-84. Measuring travel times from highway to highway, or to the mid-point on bridge is done for comparative purposes only. In reality, vehicle trips begin and end at origins and destination, not on a highway. **Exhibit 4-15** summarizes northbound travel times for the two-hour afternoon/evening peak by alternative. The three travel time segments reported include I-84 to bridge mid-point, bridge mid-point to SR 500, and the combined segment from I-84 to SR 500.

4.1.5 Service Volumes

Service volumes refer to the total number of vehicles that are actually able to travel through a transportation facility. Existing and forecast 2030 I-5 service volumes across the I-5 bridge are summarized in **Exhibit 4-16**. The four-hour peak service volumes are summarized by direction by alternative. Existing and forecast 2030 I-205 service volumes across the I-205 bridge are summarized in **Exhibit 4-17**. The two-hour peak service volumes are summarized by direction by alternative. Similarly, four-hour peak I-5 truck service volumes across the Interstate Bridge are summarized by direction and by alternative in **Exhibit 4-18**.

4.1.6 Served vs. Unserved Ramp Volumes

Served ramp volumes refer to on-ramp vehicle demands that have been able to be accommodated by the highway mainline during the four-hour peaks. Unserved ramp volumes are those vehicle demands that are not able to enter the highway mainline because of congestion or other reasons.

Existing and forecast 2030 southbound morning peak served versus unserved ramp volumes are summarized within the Bridge Influence Area in **Exhibit 4-19**. The volumes are summarized by ramp by alternative. **Exhibit 4-20** summarizes northbound served versus unserved ramp volumes within the Bridge Influence Area by ramp by alternative.

4.1.7 Person Throughput

Person throughput is defined as the total number of persons crossing a defined point in space for a stated time period, regardless of travel mode. **Exhibit 4-21** shows peak northbound and southbound person throughput across the I-5 bridge.

4.2 Local Street Performance

4.2.1 Travel Demand

Screenlines are part of a traffic analysis method used to examine local street operations. This technique measures entering and exiting traffic volumes across key north-south and east-west screenlines. Comparison of screenline volumes across different models yields information regarding the performance of local streets, especially when examined in conjunction with intersection LOS calculations.

For Vancouver, four screenlines were chosen to represent traffic moving north and south through the city, and three screenlines were selected to measure east and west travel. Vancouver screenline locations are shown in **Exhibit 4-22**.

For Portland, three screenlines were chosen to represent traffic moving north and south through the city, and three screenlines were selected to measure east and west travel. Portland screenline locations are shown in **Exhibit 4-23**.

Exhibits 4-24 and **4-25** display the screenline results for the morning and afternoon/evening peaks in Vancouver. The north-south screenline table summarizes the eastbound and westbound volume data and the east-west screenline table summarizes the southbound and northbound volume data. Volumes are rounded to the nearest 50 vehicles.

Exhibits 4-26 and **4-27** display the screenline results for the morning and afternoon/evening peaks in Portland. The north-south screenline table summarizes the eastbound and westbound volume data and the east-west screenline table summarizes the southbound and northbound volume data. Volumes are rounded to the nearest 50 vehicles.

4.2.2 Intersection Service Levels

Exhibits 4-28 and **4-29** display the results of the Synchro/SimTraffic analyses conducted in Vancouver for the morning and afternoon/evening peaks. For signalized intersections, results are presented for the overall intersection. For unsignalized intersections, data is given for the movement that experiences the most delay. In addition to the average delay, the tables present the corresponding LOS, the ICU or V/C of the intersection, the relevant standard for comparison, and a list of movements that exceed the available storage length, if applicable.

Exhibits 4-30 and **4-31** display the results of the Synchro/SimTraffic analyses conducted in Portland for the morning and afternoon/evening peaks. For signalized intersections, results are presented for the overall intersection. For unsignalized intersections, data is given for the movement that experiences the most delay. In addition to the average delay, the tables present the corresponding LOS, the ICU or V/C of the intersection, the relevant standard for comparison, and a list of movements that exceed the available storage length, if applicable.

4.3 Effect of Tolling

4.3.1 Service Volumes

Exhibit 4-32 summarizes the daily service volumes for I-5, I-205, and the total river crossing under different tolling scenarios. More information on tolling scenarios, tolling rate structures and highway performance for each tolling scenario can be found in **Chapter 8**.

Exhibit 4-1

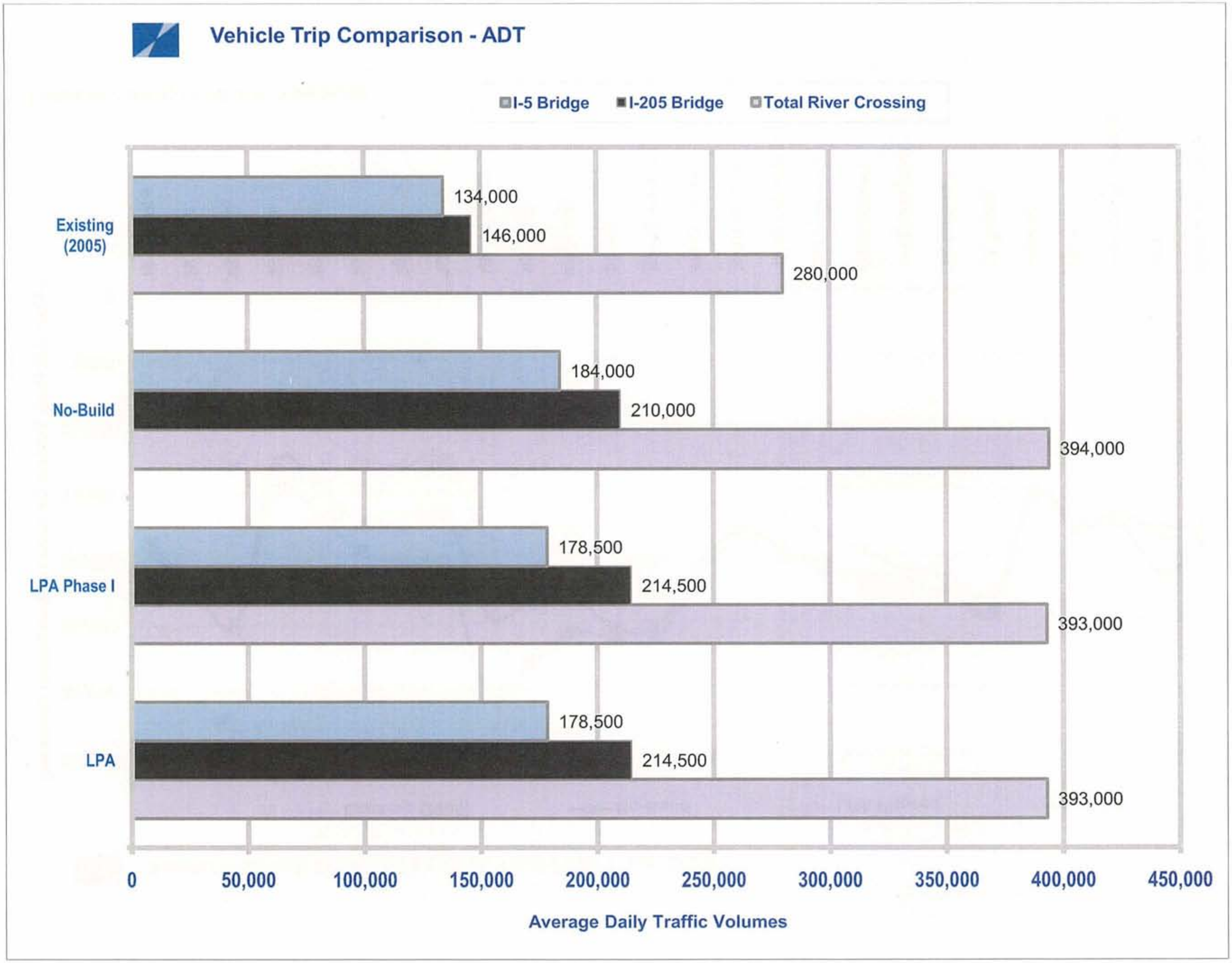
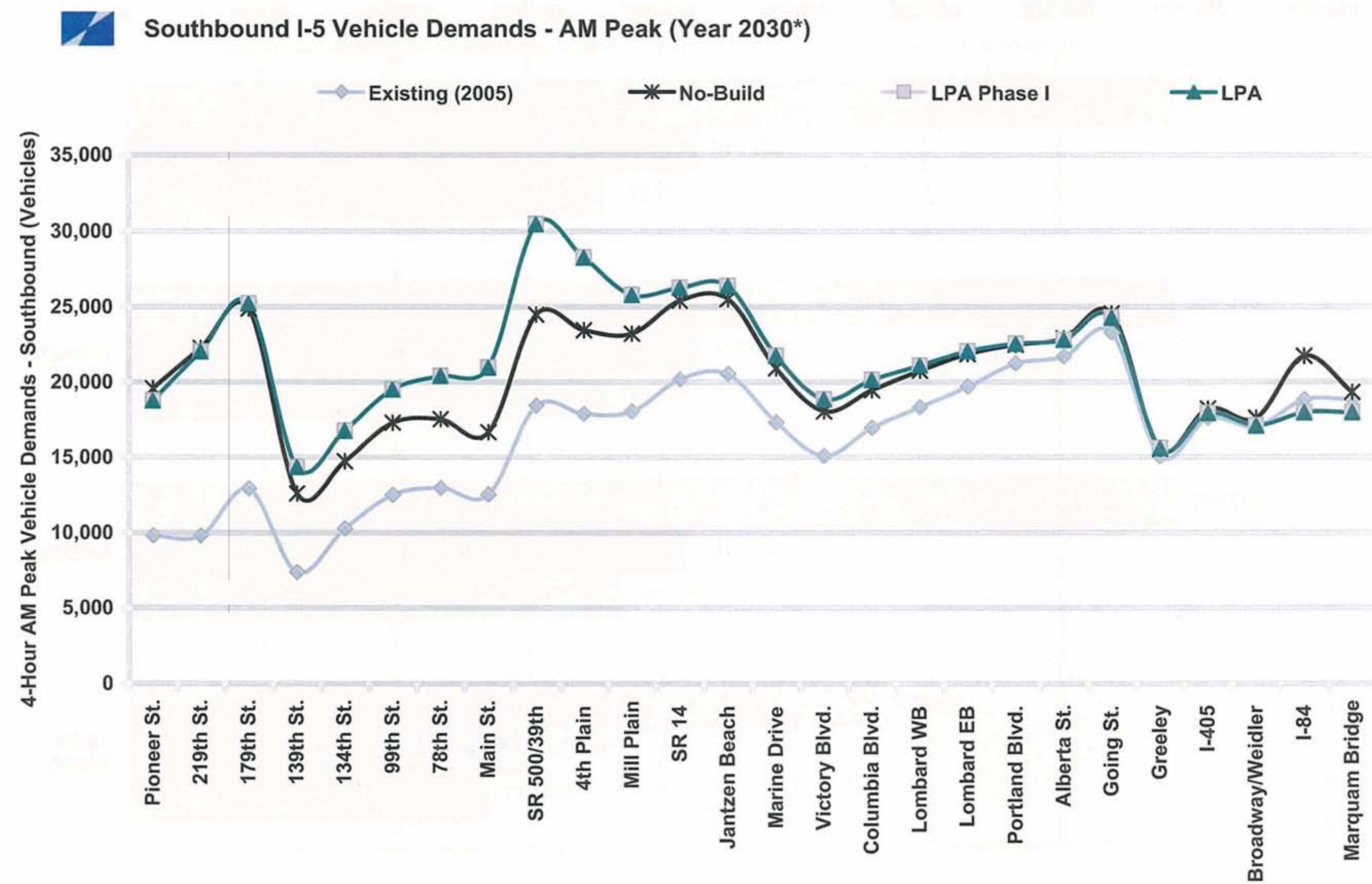

Vehicle Trip Comparison - ADT
I-5 Bridge
I-205 Bridge
Total River Crossing
Existing (2005)
No-Build
LPA Phase I
LPA
134,000
146,000
280,000
184,000
210,000
394,000
178,500
214,500
393,000
178,500
214,500
393,000
0
50,000
100,000
150,000
200,000
250,000
300,000
350,000
400,000
450,000
Average Daily Traffic Volumes

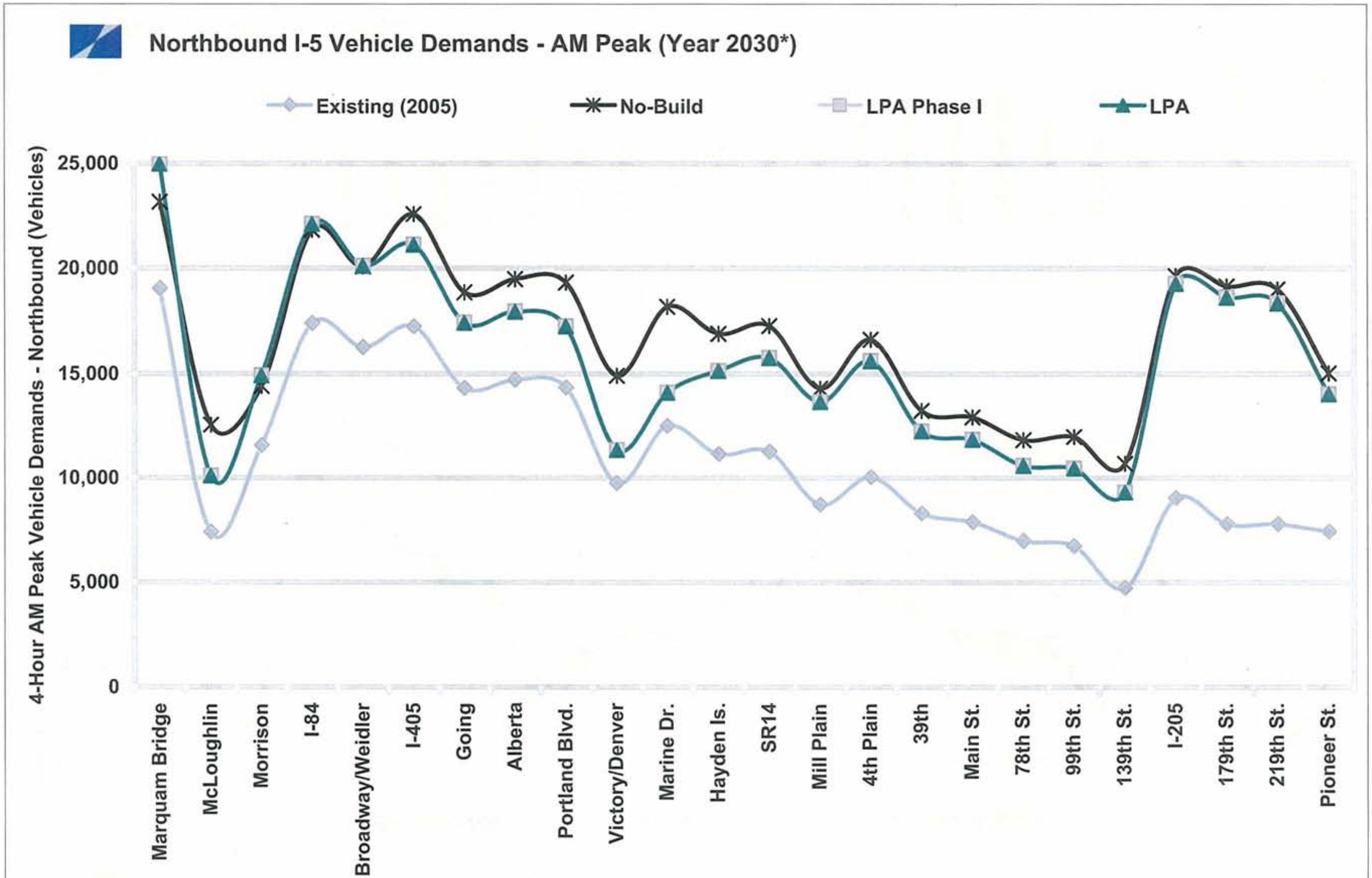
Exhibit 4-2

PRELIMINARY



*Except for Existing Conditions (Year 2005)

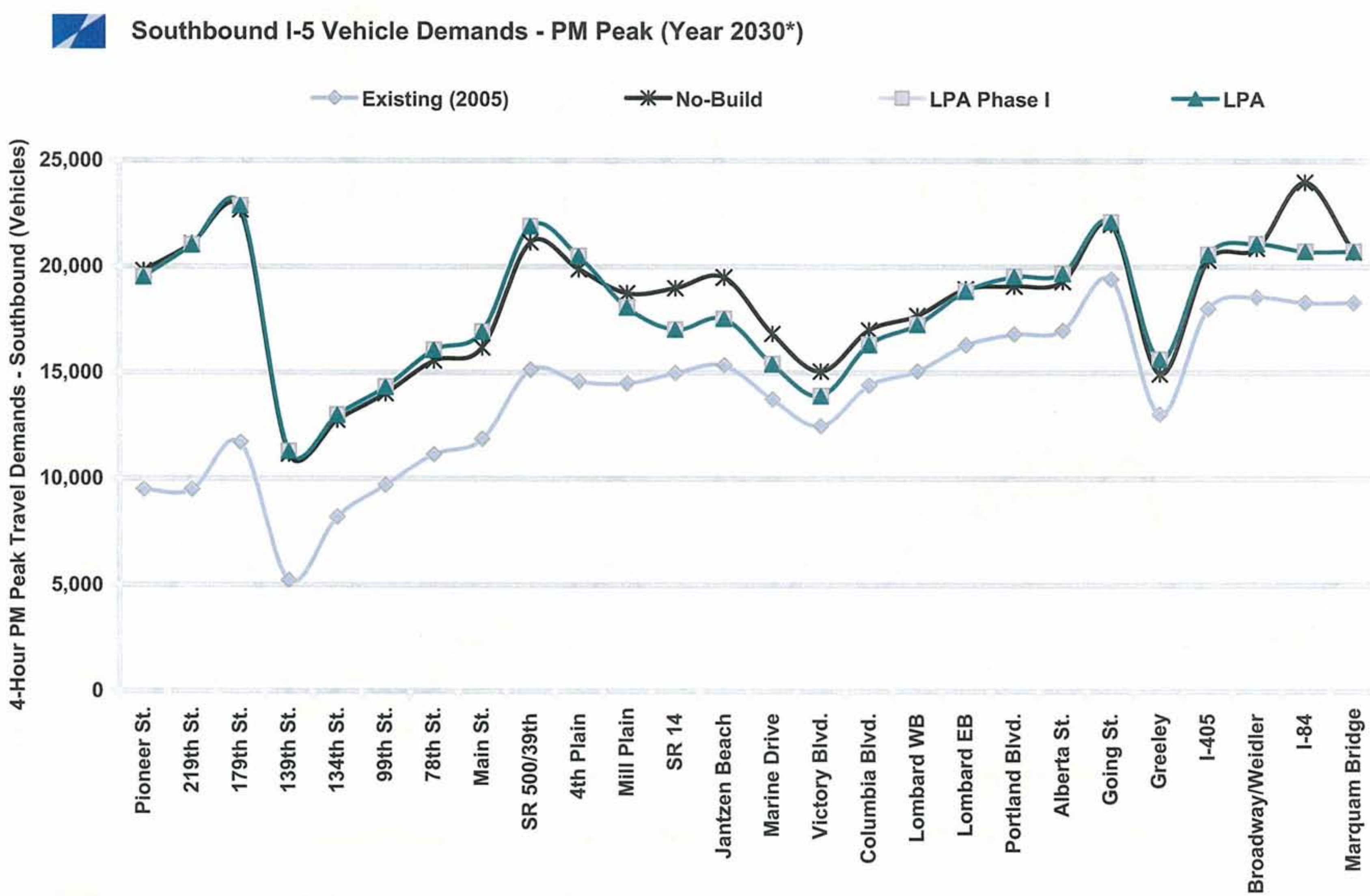
Exhibit 4-3



*Except for Existing Conditions (Year 2005)

PRELIMINARY

Exhibit 4-4



*Except for Existing Conditions (Year 2005)

Exhibit 4-5

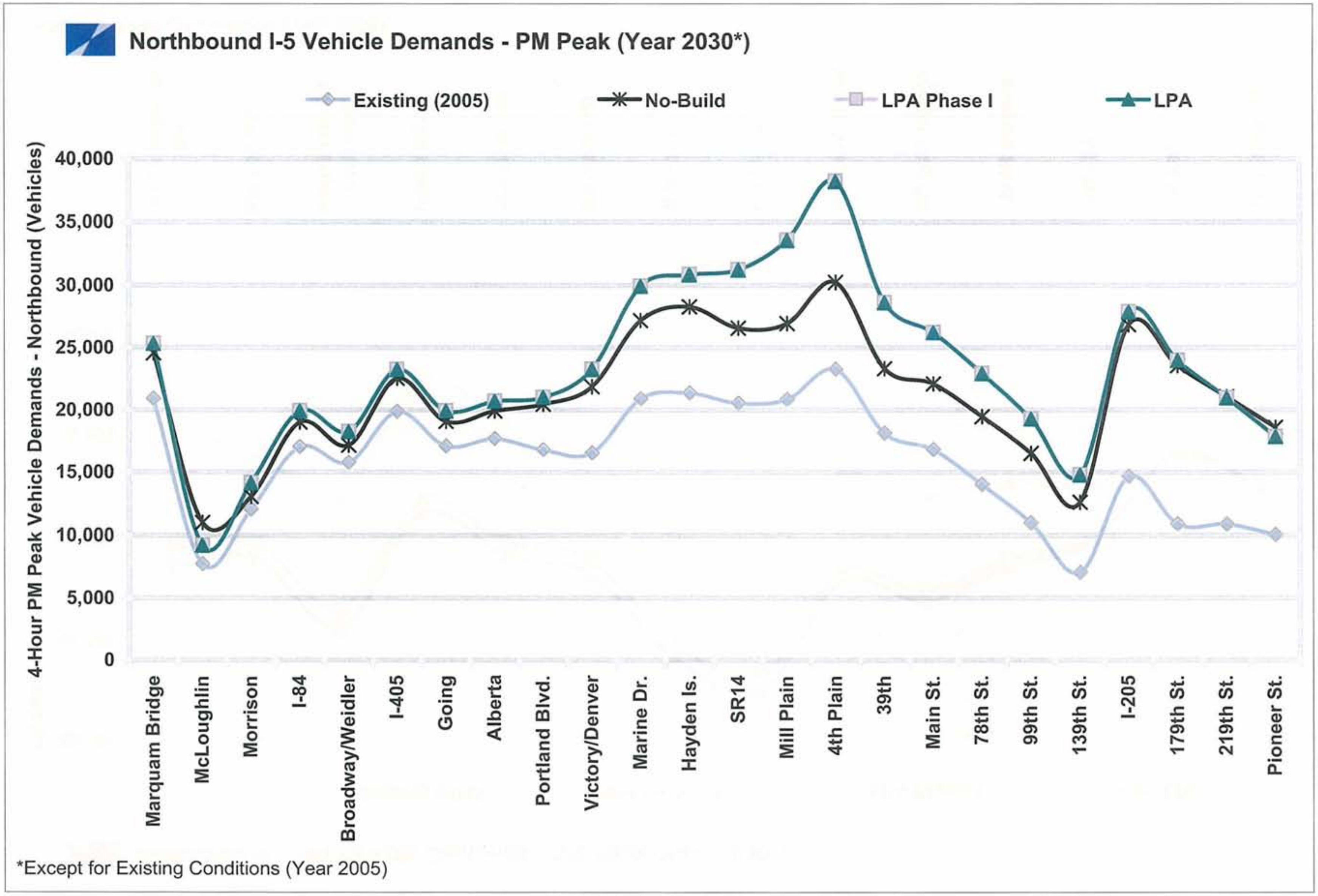
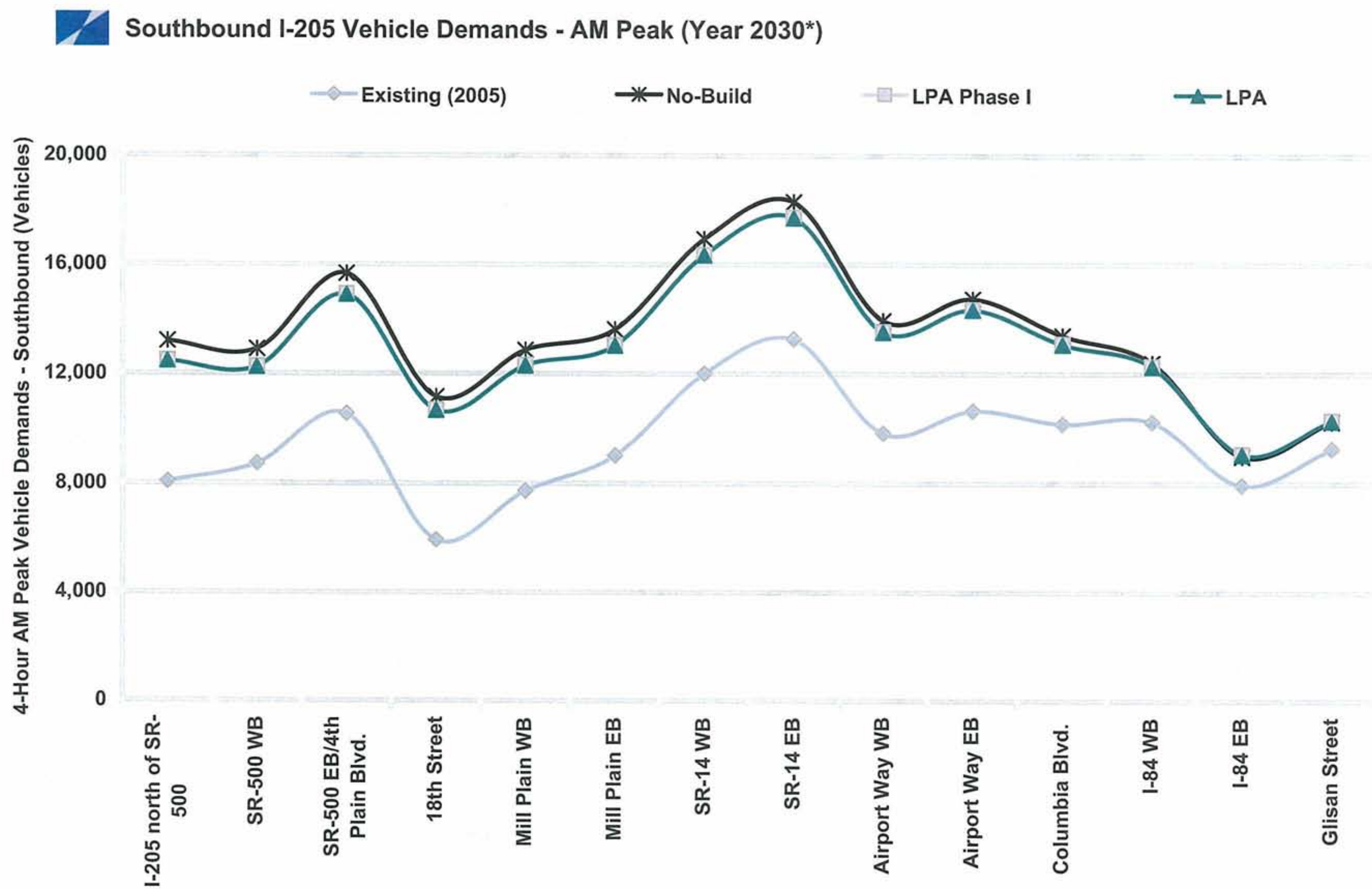

Northbound I-5 Vehicle Demands - PM Peak (Year 2030*)
Existing (2005)
No-Build
LPA Phase I
LPA
4-Hour PM Peak Vehicle Demands - Northbound (Vehicles)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Marquam Bridge
McLoughlin
Morrison
I-84
Broadway/Weidler
I-405
Going
Alberta
Portland Blvd.
Victory/Denver
Marine Dr.
Hayden Is.
SR14
Mill Plain
4th Plain
39th
Main St.
78th St.
99th St.
139th St.
I-205
179th St.
219th St.
Pioneer St.
*Except for Existing Conditions (Year 2005)

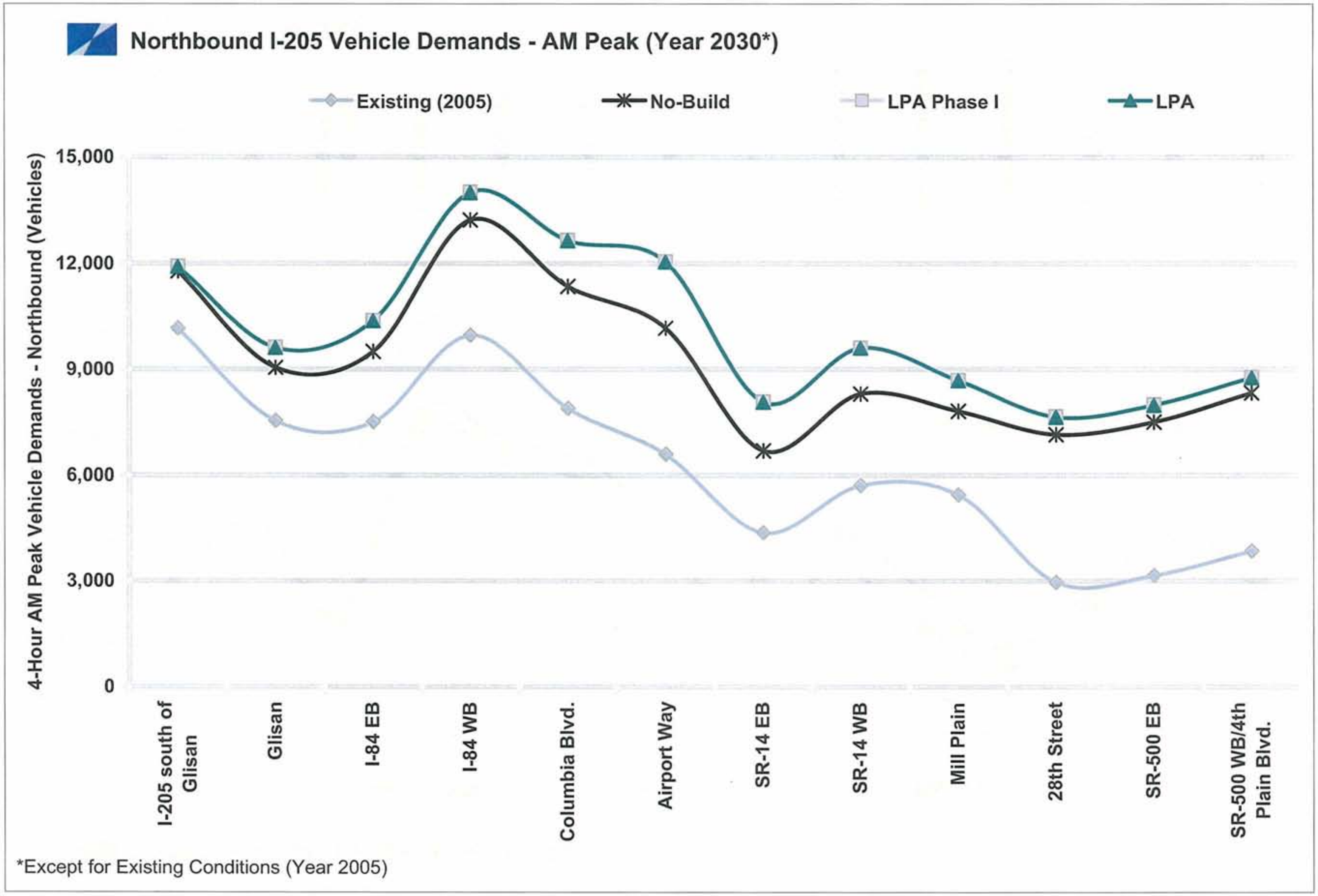
Exhibit 4-6

PRELIMINARY



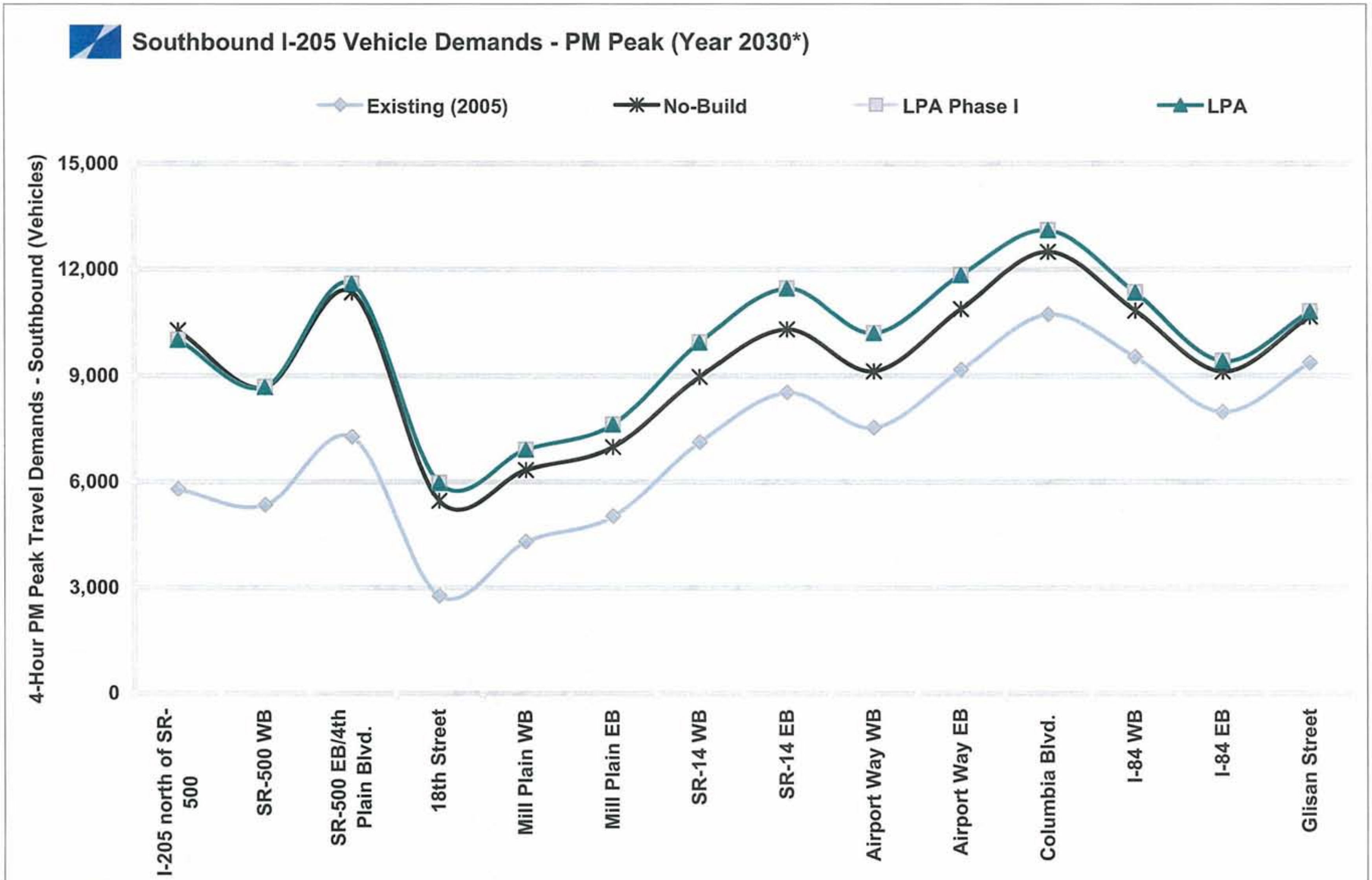
*Except for Existing Conditions (Year 2005)

Exhibit 4-7


Northbound I-205 Vehicle Demands - AM Peak (Year 2030*)
Existing (2005)
No-Build
LPA Phase I
LPA
4-Hour AM Peak Vehicle Demands - Northbound (Vehicles)
15,000
12,000
9,000
6,000
3,000
0
I-205 south of Glisan
Glisan
I-84 EB
I-84 WB
Columbia Blvd.
Airport Way
SR-14 EB
SR-14 WB
Mill Plain
28th Street
SR-500 EB
SR-500 WB/4th Plain Blvd.
*Except for Existing Conditions (Year 2005)

PRELIMINARY

Exhibit 4-8



*Except for Existing Conditions (Year 2005)

Exhibit 4-9

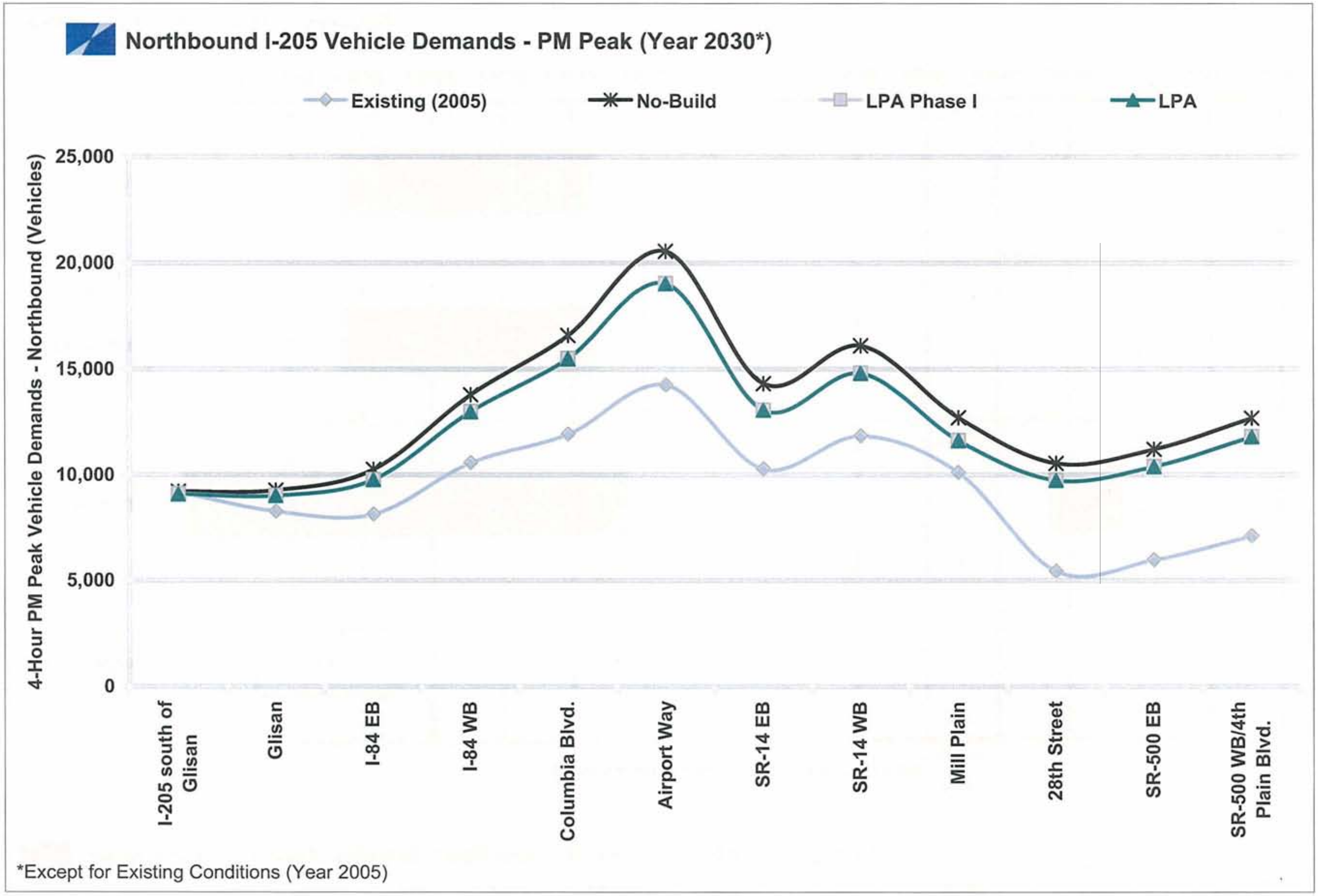
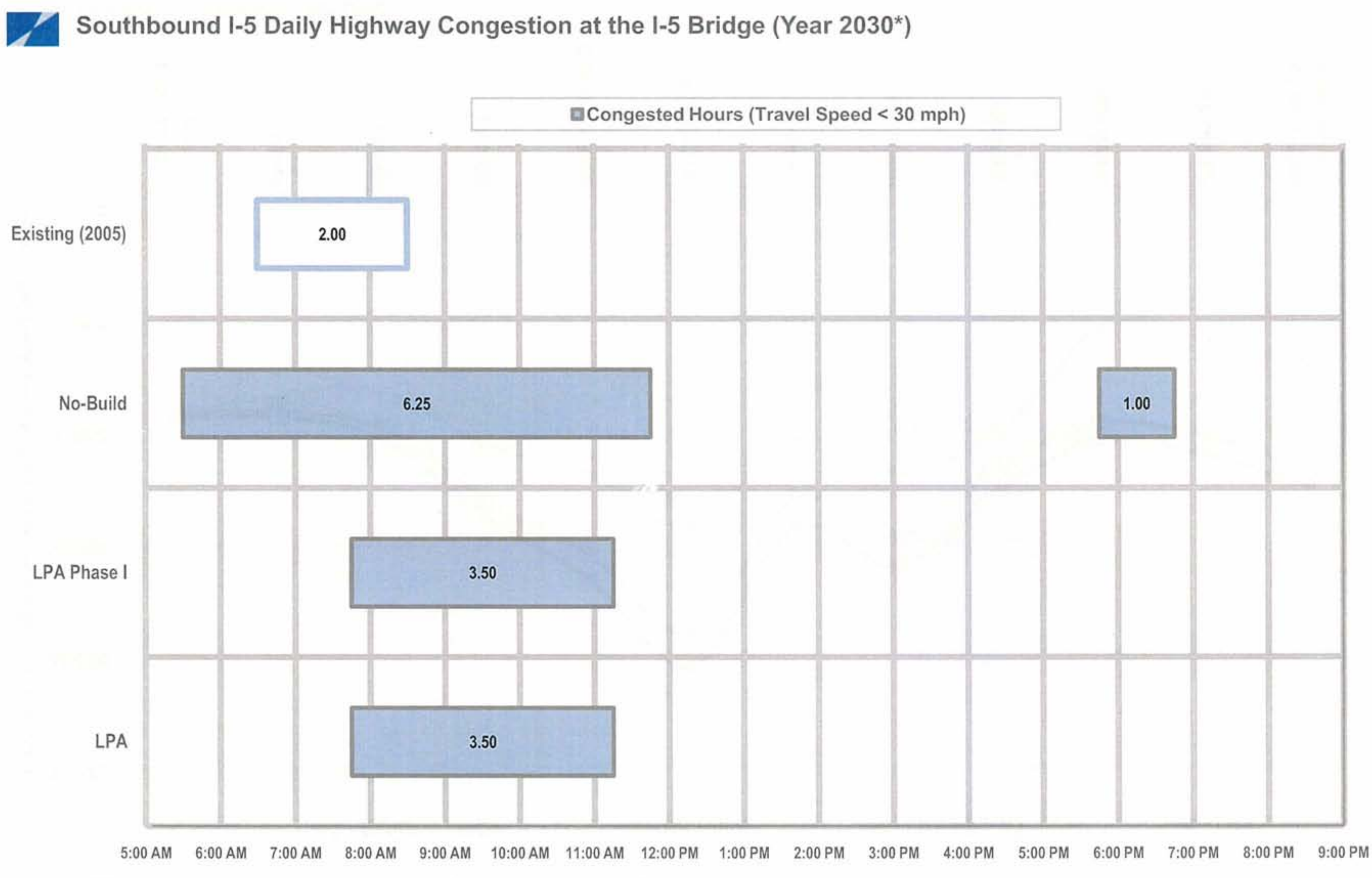

Northbound I-205 Vehicle Demands - PM Peak (Year 2030*)
Existing (2005)
No-Build
LPA Phase I
LPA
4-Hour PM Peak Vehicle Demands - Northbound (Vehicles)
25,000
20,000
15,000
10,000
5,000
0
I-205 south of Glisan
Glisan
I-84 EB
I-84 WB
Columbia Blvd.
Airport Way
SR-14 EB
SR-14 WB
Mill Plain
28th Street
SR-500 EB
SR-500 WB/4th Plain Blvd.
*Except for Existing Conditions (Year 2005)

Exhibit 4-10



*Except for Existing Conditions (Year 2005)

Exhibit 4-11

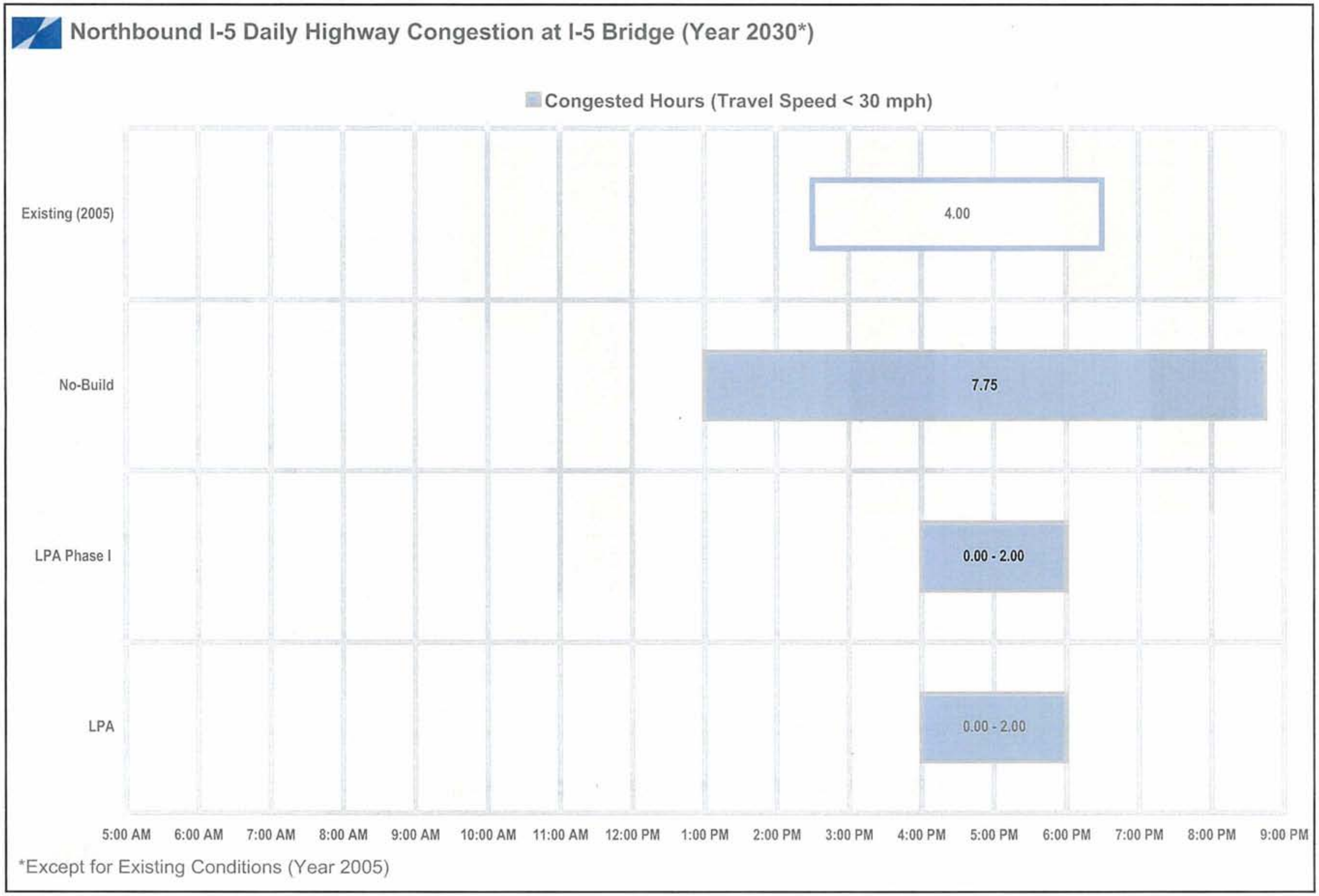

Northbound I-5 Daily Highway Congestion at I-5 Bridge (Year 2030*)
Congested Hours (Travel Speed < 30 mph)
Existing (2005)
4.00
No-Build
7.75
LPA Phase I
0.00 - 2.00
LPA
0.00 - 2.00
5:00 AM
6:00 AM
7:00 AM
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
7:00 PM
8:00 PM
9:00 PM
*Except for Existing Conditions (Year 2005)

Exhibit 4-12

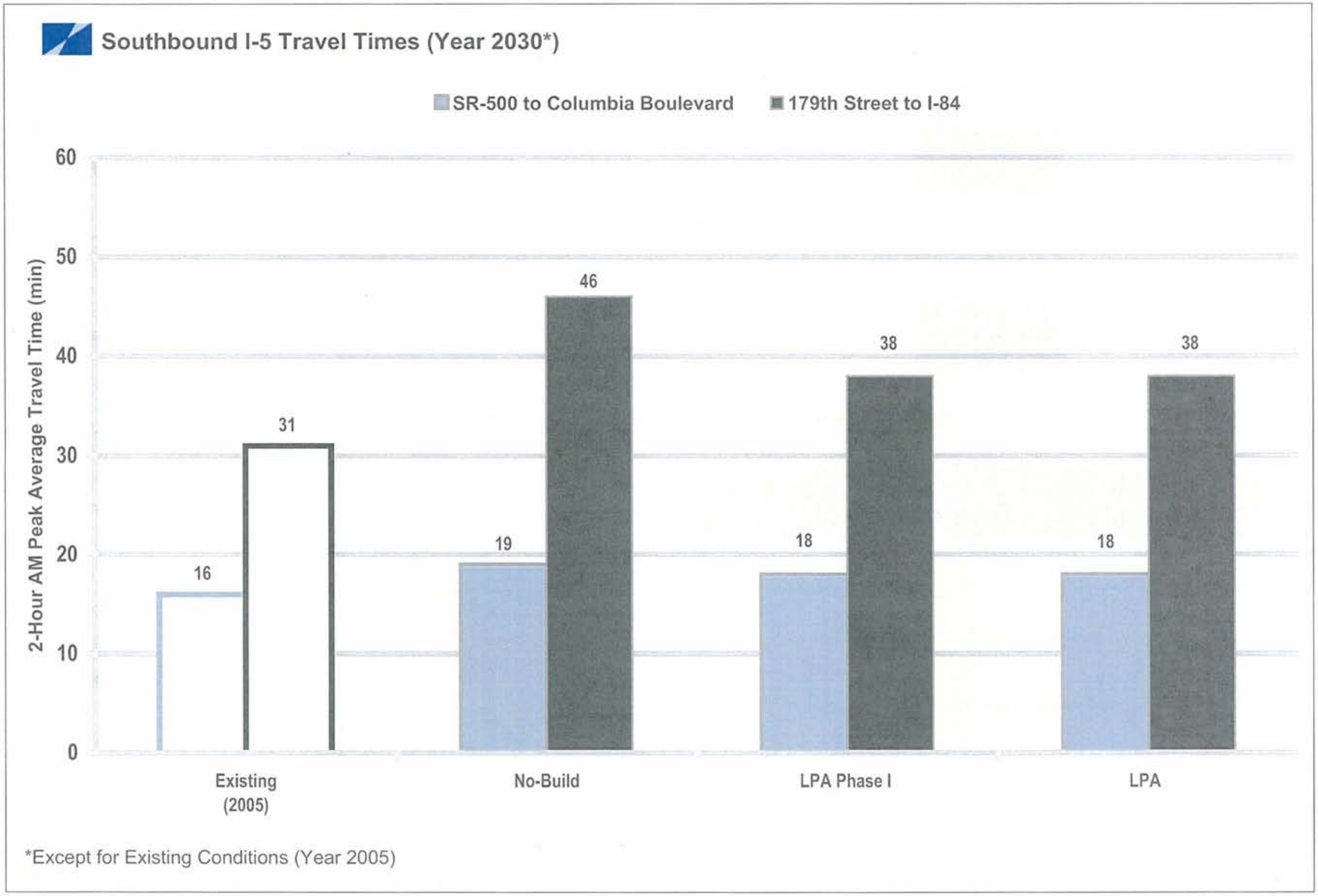

Southbound I-5 Travel Times (Year 2030*)
SR-500 to Columbia Boulevard
179th Street to I-84
2-Hour AM Peak Average Travel Time (min)
60
50
40
30
20
10
0
16
31
19
46
18
38
18
38
Existing (2005)
No-Build
LPA Phase I
LPA
*Except for Existing Conditions (Year 2005)

Exhibit 4-13

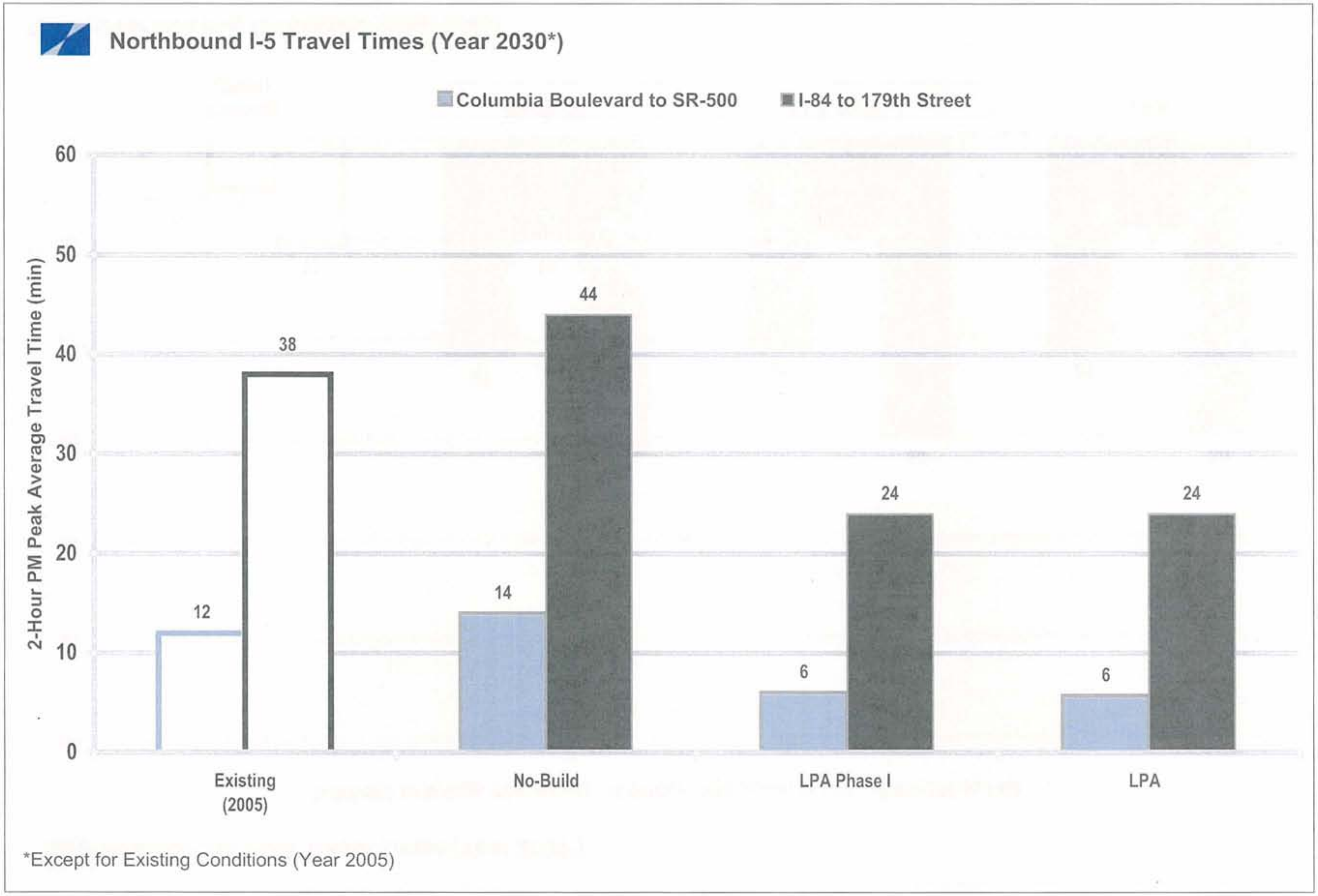

Northbound I-5 Travel Times (Year 2030*)
Columbia Boulevard to SR-500
I-84 to 179th Street
2-Hour PM Peak Average Travel Time (min)
60
50
40
30
20
10
0
12
38
14
44
6
24
6
24
Existing
(2005)
No-Build
LPA Phase I
LPA
*Except for Existing Conditions (Year 2005)

Exhibit 4-14

*Except for Existing Conditions (Year 2005)

Exhibit 4-15

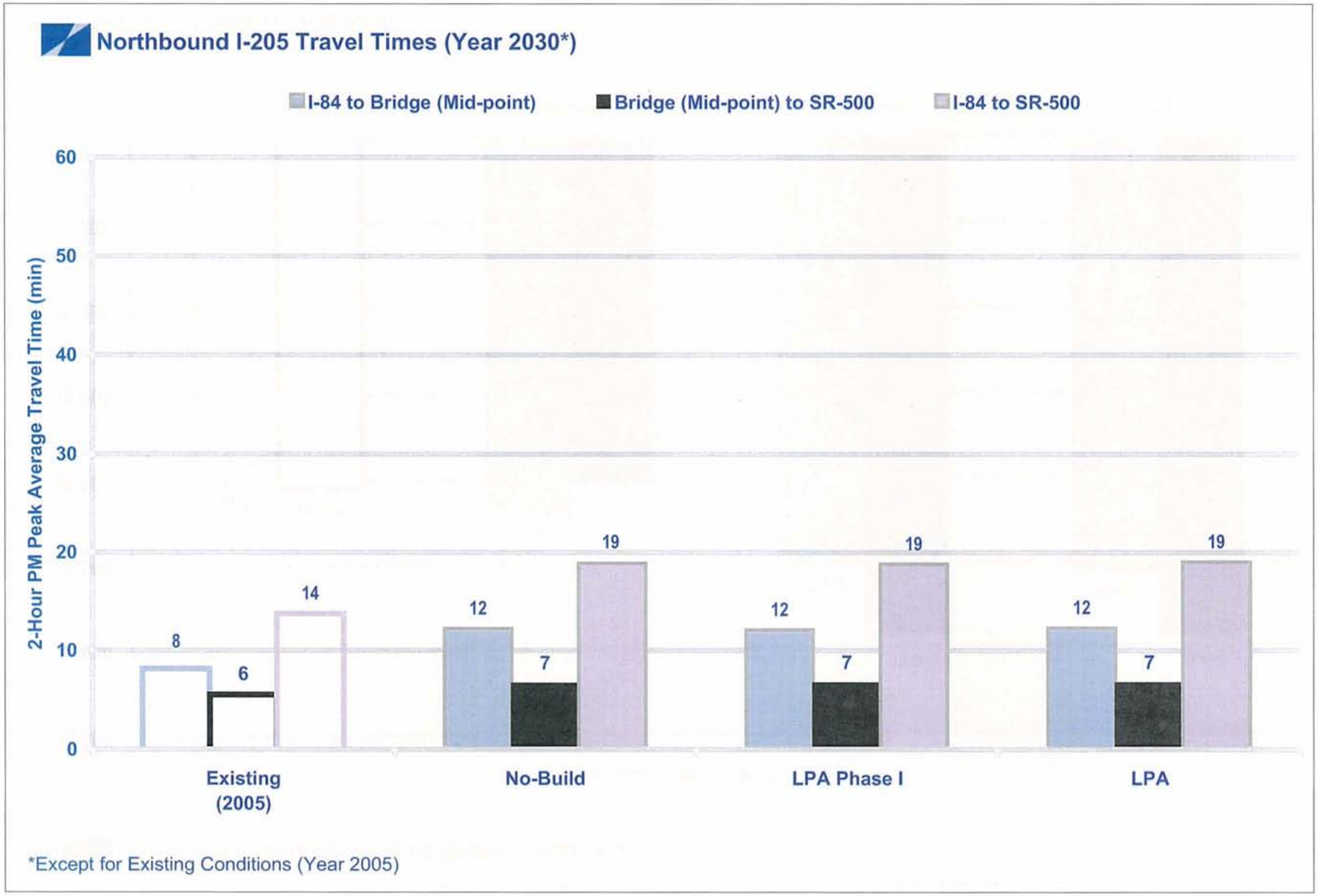

Northbound I-205 Travel Times (Year 2030*)
I-84 to Bridge (Mid-point)
Bridge (Mid-point) to SR-500
I-84 to SR-500
2-Hour PM Peak Average Travel Time (min)
60
50
40
30
20
10
0
8
6
14
12
7
19
12
7
19
12
7
19
Existing (2005)
No-Build
LPA Phase I
LPA
*Except for Existing Conditions (Year 2005)

Exhibit 4-16

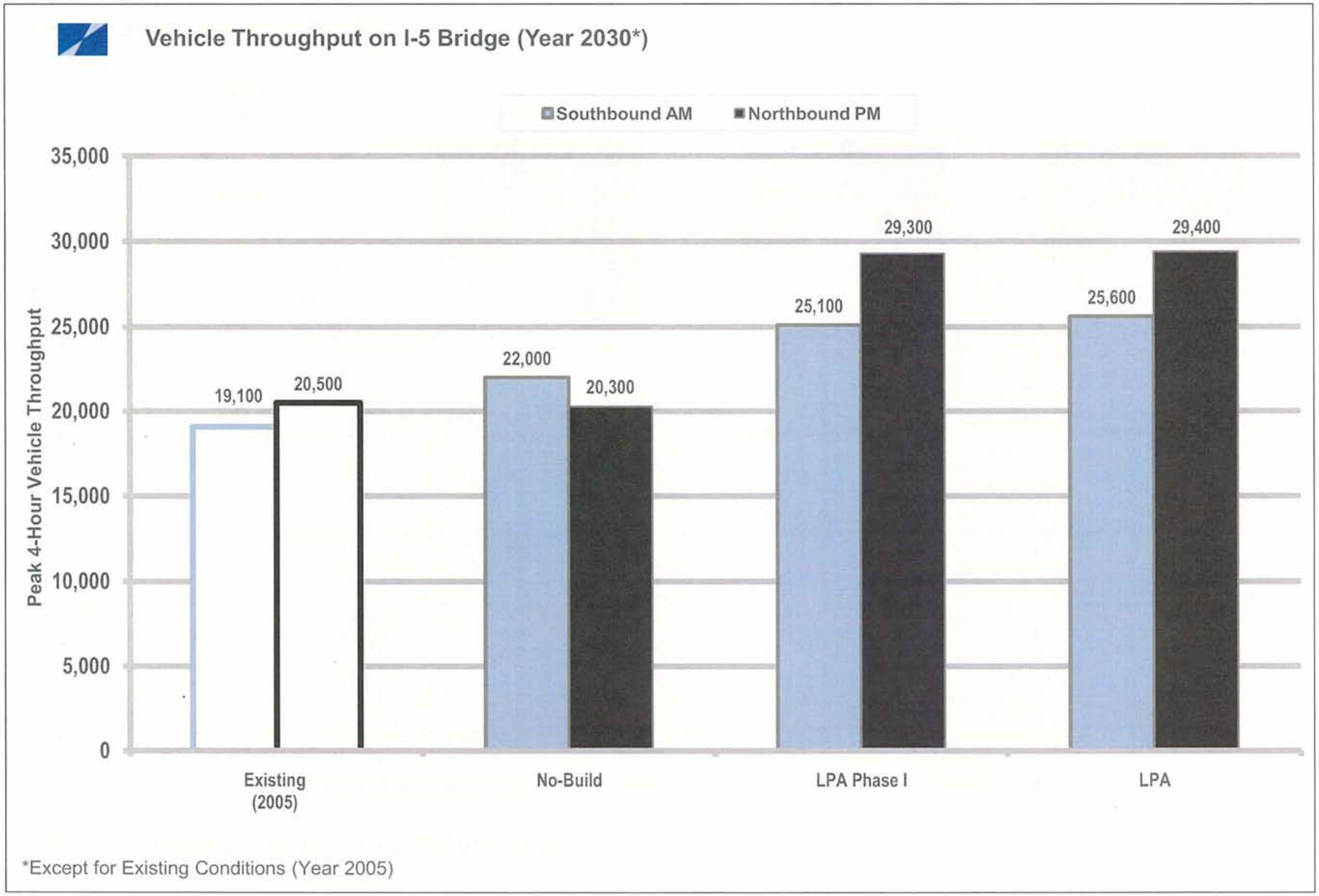

Vehicle Throughput on I-5 Bridge (Year 2030*)
Southbound AM
Northbound PM
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Peak 4-Hour Vehicle Throughput
19,100
20,500
22,000
20,300
25,100
29,300
25,600
29,400
Existing (2005)
No-Build
LPA Phase I
LPA
*Except for Existing Conditions (Year 2005)

Exhibit 4-17

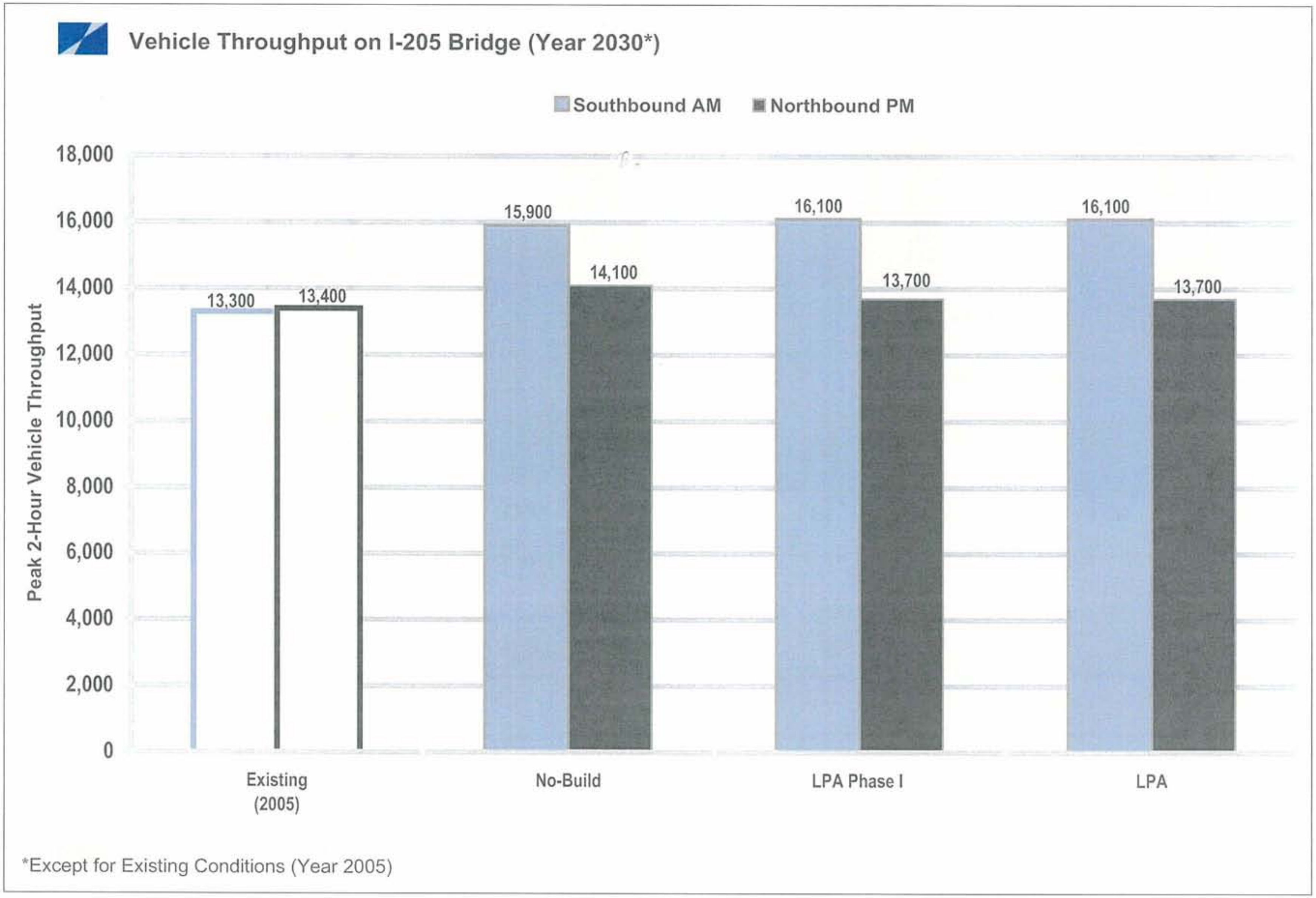

Vehicle Throughput on I-205 Bridge (Year 2030*)
Southbound AM
Northbound PM
Peak 2-Hour Vehicle Throughput
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
13,300
13,400
15,900
14,100
16,100
13,700
16,100
13,700
Existing (2005)
No-Build
LPA Phase I
LPA
*Except for Existing Conditions (Year 2005)

Exhibit 4-18

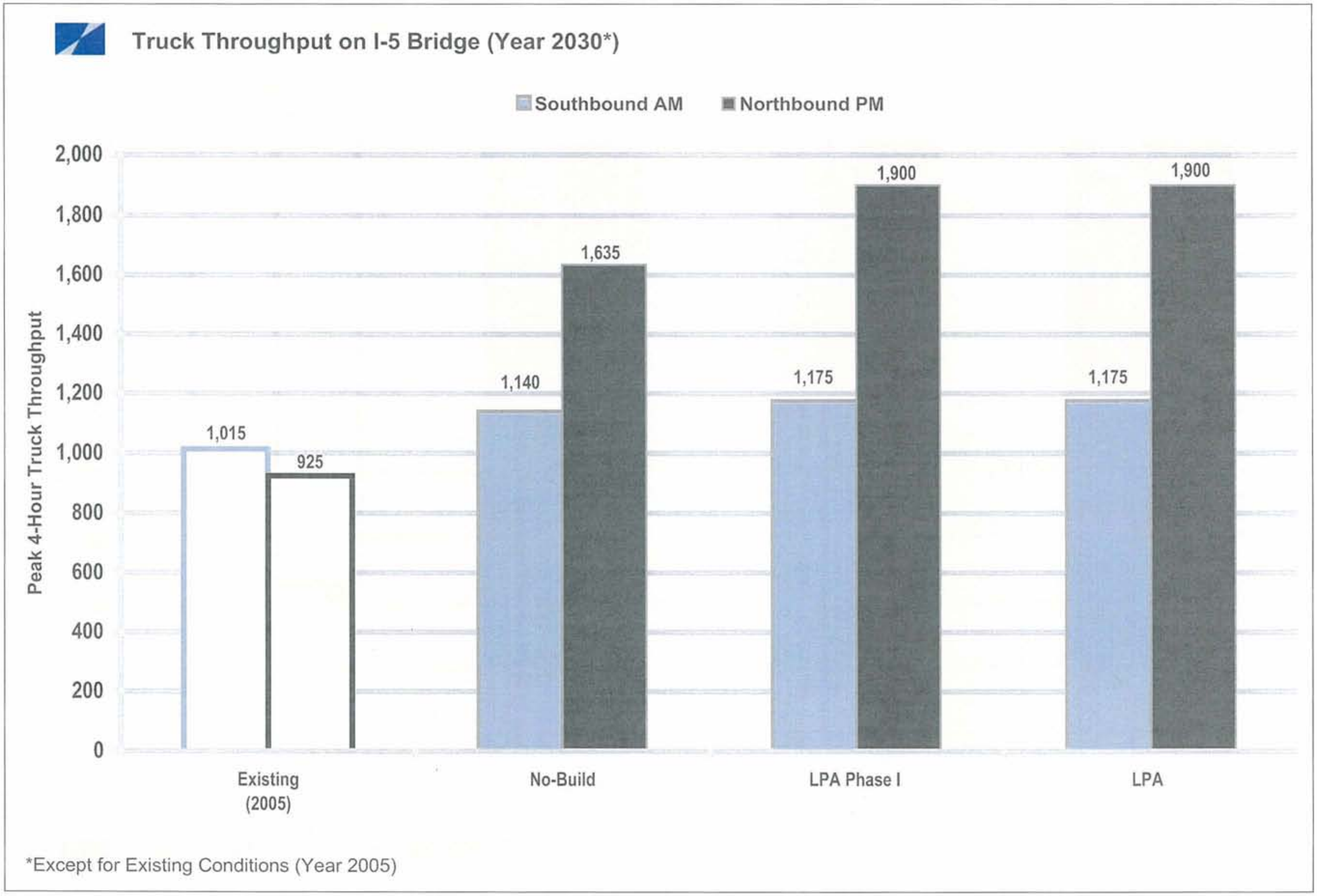
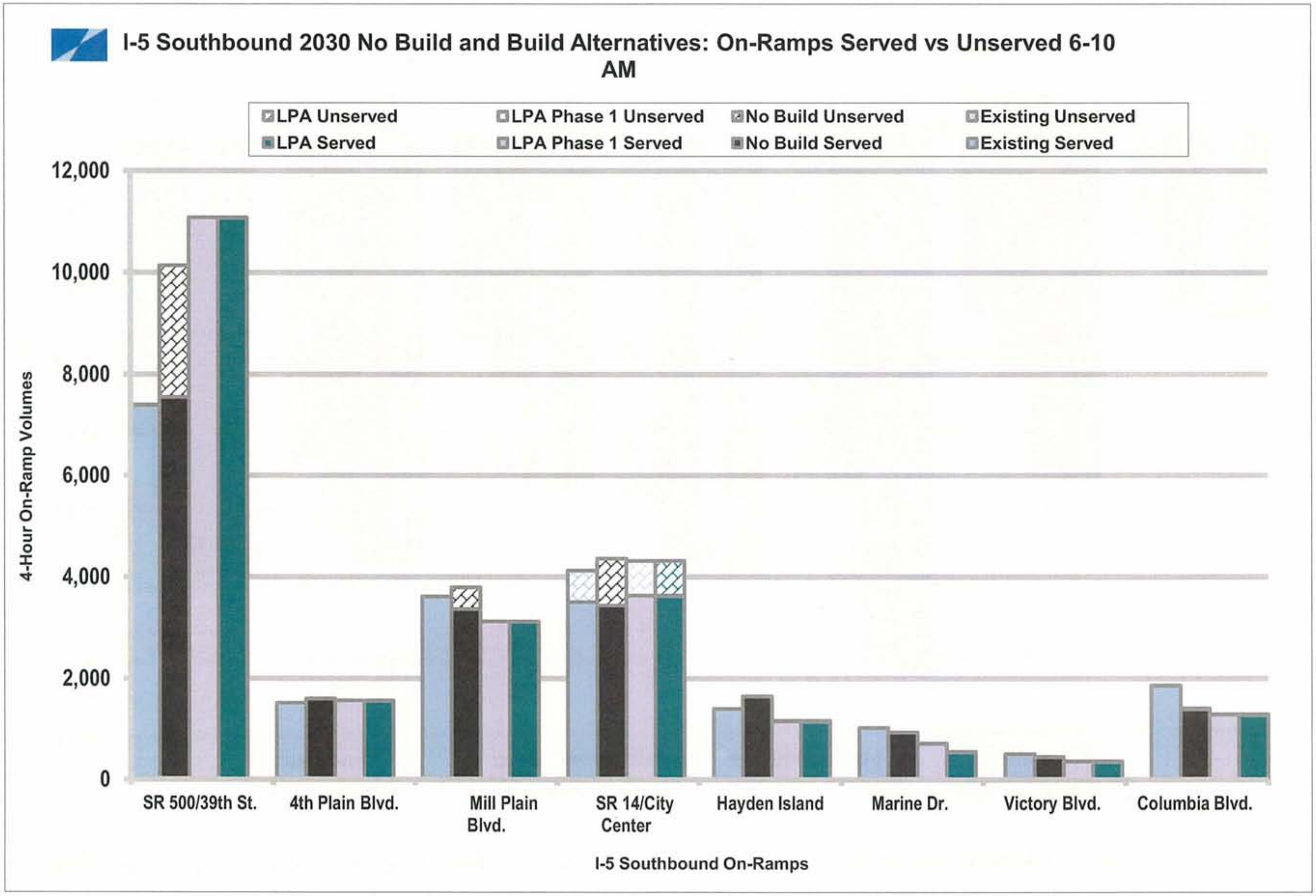

Truck Throughput on I-5 Bridge (Year 2030*)
Southbound AM
Northbound PM
Peak 4-Hour Truck Throughput
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1,015
925
1,140
1,635
1,175
1,900
1,175
1,900
Existing (2005)
No-Build
LPA Phase I
LPA
*Except for Existing Conditions (Year 2005)

Exhibit 4-19



I-5 Southbound 2030 No Build and Build Alternatives: On-Ramps Served vs Unserved 6-10 AM
LPA Unserved
LPA Served
LPA Phase 1 Unserved
LPA Phase 1 Served
No Build Unserved
No Build Served
Existing Unserved
Existing Served
4-Hour On-Ramp Volumes
12,000
10,000
8,000
6,000
4,000
2,000
0
SR 500/39th St.
4th Plain Blvd.
Mill Plain Blvd.
SR 14/City Center
Hayden Island
Marine Dr.
Victory Blvd.
Columbia Blvd.
I-5 Southbound On-Ramps

Exhibit 4-20

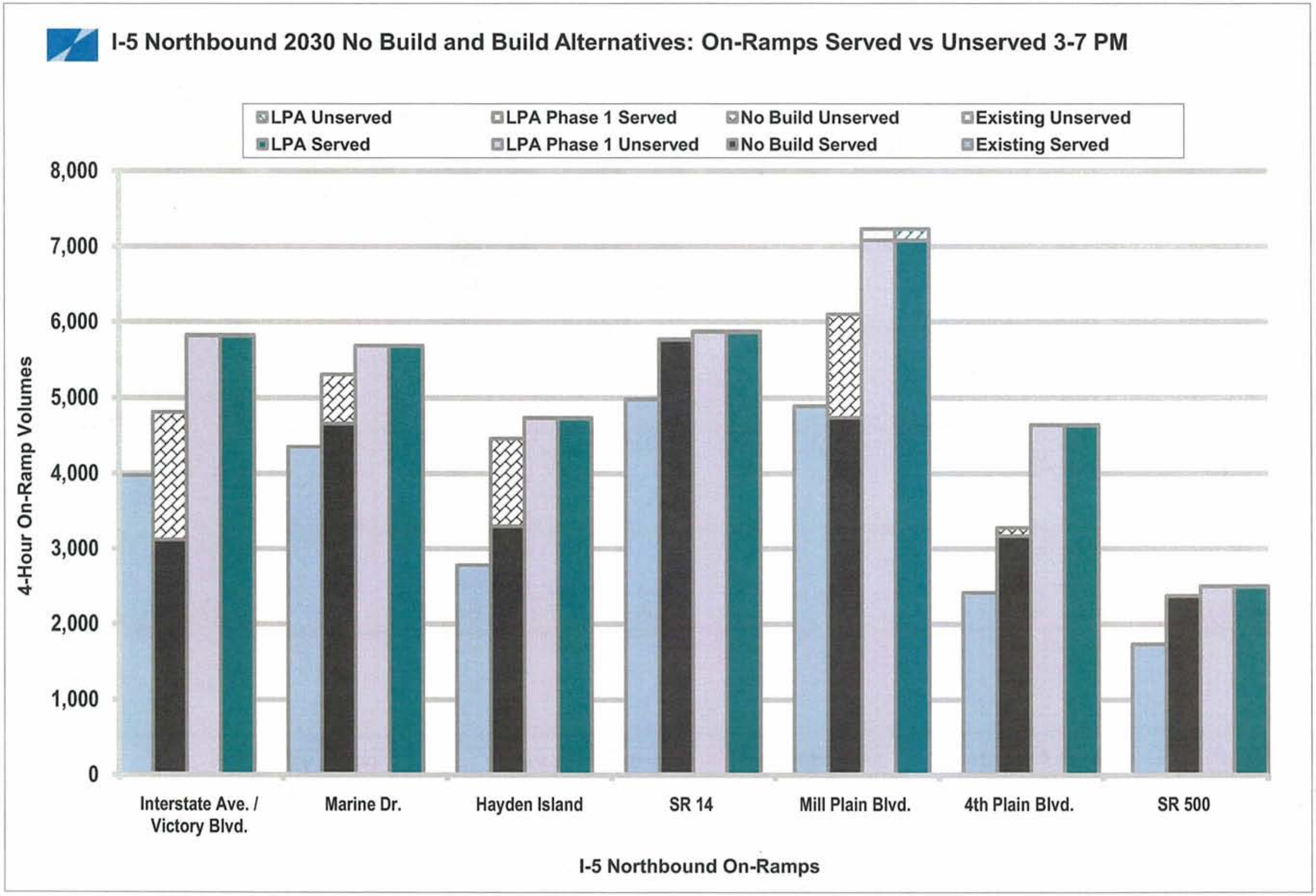

I-5 Northbound 2030 No Build and Build Alternatives: On-Ramps Served vs Unserved 3-7 PM
LPA Unserved
LPA Served
LPA Phase 1 Served
LPA Phase 1 Unserved
No Build Unserved
No Build Served
Existing Unserved
Existing Served
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
4-Hour On-Ramp Volumes
Interstate Ave. / Victory Blvd.
Marine Dr.
Hayden Island
SR 14
Mill Plain Blvd.
4th Plain Blvd.
SR 500
I-5 Northbound On-Ramps

Exhibit 4-21

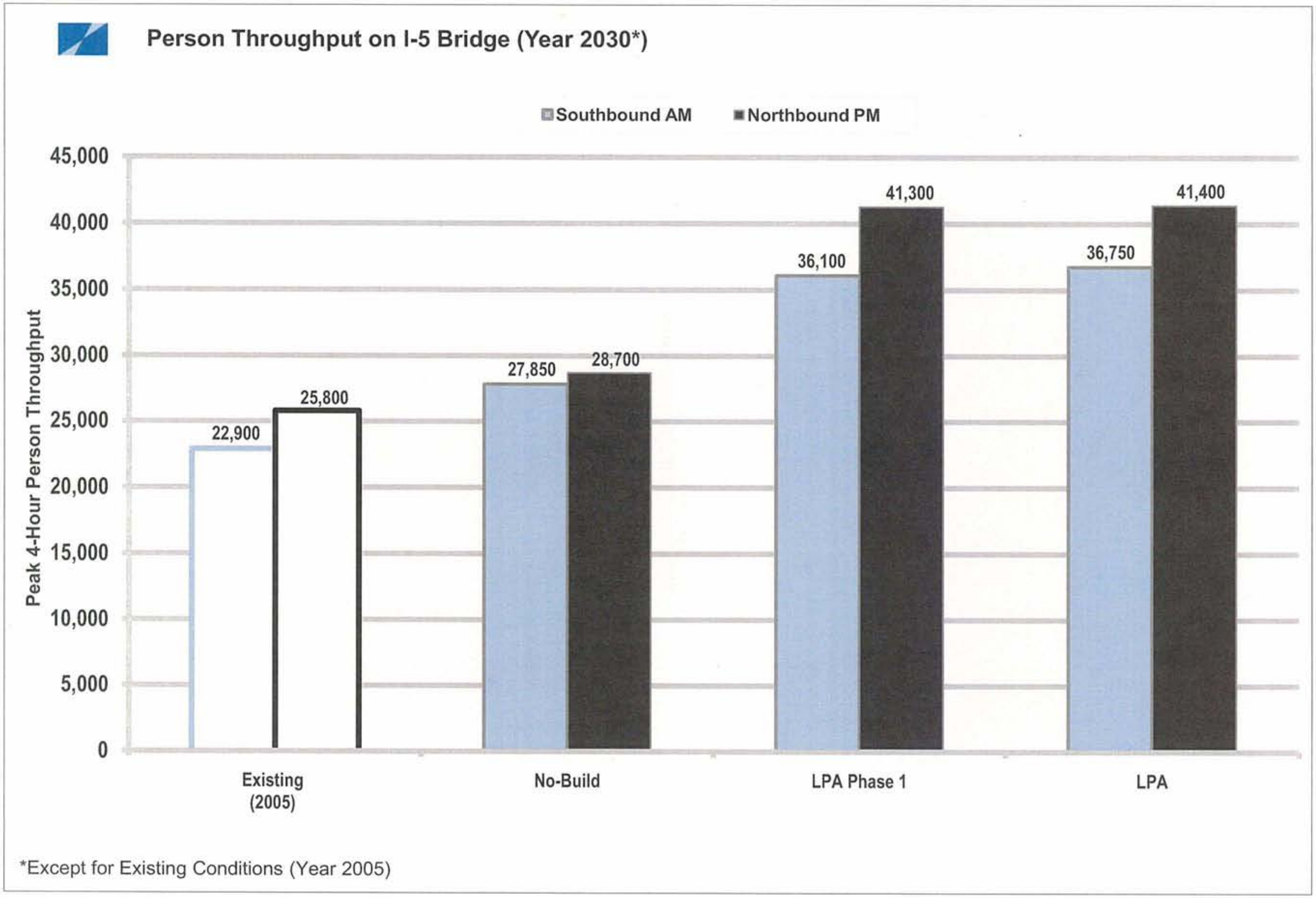

Person Throughput on I-5 Bridge (Year 2030*)
Southbound AM
Northbound PM
Peak 4-Hour Person Throughput
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
22,900
25,800
27,850
28,700
36,100
41,300
36,750
41,400
Existing (2005)
No-Build
LPA Phase 1
LPA
*Except for Existing Conditions (Year 2005)

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Exhibit 4-22

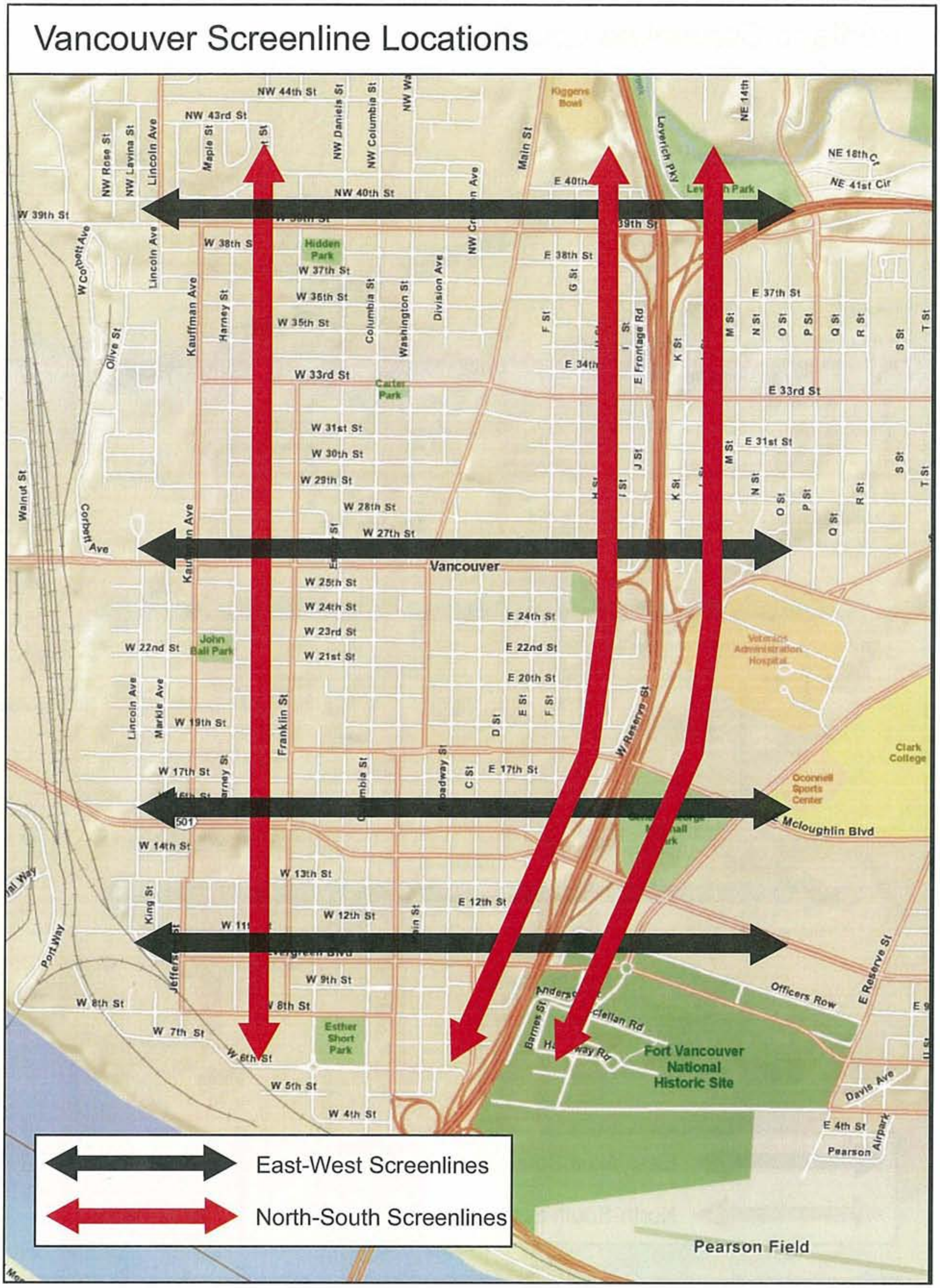

Vancouver Screenline Locations
East-West Screenlines
North-South Screenlines
Vancouver
Fort Vancouver National Historic Site
Pearson Field
Clark College

Exhibit 4-23

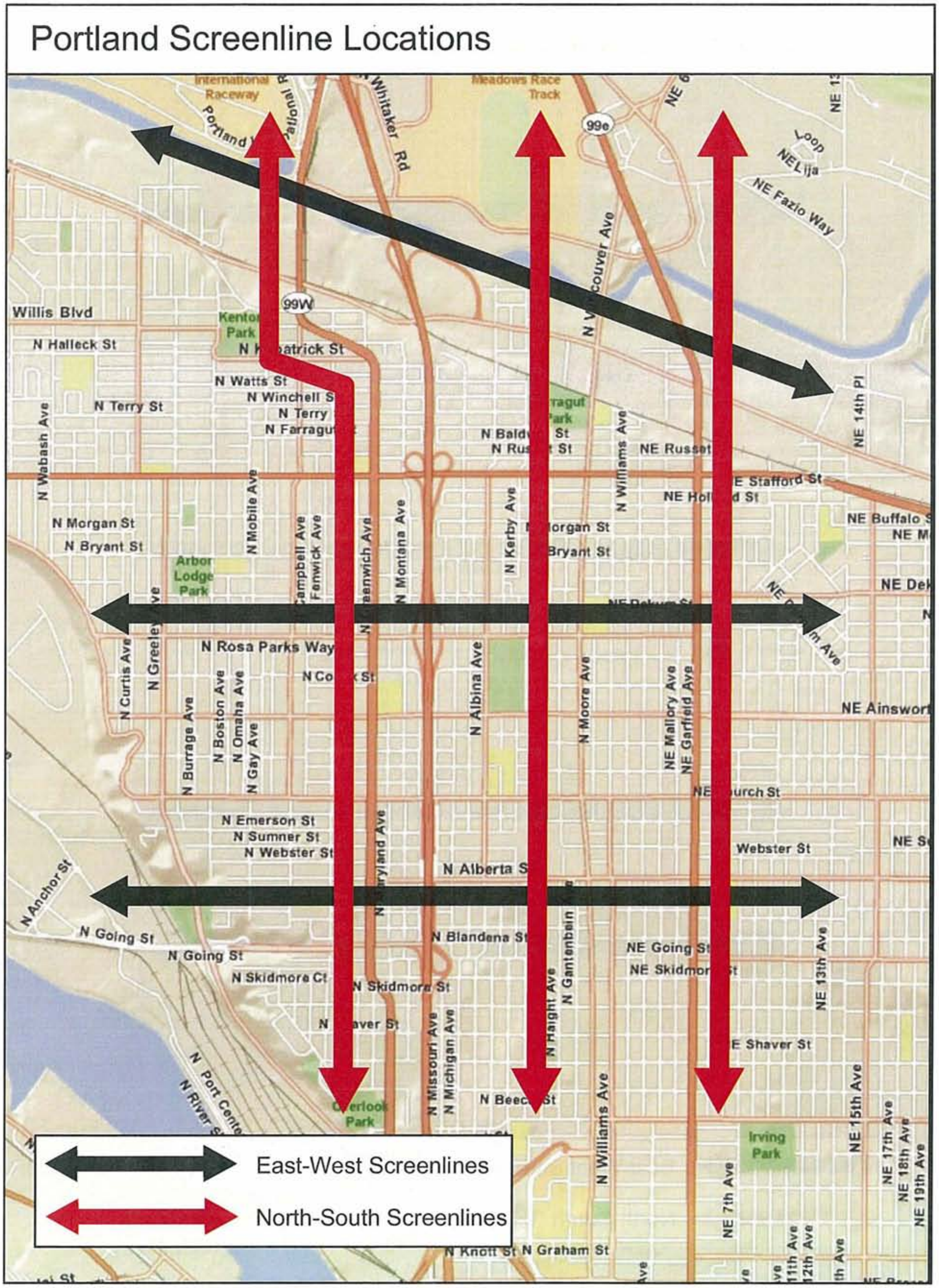

Portland Screenline Locations
East-West Screenlines
North-South Screenlines

Exhibit 4-24

Vancouver North-South Screenlines - AM Peak Hour Volumes				
Screenline	**Existing**	**No Build**	**LPA Phase I**	**LPA**
West of Franklin St				
Westbound Total	1,350	2,850	3,150	3,150
Eastbound Total	1,400	2,000	2,300	2,300
West of I-5				
Westbound Total	3,100	4,450	5,050	5,050
Eastbound Total	2,750	3,350	3,900	3,750
East of I-5				
Westbound Total	2,550	3,450	3,500	3,500
Eastbound Total	2,300	3,000	3,850	3,100

Vancouver East-West Screenlines - AM Peak Hour Volumes				
Screenline	**Existing**	**No Build**	**LPA Phase I**	**LPA**
North of Evergreen Blvd				
Southbound Total	950	1,450	1,600	1,600
Northbound Total	800	1,050	1,100	1,100
North of 15th St				
Southbound Total	1,300	2,100	1,800	1,800
Northbound Total	450	500	600	600
North of 4th Plain Blvd				
Southbound Total	1,500	2,200	1,650	1,650
Northbound Total	350	350	450	450
North of 39th St				
Southbound Total	800	1,250	850	850
Northbound Total	250	250	450	450

PRELIMINARY

Exhibit 4-25

Vancouver North-South Screenlines - PM Peak Hour Volumes				
Screenline	**Existing**	**No Build**	**LPA Phase I**	**LPA**
West of Franklin St				
Westbound Total	1,550	2,500	2,950	2,950
Eastbound Total	1,750	3,500	3,600	3,600
West of I-5				
Westbound Total	2,900	3,950	4,450	4,450
Eastbound Total	4,200	5,950	6,550	6,300
East of I-5				
Westbound Total	2,550	3,050	3,450	3,450
Eastbound Total	4,050	5,800	5,250	4,350

Vancouver East-West Screenlines - PM Peak Hour Volumes				
Screenline	**Existing**	**No Build**	**LPA Phase I**	**LPA**
North of Evergreen Blvd				
Southbound Total	950	1,050	1,200	1,200
Northbound Total	1,200	1,850	1,750	1,750
North of 15th St				
Southbound Total	850	1,000	1,050	1,050
Northbound Total	950	1,350	1,250	1,250
North of 4th Plain Blvd				
Southbound Total	600	650	650	650
Northbound Total	950	1,300	950	950
North of 39th St				
Southbound Total	500	550	650	650
Northbound Total	650	950	900	900

Exhibit 4-26

PRELIMINARY

Portland North-South Screenlines - AM Peak Hour Volumes				
Screenline	**Existing**	**No Build**	**LPA Phase I**	**LPA**
West of Interstate				
Westbound Total	3,050	4,250	4,250	4,250
Eastbound Total	2,500	3,200	2,900	2,900
East of I-5				
Westbound Total	2,700	3,450	3,150	3,150
Eastbound Total	2,100	2,950	3,050	3,050
East of MLK Jr Blvd				
Westbound Total	3,350	3,950	3,900	3,900
Eastbound Total	2,250	2,850	3,100	3,100

Portland East-West Screenlines - AM Peak Hour Volumes				
Screenline	**Existing**	**No Build**	**LPA Phase I**	**LPA**
Columbia Slough				
Southbound Total	1,200	1,400	1,400	1,400
Northbound Total	950	1,150	1,050	1,050
North of Rosa Parks				
Southbound Total	1,100	1,150	1,200	1,200
Northbound Total	600	750	750	750
South of Alberta St				
Southbound Total	1,600	1,800	1,800	1,800
Northbound Total	700	1,250	1,000	1,000

Exhibit 4-27

Portland North-South Screenlines - PM Peak Hour Volumes				
Screenline	**Existing**	**No Build**	**LPA Phase I**	**LPA**
West of Interstate				
Westbound Total	2,350	3,100	3,200	3,200
Eastbound Total	3,450	4,950	4,700	4,700
East of I-5				
Westbound Total	2,600	3,300	3,550	3,550
Eastbound Total	2,950	3,850	3,650	3,650
East of MLK Jr Blvd				
Westbound Total	2,650	3,300	3,200	3,200
Eastbound Total	3,350	4,050	3,900	3,900

Portland East-West Screenlines - PM Peak Hour Volumes				
Screenline	**Existing**	**No Build**	**LPA Phase I**	**LPA**
Columbia Slough				
Southbound Total	1,200	1,450	1,350	1,350
Northbound Total	1,350	1,550	1,650	1,650
North of Rosa Parks				
Southbound Total	1,100	1,550	1,400	1,400
Northbound Total	1,600	1,850	1,900	1,900
South of Alberta St				
Southbound Total	1,250	1,750	1,600	1,600
Northbound Total	2,100	2,550	2,400	2,400

Exhibit 4-28

PRELIMINARY

Vancouver Intersection Performance Results

AM Peak Hour — 2005 Existing Conditions

#	Intersection	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
A	Esther St @ Columbia Way								
B	Columbia St @ Columbia Way								
AA	Main St @ Columbia Way								
01	3rd/4th St @ Columbia St	Westbound Left/Right	3.7	A	0.03	LOS E	Y	-	-
BB	SR 14 and Main Street								
CC	SR 14 Park and Ride @ Main Street								
C	3rd/4th St @ Esther St								
02	4th St @ Columbia St	Eastbound Left/Thru/Right	4.4	A	0.03	LOS E	Y	-	-
03	4th St @ Washington St	Eastbound Right	1.1	A	0.01	LOS E	Y	-	-
04	5th St @ Columbia St	Southbound Left	12.6	B	0.15	LOS E	Y	50	100 (SBL)
DD	5th St @ Columbia Park and Ride								
05	5th St @ Washington St	Overall Intersection	30.8	D	0.42	LOS E	Y	180 215	200 (EBR to I-5) 225 (SBL)
EE	5th St @ Main St								
06	6th St @ Columbia St	Overall Intersection	7.8	A	0.42	LOS E	Y	-	-
07	6th St @ Washington St	Overall Intersection	20.3	C	0.35	LOS E	Y	-	-
08	6th St @ Main St	Overall Intersection	6.5	A	0.38	LOS E	Y	-	-
09	7th St @ Broadway	Southbound Right	1.8	A	0.02	LOS E	Y	-	-
10	8th St @ C St	Northbound Left/Thru	5.7	A	-	LOS E	Y	-	-
11	8th St @ Esther St	Southbound Left/Thru/Right	6.0	A	0.08	LOS E	Y	-	-
12	8th St @ Columbia St	Overall Intersection	10.8	B	0.51	LOS E	Y	-	-
13	8th St @ Washington St	Overall Intersection	5.4	A	0.55	LOS E	Y	-	-
14	8th St @ Main St	Overall Intersection	11.5	B	0.55	LOS E	Y	-	-
15	9th St @ Broadway	Southbound Left	6.6	A	0.22	LOS E	Y	-	-
16	9th St @ C St	Overall Intersection	10.0	A	0.48	LOS E	Y	-	-
17	9th St @ Esther St	Westbound Left/Thru/Right	5.6	A	0.08	LOS E	Y	-	-
18	9th St @ Columbia St	Eastbound Left/Thru/Right	5.4	A	0.06	LOS E	Y	-	-
19	9th St @ Washington St	Westbound Left	6.4	A	0.01	LOS E	Y	-	-
20	9th St @ Main St	Northbound Left	6.2	A	0.05	LOS E	Y	50	75 (NBL)
21	9th St @ Broadway	Southbound Thru/Right	5.5	A	0.27	LOS E	Y	-	-
22	Evergreen Blvd @ Esther St	Northbound Left/Thru/Right	4.7	A	0.12	LOS E	Y	-	-
23	Evergreen Blvd @ Columbia St	Overall Intersection	13.4	B	0.49	LOS E	Y	-	-
24	Evergreen Blvd @ Washington St	Overall Intersection	9.1	A	0.53	LOS E	Y	-	-
25	Evergreen Blvd @ Main St	Overall Intersection	7.9	A	0.53	LOS E	Y	-	-
26	Evergreen Blvd @ Broadway	Overall Intersection	18.7	B	0.63	LOS E	Y	75 100 210	75 (WBL) 100 (SBL) 225 (SBTR)
27	Evergreen Blvd @ C St	Overall Intersection	11.9	B	0.83	LOS E	Y	-	-
28	11th St @ Esther St	Southbound Left/Thru/Right	4.3	A	0.03	LOS E	Y	-	-
29	11th St @ Columbia St	Westbound Left/Thru/Right	6.9	A	0.14	LOS E	Y	-	-
30	11th St @ Washington St	Eastbound Thru/Right	8.0	A	0.07	LOS E	Y	-	-
31	11th St @ Main St	Eastbound Thru/Right	4.7	A	0.08	LOS E	Y	-	-
32	11th St @ Broadway	Eastbound Thru/Right	6.1	A	0.06	LOS E	Y	-	-
33	11th St @ C St	Eastbound Left/Thru	4.2	A	0.08	LOS E	Y	-	-
34	Mill Plain Blvd @ Columbia St	Overall Intersection	12.6	B	0.66	LOS E	Y	-	-
35	Mill Plain Blvd @ Washington St	Overall Intersection	7.2	A	0.40	LOS E	Y	-	-
36	Mill Plain Blvd @ Main St	Overall Intersection	4.7	A	0.57	LOS E	Y	-	-
37	Mill Plain Blvd @ Broadway	Overall Intersection	12.2	B	0.51	LOS E	Y	100	200 (SBLT)
38	Mill Plain Blvd @ C St	Overall Intersection	6.3	A	0.34	LOS E	Y	-	-
39	Mill Plain Blvd @ I-5 SB On/Off-Ramps	Overall Intersection	18.6	B	0.58	LOS E	Y	300 275	375 (EBR) 350 (WBL)
FF	Mill Plain Blvd @ I-5 SPUI								
40	Mill Plain Blvd @ I-5 NB On/Off-Ramps	Overall Intersection	21.6	C	0.54	LOS E	Y	75	100 (WBR)
41	15th St @ Columbia St	Overall Intersection	10.1	B	0.53	LOS E	Y	-	-
42	15th St @ Washington St	Overall Intersection	4.9	A	0.44	LOS E	Y	-	-
GG	15th St @ Mill District Park & Ride								
43	15th St @ Main St	Overall Intersection	7.5	A	0.46	LOS E	Y	-	-
44	15th St @ Broadway	Overall Intersection	18.2	B	0.47	LOS E	Y	-	-
45	15th St @ C St	Overall Intersection	8.8	A	0.48	LOS E	Y	-	-
D	16th St @ Washington St								
HH	16th St @ Mill District Park & Ride								
E	16th St @ Main St								
F	17th Street & Washington								
G	17th Street & Main								
H	17th Street & Broadway								
I	17th Street & C Street								
J	17th Street & G Street								
46	McLoughlin Blvd @ Columbia St	Overall Intersection	7.3	A	0.52	LOS E	Y	-	-
K	McLoughlin Blvd @ Washington St								
47	McLoughlin Blvd @ Main St	Overall Intersection	11.0	B	0.56	LOS E	Y	-	-
48	McLoughlin Blvd @ Broadway	Overall Intersection	10.1	B	0.46	LOS E	Y	-	-
L	McLoughlin Blvd @ C St								
M	McLoughlin Blvd @ G St								
N	McLoughlin Blvd @ Clark College Park & Ride								
JJ	McLoughlin Blvd @ Marshall CC East								
49	McLoughlin Blvd @ Fort Vancouver Way	Overall Intersection	8.1	A	0.38	LOS D	Y	-	-
50	24th St @ Columbia St	Westbound Left/Thru/Right	8.4	A	0.12	LOS E	Y	-	-
51	24th St @ Main St	Eastbound Left/Right	6.6	A	0.06	LOS E	Y	-	-
52	4th Plain Blvd @ Columbia St	Overall Intersection	16.8	B	0.81	LOS D	Y	-	-
53	4th Plain Blvd @ Main St	Overall Intersection	36.7	D	0.66	LOS D	Y	125 200 75 470	150 (WBL) 200 (WBTR) 100 (SBL) 475 (SBTR)
54	4th Plain Blvd @ Broadway	Overall Intersection	18.4	B	0.60	LOS D	Y	-	-
55	4th Plain Blvd @ F St	Overall Intersection	12.5	B	0.50	LOS D	Y	150	200 (EBL)
56	4th Plain Blvd @ I-5 SB On/Off-Ramps	Overall Intersection	8.8	A	0.48	LOS D	Y	-	-
57	4th Plain Blvd @ I-5 NB On/Off-Ramps	Overall Intersection	12.3	B	0.51	LOS D	Y	75	150 (WBR)
58	4th Plain Blvd @ Fort Cemetery	Eastbound Left	6.5	A	0.01	LOS E	Y	-	-
59	4th Plain Blvd @ St. Johns Blvd	Overall Intersection	13.2	B	0.41	LOS D	Y	-	-
60	29th St @ Main St	Eastbound Left/Thru/Right	> 100	F	0.67	LOS E	N	215	225 (SBTR)
61	29th St @ Broadway	Northbound Thru/Right	1.0	A	-	LOS E	Y	-	-
62	29th St @ Main St @ Broadway	Eastbound Left/Thru/Right	21.8	C	-	LOS E	Y	-	-
63	33rd St @ Main St	Overall Intersection	18.3	B	0.54	LOS D	Y	50 75	75 (WBL) 100 (SBL)

2030 No-Build

#	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
A	Eastbound Left	3.8	A	0.01	LOS E	Y	-	-
B	Eastbound Left	4.5	A	0.05	LOS E	Y	-	-
AA								
01	Eastbound Left/Right	4.8	A	0.04	LOS E	Y	-	-
BB								
CC								
C	Westbound Left/Right	3.8	A	0.09	LOS E	Y	-	-
02	Northbound Thru/Right	3.2	A	0.04	LOS E	Y	-	-
03	Eastbound Right	2.7	A	0.03	LOS E	Y	-	-
04	Southbound Left	3.0	A	0.12	LOS E	Y	-	-
DD								
05	Overall Intersection	8.5	A	0.44	LOS E	Y	-	-
EE								
06	Overall Intersection	7.9	A	0.45	LOS E	Y	-	-
07	Overall Intersection	11.8	B	0.48	LOS E	Y	-	-
08	Overall Intersection	7.6	A	0.53	LOS E	Y	-	-
09	Southbound Right	4.7	A	0.36	LOS E	Y	-	-
10	Northbound Left/Thru	16.7	C	-	LOS E	Y	550	600 (NBLT)
11	Southbound Left/Thru/Right	8.8	A	0.19	LOS E	Y	-	-
12	Overall Intersection	12.2	B	0.85	LOS E	Y	-	-
13	Overall Intersection	11.5	B	0.58	LOS E	Y	-	-
14	Overall Intersection	12.2	B	0.58	LOS E	Y	-	-
15	Southbound Left/Thru/Right	10.3	B	0.65	LOS E	Y	-	-
16	Overall Intersection	16.2	B	0.59	LOS E	Y	-	-
17	Westbound Left/Thru/Right	4.2	A	0.60	LOS E	Y	-	-
18	Westbound Left/Thru/Right	7.0	A	0.13	LOS E	Y	-	-
19	Westbound Left	5.4	A	0.04	LOS E	Y	-	-
20	Eastbound Left/Thru/Right	4.0	A	0.06	LOS E	Y	-	-
21	Eastbound Left/Right	3.8	A	0.04	LOS E	Y	-	-
22	Northbound Left/Thru/Right	7.6	A	0.12	LOS E	Y	-	-
23	Overall Intersection	13.0	B	0.63	LOS E	Y	-	-
24	Overall Intersection	17.2	B	0.69	LOS E	Y	75	100 (WBL)
25	Overall Intersection	14.8	B	0.66	LOS E	Y	-	-
26	Overall Intersection	14.9	B	0.70	LOS E	Y	75 210	125 (WBL) 225 (WBTR)
27	Overall Intersection	14.3	B	0.64	LOS E	Y	-	-
28	Southbound Left/Thru/Right	4.6	A	0.05	LOS E	Y	-	-
29	Westbound Left/Thru/Right	8.1	A	0.29	LOS E	Y	-	-
30	Westbound Left/Thru	7.8	A	0.23	LOS E	Y	-	-
31	Westbound Left/Thru/Right	8.2	A	0.38	LOS E	Y	-	-
32	Westbound Left/Thru/Right	6.9	A	0.22	LOS E	Y	-	-
33	Eastbound Left/Thru	6.3	A	0.17	LOS E	Y	-	-
34	Overall Intersection	18.4	B	0.77	LOS E	Y	75 215	150 (SBL) 225 (SBT)
35	Overall Intersection	7.8	A	0.43	LOS E	Y	-	-
36	Overall Intersection	11.5	B	1.01	LOS E	Y	70	150 (SBL)
37	Overall Intersection	10.3	B	0.68	LOS E	Y	70	150 (SBL)
38	Overall Intersection	8.5	A	0.38	LOS E	Y	-	-
39	Overall Intersection	20.4	C	0.78	LOS E	Y	600 350 275	800 (EBT) 500 (EBR) 350 (WBL)
FF								
40	Overall Intersection	35.0	D	0.88	LOS E	Y	550 325	800 (NBLT) 500 (NBR)
41	Overall Intersection	17.4	B	0.77	LOS E	Y	220	225 (WBLT)
42	Overall Intersection	12.3	B	0.54	LOS E	Y	210 215	250 (WBL) 225 (WBT)
GG								
43	Overall Intersection	14.7	B	1.01	LOS E	Y	195	300 (WBTR)
44	Overall Intersection	14.2	B	0.68	LOS E	Y	205	225 (WBLT)
45	Overall Intersection	8.3	A	0.58	LOS E	Y	-	-
D	Westbound Left/Thru	8.1	A	0.18	LOS E	Y	-	-
HH								
E	Eastbound Left/Thru/Right	9.8	A	0.17	LOS E	Y	-	-
F	Westbound Left/Thru	8.8	A	0.14	LOS E	Y	-	-
G	Eastbound Thru/Right	10.5	B	0.14	LOS E	Y	-	-
H	Westbound Left/Thru/Right	8.5	A	0.11	LOS E	Y	-	-
I	Eastbound Left/Thru	5.7	A	0.09	LOS E	Y	-	-
J	Eastbound Left/Thru/Right	2.7	A	0.02	LOS E	Y	-	-
46	Overall Intersection	12.2	B	0.64	LOS E	Y	-	-
K	Overall Intersection	5.5	A	0.39	LOS E	Y	-	-
47	Overall Intersection	18.1	B	0.70	LOS E	Y	-	-
48	Overall Intersection	18.0	B	0.59	LOS E	Y	75	100 (WBL)
L	Overall Intersection	5.9	A	0.30	LOS E	Y	-	-
M	Northbound Left/Thru/Right	8.2	A	-	LOS E	Y	-	-
N								
JJ								
49	Overall Intersection	11.7	B	0.42	LOS D	Y	-	-
50	Eastbound Left/Thru/Right	8.0	A	0.04	LOS E	Y	-	-
51	Eastbound Left/Right	9.8	A	0.05	LOS E	Y	-	-
52	Overall Intersection	20.4	C	0.74	LOS D	Y	235	250 (SBTR)
53	Overall Intersection	36.1	D	0.76	LOS D	Y	170 155 75 470	200 (WBL) 200 (WBT) 125 (SBL) 475 (SBTR)
54	Overall Intersection	> 100	F	0.67	LOS D	N	155 455	300 (EBLT) 500 (WBT)
55	Overall Intersection	11.2	B	0.53	LOS D	Y	150	150 (EBT)
56	Overall Intersection	17.5	B	0.64	LOS D	Y	200	275 (EBL)
57	Overall Intersection	16.2	B	0.64	LOS D	Y	75	125 (WBR)
58	Eastbound Left	7.4	A	0.05	LOS E	Y	-	-
59	Overall Intersection	18.8	B	0.62	LOS D	Y	-	-
60	Eastbound Left/Thru/Right	> 100	F	0.10	LOS E	N	215	225 (SBTR)
61	Westbound Left	5.4	A	0.24	LOS E	Y	-	-
62	Westbound Left/Thru/Right	74.6	F	-	LOS E	N	1000	1000 (SBTR)
63	Overall Intersection	34.8	C	0.70	LOS D	Y	50 50 75	50 (EBL) 75 (WBL) 100 (NBL)

2030 LPA with Highway Phasing (Broadway-Washington/17th)

#	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
A	Southbound Left/Right	5.4	A	0.32	LOS E	Y	-	-
B	Southbound Left/Right	2.3	A	0.29	LOS E	Y	-	-
AA	Westbound Thru/Right	1.3	A	0.25	LOS E	Y	-	-
01	Southbound Left/Thru/Right	7.8	A	0.73	LOS E	Y	-	-
BB	Southbound Left/Thru	2.4	A	0.34	LOS E	Y	-	-
CC	Southbound Thru/Right	1.3	A	0.24	LOS E	Y	-	-
C	Westbound Left/Right	5.1	A	0.31	LOS E	Y	-	-
02								
03								
04	Southbound Left	8.7	A	0.15	LOS E	Y	-	-
DD	Northbound Left/Right	2.6	A	0.67	LOS E	Y	-	-
05	Overall Intersection	9.2	A	0.43	LOS E	Y	-	-
EE	Overall Intersection	18.2	B	0.80	LOS E	Y	180 75 165	175 (SBLTR) 100 (SBL) 200 (SBTR)
06	Overall Intersection	15.0	B	0.88	LOS E	Y	200 75 205	200 (WBLTR) 100 (NBL) 225 (NBTR)
07	Overall Intersection	14.6	B	0.29	LOS E	Y	-	-
08	Overall Intersection	8.6	A	0.79	LOS E	Y	75 165	100 (NBL) 200 (NBTR)
09	Eastbound Left/Thru	1.7	A	0.25	LOS E	Y	-	-
10	Southbound Thru	3.7	A	0.36	LOS E	Y	-	-
11	Northbound Left/Thru/Right	7.3	A	0.27	LOS E	Y	-	-
12	Overall Intersection	15.4	B	0.68	LOS E	Y	75 75 210	125 (SBL) 100 (WBL) 225 (WBTR)
13	Overall Intersection	11.9	B	0.54	LOS E	Y	-	-
14	Overall Intersection	15.2	B	0.63	LOS E	Y	-	-
15	Overall Intersection	7.0	A	0.63	LOS E	Y	-	-
16	Overall Intersection	11.2	B	0.52	LOS E	Y	-	-
17	Westbound Left/Thru/Right	5.9	A	0.07	LOS E	Y	-	-
18	Westbound Left/Thru/Right	6.2	A	0.08	LOS E	Y	-	-
19	Overall Intersection	8.0	A	0.44	LOS E	Y	-	-
20	Eastbound Left/Thru/Right	7.9	A	0.17	LOS E	Y	-	-
21	Overall Intersection	3.6	A	0.35	LOS E	Y	-	-
22	Northbound Left/Thru/Right	10.5	B	0.23	LOS E	Y	-	-
23	Overall Intersection	18.4	B	0.75	LOS E	Y	225 100 205	225 (WBTR) 125 (NBL) 225 (SBTR)
24	Overall Intersection	11.8	B	0.56	LOS E	Y	210	225 (SBTR)
25	Overall Intersection	10.4	B	0.65	LOS E	Y	-	-
26	Overall Intersection	10.3	B	0.52	LOS E	Y	-	-
27	Overall Intersection	11.5	B	0.68	LOS E	Y	-	-
28	Northbound Left/Thru/Right	4.8	A	0.14	LOS E	Y	-	-
29	Eastbound Left/Thru/Right	15.6	C	0.25	LOS E	Y	-	-
30	Overall Intersection	10.1	B	0.46	LOS E	Y	-	-
31	Westbound Left/Thru/Right	10.5	B	0.19	LOS E	Y	-	-
32	Overall Intersection	10.1	B	0.40	LOS E	Y	-	-
33	Eastbound Left/Thru/Right	6.7	A	0.14	LOS E	Y	-	-
34	Overall Intersection	15.4	B	1.06	LOS E	Y	75 210	160 (SBL) 225 (SBT)
35	Overall Intersection	17.7	B	0.50	LOS E	Y	205	225 (SBLT)
36	Overall Intersection	14.3	B	1.00	LOS E	Y	70 210	150 (SBL) 225 (SBT)
37	Overall Intersection	9.4	A	0.38	LOS E	Y	-	-
38	Overall Intersection	12.8	B	1.02	LOS E	Y	200 75 200	200 (EBLTR) 125 (SBL) 200 (SBT)
39								
FF	Overall Intersection	22.1	C	0.83	LOS E	Y	-	-
40								
41	Overall Intersection	22.5	C	1.06	LOS E	Y	225 75	225 (WBLTR) 75 (NBL)
42	Overall Intersection	7.4	A	0.56	LOS E	Y	70	75 (WBT)
GG	Westbound Thru/Right	2.1	A	0.41	LOS E	Y	90	100 (WBTR)
43	Overall Intersection	24.2	C	1.09	LOS E	Y	100 225	200 (WBT) 225 (SBTR)
44	Overall Intersection	11.0	B	0.59	LOS E	Y	200	200 (WBTR)
45	Overall Intersection	47.1	D	1.02	LOS E	Y	-	-
D	Overall Intersection	21.6	C	0.30	LOS E	Y	65	75 (WBLTR)
HH	Northbound Right	2.5	A	0.03	LOS E	Y	-	-
E	Overall Intersection	12.8	B	0.49	LOS E	Y	180	200 (SBLTR)
F	Overall Intersection	8.6	A	0.27	LOS E	Y	-	-
G	Overall Intersection	4.1	A	0.90	LOS E	Y	-	-
H	Overall Intersection	9.2	A	0.15	LOS E	Y	-	-
I	Overall Intersection	8.0	A	0.23	LOS E	Y	-	-
J	Overall Intersection	6.0	A	0.13	LOS E	Y	-	-
46	Overall Intersection	11.8	B	0.65	LOS E	Y	-	-
K	Overall Intersection	8.1	A	0.52	LOS E	Y	-	-
47	Overall Intersection	21.2	C	0.83	LOS E	Y	220 50	225 (WBLTR) 100 (SBR)
48	Overall Intersection	23.7	C	0.84	LOS E	Y	200	200 (WBT)
L	Overall Intersection	11.3	B	0.49	LOS E	Y	-	-
M	Southbound Left/Thru/Right	5.5	A	-	LOS E	Y	-	-
N	Overall Intersection	10.3	B	0.33	LOS D	Y	-	-
JJ	Overall Intersection	1.9	A	0.30	LOS D	Y	-	-
49	Overall Intersection	15.4	B	0.55	LOS D	Y	-	-
50	Eastbound Left/Thru/Right	7.9	A	0.03	LOS E	Y	-	-
51	Eastbound Left/Right	7.8	A	0.04	LOS E	Y	-	-
52	Overall Intersection	16.5	B	0.64	LOS D	Y	235	250 (SBTR)
53	Overall Intersection	49.5	D	0.72	LOS D	Y	170 195 75 75 470	225 (WBL) 200 (WBTR) 75 (NBR) 125 (SBL) 475 (SBTR)
54	Overall Intersection	42.8	D	0.80	LOS D	Y	455 195	500 (WBTR) 300 (SBLTR)
55	Overall Intersection	10.6	A	0.55	LOS D	Y	150	150 (EBT)
56	Overall Intersection	21.9	C	0.58	LOS D	Y	200	250 (EBL)
57	Overall Intersection	18.8	B	0.51	LOS D	Y	-	-
58	Eastbound Left	6.7	A	0.01	LOS E	Y	-	-
59	Overall Intersection	17.5	B	0.43	LOS D	Y	-	-
60	Eastbound Left/Thru/Right	> 100	F	0.23	LOS E	Y**	325 215	325 (EBLTR) 225 (SBTR)
61	Westbound Left	4.2	A	0.11	LOS E	Y	-	-
62	Westbound Left/Thru/Right	> 100	F	-	LOS E	N	1000	1000 (SBTR)
63	Overall Intersection	15.2	B	0.57	LOS D	Y	50	75 (WBL)

2030 LPA (Broadway-Washington/17th)

#	Approach/Movement	Delay (Seconds)	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
A	Southbound Left/Right	5.4	5.4	A	0.32	LOS E	Y	-	-
B	Southbound Left/Right	2.3	2.3	A	0.29	LOS E	Y	-	-
AA	Westbound Thru/Right	1.3	1.3	A	0.25	LOS E	Y	-	-
01	Southbound Left/Thru/Right	7.8	7.8	A	0.73	LOS E	Y	-	-
BB	Southbound Left/Thru	2.4	2.4	A	0.34	LOS E	Y	-	-
CC	Southbound Thru/Right	1.3	1.3	A	0.24	LOS E	Y	-	-
C	Westbound Left/Right	5.1	5.1	A	0.31	LOS E	Y	-	-
02									
03									
04	Southbound Left	8.7	8.7	A	0.15	LOS E	Y	-	-
DD	Northbound Left/Right	2.6	2.6	A	0.67	LOS E	Y	-	-
05	Overall Intersection	9.2	9.2	A	0.43	LOS E	Y	-	-
EE	Overall Intersection	18.2	18.2	B	0.80	LOS E	Y	180 75 165	175 (SBLTR) 100 (SBL) 200 (SBTR)
06	Overall Intersection	15.0	15.0	B	0.88	LOS E	Y	200 75 205	200 (WBLTR) 100 (NBL) 225 (NBTR)
07	Overall Intersection	14.6	14.6	B	0.29	LOS E	Y	-	-
08	Overall Intersection	8.6	8.6	A	0.78	LOS E	Y	75 165	100 (NBL) 200 (NBTR)
09	Eastbound Left/Thru	1.7	1.7	A	0.25	LOS E	Y	-	-
10	Southbound Thru	3.7	3.7	A	0.36	LOS E	Y	-	-
11	Northbound Left/Thru/Right	7.3	7.3	A	0.27	LOS E	Y	-	-
12	Overall Intersection	15.4	15.4	B	0.68	LOS E	Y	75 75 210	125 (SBL) 100 (WBL) 225 (WBTR)
13	Overall Intersection	11.9	11.9	B	0.54	LOS E	Y	-	-
14	Overall Intersection	15.2	15.2	B	0.63	LOS E	Y	-	-
15	Overall Intersection	7.0	7.0	A	0.63	LOS E	Y	-	-
16	Overall Intersection	11.2	11.2	B	0.52	LOS E	Y	-	-
17	Westbound Left/Thru/Right	5.9	5.9	A	0.07	LOS E	Y	-	-
18	Westbound Left/Thru/Right	6.2	6.2	A	0.08	LOS E	Y	-	-
19	Overall Intersection	8.0	8.0	A	0.44	LOS E	Y	-	-
20	Eastbound Left/Thru/Right	7.9	7.9	A	0.17	LOS E	Y	-	-
21	Overall Intersection	3.6	3.6	A	0.35	LOS E	Y	-	-
22	Northbound Left/Thru/Right	10.5	10.5	B	0.23	LOS E	Y	-	-
23	Overall Intersection	18.4	18.4	B	0.75	LOS E	Y	225 100 205	225 (WBTR) 125 (NBL) 225 (SBTR)
24	Overall Intersection	11.8	11.8	B	0.56	LOS E	Y	210	225 (SBTR)
25	Overall Intersection	10.4	10.4	B	0.65	LOS E	Y	-	-
26	Overall Intersection	10.3	10.3	B	0.52	LOS E	Y	-	-
27	Overall Intersection	11.5	11.5	B	0.68	LOS E	Y	-	-
28	Northbound Left/Thru/Right	4.8	4.8	A	0.14	LOS E	Y	-	-
29	Eastbound Left/Thru/Right	15.6	15.6	C	0.25	LOS E	Y	-	-
30	Overall Intersection	10.1	10.1	B	0.46	LOS E	Y	-	-
31	Westbound Left/Thru/Right	10.5	10.5	B	0.19	LOS E	Y	-	-
32	Overall Intersection	10.1	10.1	B	0.40	LOS E	Y	-	-
33	Eastbound Left/Thru/Right	6.7	6.7	A	0.14	LOS E	Y	-	-
34	Overall Intersection	15.4	15.4	B	1.06	LOS E	Y	75 210	160 (SBL) 225 (SBT)
35	Overall Intersection	17.7	17.7	B	0.50	LOS E	Y	205	225 (SBLT)
36	Overall Intersection	14.3	14.3	B	1.00	LOS E	Y	70 210	150 (SBL) 225 (SBT)
37	Overall Intersection	9.4	9.4	A	0.38	LOS E	Y	-	-
38	Overall Intersection	12.8	12.8	B	1.02	LOS E	Y	200 75 200	200 (EBLTR) 125 (SBL) 200 (SBT)
39									
FF	Overall Intersection	22.1	22.1	C	0.83	LOS E	Y	-	-
40									
41	Overall Intersection	22.5	22.5	C	1.06	LOS E	Y	225 75	225 (WBLTR) 75 (NBL)
42	Overall Intersection	7.4	7.4	A	0.56	LOS E	Y	70	75 (WBT)
GG	Westbound Thru/Right	2.1	2.1	A	0.41	LOS E	Y	90	100 (WBTR)
43	Overall Intersection	24.2	24.2	C	1.09	LOS E	Y	100 225	200 (WBT) 225 (SBTR)
44	Overall Intersection	11.0	11.0	B	0.59	LOS E	Y	200	200 (WBTR)
45	Overall Intersection	47.1	47.1	D	1.02	LOS E	Y	-	-
D	Overall Intersection	21.6	21.6	C	0.30	LOS E	Y	65	75 (WBLTR)
HH	Northbound Right	2.5	2.5	A	0.03	LOS E	Y	-	-
E	Overall Intersection	12.8	12.8	B	0.49	LOS E	Y	180	200 (SBLTR)
F	Overall Intersection	8.6	8.6	A	0.27	LOS E	Y	-	-
G	Overall Intersection	4.1	4.1	A	0.00	LOS E	Y	-	-
H	Overall Intersection	9.2	9.2	A	0.15	LOS E	Y	-	-
I	Overall Intersection	8.0	8.0	A	0.23	LOS E	Y	-	-
J	Overall Intersection	6.0	6.0	A	0.13	LOS E	Y	-	-
46	Overall Intersection	11.8	11.8	B	0.65	LOS E	Y	-	-
K	Overall Intersection	8.1	8.1	A	0.52	LOS E	Y	-	-
47	Overall Intersection	21.2	21.2	C	0.83	LOS E	Y	220 50	225 (WBLTR) 100 (SBR)
48	Overall Intersection	23.7	23.7	C	0.84	LOS E	Y	200	200 (WBT)
L	Overall Intersection	11.3	11.3	B	0.49	LOS E	Y	-	-
M	Southbound Left/Thru/Right	5.5	5.5	A	-	LOS E	Y	-	-
N	Overall Intersection	10.3	10.3	B	0.33	LOS D	Y	-	-
JJ	Overall Intersection	1.9	1.9	A	0.30	LOS D	Y	-	-
49	Overall Intersection	15.4	15.4	B	0.55	LOS D	Y	-	-
50	Eastbound Left/Thru/Right	7.9	7.9	A	0.03	LOS E	Y	-	-
51	Eastbound Left/Right	7.8	7.8	A	0.04	LOS E	Y	-	-
52	Overall Intersection	16.5	16.5	B	0.64	LOS D	Y	235	250 (SBTR)
53	Overall Intersection	49.5	49.5	D	0.72	LOS D	Y	170 195 75 75 470	225 (WBL) 200 (WBTR) 75 (NBR) 125 (SBL) 475 (SBTR)
54	Overall Intersection	42.8	42.8	D	0.80	LOS D	Y	455 195	500 (WBTR) 300 (SBLTR)
55	Overall Intersection	10.6	10.6	A	0.55	LOS D	Y	150	150 (EBT)
56	Overall Intersection	21.9	21.9	C	0.58	LOS D	Y	200	250 (EBL)
57	Overall Intersection	19.9	19.9	B	0.51	LOS D	Y	-	-
58	Eastbound Left	6.7	6.7	A	0.01	LOS E	Y	-	-
59	Overall Intersection	17.5	17.5	B	0.43	LOS D	Y	-	-
60	Eastbound Left/Thru/Right	520.0	> 100	F	0.23	LOS E	Y**	325 215	325 (EBLTR) 225 (SBTR)
61	Westbound Left	4.2	4.2	A	0.11	LOS E	Y	-	-
62	Westbound Left/Thru/Right	264.6	> 100	F	-	LOS E	N	1000	1000 (SBTR)
63	Overall Intersection	21.6	21.6	C	0.57	LOS D	Y	50	75 (WBL)

Continued on next page

Exhibit 4-28

PRELIMINARY

Vancouver Intersection Performance Results

AM Peak Hour — 2005 Existing Conditions

#	Intersection	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
64	39th St @ Main St	Overall Intersection	28.5	C	0.69	LOS D	Y	75 75 215 125	125 (EBL) 125 (WBL) 225 (WBTR) 175 (SBL)
65	39th St @ F St	Southbound Left/Thru/Right	22.8	C	0.12	LOS E	Y	50	75 (WBL)
66	39th St @ H St	Overall Intersection	8.2	A	0.54	LOS D	Y	135	150 (WBTR)
67	39th St @ I-5 SB On-/Off-Ramps	Northbound Left	68.0	F	1.55	LOS E	N	1800 125	600 (NBL) 200 (NBR)
68	39th St @ I-5 NB On-/Off-Ramps	Overall Intersection	11.9	B	0.59	LOS D	Y	-	-
69	WSDOT/40th St @ Main St	Overall Intersection	4.5	A	0.44	LOS D	Y	-	-
70	45th St @ Main St	Overall Intersection	7.4	A	0.44	LOS D	Y	-	-
71	Hazel Dell @ Main St (West)	Overall Intersection	8.7	A	0.50	LOS D	Y	-	-
72	Ross St @ Main St	Overall Intersection	4.6	A	0.29	LOS D	Y	-	-
73	Ross St @ North Rd	Northbound Left/Thru	6.6	A	0.24	LOS E	Y	-	-

2030 No-Build

#	Intersection	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
64	39th St @ Main St	Overall Intersection	> 100	F	0.93	LOS D	N	75 1310 75 215 75 125 360	125 (EBL) 1325 (EBTR) 125 (WBL) 325 (WBTR) 125 (NBL) 200 (SBL) 375 (SBT)
65	39th St @ F St	Northbound Left/Thru/Right	> 100	F	0.12	LOS E	N	50 430	75 (WBL) [illegible] (WBTR)
66	39th St @ H St	Overall Intersection	20.0	C	0.88	LOS D	Y	135	150 (WBTR)
67	39th St @ I-5 SB On-/Off-Ramps	Overall Intersection	64.4	E	0.80	LOS D	N	135 55 275 715 1600 125	150 (EBT) 100 (EBR) 375 (WBL) 725 (WBT) 1675 (NBL) 275 (NBR)
68	39th St @ I-5 NB On-/Off-Ramps	Overall Intersection	> 100	F	0.80	LOS D	N	300 715 1170 790 75	325 (EBL) 725 (EBT) 1175 (WBTR) 800 (NBLT) 75 (NBR)
69	WSDOT/40th St @ Main St	Overall Intersection	21.5	C	0.57	LOS D	Y	-	-
70	45th St @ Main St	Overall Intersection	9.4	A	0.64	LOS D	Y	-	-
71	Hazel Dell @ Main St (West)	Overall Intersection	13.9	B	0.71	LOS D	Y	-	-
72	Ross St @ Main St	Overall Intersection	6.7	A	0.47	LOS D	Y	60	75 (WBL)
73	Ross St @ North Rd	Northbound Left/Thru	7.2	A	0.35	LOS E	Y	-	-

2030 LPA with Highway Phasing (Broadway-Washington/17th)

#	Intersection	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
64	39th St @ Main St	Overall Intersection	> 100	F	0.98	LOS D	Y**	75 1310 75 215 75 125 360	175 (EBL) 1325 (EBTR) 250 (WBL) 225 (WBTR) 125 (NBL) 225 (SBL) 375 (SBTR)
65	39th St @ F St	Westbound Thru/Right	33.9	D	0.67	LOS E	Y	215 430	225 (EBTR) 450 (WBTR)
66	39th St @ H St	Overall Intersection	69.4	E	0.79	LOS D	N	430 135	400 (EBTR) 150 (WBTR)
67	39th St @ I-5 SB On-/Off-Ramps	Overall Intersection	35.2	C	0.96	LOS D	Y	135 55 730 130	150 (EBT) 125 (EBR) 750 (WBT) 225 (NBLR)
68	39th St @ I-5 NB On-/Off-Ramps	Overall Intersection	> 100	F	1.05	LOS D	Y**	300 1175 790	375 (EBL) 1175 (WBT) 825 (NBL)
69	WSDOT/40th St @ Main St	Overall Intersection	60.6	D	0.47	LOS D	Y	150	200 (SBL)
70	45th St @ Main St	Overall Intersection	19.4	B	0.54	LOS D	Y	-	-
71	Hazel Dell @ Main St (West)	Overall Intersection	11.8	B	0.61	LOS D	Y	205	225 (SBLT)
72	Ross St @ Main St	Overall Intersection	8.6	A	0.52	LOS D	Y	60	75 (WBL)
73	Ross St @ North Rd	Northbound Left/Thru	7.7	A	0.41	LOS E	Y	-	-

2030 LPA (Broadway-Washington/17th)

#	Intersection	Approach/Movement	Delay (Seconds)	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
64	39th St @ Main St	Overall Intersection	76.9	76.9	E	0.90	LOS D	Y*	75 1310 75 215 75 125 360	175 (EBL) 1325 (EBTR) 225 (WBL) 225 (WBTR) 125 (NBL) 200 (SBL) 350 (SBT)
65	39th St @ F St	Westbound Thru/Right	33.3	33.3	D	0.66	LOS E	Y	435	450 (WBTR)
66	39th St @ H St	Overall Intersection	18.4	18.4	B	0.78	LOS D	Y	135	155 (WBTR)
67	39th St @ I-5 SB On-/Off-Ramps	Westbound Thru	38.7	38.7	E	0.64	LOS E	Y	55 730	100 (EBR) 750 (WBT)
68	39th St @ I-5 NB On-/Off-Ramps	Overall Intersection	72.8	72.8	E	0.72	LOS D	Y*	1175 700	1175 (WBT) 800 (NBL)
69	WSDOT/40th St @ Main St	Overall Intersection	29.3	29.3	C	0.47	LOS D	Y	150	175 (SBL)
70	45th St @ Main St	Overall Intersection	11.6	11.6	B	0.54	LOS D	Y	-	-
71	Hazel Dell @ Main St (West)	Overall Intersection	11.5	11.5 > 100	B -	0.61	LOS D	Y	200	225 (SBLT)
72	Ross St @ Main St	Overall Intersection	8.4	8.4	A	0.52	LOS D	Y	60	75 (WBL)
73	Ross St @ North Rd	Northbound Left/Thru	7.8	7.8	A	0.41	LOS E	Y	-	-

(yellow)	Delay / LOS affected by freeway congestion
(blue)	Intersection queuing spills back into upstream intersection
Note 1	The ICU is used for overall intersections (signalized and unsignalized). The V/C is used for the identified movement(s) at unsignalized intersections
Note 2	The 2003 Vancouver Concurrency Administration Manual designates an acceptable LOS standard of LOS E for downtown and LOS D for all other intersections
Note 3	2030 LPA and LPA Phase I Roundabout intersection operations taken from VISSIM analysis
*	Intersection not modeled in existing conditions scenario
Y*	Intersection does not meet standard in the Build scenario, but meets the "do no worse" criteria as compared to the No Build
Y**	Intersection operations are no worse than No Build, and no mitigation is required

Exhibit 4-29

Vancouver Intersection Performance Results

PM Peak Hour

2005 Existing Conditions

#	Intersection	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
A	Esther St @ Columbia Way								
B	Columbia St @ Columbia Way'								
AA	Main St @ Columbia Way'								
01	3rd/4th St @ Columbia St'	Westbound Left/Right	4.7	A	0.05	LOS E	Y	-	-
BB	SR 14 and Main Street'								
CC	SR 14 Park and Ride @ Main Street								
C	3rd/4th St @ Esther St								
02	4th St @ Columbia St	Westbound Left/Thru/Right	4.8	A	0.05	LOS E	Y	-	-
03	4th St @ Washington St	Eastbound Right	1.6	A	0.01	LOS E	Y	-	-
04	5th St @ Columbia St	Southbound Left	3.6	A	0.22	LOS E	Y	-	-
DD	5th St @ Columbia Park and Ride								
05	5th St @ Washington St	Overall Intersection	8.1	A	0.34	LOS E	Y	-	-
EE	7th St @ Main St								
06	8th St @ Columbia St	Overall Intersection	10.7	B	0.42	LOS E	Y	-	-
07	6th St @ Washington St	Overall Intersection	11.6	B	0.36	LOS E	Y	-	-
08	6th St @ Main St	Overall Intersection	5.3	A	0.43	LOS E	Y	-	-
09	8th St @ Broadway	Southbound Right	4.6	A	0.22	LOS E	Y	-	-
10	8th St @ C St	Northbound Left/Thru	2.1	A	-	LOS E	Y	-	-
11	8th St @ Esther St	Northbound Left/Thru/Right	8.0	A	0.31	LOS E	Y	-	-
12	8th St @ Columbia St	Overall Intersection	15.1	B	0.74	LOS E	Y	-	-
13	9th St @ Washington St	Overall Intersection	9.5	A	0.58	LOS E	Y	75	125 (WBL)
14	9th St @ Main St	Overall Intersection	17.0	B	0.58	LOS E	Y	-	-
15	9th St @ Broadway	Southbound Thru/Right	10.2	B	0.13	LOS E	Y	-	-
16	9th St @ C St	Overall Intersection	14.3	B	0.34	LOS E	Y	-	-
17	9th St @ Esther St	Westbound Left/Thru/Right	4.5	A	0.07	LOS E	Y	-	-
18	9th St @ Columbia St	Westbound Left/Thru/Right	4.3	A	0.18	LOS E	Y	-	-
19	9th St @ Washington St	Westbound Thru	8.5	A	0.08	LOS E	Y	-	-
20	9th St @ Main St	Northbound Thru	8.7	A	0.34	LOS E	Y	50	50 (NBL)
21	9th St @ Broadway	Southbound Thru/Right	6.2	A	0.24	LOS E	Y	-	-
22	Evergreen Blvd @ Esther St	Southbound Left/Thru/Right	8.6	A	0.14	LOS E	Y	-	-
23	Evergreen Blvd @ Columbia St	Overall Intersection	10.9	B	0.53	LOS E	Y	-	-
24	Evergreen Blvd @ Washington St	Overall Intersection	10.6	B	0.56	LOS E	Y	-	-
25	Evergreen Blvd @ Main St	Overall Intersection	9.7	A	0.56	LOS E	Y	-	-
26	Evergreen Blvd @ Broadway	Overall Intersection	12.7	B	0.56	LOS E	Y	210	225 (SBTR)
27	Evergreen Blvd @ C St	Overall Intersection	13.0	B	0.56	LOS E	Y	-	-
28	11th St @ Esther St	Northbound Left/Thru/Right	6.3	A	0.11	LOS E	Y	-	-
29	11th St @ Columbia St	Eastbound Left/Thru/Right	6.9	A	0.34	LOS E	Y	-	-
30	11th St @ Washington St	Eastbound Thru/Right	7.0	A	0.21	LOS E	Y	-	-
31	11th St @ Main St	Eastbound Thru/Right	7.5	A	0.41	LOS E	Y	-	-
32	11th St @ Broadway	Eastbound Thru/Right	8.2	A	0.19	LOS E	Y	-	-
33	11th St @ C St	Eastbound Left/Thru	7.6	A	0.18	LOS E	Y	-	-
34	Mill Plain Blvd @ Columbia St	Overall Intersection	14.7	B	0.75	LOS E	Y	-	-
35	Mill Plain Blvd @ Washington St	Overall Intersection	8.2	A	0.45	LOS E	Y	-	-
36	Mill Plain Blvd @ Main St	Overall Intersection	12.4	B	0.62	LOS E	Y	100	150 (NBR)
37	Mill Plain Blvd @ Broadway	Overall Intersection	16.6	B	0.70	LOS E	Y	-	-
38	Mill Plain Blvd @ C St	Overall Intersection	14.1	B	0.60	LOS E	Y	-	-
39	Mill Plain Blvd @ I-5 SB On-/Off-Ramps	Overall Intersection	37.6	D	0.72	LOS E	Y	275	300 (WBL)
FF	Mill Plain Blvd @ I-5 SPUI								
40	Mill Plain Blvd @ I-5 NB On-/Off-Ramps	Overall Intersection	26.8	C	0.86	LOS E	Y	610 610 75	725 (EBL) 825 (EBT) 125 (WBR)
41	15th St @ Columbia St	Overall Intersection	5.0	A	0.54	LOS E	Y	-	-
42	15th St @ Washington St	Overall Intersection	5.6	A	0.37	LOS E	Y	-	-
GG	15th St @ Mill District Park & Ride								
43	15th St @ Main St	Overall Intersection	9.0	A	0.19	LOS E	Y	-	-
44	15th St @ Broadway	Overall Intersection	24.8	C	0.43	LOS E	Y	210	250 (WBL)
45	15th St @ C St	Overall Intersection	4.7	A	0.41	LOS E	Y	-	-
D	16th St @ Washington St								
HH	16th St @ Mill District Park & Ride								
E	16th St @ Main St								
F	17th Street & Washington								
G	17th Street & Main								
H	17th Street & Broadway								
I	17th Street & C Street								
J	17th Street & G Street								
46	McLoughlin Blvd @ Columbia St	Overall Intersection	8.4	A	0.42	LOS E	Y	-	-
K	McLoughlin Blvd @ Washington St								
47	McLoughlin Blvd @ Main St	Overall Intersection	11.6	B	0.67	LOS E	Y	-	-
48	McLoughlin Blvd @ Broadway	Overall Intersection	7.6	A	0.39	LOS E	Y	-	-
L	McLoughlin Blvd @ C St								
M	McLoughlin Blvd @ G St								
II	McLoughlin Blvd @ Clark College Park & Ride								
JJ	McLoughlin Blvd @ Marshall CC East								
49	McLoughlin Blvd @ Fort Vancouver Way	Overall Intersection	12.6	B	0.43	LOS D	Y	-	-

2030 No-Build

#	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
A	Eastbound Left	8.2	A	0.08	LOS E	Y	-	-
B	Eastbound Left	6.0	A	0.07	LOS E	Y	-	-
AA								
01	Eastbound Left/Right	6.7	A	0.18	LOS E	Y	-	-
BB								
CC								
C	Westbound Left/Right	3.1	A	0.01	LOS E	Y	-	-
02	Northbound Thru/Right	0.4	A	0.21	LOS E	Y	-	-
03	Eastbound Right	2.7	A	0.01	LOS E	Y	-	-
04	Southbound Left	9.1	A	0.41	LOS E	Y	50	125 (SBL)
DD								
05	Overall Intersection	13.4	B	0.54	LOS E	Y	180 210	200 (EBR to SR-14) 225 (EBT)
EE								
06	Overall Intersection	13.1	B	0.69	LOS E	Y	-	-
07	Overall Intersection	15.2	B	0.57	LOS E	Y	-	-
08	Overall Intersection	6.5	A	0.60	LOS E	Y	-	-
09	Southbound Right	4.7	A	0.22	LOS E	Y	-	-
10	Northbound Left/Thru	2.9	A	0.30	LOS E	Y	-	-
11	Northbound Left/Thru/Right	14.6	B	0.50	LOS E	Y	-	-
12	Overall Intersection	21.6	C	1.10	LOS E	Y	215	225 (SBLTR)
13	Overall Intersection	10.2	B	0.56	LOS E	Y	-	-
14	Overall Intersection	13.5	B	0.58	LOS E	Y	-	-
15	Southbound Left/Thru/Right	8.1	A	0.38	LOS E	Y	-	-
16	Overall Intersection	15.3	B	0.42	LOS E	Y	-	-
17	Eastbound Left/Thru/Right	3.7	A	0.02	LOS E	Y	-	-
18	Eastbound Left/Thru/Right	13.6	B	0.14	LOS E	Y	-	-
19	Westbound Thru	7.2	A	0.08	LOS E	Y	-	-
20	Eastbound Left/Thru/Right	6.9	A	0.36	LOS E	Y	-	-
21	Eastbound Left/Right	4.0	A	0.04	LOS E	Y	-	-
22	Southbound Left/Thru/Right	6.4	A	0.12	LOS E	Y	-	-
23	Overall Intersection	18.4	B	0.59	LOS E	Y	225	225 (NBTR)
24	Overall Intersection	13.2	B	0.55	LOS E	Y	-	-
25	Overall Intersection	13.1	B	0.55	LOS E	Y	-	-
26	Overall Intersection	10.0	A	0.54	LOS E	Y	-	-
27	Overall Intersection	16.8	B	0.63	LOS E	Y	75	100 (EBL)
28	Northbound Left/Thru/Right	5.8	A	0.11	LOS E	Y	-	-
29	Eastbound Left/Thru/Right	11.6	B	0.34	LOS E	Y	-	-
30	Eastbound Thru/Right	7.4	A	0.17	LOS E	Y	-	-
31	Eastbound Left/Thru/Right	15.6	C	0.31	LOS E	Y	-	-
32	Westbound Left/Thru/Right	6.7	A	0.30	LOS E	Y	-	-
33	Westbound Right	11.1	B	0.19	LOS E	Y	-	-
34	Overall Intersection	> 100	F	0.79	LOS E	N	810 150 75	825 (EBLTR) 225 (NBR) 100 (SBL)
35	Overall Intersection	54.8	D	0.57	LOS E	Y	215	200 (EBTR)
36	Overall Intersection	78.5	E	0.79	LOS E	Y	210 765 70	225 (EBT) 775 (NBTR) 100 (SBL)
37	Overall Intersection	39.9	D	0.77	LOS E	Y	210 70	225 (EBT) 100 (SBL)
38	Overall Intersection	51.9	D	0.78	LOS E	Y	200	225 (EBT)
39	Overall Intersection	54.4	F	0.87	LOS E	N	700 300 275 610	800 (EBT) 825 (EBR) 400 (WBL) 625 (WBT)
FF								
40	Overall Intersection	36.5	D	0.87	LOS E	Y	400 75	450 (WBT) 150 (WBR)
41	Overall Intersection	8.3	A	0.75	LOS E	Y	-	-
42	Overall Intersection	10.1	B	0.43	LOS E	Y	-	-
GG								
43	Overall Intersection	8.8	A	0.76	LOS E	Y	-	-
44	Overall Intersection	8.3	A	0.77	LOS E	Y	70 25	100 (NBL) 75 (SBR)
45	Overall Intersection	12.1	B	0.50	LOS E	Y	-	-
D	Westbound Left/Thru	6.1	A	0.19	LOS E	Y	-	-
HH								
E	Eastbound Left/Thru/Right	8.1	A	0.24	LOS E	Y	-	-
F	Westbound Left/Thru	5.6	A	0.06	LOS E	Y	-	-
G	Westbound Left/Thru/Right	8.6	A	0.15	LOS E	Y	-	-
H	Eastbound Left/Thru/Right	7.1	A	0.14	LOS E	Y	-	-
I	Eastbound Left/Thru	8.1	A	0.14	LOS E	Y	-	-
J	Southbound Left/Thru/Right	3.4	A	0.03	LOS E	Y	-	-
46	Overall Intersection	12.1	B	0.61	LOS E	Y	-	-
K	Overall Intersection	5.9	A	0.18	LOS E	Y	-	-
47	Overall Intersection	15.7	B	0.78	LOS E	Y	-	-
48	Overall Intersection	12.0	B	0.60	LOS E	Y	-	-
L	Overall Intersection	9.0	A	0.36	LOS E	Y	-	-
M	Northbound Left/Thru/Right	5.8	A	-	LOS E	Y	-	-
II								
JJ								
49	Overall Intersection	12.5	B	0.42	LOS D	Y	-	-

2030 LPA with Highway Phasing (Broadway-Washington/17th)

#	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
A	Southbound Left/Right	8.7	A	0.42	LOS E	Y	-	-
B	Southbound Left/Right	2.2	A	0.40	LOS E	Y	-	-
AA	Eastbound Left/Thru	1.2	A	0.20	LOS E	Y	-	-
01	Southbound Left/Thru/Right	4.5	A	0.73	LOS E	Y	-	-
BB	Eastbound Left/Thru/Right	14.1	B	0.79	LOS E	Y	-	-
CC	Eastbound Left/Right	8.2	A	0.03	LOS E	Y	-	-
C	Westbound Left/Right	6.6	A	0.12	LOS E	Y	-	-
02								
03								
04	Westbound Left/Right	3.6	A	0.04	LOS E	Y	-	-
DD	Northbound Left/Right	3.9	A	0.23	LOS E	Y	-	-
05	Overall Intersection	9.7	A	0.32	LOS E	Y	85	100 (EBTR)
EE	Overall Intersection	12.7	B	0.60	LOS E	Y	175	175 (SBTR)
06	Overall Intersection	22.2	C	0.85	LOS E	Y	200 205 75	200 (WBLTR) 225 (NBTR) 75 (SBL)
07	Overall Intersection	4.7	A	0.33	LOS E	Y	-	-
08	Overall Intersection	14.4	B	0.70	LOS E	Y	165 220	175 (NBLTR) 225 (SBLTR)
09	Eastbound Left/Thru	2.0	A	0.21	LOS E	Y	-	-
10	Southbound Thru	5.8	A	0.84	LOS E	Y	-	-
11	Northbound Left/Thru/Right	14.3	B	0.35	LOS E	Y	-	-
12	Overall Intersection	30.2	C	0.75	LOS E	Y	150 75 75	200 (EBL) 125 (WBL) 125 (SBL)
13	Overall Intersection	12.8	B	0.56	LOS E	Y	-	-
14	Overall Intersection	24.2	C	0.74	LOS E	Y	75 200 75 215 215	125 (EBL) 200 (EBTR) 125 (WBL) 225 (NBLTR) 225 (SBLTR)
15	Overall Intersection	23.0	C	0.64	LOS E	Y	-	-
16	Overall Intersection	12.3	B	0.70	LOS E	Y	-	-
17	Westbound Left/Thru/Right	5.1	A	0.06	LOS E	Y	-	-
18	Eastbound Left/Thru/Right	15.9	C	0.34	LOS E	Y	-	-
19	Overall Intersection	11.2	B	0.40	LOS E	Y	-	-
20	Eastbound Left/Thru/Right	18.0	C	0.36	LOS E	Y	-	-
21	Overall Intersection	26.7	C	0.37	LOS E	Y	-	-
22	Northbound Left/Thru/Right	9.7	A	0.22	LOS E	Y	-	-
23	Overall Intersection	28.8	C	0.71	LOS E	Y	100 220 205	125 (EBL) 225 (NBTR) 225 (SBTR)
24	Overall Intersection	19.6	B	0.61	LOS E	Y	225 210	225 (EBTR) 225 (SBLTR)
25	Overall Intersection	29.3	C	0.74	LOS E	Y	75 210 75 215	125 (EBL) 300 (EBTR) 125 (WBL) 225 (NBLTR)
26	Overall Intersection	19.3	B	0.66	LOS E	Y	100 210 220	150 (EBL) 225 (EBTR) 225 (NBLTR)
27	Overall Intersection	28.2	C	0.77	LOS E	Y	75 200 150 100 215	150 (EBL) 200 (EBTR) 175 (WBL) 125 (SBL) 225 (SBTR)
28	Northbound Left/Thru/Right	8.2	A	0.10	LOS E	Y	-	-
29	Eastbound Left/Thru/Right	12.1	B	0.38	LOS E	Y	-	-
30	Overall Intersection	11.5	B	0.44	LOS E	Y	-	-
31	Eastbound Left/Thru/Right	12.0	B	0.50	LOS E	Y	-	-
32	Overall Intersection	11.7	B	0.47	LOS E	Y	-	-
33	Eastbound Left/Thru/Right	21.9	C	0.24	LOS E	Y	-	-
34	Overall Intersection	> 100	F	1.10	LOS E	Y**	810 200 150	825 (EBLTR) 200 (NBT) 175 (NBR)
35	Overall Intersection	46.6	D	0.61	LOS E	Y	235	250 (EBTR)
36	Overall Intersection	37.9	D	0.71	LOS E	Y	200 100 70	225 (EBLTR) 150 (NBR) 150 (SBL)
37	Overall Intersection	44.0	D	0.71	LOS E	Y	210 210	225 (EBLT) 225 (NBTR)
38	Overall Intersection	81.4	F	1.35	LOS E	N	200 215 75 195	200 (EBLTR) 225 (NBTR) 100 (SBL) 200 (SBT)
39								
FF	Overall Intersection	63.3	E	0.99	LOS E	Y	700 700 740 200	800 (EBL) 850 (EBT) 750 (WBT) 275 (WBR)
40								
41	Overall Intersection	12.0	B	1.10	LOS E	Y	-	-
42	Overall Intersection	8.4	A	0.52	LOS E	Y	60	75 (WBT)
GG	Westbound Thru/Right	0.9	A	0.34	LOS E	Y	-	-
43	Overall Intersection	9.5	A	0.71	LOS E	Y	75	75 (NBL)
44	Overall Intersection	6.5	A	0.54	LOS E	Y	-	-
45	Overall Intersection	> 100	F	1.35	LOS E	N	-	-
D	Overall Intersection	23.5	C	0.29	LOS E	Y	65	75 (WBLT)
HH	Northbound Right	3.9	A	0.15	LOS E	Y	-	-
E	Overall Intersection	11.2	B	0.61	LOS E	Y	85	100 (EBLTR)
F	Overall Intersection	10.4	B	0.26	LOS E	Y	-	-
G	Overall Intersection	8.3	A	0.35	LOS E	Y	-	-
H	Overall Intersection	8.4	A	0.18	LOS E	Y	-	-
I	Overall Intersection	15.0	B	0.23	LOS E	Y	-	-
J	Overall Intersection	4.5	A	0.13	LOS E	Y	-	-
46	Overall Intersection	19.0	B	0.60	LOS E	Y	-	-
K	Overall Intersection	6.5	A	0.53	LOS E	Y	-	-
47	Overall Intersection	14.4	B	0.87	LOS E	Y	200 50	200 (NBLTR) 100 (SBR)
48	Overall Intersection	12.9	B	0.61	LOS E	Y	75	125 (EBL)
L	Overall Intersection	8.5	A	0.45	LOS E	Y	-	-
M	Southbound Left/Thru/Right	6.5	A	-	LOS E	Y	-	-
II	Overall Intersection	8.7	A	0.38	LOS D	Y	-	-
JJ	Overall Intersection	8.1	A	0.32	LOS D	Y	-	-
49	Overall Intersection	15.4	B	0.55	LOS D	Y	-	-

2030 LPA (Broadway-Washington/17th)

#	Approach/Movement	Delay (Seconds)	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
A	Southbound Left/Right	8.7	8.7	A	0.42	LOS E	Y	-	-
B	Southbound Left/Right	2.2	2.2	A	0.40	LOS E	Y	-	-
AA	Eastbound Left/Thru	1.2	1.2	A	0.20	LOS E	Y	-	-
01	Southbound Left/Thru/Right	4.9	4.9	A	0.73	LOS E	Y	-	-
BB	Eastbound Left/Thru/Right	14.1	14.1	B	0.79	LOS E	Y	-	-
CC	Eastbound Left/Right	8.2	8.2	A	0.03	LOS E	Y	-	-
C	Westbound Left/Right	6.0	6.0	A	0.12	LOS E	Y	-	-
02									
03									
04	Westbound Left/Right	3.6	3.6	A	0.04	LOS E	Y	-	-
DD	Northbound Left/Right	3.9	3.9	A	0.23	LOS E	Y	-	-
05	Overall Intersection	9.7	9.7	A	0.32	LOS E	Y	85	100 (EBTR)
EE	Overall Intersection	12.7	12.7	B	0.60	LOS E	Y	175	175 (SBTR)
06	Overall Intersection	22.2	22.2	C	0.85	LOS E	Y	200 205 75	200 (WBLTR) 225 (NBTR) 75 (SBL)
07	Overall Intersection	4.7	4.7	A	0.33	LOS E	Y	-	-
08	Overall Intersection	14.4	14.4	B	0.70	LOS E	Y	165 220	175 (NBLTR) 225 (SBLTR)
09	Eastbound Left/Thru	2.0	2.0	A	0.21	LOS E	Y	-	-
10	Southbound Thru	5.8	5.8	A	0.84	LOS E	Y	-	-
11	Northbound Left/Thru/Right	14.3	14.3	B	0.35	LOS E	Y	-	-
12	Overall Intersection	30.2	30.2	C	0.75	LOS E	Y	150 75 75	200 (EBL) 125 (WBL) 125 (SBL)
13	Overall Intersection	12.8	12.8	B	0.56	LOS E	Y	-	-
14	Overall Intersection	24.2	24.2	C	0.74	LOS E	Y	75 200 75 215 215	125 (EBL) 200 (EBTR) 125 (WBL) 225 (NBLTR) 225 (SBLTR)
15	Overall Intersection	23.0	23.0	C	0.64	LOS E	Y	-	-
16	Overall Intersection	12.3	12.3	B	0.70	LOS E	Y	-	-
17	Westbound Left/Thru/Right	5.1	5.1	A	0.06	LOS E	Y	-	-
18	Eastbound Left/Thru/Right	15.9	15.9	C	0.34	LOS E	Y	-	-
19	Overall Intersection	11.2	11.2	B	0.40	LOS E	Y	-	-
20	Eastbound Left/Thru/Right	18.0	18.0	C	0.36	LOS E	Y	-	-
21	Overall Intersection	26.7	26.7	C	0.37	LOS E	Y	-	-
22	Northbound Left/Thru/Right	9.7	9.7	A	0.22	LOS E	Y	-	-
23	Overall Intersection	28.8	28.8	C	0.71	LOS E	Y	100 220 205	125 (EBL) 225 (NBTR) 225 (SBTR)
24	Overall Intersection	19.6	19.6	B	0.61	LOS E	Y	225 210	225 (EBTR) 225 (SBLTR)
25	Overall Intersection	29.3	29.3	C	0.74	LOS E	Y	75 210 75 215	125 (EBL) 300 (EBTR) 125 (WBL) 225 (NBLTR)
26	Overall Intersection	19.3	19.3	B	0.66	LOS E	Y	100 210 220	150 (EBL) 225 (EBTR) 225 (NBLTR)
27	Overall Intersection	28.2	28.2	C	0.77	LOS E	Y	75 200 150 100 215	150 (EBL) 200 (EBTR) 175 (WBL) 125 (SBL) 225 (SBTR)
28	Northbound Left/Thru/Right	8.2	8.2	A	0.10	LOS E	Y	-	-
29	Eastbound Left/Thru/Right	12.1	12.1	B	0.38	LOS E	Y	-	-
30	Overall Intersection	11.5	11.5	B	0.44	LOS E	Y	-	-
31	Eastbound Left/Thru/Right	12.0	12.0	B	0.50	LOS E	Y	-	-
32	Overall Intersection	11.7	11.7	B	0.47	LOS E	Y	-	-
33	Eastbound Left/Thru/Right	21.9	21.9	C	0.24	LOS E	Y	-	-
34	Overall Intersection	128.0	> 100	F	1.10	LOS E	Y**	810 200 150	825 (EBLTR) 200 (NBT) 175 (NBR)
35	Overall Intersection	46.6	46.6	D	0.61	LOS E	Y	235	250 (EBTR)
36	Overall Intersection	37.9	37.9	D	0.71	LOS E	Y	200 100 70	225 (EBLTR) 150 (NBR) 150 (SBL)
37	Overall Intersection	44.0	44.0	D	0.71	LOS E	Y	210 210	225 (EBLT) 225 (NBTR)
38	Overall Intersection	81.4	81.4	F	1.35	LOS E	N	200 215 75 195	200 (EBLTR) 225 (NBTR) 100 (SBL) 200 (SBT)
39									
FF	Overall Intersection	63.3	63.3	E	0.99	LOS E	Y	700 700 740 200	800 (EBL) 850 (EBT) 750 (WBT) 275 (WBR)
40									
41	Overall Intersection	12.0	12.0	B	1.10	LOS E	Y	-	-
42	Overall Intersection	8.4	8.4	A	0.52	LOS E	Y	60	75 (WBT)
GG	Westbound Thru/Right	0.9	0.9	A	0.34	LOS E	Y	-	-
43	Overall Intersection	9.5	9.5	A	0.71	LOS E	Y	75	75 (NBL)
44	Overall Intersection	6.5	6.5	A	0.54	LOS E	Y	-	-
45	Overall Intersection	119.0	> 100	F	1.35	LOS E	N	-	-
D	Overall Intersection	21.5	21.5	C	0.29	LOS E	Y	65	75 (WBLT)
HH	Northbound Right	3.9	3.9	A	0.15	LOS E	Y	-	-
E	Overall Intersection	11.2	11.2	B	0.61	LOS E	Y	85	100 (EBLTR)
F	Overall Intersection	10.4	10.4	B	0.26	LOS E	Y	-	-
G	Overall Intersection	8.3	8.3	A	0.35	LOS E	Y	-	-
H	Overall Intersection	8.4	8.4	A	0.18	LOS E	Y	-	-
I	Overall Intersection	15.0	15.0	B	0.23	LOS E	Y	-	-
J	Overall Intersection	4.5	4.5	A	0.13	LOS E	Y	-	-
46	Overall Intersection	19.0	19.0	B	0.60	LOS E	Y	-	-
K	Overall Intersection	6.5	6.5	A	0.53	LOS E	Y	-	-
47	Overall Intersection	14.4	14.4	B	0.87	LOS E	Y	200 50	200 (NBLTR) 100 (SBR)
48	Overall Intersection	12.9	12.9	B	0.61	LOS E	Y	75	125 (EBL)
L	Overall Intersection	8.5	8.5	A	0.45	LOS E	Y	-	-
M	Southbound Left/Thru/Right	6.5	6.5	A	-	LOS E	Y	-	-
II	Overall Intersection	8.7	8.7	A	0.38	LOS D	Y	-	-
JJ	Overall Intersection	8.1	8.1	A	0.32	LOS D	Y	-	-
49	Overall Intersection	15.4	15.4	B	0.55	LOS D	Y	-	-

Continued on next page

Exhibit 4-29

PRELIMINARY

Vancouver Intersection Performance Results

PM Peak Hour — 2005 Existing Conditions

#	Intersection	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
50	24th St @ Columbia St	Eastbound Left/Thru/Right	5.4	A	-	LOS E	Y	-	-
51	24th St @ Main St	Eastbound Left/Right	7.7	A	0.07	LOS E	Y	-	-
52	4th Plain Blvd @ Columbia St	**Overall Intersection**	15.6	B	0.50	LOS D	Y	-	-
53	4th Plain Blvd @ Main St	**Overall Intersection**	28.3	C	0.66	LOS D	Y	125 200 75 75 75	150 (WBL) 200 (WBTR) 100 (NBL) 125 (NBR) 125 (SBL)
54	4th Plain Blvd @ Broadway	**Overall Intersection**	24.0	C	0.54	LOS D	Y	125 495	150 (WBL) 300 (WBTR)
55	4th Plain Blvd @ F St	**Overall Intersection**	7.1	A	0.57	LOS D	Y	150	150 (EBT)
56	4th Plain Blvd @ I-5 SB On-/Off-Ramps	**Overall Intersection**	11.3	B	0.54	LOS D	Y	-	-
57	4th Plain Blvd @ I-5 NB On-/Off-Ramps	**Overall Intersection**	16.0	B	0.63	LOS D	Y	75	150 (WBR)
58	4th Plain Blvd @ Post Cemetery	Eastbound Left	7.0	A	-	LOS E	Y	-	-
59	4th Plain Blvd @ St. Johns Blvd	**Overall Intersection**	16.6	B	0.54	LOS D	Y	-	-
60	29th St @ Main St	Eastbound Left/Thru/Right	6.8	A	0.03	LOS E	Y	-	-
61	29th St @ Broadway	Northbound Thru/Right	1.9	A	-	LOS E	Y	-	-
62	29th St @ Main St / Broadway	Eastbound Left/Thru/Right	12.5	B	-	LOS E	Y	-	-
63	33rd St @ Main St	**Overall Intersection**	18.3	B	0.45	LOS D	Y	50 50	75 (EBL) 75 (WBL)
64	39th St @ Main St	**Overall Intersection**	38.3	D	0.71	LOS D	Y	75 495 75 215 75 125	125 (EBL) 500 (EBTR) 100 (WBL) 225 (WBTR) 125 (NBL) 175 (SBL)
65	39th St @ F St	Northbound Left/Thru/Right	> 100	F	0.16	LOS E	N	- 50 430	- 75 (WBL) 400 (WBTR)
66	39th St @ H St	**Overall Intersection**	8.3	A	0.57	LOS D	Y	135	150 (WBTR)
67	39th St @ I-5 SB On-/Off-Ramps	Northbound Left	30.0	D	-	LOS E	Y	- 55 125	- 100 (EBR) 175 (NBR)
68	39th St @ I-5 NB On-/Off-Ramps	**Overall Intersection**	23.1	C	0.78	LOS D	Y	75	125 (NBR)
69	WSDOT/40th St @ Main St	**Overall Intersection**	4.9	A	0.33	LOS D	Y	-	-
70	45th St @ Main St	**Overall Intersection**	9.1	A	0.44	LOS D	Y	-	-
71	Hazel Dell @ Main St (West)	**Overall Intersection**	8.5	A	0.45	LOS D	Y	-	-
72	Ross St @ Main St	**Overall Intersection**	8.5	A	0.46	LOS D	Y	60 60	75 (WBL) 75 (WBR)
73	Ross St @ Ninth Rd	Southbound Thru/Right	5.0	A	0.18	LOS E	Y	-	-

2030 No-Build

#	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
50	Eastbound Left/Thru/Right	4.2	A	0.01	LOS E	Y	-	-
51	Eastbound Left/Right	46.2	E	0.07	LOS E	Y	-	-
52	**Overall Intersection**	23.8	C	0.68	LOS D	Y	-	-
53	**Overall Intersection**	38.5	D	0.78	LOS D	Y	250 495 170 165 75 425 75 75	300 (EBL) 500 (EBTR) 200 (WBL) 300 (WBT) 100 (NBL) 425 (NBT) 125 (NBR) 125 (SBL)
54	**Overall Intersection**	22.4	C	0.58	LOS D	Y	195 125	200 (EBTR) 150 (WBL)
55	**Overall Intersection**	6.6	A	0.54	LOS D	Y	150	150 (EBT)
56	**Overall Intersection**	19.8	B	0.82	LOS D	Y	200 555	275 (EBL) 575 (EBT)
57	**Overall Intersection**	53.7	D	0.88	LOS D	Y	275 850 75 600	375 (EBL) 850 (EBT) 150 (WBR) 625 (NBR)
58	Eastbound Left	9.1	A	0.01	LOS E	Y	-	-
59	**Overall Intersection**	30.6	C	0.65	LOS D	Y	170	250 (EBL)
60	Eastbound Left/Thru/Right	6.3	A	0.03	LOS E	Y	-	-
61	Northbound Thru/Right	2.3	A	0.26	LOS E	Y	-	-
62	Westbound Left/Thru/Right	82.4	F	-	LOS E	N	-	-
63	**Overall Intersection**	48.6	D	0.56	LOS D	Y	50 50	100 (EBL) 100 (WBL)
64	**Overall Intersection**	> 100	F	0.96	LOS D	N	75 1270 75 215 75 1570 125 360	125 (EBL) 1275 (EBTR) 125 (WBL) 225 (WBTR) 125 (NBL) 1575 (NBTR) 175 (SBL) 375 (SBT)
65	Northbound Left/Thru/Right	> 100	F	0.33	LOS E	N	215 50 430 305	225 (EBTR) 75 (WBL) 450 (WBTR) 325 (NBLR)
66	**Overall Intersection**	64.3	E	0.76	LOS D	N	430 135 310	400 (EBTR) 150 (WBTR) 325 (SBLTR)
67	**Overall Intersection**	43.7	D	0.76	LOS D	Y	135 55 710 1600	150 (EBT) 100 (EBR) 725 (WBT) 1150 (NBR)
68	**Overall Intersection**	> 100	F	0.91	LOS D	N	300 710 780 75	325 (EBL) 725 (EBT) 800 (NBLT) 100 (NBR)
69	**Overall Intersection**	45.3	D	0.53	LOS D	Y	300	375 (WBTR)
70	**Overall Intersection**	16.5	B	0.51	LOS D	Y	330 25	350 (NBL) 50 (NBR)
71	**Overall Intersection**	20.5	C	0.58	LOS D	Y	-	-
72	**Overall Intersection**	13.0	B	0.63	LOS D	Y	60 65	75 (WBL) 75 (WBR)
73	Southbound Thru/Right	23.0	C	0.32	LOS E	Y	-	-

2030 LPA with Highway Phasing (Broadway-Washington/17th)

#	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
50	Eastbound Left/Thru/Right	4.5	A	0.52	LOS E	Y	-	-
51	Eastbound Left/Right	9.3	A	0.07	LOS E	Y	-	-
52	**Overall Intersection**	32.8	C	0.64	LOS D	Y	-	-
53	**Overall Intersection**	49.5	D	0.78	LOS D	Y	250 405 170 165 75 75 75	300 (EBL) 500 (EBTR) 225 (WBL) 200 (WBTR) 100 (NBL) 125 (NBR) 125 (SBL)
54	**Overall Intersection**	33.9	C	0.73	LOS D	Y	195 195	200 (EBLTR) 200 (SBLTR)
55	**Overall Intersection**	7.3	A	0.55	LOS D	Y	195	150 (EBT)
56	**Overall Intersection**	16.5	B	0.56	LOS D	Y	200	275 (EBL)
57	**Overall Intersection**	29.7	C	0.72	LOS D	Y	-	-
58	Eastbound Left	21.5	C	0.01	LOS E	Y	-	-
59	**Overall Intersection**	40.3	D	0.57	LOS D	Y	175	250 (EBL)
60	Eastbound Left/Thru/Right	9.5	A	0.10	LOS E	Y	-	-
61	Westbound Left	4.6	A	0.03	LOS E	Y	-	-
62	Westbound Left/Thru/Right	29.7	D	0.00	LOS E	Y	-	-
63	**Overall Intersection**	> 100	F	0.58	LOS D	N	50 770 50 605 1000 75	100 (EBL) 775 (EBTR) 100 (WBL) 600 (WBTR) 1000 (NBT) 105 (SBL)
64	**Overall Intersection**	> 100	F	1.06	LOS D	Y**	75 1270 75 215 75 1570 125 360	200 (EBL) 1275 (EBTR) 225 (WBL) 225 (WBTR) 125 (NBL) 1575 (NBTR) 175 (SBL) 375 (SBT)
65	Westbound Thru/Right	50.4	F	0.60	LOS E	Y*	215 430	225 (EBTR) 400 (WBTR)
66	**Overall Intersection**	> 100	F	0.81	LOS D	N	430 135 310	490 (EBTR) 150 (WBTR) 325 (SBLTR)
67	**Overall Intersection**	60.7	E	0.88	LOS D	N	135 55 730 600	200 (EBT) 125 (EBR) 775 (WBT) 725 (NBR)
68	**Overall Intersection**	> 100	F	1.10	LOS D	Y**	300 710 1170 790 75	425 (EBL) 725 (EBT) 1175 (WBTR) 800 (NBLT) 150 (NBR)
69	**Overall Intersection**	40.1	E	0.38	LOS D	N	150 1250	200 (SBL) 1250 (SBTR)
70	**Overall Intersection**	38.5	D	0.51	LOS D	Y	200 500	225 (EBL) 575 (EBTR)
71	**Overall Intersection**	27.7	C	0.63	LOS D	Y	-	-
72	**Overall Intersection**	15.2	B	0.68	LOS D	Y	60 60	100 (WBL) 75 (WBR)
73	Southbound Thru/Right	42.6	E	0.29	LOS E	Y	-	-

2030 LPA (Broadway-Washington/17th)

#	Approach/Movement	Delay (Seconds)	Delay (Seconds)	LOS	ICU / V/C[1]	Standard[2]	Meets Standard	Storage Length	95% Queue (ft)
50	Eastbound Left/Thru/Right	4.6	4.6	A	0.52	LOS E	Y	-	-
51	Eastbound Left/Right	9.3	9.3	A	0.07	LOS E	Y	-	-
52	**Overall Intersection**	32.8	32.8	C	0.64	LOS D	Y	-	-
53	**Overall Intersection**	49.5	49.5	D	0.78	LOS D	Y	250 405 170 165 75 75 75	300 (EBL) 500 (EBTR) 225 (WBL) 200 (WBTR) 100 (NBL) 125 (NBR) 125 (SBL)
54	**Overall Intersection**	33.9	33.9	C	0.73	LOS D	Y	195 195	200 (EBLTR) 200 (SBLTR)
55	**Overall Intersection**	7.3	7.3	A	0.55	LOS D	Y	195	150 (EBT)
56	**Overall Intersection**	16.5	16.5	B	0.56	LOS D	Y	200	275 (EBL)
57	**Overall Intersection**	29.7	29.7	C	0.72	LOS D	Y	-	-
58	Eastbound Left	21.5	21.5	C	0.01	LOS E	Y	-	-
59	**Overall Intersection**	40.3	40.3	D	0.57	LOS D	Y	175	250 (EBL)
60	Eastbound Left/Thru/Right	9.5	9.5	A	0.10	LOS E	Y	-	-
61	Westbound Left	4.6	4.6	A	0.03	LOS E	Y	-	-
62	Westbound Left/Thru/Right	29.7	29.7	D	0.00	LOS E	Y	-	-
63	**Overall Intersection**	14.5	14.5	B	0.54	LOS D	Y	50 50	75 (EBL) 75 (WBL)
64	**Overall Intersection**	283.4	> 100	F	1.03	LOS D	Y**	75 1270 175 215 75 125	200 (EBL) 1275 (EBTR) 200 (WBL) 205 (WBTR) 125 (NBL) 200 (SBL)
65	Westbound Thru/Right	50.6	50.6	F	0.02	LOS E	Y*	430	400 (WBTR)
66	**Overall Intersection**	30.8	30.8	C	0.76	LOS D	Y	435 135	450 (EBTR) 150 (WBTR)
67	Westbound Thru	71.0	71.0	F	0.63	LOS E	N	55 730	100 (EBR) 750 (WBT)
68	**Overall Intersection**	401.4	> 100	F	0.65	LOS D	Y**	1175 790 75	1175 (WBT) 800 (NBL) 150 (NBR)
69	**Overall Intersection**	4.2	4.2	A	0.41	LOS D	Y	-	-
70	**Overall Intersection**	11.6	11.6	B	0.51	LOS D	Y	-	-
71	**Overall Intersection**	18.8	18.8	B	0.63	LOS D	Y	-	-
72	**Overall Intersection**	15.2	15.2	B	0.68	LOS D	Y	60 60	100 (WBL) 75 (WBR)
73	Southbound Thru/Right	47.8	47.8	E	0.29	LOS E	Y	-	-

(Yellow) Delay / LOS affected by freeway congestion
(Blue) Intersection queuing spills back into upstream intersection
Note 1 The ICU is used for overall intersections (signalized and unsignalized). The V/C is used for the identified movement(s) at unsignalized intersections.
Note 2 The 2003 Vancouver Concurrency Administration Manual designates an acceptable LOS standard of LOS E for downtown and LOS D for all other intersections.
Note 3 2030 LPA and LPA Phase I Roundabout intersection operations taken from VISSIM analysis.
\- Intersection not modeled in existing conditions scenario.
Y* Intersection does not meet standard in the Build scenario, but meets the "do no worse" criteria as compared to the No Build.
Y** Intersection operations are no worse than No Build, and no mitigation is required.

Exhibit 4-30

PRELIMINARY

Portland Intersection Performance Results

AM Peak Hour		2005 Existing Conditions								2030 No-Build								2030 LPA Option A with Highway Phasing								2030 LPA Option A								2030 LPA Option B with Highway Phasing								2030 LPA Option B							
#	Intersection	Approach/Movement	Delay (Seconds)	LOS	V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)	Approach/Movement	Delay (Seconds)	LOS	V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)	Approach/Movement	Delay (Seconds)	LOS	V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)	Approach/Movement	Delay (Seconds)	LOS	V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)	Approach/Movement	Delay (Seconds)	LOS	V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)	Approach/Movement	Delay (Seconds)	LOS	V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

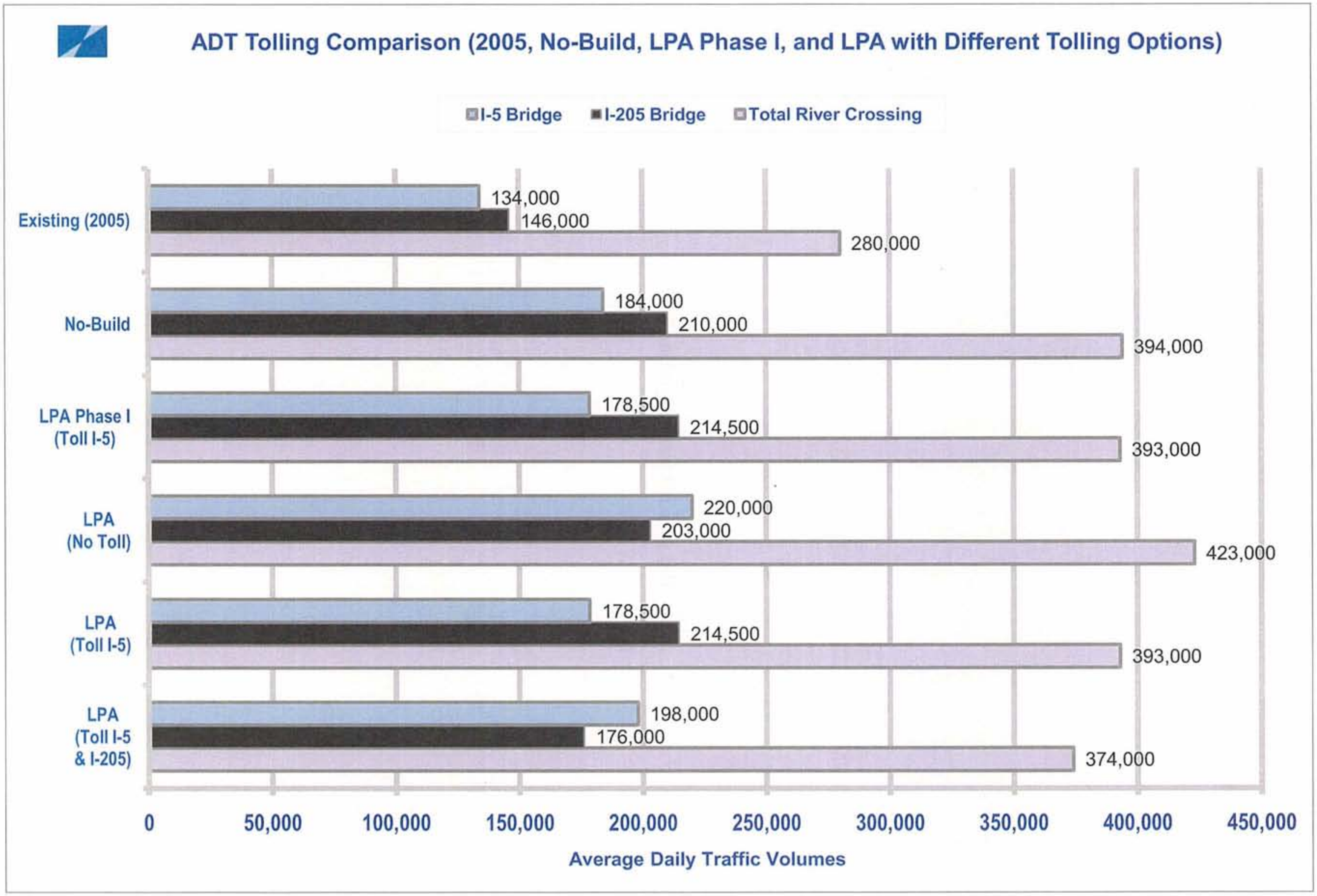
Exhibit 4-31

PRELIMINARY

Portland Intersection Performance Results

PM Peak Hour		2005 Existing Conditions								2030 No-Build								2030 LPA Option A with Highway Phasing								2030 LPA Option A								2030 LPA Option B with Highway Phasing								2030 LPA Option B							
#	Intersection	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)	Approach/Movement	Delay (Seconds)	LOS	ICU / V/C	Standard	Meets Standard	Storage Length	95% Queue (ft)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Exhibit 4-32



ADT Tolling Comparison (2005, No-Build, LPA Phase I, and LPA with Different Tolling Options)
I-5 Bridge
I-205 Bridge
Total River Crossing
Existing (2005)
134,000
146,000
280,000
No-Build
184,000
210,000
394,000
LPA Phase I (Toll I-5)
178,500
214,500
393,000
LPA (No Toll)
220,000
203,000
423,000
LPA (Toll I-5)
178,500
214,500
393,000
LPA (Toll I-5 & I-205)
198,000
176,000
374,000
0
50,000
100,000
150,000
200,000
250,000
300,000
350,000
400,000
450,000
Average Daily Traffic Volumes

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5. Affected Environment / Existing Conditions

5.1 Description of Existing Facilities

5.1.1 I-5 and I-205 Roadway System Inventory

Interstate 5 was evaluated for traffic performance and safety considerations from the city of Ridgefield in Clark County to the Marquam Bridge in downtown Portland. This 23-mile highway segment generally consists of three mainline through-lanes in each direction and includes 23 interchanges. Speed limits are 70 miles per hour (mph) north of 179th Street, 60 mph between 179th Street and Mill Plain Boulevard, 50 mph from Mill Plain Boulevard to Marine Drive, 55 mph from Marine Drive to I-405, and 50 mph from I-405 to the Marquam Bridge.

The proposed project would rebuild I-5 within the 4.8-mile Bridge Influence Area. This area extends from the SR 500/39th Street interchange in Vancouver to near the Interstate Avenue/Victory Boulevard interchange in Portland. The following seven interchanges would be affected:

- SR 500/39th Street: A partially directional (SR 500) and diamond (39th Street) interchange configuration;
- Fourth Plain Boulevard: A diamond with one folded quadrant interchange configuration;
- Mill Plain Boulevard: A diamond interchange configuration;
- SR 14/City Center: A directional cloverleaf with flyover ramps;
- Hayden Island: Gull-wing interchange configuration;
- Marine Drive: Modified partial cloverleaf configuration; and
- Interstate Avenue/Victory Boulevard: A diamond interchange configuration.

In addition to I-5, traffic performance along a 9-mile segment of I-205 was evaluated. The segment extends from SR 500 in Vancouver to I-84 in Portland and generally consists of three mainline through-lanes in each direction, except across the Glenn Jackson Bridge, which has four lanes in each direction. There are seven interchanges along this segment of I-205 and the posted speed limit is 60 mph.

5.1.2 Local Streets

Seventy-three intersections in Vancouver and 25 intersections in Portland were studied to complement the analyses on I-5 and I-205. The study intersections were chosen based on discussions with WSDOT, ODOT, City of Vancouver, and City of Portland. The goal was to identify locations that might be potentially negatively or positively affected by the proposed project. An indexed list of Vancouver intersections studied is shown in **Exhibit 5-1**, followed by a corresponding map of the intersections in **Exhibit 5-2**. The indexed list of Portland intersections are shown in **Exhibit 5-3**, followed by a corresponding map of the intersections in **Exhibit 5-4**.

5.2 I-5 and I-205 Performance

This section summarizes existing performance for the I-5 and I-205 study areas. This data was collected in 2005.

5.2.1 Daily Traffic Levels

Average daily traffic volumes represent the average 24-hour weekday volume on a roadway segment. The I-5 bridge currently carries 134,000 vehicles each day. The I-205 Glenn Jackson Bridge, located six and one half miles to the east, carries 146,000 vehicles each day. **Exhibit 5-5** summarizes existing ADT volumes on the I-5 bridge, the I-205 bridge, and the total river crossing.

5.2.2 Traffic Demand – Vehicles

5.2.2.1 Peak Travel Patterns along I-5 in Bridge Influence Area

According to the analysis of results of regional transportation modeling performed by Metro, the average trip length of trips across the bridge during the four-hour PM peak period is in excess of 18.9 miles. Excluding the trips that pass through the Portland-Vancouver region, the average trip length is still in excess of 15.6 miles. This is in distinct contrast to the region's average trip length, which is calculated to be approximately six miles for all trips made within the region. Furthermore, the typical motorist's trip across the Interstate Bridge uses I-5 for only a short portion of their trip with much of their travel on regional arterials, collectors and local roads. Vehicle license plate surveys were undertaken in 2005 to determine where peak direction vehicle trips across the Interstate Bridge enter and exit I-5 or roadway ramps within the Bridge Influence Area. As shown in **Exhibit 5-6**, during the weekday morning peak, 25 percent of southbound traffic across the I-5 bridge traveled on I-5 from north of SR 500 to I-5 south of Columbia Boulevard. In other words, 75 percent of southbound morning traffic across the bridge entered and/or exited I-5 via a ramp in the Bridge Influence Area.

During the afternoon/evening peak, 32 percent of northbound traffic across the Interstate Bridge traveled on I-5 from south of Columbia Boulevard to I-5 north of SR 500, meaning that 68 percent of northbound afternoon/evening peak traffic across the bridge entered and/or exited I-5 via a ramp within the Bridge Influence Area (see **Exhibit 5-7**).

The 4.8-mile Bridge Influence Area provides connections to seven major roadways in both Vancouver and Portland. Peak period travel demand in I-5's study corridor, further discussed below, are the heaviest within the Bridge Influence Area due to the limited available crossings of the Columbia River and I-5's interface with key east-west highways and arterial roadways immediately north and south of the Columbia River. The high traffic demands, in combination with short spacing between on- and off-ramps, result in congested traffic conditions and safety issues.

5.2.2.2 Vehicle Demand on I-5

The terms "traffic demand" and "traffic throughput", both used throughout this document, have different meanings. Traffic demand refers to the total number of motorists attempting to access the transportation system, including those caught in congestion. Traffic throughput is the total number of motorists actually able to travel through the transportation system in a measured time interval. When traffic demand exceeds traffic throughput, traffic congestion occurs and some motorists are forced to take an alternate route or experience delay.

Current traffic volumes within the study area are typically at their highest on weekdays during the four-hour morning peak between 6 a.m. and 10 a.m. and during the four-hour afternoon/evening peak from 3 p.m. to 7 p.m. During the morning peak, southbound traffic demand is greatest, whereas northbound traffic demand is greatest during the afternoon/evening peak.

Exhibit 5-8 illustrates southbound I-5 four-hour morning peak traffic demands. Southbound traffic demand varies widely along the 23-mile study corridor, ranging from a low of about 10,000 vehicles near Pioneer Street in Ridgefield to a high of over 23,000 vehicles north of the I-5/I-405 split in Portland. Note that southbound traffic demand builds as one moves south toward the Interstate Bridge (four-hour demand of 20,200), then drops at the Marine Drive and Victory Boulevard interchanges (to about 15,000) before building again further south. During the four-hour morning peak, southbound traffic demands at the Interstate Bridge reach 20,200 vehicles, which exceed the capacity of the Interstate Bridge and result in substantial traffic congestion.

Exhibit 5-9 illustrates the northbound traffic demands during the four-hour morning peak. This is the same time period, but the opposite direction of the previous exhibit. Northbound traffic demands along the 23-mile corridor vary even more widely than in the southbound direction. As shown in **Exhibit 5-9**, the northbound four-hour morning demand is just under 20,000 vehicles at the Marquam Bridge in Portland. That drops to less than 8,000 with traffic exiting to I-84, but traffic demand increases with traffic added from Morrison and I-84 where it reaches 17,000. North of I-405, the demand follows a generally downward trend dropping to just under 10,000 at the Victory Boulevard interchange. Demand rises again with the addition of Marine Drive traffic (to about 13,000) before falling to about 5,000 during the four-hour morning peak at the 139th Street interchange.

Exhibit 5-10 illustrates the southbound four-hour afternoon/evening peak traffic demands along the I-5 corridor. Southbound I-5 traffic demand during the four-hour afternoon/evening peak is very similar to, but lower than, the four-hour morning peak. Southbound I-5 demand climbs from about 5,000 vehicles at the 139th Street interchange to about 15,000 vehicles at the Interstate Bridge during the four-hour afternoon/evening peak. Like the morning peak period, the southbound afternoon/evening peak demand drops after crossing the bridge before building again to a high of just under 20,000 vehicles north of the I-405 split in Portland. Demands then drop to about 13,000 after the I-405 split before rising again to almost 19,000 near the Rose Quarter during the four-hour afternoon/evening peak.

Exhibit 5-11 depicts the northbound four-hour afternoon/evening peak period travel demand in the I-5 corridor. South of Broadway/Weidler, northbound I-5 traffic demand is basically the same during the morning and afternoon/evening peak periods. However, north of Broadway/Weidler, northbound I-5 traffic demands are substantially higher during the afternoon/evening period than during the morning peak. Traffic demand where I-405 joins I-5 is about 20,000 during the four-hour afternoon/evening peak, but drops to about 16,000 at Victory/Denver before climbing to about 21,400 at the Interstate Bridge, exceeding I-5's capacity and resulting in substantial congestion, as discussed later in this chapter. Northbound traffic demands along the I-5 peak at almost 24,000 vehicles just north of Fourth Plain Boulevard in Vancouver before falling to a low of about 7,000 vehicles near 139th Street in Vancouver.

5.2.2.3 Vehicle Demand on I-205

Travel demand in the I-205 corridor is available for the two-hour morning and two-hour afternoon/evening peak periods, rather than the four-hour periods summarized for I-5.

Exhibit 5-12 illustrates the southbound I-205 two-hour morning peak traffic demand. Two-hour demand is close to 8,000 vehicles north of SR 500. It rises to more than 10,000 in the vicinity of SR 500, falls to 6,000 at 18th Street and peaks near 13,000 vehicles at the I-205 Glenn Jackson Bridge. Southbound demand drops to about 10,000 vehicles at Airport Way and decreases to 9,000 vehicles near I-84.

Exhibit 5-13 summarizes northbound I-205 two-hour morning peak traffic demands. The highest northbound demand is approximately 10,000 vehicles near I-84. It drops to less than 5,000 vehicles in the vicinity of SR 14 and declines to less than 3,000 at 28th Street.

Exhibit 5-14 summarizes southbound I-205 two-hour afternoon/evening peak traffic demands. Southbound demand is about 6,000 vehicles at SR 500, decreasing to 3,000 vehicles north of Mill Plain Boulevard. It increases approaching the Glenn Jackson Bridge to about 9,000. Traffic demand continues to grow in Portland reaching about 11,000 at Columbia Boulevard and then decreases approaching the I-84 interchange. South of Columbia Boulevard, the two-hour morning and afternoon/evening peak travel demands are very similar.

Exhibit 5-15 illustrates the northbound I-205 two-hour travel demand. South of I-84, the morning and afternoon/evening peak travel demands for I-205 are similar. North of I-84, the northbound I-205 two-hour traffic demands are higher during the afternoon/evening peak than during the morning peak. In the vicinity of Glisan Street, northbound travel demand is less than 9,000 vehicles during the two-hour afternoon/evening peak. That rises to near 14,000 vehicles on the Glenn Jackson Bridge. The northbound demand falls to less than 6,000 vehicles at 28th Street.

5.2.3 Traffic Demand – Truck Freight

The I-5 crossing is critical to national and international freight flow. I-5 serves direct international land connections to Mexico and Canada, and carries over 10 million tons of freight to and from California. National, West Coast, and regional freight flows depend daily on the efficient functioning of I-5 within the Bridge Influence Area.

Approximately 11,000 trucks cross the I-5 bridges on an average weekday, accounting for over eight percent of all bridge traffic. On the I-205 crossing five percent of all traffic is from trucks, with an average of 7,750 trucks per day. Although the I-5 crossing carries less total traffic than the I-205 crossing, it carries about 42 percent more trucks.

The rapid increase in freight volumes, particularly those carried by trucks, is well recognized by the Oregon and Washington transportation plans. Oregon and Washington combined have a $350 billion economy and export goods valued at $45 billion per year. The six most freight-intensive industry sectors sensitive to transportation along Portland-Vancouver highways and rail corridors are wood and paper products, transportation equipment, steel, farm and food products, high technology, and distribution and wholesale trade. These industries account for approximately 70 percent of the commodity tonnage crossing the Columbia River via I-5 and I-205 on large trucks.

Truck trips are associated with certain industries. Manufacturing industries tend to produce and attract long-haul truck trips that originate over 250 miles from their destination. Manufacturers also attract and generate short-haul trips to and from ports and other local manufacturers. Wholesalers, which distribute goods throughout the region, attract long-haul and short-haul truck trips, and generate the majority of local truck trips (less than 50 miles long). Retail establishments are the primary attraction for local distribution truck trips generated by the wholesale industries.

The main sources of regional truck traffic are the Port of Portland, the Columbia Corridor industrial area, the Port of Vancouver, and the Columbia Industrial Park in Washington. **Exhibit 5-16** provides a corridor view of the relationship between truck trips and land uses that generate truck trips. The midday hourly truck volumes are compared to overall hourly volumes to illustrate that trucks prefer to travel during this time. The highest truck demands occur in the vicinity of Columbia Boulevard and Marine Drive interchanges. In Washington, regional truck movements are highest by the SR 14 and Mill Plain Boulevard interchanges.

Interstate 5 is the primary truck route for local, regional, national, and international movement of goods through the Portland-Vancouver region. As shown in **Exhibit 5-17**, trucks carry 67 percent of all freight in the region today, twice as much freight in the Portland-Vancouver region than the other five modes (rail, ocean, barge, pipeline, and air) combined.

5.2.3.1 Oversized Loads

Trucks carry oversize loads on a daily basis through the Bridge Influence Area. Oversize loads are trucks carrying goods that cause them to be over-length, over-height, over-width, and/or over-weight. On highways and arterials, the primary limiting factor for oversize load route choice is vertical clearance.

Within the Bridge Influence Area there are unique and strategically important oversize load transport routes. For example, the Port of Vancouver currently generates over-length and over-height loads of wind turbines and wind turbine parts going to eastern Washington and Oregon wind energy farms. These shipments leave the Port of Vancouver on Mill Plain Boulevard, enter I-5 southbound, and exit to SR 14 eastbound. The Columbia Industrial Park generates oversize loads destined for the Port of Vancouver and to points north and south on I-5. These loads travel westbound on SR 14 towards I-5, access I-5 (northbound or southbound), and exit onto Mill Plain Boulevard. In Oregon, the high-volume oversize load activity occurs on I-5 and exits I-5 southbound at Marine Drive to access Martin Luther King Jr. Boulevard, or exits I-5 northbound at Columbia Boulevard to access the Columbia Corridor industrial area and the Port of Portland.

5.2.3.2 Freight Rail

Two Class I freight railroad mainlines pass through the Bridge Influence Area. As shown in **Exhibit 5-17**, freight rail carries 11 percent of the regional freight tonnage. The Union Pacific's (UP) Portland-to-Hinkle line passes under I-5 south of Columbia Boulevard. The UP railroad line also crosses over Columbia Boulevard on the west side of I-5. On the north side of the river, the Burlington Northern Santa Fe Railway's (BNSF) Columbia River route crosses over I-5 between the Columbia River and SR 14. The BNSF line serves the Port of Vancouver, the Port of Portland and points east and north. The BNSF owns and operates a double-tracked swing-span bridge over the Columbia River located approximately one mile downstream of the Interstate Bridge. Union Pacific has trackage rights on the BNSF Columbia River Bridge and on the BNSF mainline north to the Seattle area.

5.2.4 Effects of Congestion

5.2.4.1 Duration of Congestion on Southbound I-5

Travel speed and traffic congestion profiles were created to show travel speeds at different locations along the I-5 corridor at different times of day. The regional travel demand model provided four-hour morning (6–10 a.m.) and four-hour afternoon/evening (3–7 p.m.) traffic forecasts. The forecast information was post-processed and input into the VISSIM traffic operations model to estimate travel speeds by location throughout the two peak periods. This data was summarized by 15-minute time increments to create an accurate picture of beginning and end of congestion at each specific location.

Using the eight hours of VISSIM results, interpolation and extrapolation between and outside of these time periods was performed to develop 16-hour profiles. These profiles, encompassing the period from 5 a.m. to 9 p.m., assist in assessing early morning, midday, and afternoon/evening effects. The interpolation/extrapolation technique used non-peak period speed and travel time data collected for the CRC project, archived loop detector data, observations from highway cameras, and corridor speed plots available from the Oregon and Washington departments of transportation.

Exhibit 5-18 shows the existing conditions along southbound I-5 (y-axis) by time of day (x-axis). Different colors represent varying speeds summarized by location. Red represents 0-10 mph, dark orange represents 10-20 mph, light orange represents 20-30 mph, yellow represents 30-40 mph, light green represents 40-50 mph, and dark green represents greater than 50 mph. Congestion is defined in this study as occurring when travel speeds are less than 30 mph.

As shown in **Exhibit 5-18**, under existing conditions I-5 undergoes a fairly regular operational cycle in both directions of travel during typical weekday conditions. In the morning peak congestion and queuing occur at four southbound locations: 1) I-5 bridge, 2) Delta Park lane drop, 3) north of the I-405 split, and 4) the Rose Quarter/I-84 off-ramp section. The queues are caused by capacity restrictions and disruptions in traffic flow due to inadequate merging, diverging, and weaving distances for vehicles. These bottlenecks interact with each other and control the flow throughput of upstream locations.

The Interstate Bridge is generally congested for two hours during the morning as a result of the bridge's limited capacity and the downstream Delta Park bottleneck. Three hours of congestion generally occurs at Delta Park lane drop during the morning peak. About 2.5 hours of congestion occur north of the I-405 split due to high traffic demands within the three-lane section north of the I-5/I-405 split.

During the afternoon/evening peak, southbound congestion and vehicular queuing occurs at two bottleneck locations: 1) north of the I-405 split, and 2) the Rose Quarter/I-84 off-ramp section.

In addition, midday queuing and related congestion occurs at the Delta Park lane drop and Rose Quarter/I-84 off-ramp section. This queuing occurs independently of peak commute period congestion and lasts multiple hours throughout the day.

5.2.4.2 Duration of Congestion on Northbound I-5

Northbound I-5 experiences multiple hours of congestion along I-5 between Portland, Oregon and Ridgefield, Washington. **Exhibit 5-19** summarizes the duration of congestion for existing conditions between 5 a.m. and 9 p.m. During the afternoon/evening peak, northbound congestion and vehicular queuing occurs at two distinct locations:
1) Broadway Avenue on-ramp and I-405 off-ramp, and 2) the Interstate Bridge.

The Interstate Bridge bottleneck, which lasts for four hours, is more restrictive and extends longer than the Broadway/I-405 bottleneck, which lasts almost two hours. During the morning travel period, queuing occurs between the I-84 on-ramp and the I-405 off-ramp and extends for almost two hours.

5.2.5 Travel Times

5.2.5.1 Travel Times along I-5

Existing peak period travel times during the two-hour morning peak are summarized for southbound I-5 in **Exhibit 5-20**. The southbound travel time between SR 500 and

Columbia Boulevard (5.2 miles) is 16 minutes and between 179th Street and I-84 (16.6 miles) is 31 minutes.

Travel times during the two-hour afternoon/evening peak are summarized for northbound I-5 in **Exhibit 5-21**. The northbound travel time between Columbia Boulevard and SR 500 is 12 minutes and between I-84 and 179th Street is 38 minutes.

5.2.5.2 Travel Times along I-205

Existing peak period travel times during the two-hour morning peak are summarized for southbound I-205 in **Exhibit 5-22**. The southbound travel time between SR 500 and I-84 (10.6 miles) is 11 minutes. The Washington portion of this trip between SR 500 and the midpoint on the Glenn Jackson Bridge is six minutes; the Oregon portion is five minutes.

Northbound I-205 travel times during the two-hour afternoon/evening peak are summarized in **Exhibit 5-23**. The northbound travel time between I-84 and SR 500 is 14 minutes. The Oregon portion of this trip between I-84 and the midpoint on the Glenn Jackson Bridge is eight minutes; the Washington portion is six minutes.

5.2.6 Service Volumes – Vehicles

5.2.6.1 Vehicle Throughput (Served Volume) on Southbound I-5

In addition to the travel speed and traffic congestion profiles, served traffic volume and travel speed profiles were developed to show the different levels of throughput between alternatives, as shown in **Exhibits 5-24** and **5-25**. The previously identified constraints along I-5 (defined in **Sections 5.2.4.1** and **5.2.4.2**) limit the amount of vehicular demand that can be served along the corridor in the peak travel directions during the morning and afternoon/evening peaks. These diagrams were created to compare, on an hour-by-hour basis, traffic levels served along various locations of the highway corridor. Color codes, consistent with those used for the travel speed and traffic congestion profiles, illustrate average hourly travel speeds.

Exhibit 5-24 shows the existing levels of southbound vehicular throughput versus travel speeds along the 23-mile I-5 study corridor during the four-hour morning peak. As shown, the highest service volumes occur in the vicinity of Going Street. The relationship between travel speed and service volume can be compared at any point along the corridor for each of the four hours of the morning peak period. Within the Bridge Influence Area, for example, the graphic shows that as volume rises during the second hour, the speed deteriorates. During the third hour, speed deteriorates further, though service volumes remain the same. Finally, speeds begin to recover during the fourth hour of the morning peak. The graphic also illustrates how congestion occurs at the previously identified four southbound bottlenecks influences the upstream corridor.

5.2.6.2 Vehicle Throughput (Served Volume) on Northbound I-5

Exhibit 5-25 shows the existing levels of northbound vehicular throughput during the four-hour afternoon/evening peak. The highest service volumes occur in the vicinity of the Morrison Bridge and 134th Street in the north part of Vancouver. The graphic illustrates how travel speeds change from hour to hour and the effect on the upstream corridor from the bottleneck in the vicinity of Marine Drive that begins to occur during the first hour of the afternoon peak. The graphic also illustrates the congestion dissipates with increases in travel speed during the last hour of the afternoon/evening peak. Within the Bridge Influence Area, the highest vehicle throughput occurs on the fringes of the afternoon/evening peak. The northbound vehicle throughput reaches 20,500 vehicles at the Interstate Bridge.

5.2.7 Service Volumes – Trucks

The data and analysis of truck volumes include all medium and heavy trucks. The terms "medium" and "heavy" refer to specific classes in the Federal Highway Administration's (FHWA) 13 vehicle-type classification system. Medium trucks are single unit trucks with three or four axles and comprise FHWA Class 6 and 7. Heavy trucks include all tractor-trailer configurations and may include more than one trailer. Heavy trucks fall into FHWA Classes 8, 9, 10, 11, 12, and 13.

Although I-5 carries less total daily traffic than I-205 across the Columbia River, the I-5 bridge carries about 3,200 (42 percent) more medium and heavy trucks per day than the I-205 bridge. This differential may be explained by a number of factors. During uncongested periods, regional truck through-trips typically remain on I-5 because it provides a shorter and faster route than I-205 (the travel distance on I-5 from the south I-205 junction to the north I-205 junction is 28.1 miles, while the travel distance between the two junctions on I-205 is 37.3 miles). Distance is a cost factor for a truck trip and includes the cost of truck operations, fuel, and travel time for the driver. During congested conditions some through trucks avoid I-5 and divert to I-205.

Exhibit 5-26 presents the daily northbound and southbound volume of medium and heavy trucks on I-5 at several locations. The last pair of columns on the right of the exhibit shows I-205 on the Glenn Jackson Bridge for comparison.

Exhibit 5-26 shows that the highest truck volume in the I-5 study area occurs north of I-405. Northbound truck volume in this segment is higher than southbound volume. The daily truck volume between Lombard Street and Columbia Boulevard is 12 percent of all daily traffic at this location, and over the Interstate Bridge trucks constitute eight percent of all traffic.

Exhibit 5-27 shows the daily southbound hourly traffic volumes for general purpose and truck traffic over the Interstate Bridge. Traffic volumes across the Interstate Bridge are relatively similar between 6 a.m. and 6 p.m., except for the morning peak hours. Truck volumes are highest during the midday during regular business hours, to take advantage of less congested highway conditions. On the Interstate Bridge, trucks make up between nine and 10 percent of all traffic between 9 a.m. and 2 p.m. During the late evening and early morning hours, trucks constitute a much larger percentage of total highway traffic, reaching almost one quarter of all traffic at 2 a.m. The morning and afternoon/evening peaks have smaller truck shares of overall traffic.

Northbound hourly traffic volumes for general purpose and truck volumes are shown in **Exhibit 5-28**. Unlike the southbound direction, there are clearly higher volumes during the afternoon/evening peak period in the peak northbound commuting direction. Traffic volumes steadily increase from the early morning hours until 6 p.m. The late morning and midday hours between 8 a.m. and 1 p.m. experience truck percentages that exceed the daily average. Trucks constitute a large portion of traffic during the early morning hours, with more than one third of vehicles during the 4 a.m. hour. The volume of trucks relative to the total traffic volume is smaller during the afternoon/evening peak when congestion occurs and traffic speeds are slow, especially between 5 p.m. and 7 p.m.

Exhibit 5-29 presents medium and heavy truck volumes from 7 a.m. to 7 p.m. Approximately 42 percent of the daily truck volume occurs between 9 a.m. and 3 p.m. when conditions are generally uncongested and travel times are more reliable for truck movement. Approximately 18 percent of the truck volume occurs during the afternoon/evening peak, from 3 p.m. to 7 p.m., when over 1,000 trucks travel northbound and 1,100 trucks travel southbound across the bridge. Almost 30 percent of daily truck travel across the I-5 bridge occurs during the late evening and early morning hours between 7 p.m. and 7 a.m.

5.2.8 Served vs. Unserved Ramp Volumes

5.2.8.1 Served vs. Unserved Ramp Volumes on Southbound I-5

Existing morning peak served versus unserved on-ramp volumes are summarized for southbound I-5 in **Exhibit 5-30**. The morning peak ramp demands are served at all southbound on-ramps within the I-5 Bridge Influence Area except for at the southbound SR 14/City Center on-ramp which is estimated to have 600 unserved vehicles over the four-hour period.

5.2.8.2 Served vs. Unserved Ramp Volumes on Northbound I-5

Existing afternoon/evening peak served versus unserved on-ramp volumes are summarized for northbound I-5 in **Exhibit 5-31**. All of the northbound I-5 on-ramps within the Bridge Influence Area are able to serve the four-hour travel demand throughout the afternoon/evening peak.

5.2.9 Person Throughput

About 21,400 persons in vehicles and 1,500 persons in buses cross the I-5 bridge southbound during the four-hour morning peak. During the afternoon/evening peak, about 24,600 persons in vehicles and 1,200 persons in buses travel over the bridge northbound. **Exhibit 5-32** shows peak north and southbound person throughput across the I-5 bridge.

5.2.10 Bridge Lifts

Bridge lift, or more specifically, gate closure data for the Interstate Bridge was obtained from ODOT for the three-year period from January 1, 2005 to December 31, 2007. The data was analyzed for the number of times traffic was stopped by the signals for gate closures, average time that the closures began, day of closures, duration of closures, the reason for closures, and the direction of traffic requiring closure.

The gate closure data revealed that not all gate closures involved lifting of the bridge spans. Also, depending on the reason for closure, the traffic may be stopped in one direction, or both directions of traffic. Generally, a bridge closure may result due to the following four reasons:

1. Cargo Boats: The bridge spans are lifted for the passage of commercial vessels. Auto and non-auto traffic is stopped along both northbound and southbound directions.
2. Non-commercial Boats: The bridge spans are lifted for the passage of non-commercial vessels. Auto and non-auto traffic is stopped along both northbound and southbound directions.
3. Maintenance: The bridge spans are lifted to allow for maintenance. Individual east or west spans of the Interstate Bridge may be maintained at the same time or different times. Accordingly, auto and non-auto traffic are closed in either one or both directions.
4. Stoppage: Gates are closed to stop auto and non-auto traffic (northbound and/or southbound) but without requiring a bridge lift. The stoppage may be due to several reasons including maintenance. Accordingly, auto and non-auto traffic are closed in either one or both directions.

In addition to the above mentioned reasons, sometimes gates may be closed with or without the bridge span lift to allow for the on-site training of the DOT personnel. For the current analysis, DOT training related closures were either summarized under Maintenance or Stoppage categories, depending on the reason for training.

The detailed results for the bridge gate closure data are presented below and are divided into two sections. The first section presents the gate closure results for all 365 days of the year (weekday and weekend) for the three-year period. Since higher traffic demands occur on weekdays and traffic modeling for the Columbia River Crossing project focuses on weekdays, the second section presents the results for the three-year period for weekday gate closures.

5.2.10.1 Gate Closure Statistics for All Days

Overall, there were a total of 1,401 gate closures recorded over the three-year period. On average, this works out to be 467 closures per year and 1.28 closures per day. Over half of the closures that occurred were for maintenance involving a bridge lift (51 percent). About one-third (32 percent) of the closures were for bridge lifts related to cargo or non-commercial boats. The remaining 17 percent of the gate closures were due to stoppages that did not involve a bridge lift.

Additionally, of the total maintenance and stoppage closures recorded, only half (50 percent) included a directional designation. It wasn't clear what direction of traffic had been impacted by the remaining half of the traffic closures. For the maintenance and stoppage closures with directional indication, 80 percent were directional (either northbound or southbound) and 20 percent were for both directions. The uni-directional closures were split at approximately 50/50.

Due to the high volume of traffic crossing the bridge during weekday peak periods, bridge closures are restricted (not prohibited, i.e. under some circumstances bridge closures may be allowed) from 6:30 a.m. to 9:00 a.m. and 2:30 p.m. to 6:00 p.m., resulting in most closures occurring at night. Of the data analyzed, nearly three-quarters (74 percent) of all closures occurred during the overnight hours (6:00 p.m. to 6:30 a.m.). Of the closures occurring during the overnight hours, 62 percent were for maintenance, 20 percent were for cargo or non-commercial boats, and 17 percent were stoppages.

5.2.10.2 Gate Closure Statistics for Weekdays

The three-year data was further evaluated for weekdays only. For the weekdays, there were 1,155 traffic closures from 2005 to 2007. The analysis showed that on an average more than one closure was likely during any given weekday (about 1.48 closures per weekday) versus on an average not all weekend days had a closure (0.78 closures per weekend day (Saturday or Sunday).

On weekdays, about 57 percent of the total closures were for maintenance, about 26 percent were cargo boat or non-commercial boat related, and only 18 percent were stoppages. Of the maintenance and stoppage closures that were classified by direction, 86 percent stopped one direction (43 percent northbound and 43 percent southbound) and 14 percent stopped both directions of traffic.

Also, during the weekdays, approximately 81 percent of all closures occurred between 6:00 p.m. and 6:30 a.m. Nearly two-thirds of these overnight closures were for maintenance (66 percent) and the remaining were traffic stoppages (17 percent) and for cargo or non-commercial boats (17 percent). In addition, about 18 percent of the weekday total closures occurred between 9:00 a.m. to 2:30 p.m. and were either for boat-passage (61 percent), stoppage (20 percent), or maintenance (19 percent). Although bridge lifts are restricted during the weekday rush hour, about 0.3 percent of all closures (3 maintenance lifts) occurred in the morning peak period (6:30 a.m. to 9:00 a.m.) and about 0.7 percent of all closures (six boat lifts and two stoppages) occurred in the evening peak period (2:30 p.m. to 6:00 p.m.).

The in-depth analyses of data showed that the typical weekday bridge closure included the following characteristics:

1. The likelihood of a bridge gate closure was noted to be highest during the night hours and peaked around midnight (12:00 a.m. to 1:00 a.m.). **Exhibit 5-33** shows the relative number and proportion of average weekday traffic closures by hour.
2. There were no recorded closures during the peak of the peak periods: the 7:00 a.m. hour and the 5:00 p.m. hour.
3. The average duration of closures, classified by reason of closure, showed that:

- Overall, weekday closures were 10.6 minutes long.
- Traffic Stoppage (without lift) related closures lasted four minutes, and
- Closures involving bridge lifts (maintenance or cargo or non-commercial boat passage related) ranged from 10.5 to 12.0 minutes.

While the number of weekday bridge gate closures was consistently higher in the overnight hours, this cannot be said for their durations (refer to **Exhibit 5-34**). The average duration of bridge gate closure varied over the day and on an hourly basis and impacted traffic between 4.5 and 20 minutes.

5.2.11 Safety

This section provides an overview of vehicular collision analysis conducted for the CRC Bridge Influence Area. Vehicular collision analyses were conducted to determine historic crash rates, crash types and severities, and to ascertain how existing non-standard highway geometrics, I-5 lift bridge operations, traffic volumes, and traffic congestion correlate with the highway corridor's crash history.

5.2.11.1 Number of Vehicular Collisions and Collision Rates

A review of motor vehicle collisions reported within and slightly outside the Bridge Influence Area was conducted. Collision data was obtained from both the Washington and the Oregon departments of transportation for the five-year period from January 1, 2002 to December 31, 2006.

During the five-year period, 2,051 collisions were reported on the I-5 mainline and ramps within the Bridge Influence Area. There are no estimates available for the number of collisions that did not meet the criteria for crash reporting or were not reported for other reasons. There was an average rate of 1.12 reported collisions per day. The rate of 1.12 collisions per day was determined by dividing the number of days in the five-year study period (1,826) into the total number of collisions during the five-year study period (2,051).

The standard transportation engineering method of reporting collision rates are in collisions per million vehicle-miles traveled (MVMT). The average collision rate for "urban city interstate highways" in Oregon during the five-year study period is 0.55 collisions per MVMT. The average crash rate for "urban interstates" throughout the state of Washington for the year 2004-2006 (data is not available for 2002 or 2003) is 1.41 collisions per MVMT. For WSDOT's SW Region, which includes the segment of I-5 in the Bridge Influence Area, the average crash rate for "urban interstates" is 0.99 collisions per MVMT. WSDOT's collision rate calculations for interstate highways, unlike ODOT, take into account collisions that occur on the on- and off-ramps adjoining the highway system. This has the effect of adding more collisions to the overall rate calculation, resulting in generally higher collision rates; the difference in methodology also reduces the ability to compare the collision rates across the two states.

The collision rate experienced on I-5 within the Oregon segment of the Bridge Influence Area, was 1.08 collisions per MVMT. This rate is nearly twice that of the comparable statewide average of 0.55 collisions per MVMT. The collision rate experienced within the Washington segment of the Bridge Influence Area was 1.58 collisions per MVMT. This rate is nearly 60 percent higher than the most comparable rate (0.99 collisions per MVMT) for WSDOT's SW Region.

5.2.11.2 Vehicular Collisions by Type and Severity

The number, type and severity of collisions reported during the five-year period were compiled and plotted by direction (northbound and southbound) in 0.1-mile increments on maps of I-5. Four collision types were reported: rear-end, side-swipe, fixed object, and other. Three severity types were reported: property damage only (PDO), injury, and fatality.

Exhibit 5-35 shows the total number and type of collisions reported within the Bridge Influence Area in Washington for each tenth of a mile segment and for the ramp sections. **Exhibit 5-36** shows the number and type of collisions reported within the Bridge Influence Area in Oregon for each tenth of a mile segment and ramp sections. A high percentage of the reported collisions occurred near the approaches to the Interstate Bridge on either side of Columbia River. Other notable collision locations in Washington included southbound I-5 at SR 14, between SR 500 and the Fourth Plain Boulevard interchange, and near the Mill Plain Boulevard interchange. In Oregon high collision locations were on Hayden Island, at Victory Boulevard, Columbia Boulevard and Lombard Street interchanges.

In Washington, the total of southbound collisions was nearly three times those northbound. Fifty-seven percent of these collisions were rear-ends and 15 percent were side-swipes. Southbound collisions were much higher than northbound collisions, reflecting recurrent southbound traffic congestion at and near the bridgehead to the Interstate Bridge.

In Oregon, the percent of northbound collisions were approximately double those southbound. Seventy-seven percent of these collisions were rear-ends and 13 percent were side-swipes. Northbound crashes were much higher than southbound crashes in Oregon, also reflective of high northbound congestion levels at and near the I-5 bridge bridgehead.

Exhibit 5-37 shows the number and severity of collisions reported within the Bridge Influence Area in Washington. **Exhibit 5-38** shows the number and severity of collisions reported within the Bridge Influence Area in Oregon. The majority of crashes were identified as property damage only, and accounted for approximately 61 percent of the total. Injury crashes accounted for almost all the remainder of the crashes, or nearly 39 percent. Injury crashes were more prevalent in the peak direction of travel: southbound in Washington, northbound in Oregon.

Three fatalities occurred during the five-year crash study period between 2002 and 2006, representing 0.1 percent of all collisions. The three fatalities involved either a pedestrian or a bicyclist being struck by a vehicle or truck. Two of the three crashes occurred on southbound I-5 near the Interstate Bridge, one near the Hayden Island southbound on-ramp and one near the southbound SR 14 on-ramp. The third fatality occurred along northbound I-5 near the Victory Boulevard off-ramp.

ODOT calculates fatal and serious injury collision rates for jurisdiction and functional classifications by summing the total number of collisions classified as fatalities (coded in the ODOT crash database as 'K') or as Injury A (coded as 'A') and dividing by the appropriate vehicle miles traveled (VMT) data. The units for the resultant Fatal and Injury 'A' is per 100 million VMT, rather than the one million vehicle miles traveled (MVMT) used for the collision rates described in **Section 5.2.11.1**. WSDOT calculates a rate for fatalities only (based on 100 million VMT), a rate for injury crashes only (based on MVMT), and a rate for PDO crashes (based on MVMT).

An examination of the ODOT fatal and Injury A collision rate data for the three-year period between 2004 and 2006 (2002 and 2003 are not available) shows an average fatal and Injury A collision rate of 1.43 collisions per 100 million VMT. During the five-year crash study period, the comparable fatal and Injury A collision rate for the Oregon segment of the CRC project area is 1.66 collisions per 100 million VMT, 16 percent higher than the equivalent statewide rate.

An examination of WSDOT's SW Region fatal collision rate data for the three-year period between 2004 and 2006 (2002 and 2003 are not available) shows an average fatal collision rate of 0.15 collisions per 100 million VMT. During the five-year crash study period, the comparable fatal collision rate for the Washington segment of the CRC project area is 0.13 collisions per 100 million VMT, nearly identical to the equivalent rate.

An examination of WSDOT's SW Region injury collision rate data for the three-year period between 2004 and 2006 (2002 and 2003 are not available) shows an average injury collision rate of 0.38 collisions per MVMT. During the five-year crash study period, the comparable injury collision rate for the Washington segment of the CRC project area is 0.61 collisions per MVMT, 60 percent higher than the equivalent injury collision rate.

An examination of WSDOT's SW Region PDO collision rate data for the three-year period between 2004 and 2006 (2002 and 2003 are not available) shows an average PDO collision rate of 0.61 collisions per MVMT. During the five-year crash study period, the comparable injury collision rate for the Washington segment of the CRC project area is 0.97 collisions per MVMT, nearly 60 percent higher than the equivalent PDO collision rate.

5.2.11.3 Relationship of Vehicular Collisions to Highway Geometrics

While the highway and bridge design generally met design standards applicable at the time of their construction, vehicles have changed and standards have evolved over the years, reflecting continued research in areas such as vehicle operating characteristics, driver expectations, traffic flow theory, and physical highway elements.

The FHWA has designated 12 geometric controlling criteria that have a primary importance for safety. These criteria are: design speed, grade, lane width, stopping sight distance, shoulder width, cross-slope, bridge width, superelevation, horizontal alignment, horizontal clearance, vertical alignment, and vertical clearance.

The Washington and Oregon departments of transportation have developed geometric design standards related to each of the 12 controlling criteria. Their current design standards were compared to I-5 existing geometrics within the Bridge Influence Area. Particular emphasis was placed on the following elements, each related to one or more of the above criteria:

- Ramp-to-highway acceleration lane length;
- Highway-to-ramp deceleration lane length;
- Ramp-to-ramp separation length;
- Turning roadway – ramp merge;
- Turning roadway – ramp split;
- Highway vertical alignment;
- Highway horizontal alignment;
- Highway weaving area lane length; and
- Highway shoulder width.

Non-standard geometric features exist throughout the I-5 Bridge Influence Area, including short ramp merges/acceleration lanes, short ramp diverges/deceleration lanes, short weaving areas, vertical curves (crest and sag curves) limiting sight distance, and narrow shoulders. The greatest concentration of existing non-standard geometric features is located on the Interstate Bridge and along its approaches. Within this area, there are multiple existing non-standard features. **Exhibit 5-39** lists existing non-standard features on I-5 in the Bridge Influence Area and the degree to which the elements meet current design standards. An assessment, conducted along the entire 5-mile Bridge Influence Area segment, found the presence of 40 non-standard features.

Many ramps within the extent of the Bridge Influence Area do not provide standard acceleration or deceleration lane lengths and some weaving areas are also non-standard. Non-standard shoulder widths are prevalent throughout the Bridge Influence Area.

Based upon a comparison of the non-standard geometric features and reported collisions, there is a strong correlation between the presence of non-standard design features and the frequency and type of collisions.

For example, non-standard acceleration and deceleration lanes at several on- and off-ramps contribute to a high number of rear-end and side-swipe collisions along northbound I-5, particularly on Hayden Island, the downtown Vancouver/City Center off-ramp, and at SR 14. Along southbound I-5, non-standard acceleration and deceleration lanes contribute to a high number of rear-end and side-swipe collisions at Fourth Plain Boulevard, SR 14, on Hayden Island, and at the Victory Boulevard interchange.

Existing non-standard weaving areas contribute to a high number of rear-end and side-swipe collisions along I-5, primarily southbound between SR 500 and Fourth Plain Boulevard, between Mill Plain Boulevard and SR 14, between Hayden Island and Marine Drive, and between Marine Drive and Victory Boulevard.

The distances between the SR 14 and City/Center off-ramps on the north end of the Interstate Bridge and other ramps in the Bridge Influence Area are below standard. The bridge's vertical alignment contains non-standard crest and sag curves that results in limited sight distance. The shoulders on the Interstate Bridge and other areas in the Bridge Influence Area are significantly below standards. All of these geometric elements contribute to the number of reported collisions near or at the Interstate Bridge.

5.2.11.4 Vehicular Collisions during Interstate Bridge Gate Closures

An analysis to determine the probability of collisions during gate closures was completed. The gate closure data for the Interstate Bridge was analyzed for the number of times traffic was stopped by the signals for the gate closures, average time that closures began, day of closures, duration of closures, the reason for closures, and the direction of traffic requiring closure.

Using a five-year collision database (for years 2000-2004), a comparison was made between collisions that were reported to have occurred within a one-hour window of logged gate closures on weekdays between 9:00 a.m. and 2:30 p.m. The analysis only considered collisions that involved vehicles approaching the bridge (i.e., northbound Oregon traffic or southbound Washington traffic) as gate closures directly impact only approaching traffic.

Based on the results of the analysis, northbound collisions are three times more likely when a gate closure occurs than when it does not. Southbound collisions are four times more likely. Collisions occurring during gate closures generally result in a higher rate of rear-end collisions and greater injury frequency than those collisions that occur during peaks, when gate closures are restricted (not prohibited).

5.2.11.5 Vehicular Collisions by Time of Day

The number and type of collisions reported in the I-5 Bridge Influence Area during the five-year period were sorted by hour and direction. **Exhibit 5-40** shows the number of collisions, by hour, reported along southbound I-5. **Exhibit 5-41** shows the number of collisions, by hour, reported along northbound I-5. Graphical curves depicting existing traffic counts on the Interstate Bridge were added to **Exhibit 5-40** and **Exhibit 5-41** to determine if a correlation exists between collision frequency and traffic volumes.

As shown in **Exhibit 5-40**, during periods when traffic is uncongested along southbound I-5, the number of reported collisions is generally proportional to prevailing traffic volumes. However, during periods of high traffic volumes and congestion, collisions increase faster than overall traffic volumes. Exhibit **5-41** shows similar results for northbound I-5. During congested periods the frequency of collisions is substantially higher than during uncongested periods. The frequency of collisions during the congested peak periods is about twice the proportion during uncongested traffic periods.

5.2.11.6 Identification of Safety Improvement Locations - Washington

The Washington State Department of Transportation uses two major programs to identify and correct potentially unsafe locations. These are the high accident location (HAL) and the high accident corridor (HAC) programs.

A HAL location is a spot location less than a mile long that has experienced a higher than average rate of severe accidents during the previous two years. Several factors are considered when determining if a location meets the HAL classification criteria. The severity of an accident, the severity per million vehicles, the roadway access category, and the accumulated severity rate per million vehicle miles are all taken into account when determining whether or not a location is a HAL.

A HAC is a section of state highway one or more miles long that has a higher than average number of severe accidents over a continuous period of time. For the five-year analysis period, the following statewide benchmark averages are calculated for each of the six roadway access categories:

- Total severity points per mile.
- Total accidents per mile.
- Severity points per accident per mile.

Information provided by WSDOT revealed that within the study area of this project, the following five locations met the HAL criteria:

- The westbound SR 14 off-ramp to southbound I-5 on-ramp.
- The southbound I-5 off-ramp to eastbound SR 14 on-ramp.
- The southbound I-5 off-ramp to Mill Plain Boulevard.
- The southbound I-5 off-ramp to Fourth Plain Boulevard.
- 39th Street between the southbound and northbound ramp terminals.

All of these locations are ramp-related which supports the conclusion drawn from the crash analysis that there are safety issues with the ramps. There were no HAC locations identified within the study area of this project.

5.2.11.7 Identification of Safety Improvement Locations - Oregon

The Oregon Department of Transportation's Safety Priority Index System (SPIS) is the primary method for identifying high crash locations on state highways within Oregon. The SPIS score is based on three years of crash data and considers crash frequency, crash rate, and crash severity. ODOT bases its SPIS on 0.10 mile segments to account for variances in how crash locations are reported. To become a SPIS site, a location must meet one of the following criteria:

- Three or more crashes have occurred at the same location over the previous three years

- One or more fatal crashes have occurred at the same location over the previous three years

Each year, a list of the top 10 percent SPIS sites is generated and the top five percent of sites are investigated by the five Region Traffic managers' offices. These sites are evaluated and investigated for safety problems. If a correctable problem is identified, a benefit/cost analysis is performed and appropriate projects are initiated, often with funding from the Highway Safety Improvement Program.

While the general collision analysis covers the five-year period from 2002-2006, a search of the most recent ODOT SPIS database, covering the three-year period from 2006-2008, revealed seven locations (four which overlap) within the Oregon section of the project area that ranked among the highest 10 percent of SPIS sites in the state. These locations are summarized in **Exhibit 5-42**. Two of these locations are in the top five percent in the state with the other five in the top 10 percent. ODOT does not include crashes on the interchange ramps and intersections in the calculation of SPIS rates for the highway.

5.2.11.8 Vehicular Collisions Involving Trucks

On average, truck collisions occur at a slightly higher rate than general purpose traffic throughout the I-5 corridor. A summary of truck-related collisions is presented in **Exhibit 5-43**. There are differences in nomenclature for trucks in Oregon and Washington. Vehicles described as "semi tow, truck, or bobtail" in the ODOT database were counted as truck collisions. Vehicles described as "Truck Tractor, Truck Tractor & Semi-Trailer, Truck (Flatbed, Van, etc), Truck – Double Trailer Combinations, or Truck & Trailer" in the WSDOT database were counted as truck collisions. Even though nomenclature for truck collisions are different between the two states, the definitions and categorization of what constitutes a truck for the purpose of the truck collision calculation is generally the same.

Collisions involving trucks account for about 12 percent of all collisions reported on I-5 from Lombard Street to Main Street/Hwy 99, and are approximately equal to or higher than the proportion of truck volume to all traffic.

During the five-year study period in Oregon, 95 collisions involving trucks were reported. Forty-six percent occurred southbound and 54 percent occurred northbound. During the five-year study period in Washington, 160 collisions involved trucks. Seventy-two percent occurred southbound and 28 percent occurred northbound.

The rate of side-swipe collisions involving trucks is higher than any other type (39 percent). This could be attributed to the trucks attempting to change lanes in congested traffic as well as short acceleration/deceleration lanes and weaving sections in the Bridge Influence Area.

Locations with high numbers of truck-related collisions are the Columbia Boulevard ramps, Victory Boulevard ramps, Hayden Island, and the northbound exit to Marine Drive. The SR 14 westbound to I-5 southbound on-ramp, with its short turning radius, steep super-elevation, and uphill grade, likely contributes to the higher number of truck-related collisions at the bridge approach. Between 2002 and 2006, there were 13 reported collisions between I-5 mile post 0.39 and 0.30, immediately south of the SR 14 on-ramp.

5.3 Local Streets

This section summarizes existing local street performance for the peak hours of travel. Local street congestion is most intense near the I-5 ramps and is influenced by the travel direction and length of time that I-5 is congested each day.

5.3.1 Travel Demand

5.3.1.1 Vancouver Screenlines

Exhibit 5-44 displays existing conditions screenline data for the morning peak in Vancouver. Traffic in the Vancouver central city is highest near I-5. Commuters travel to the highway from neighborhoods north and east of the downtown area. Vehicular traffic heads to the Vancouver city core, from I-5 as well as the western and northern parts of Vancouver and Clark County. The west side of I-5 experiences larger volumes than the east side of the highway.

The largest northbound and southbound traffic volumes cross Fourth Plain Boulevard and Mill Plain Boulevard/15th Street, two of the major east-west thoroughfares in Vancouver. During the morning peak, volumes are highest southbound as motorists travel to the Vancouver Central Business District (CBD). Some commuters exit I-5 near Main Street and travel southbound along Vancouver arterials to avoid congestion on I-5. This diverted traffic, combined with local traffic destined for the Vancouver CBD, can overload certain north/south arterials. In general, given the trip attraction rate of the Vancouver CBD, traffic volumes are higher closer to downtown.

Exhibit 5-45 displays existing conditions screenline data for the afternoon/evening peak in Vancouver. Traffic volumes are highest for eastbound movements near I-5 as vehicles leave downtown during the afternoon/evening. The majority of vehicles exiting I-5 at Mill Plain Boulevard and Fourth Plain Boulevard contribute to the higher eastbound volumes split.

I-5 is generally not congested during the northbound afternoon/evening peak. Free flow conditions attract motorists from the Vancouver CBD who access I-5 from Mill Plain Boulevard and Fourth Plain Boulevard instead of using the north/south Vancouver arterials as in the morning peak. This contributes to a more even distribution of north and southbound volumes along Vancouver arterials during the afternoon/evening peak. Traffic volumes are highest in the heart of downtown and decrease further north as vehicles turn off arterials to access neighborhoods via local streets.

5.3.1.2 Portland Screenlines

Exhibit 5-46 displays existing conditions screenline data for the morning peak in Portland. Volumes are highest throughout the study area for westbound movements, especially east of I-5. In particular, traffic volumes across Martin Luther King Jr. Boulevard show a strong trend towards westbound movements, as commuters are traveling from eastern parts of the city towards the downtown area. Southbound travel is heavier than northbound and the north/south split widens closer to downtown Portland.

Exhibit 5-47 displays existing condition screenline data for the afternoon/evening peak in Portland. Travel across the screenlines is more balanced than the morning peak. The widest disparity between eastbound and westbound movements exists across the Interstate Avenue and Martin Luther King Jr. Boulevard screenlines. Northbound traffic is heavier than southbound. Similar to the morning peak, the disparity between northbound and southbound traffic is highest near Alberta Street, and the gap narrows farther north. As motorists leave the arterial network to access neighborhood streets, northbound volumes drop, leading to an almost even split of arterial traffic near the Columbia Slough.

5.3.2 Intersection Operational Performance

5.3.2.1 Vancouver – Morning and Afternoon/Evening Peak Hours

5.3.2.2 SR 14/City Center Interchange Area Operational Performance

The SR 14/City Center interchange area consists of 33 study intersections, bound by the following area as shown in **Exhibit 5-48**:

- The Columbia River to the south;
- 11th Street to the north;
- Esther Street to the west; and
- I-5 to the east.

During the morning and afternoon/evening peak hours, all 33 intersections perform at acceptable service levels and meet the City of Vancouver's standard of LOS E for downtown intersections. **Exhibits 5-49** and **5-50** list the intersection operations of all 33 intersections during the morning and afternoon/evening peak hours.

During the morning peak hour, several intersections experience traffic that backs up into upstream intersections. At the entrance to the I-5 southbound and SR 14 westbound on-ramps at Fifth Street and Washington Street, queues extend north on Washington Street. Main Street and Evergreen Boulevard experience queuing during both the morning and afternoon/evening peaks which result in vehicular queues extending into upstream intersections. The list of intersections with queues that exceed storage or backup into upstream intersections can be seen in **Exhibit 5-49** and **Exhibit 5-50**.

5.3.2.3 Mill Plain Boulevard Interchange Area Operational Performance

The Mill Plain Boulevard interchange area consists of the following 16 study intersections as shown in **Exhibit 5-51**:

- Mill Plain Boulevard at Columbia Street (Vancouver);
- Mill Plain Boulevard at Washington Street (Vancouver);
- Mill Plain Boulevard at Main Street (Vancouver);

- Mill Plain Boulevard at Broadway (Vancouver);
- Mill Plain Boulevard at C Street (Vancouver);
- Mill Plain Boulevard at I-5 southbound on- and off-ramps (WSDOT);
- Mill Plain Boulevard at I-5 northbound on- and off-ramps (WSDOT);
- 15th Street at Columbia Street (Vancouver);
- 15th Street at Washington Street (Vancouver);
- 15th Street at Main Street (Vancouver);
- 15th Street at Broadway (Vancouver);
- 15th Street at C Street (Vancouver);
- McLoughlin Boulevard at Columbia Street (Vancouver);
- McLoughlin Boulevard at Main Street (Vancouver);
- McLoughlin Boulevard at Broadway (Vancouver); and
- McLoughlin Boulevard at Fort Vancouver Way (Vancouver).

During the morning and afternoon/evening peak hours, all 16 intersections meet the City of Vancouver's LOS standard and perform acceptably. **Exhibit 5-49** and **Exhibit 5-50** list the intersection operations of all 16 intersections during the morning and afternoon/evening peak hours.

During the morning peak hour, the intersection of Mill Plain Boulevard at Main Street often experiences vehicular queues that extend beyond its southbound left-turn lane, resulting in blockage of some upstream intersections. In addition, I-5 highway congestion backs into the southbound ramp terminal at Mill Plain Boulevard. As a result, this intersection experiences vehicular queues that extend beyond its eastbound right-turn and westbound left-turn pockets.

During the afternoon/evening peak hour, the Mill Plain diamond interchange experiences eastbound vehicular queuing at the northbound ramp terminal which extends west through the southbound ramp terminal. The queuing results from the significant traffic volume which originates from the downtown area and travels north to access I-5 at Mill Plain Boulevard. The intersection of 15th Street and Broadway experiences vehicular queues that extend beyond its westbound left lane, resulting in blockage of some westbound through movements.

5.3.2.4 Fourth Plain Boulevard Interchange Area Operational Performance

The Fourth Plain Boulevard interchange area consists of the following 14 study intersections as shown in **Exhibit 5-52**:

- 24th Street at Columbia Street (Vancouver);
- 24th Street at Main Street (Vancouver);
- Fourth Plain Boulevard at Columbia Street (Vancouver);

- Fourth Plain Boulevard at Main Street (Vancouver);
- Fourth Plain Boulevard at Broadway (Vancouver);
- Fourth Plain Boulevard at F Street (Vancouver);
- Fourth Plain Boulevard at I-5 southbound on- and off-ramps (WSDOT);
- Fourth Plain Boulevard at I-5 northbound on- and off-ramps (WSDOT);
- Fourth Plain Boulevard at Post Cemetery (Vancouver);
- Fourth Plain Boulevard at St. Johns Boulevard (Vancouver);
- 28th Street at Main Street (Vancouver);
- 28th Street at Broadway (Vancouver);
- 29th Street at Main Street/Broadway (Vancouver); and
- 33rd Street at Main Street (Vancouver).

During the morning and afternoon/evening peak hours, all but one of the 14 intersections perform at acceptable service levels and meet Vancouver's standard of LOS D for signalized or LOS E for unsignalized intersections. The intersection of 28th Street at Main Street does not meet the LOS standard during the morning peak hour and performs at LOS F on the stop-controlled approach of 28th Street. During the afternoon/evening peak hour, the intersection of 28th Street at Main Street performs acceptably. **Exhibits 5-49** and **5-50** list the operations of all 14 intersections during the morning and afternoon/evening peak hours.

Fourth Plain Boulevard at Main Street experiences westbound vehicular queuing that extends through the intersection with F Street in the morning peak hour. Southbound traffic in the morning peak also experiences queues that extend into upstream intersections.

During the afternoon/evening peak hour, queuing in the vicinity of the Fourth Plain Boulevard interchange area is often substantial for both northbound and westbound traffic, resulting in some intersection blockage. The intersection of 33rd Street at Main Street often experiences vehicular queues that extend beyond its eastbound and westbound left-turn lanes, resulting in blockage of some through movements.

5.3.2.5 SR 500/Main Street/39th Street Interchange Area Operational Performance

The SR 500/Main Street/39th Street interchange area consists of the following 10 study intersections as shown in **Exhibit 5-53**:

- 39th Street at Main Street (Vancouver);
- 39th Street at F Street (Vancouver);
- 39th Street at H Street (Vancouver);
- 39th Street at I-5 southbound on- and off-ramps (WSDOT);
- 39th Street at I-5 northbound on- and off-ramps (WSDOT);

- WSDOT/40th Street at Main Street (Vancouver);
- 45th Street at Main Street (Vancouver);
- Hazel Dell at Main Street (Vancouver);
- Ross Street at Main Street (Clark County); and
- Ross Street at North Road (Clark County).

During the morning and afternoon/evening peak hours, nine of the 10 study area intersections perform at acceptable service levels. The intersection of 39th Street at the I-5 southbound ramp terminal does not meet Vancouver's unsignalized LOS E standard during the morning peak hour. During the afternoon/evening peak hour, the intersection of 39th Street at F Street does not meet the unsignalized LOS E standard. **Exhibit 5-49** and **Exhibit 5-50** list the operations of all 10 intersections during the morning and afternoon/evening peak hours.

During the morning peak hour, vehicles near the 39th Street interchange experience queues that extend beyond the left-turn lanes on all approaches at Main Street. The westbound vehicular queues extend into the intersection of 39th Street at F Street. The intersection of 39th Street at the I-5 ramp terminal often experiences vehicular queues on the northbound approach, resulting in queues of approximately 600 feet.

During the afternoon/evening peak hour, vehicles near the 39th Street at Main Street often experience queues that extend beyond the left-turn lanes on all approaches. The westbound vehicular queues extend into the intersection of 39th Street at H Street. The intersection of 39th Street at the I-5 northbound and southbound ramp terminals often experiences vehicular queues on the northbound approaches.

5.3.2.6 Portland – Morning and Afternoon/Evening Peak Hours

5.3.2.7 Hayden Island Interchange Area Operational Performance

The Hayden Island interchange area consists of the following two study intersections as shown in **Exhibit 5-54**:

- Center Avenue and I-5 southbound on- and off-ramps (ODOT); and
- Hayden Island Drive and Hayden Island Drive South (ODOT, closest signalized intersection to northbound on- and off-ramps).

During the morning and afternoon/evening peak hours, Center Avenue and the I-5 southbound ramp terminal perform at an acceptable service level and meet ODOT's 0.85 V/C ratio standard. During morning and afternoon/evening peak hours, Hayden Island Drive and Hayden Island Drive South perform at an acceptable service level and meet ODOT's 0.85 V/C ratio standard. **Exhibits 5-55** and **5-56** list the operations of both intersections during the morning and afternoon/evening peak hours.

During the afternoon/evening peak hour, the westbound left turn at the southbound ramp terminal often experiences vehicular queues that extend beyond its left-turn pocket, resulting in queuing that sometimes extends into the deceleration area of the highway off-ramp.

5.3.2.8 Marine Drive Interchange Area Operational Performance

The Marine Drive interchange area consists of the following three study intersections as shown in **Exhibit 5-57**:

- Union Court and I-5 northbound off-ramp (ODOT);
- Marine Drive and I-5 on- and off-ramps (ODOT); and
- Union Court/Marine Way and Vancouver Way (Portland).

During the morning peak hour, all three of the intersections perform at acceptable service levels and meet ODOT's 0.85 V/C ratio standard or Portland's unsignalized intersection standard of LOS E. Afternoon/evening highway congestion from I-5 northbound causes increased delay during the afternoon/evening peak hour along Marine Drive on both the east side and west side of the interchange. However, all intersections perform at acceptable service levels. **Exhibit 5-55** lists the intersection operations of the three intersections during the morning peak hour.

During the afternoon/evening peak hour, the I-5 northbound ramp meter affects the Marine Drive ramp terminal and the Union Court at Vancouver Way intersection. The on-ramp queue extends past the ramp and then east across the highway overpass. As a result, several left- and right-turn lanes at these three locations experience queues that are longer than the available storage lengths and extend through upstream intersections. However, all intersections operate at an acceptable service level. **Exhibit 5-56** lists the intersection operations of the three intersections during the afternoon/evening peak hour.

5.3.2.9 Victory Boulevard Interchange Area Operational Performance

The Victory Boulevard interchange area consists of the following four study intersections as shown in **Exhibit 5-58**:

- Interstate Avenue at Argyle Street (Portland);
- Victory Boulevard at Expo Road (Portland) ;
- Victory Boulevard at southbound on-ramp (ODOT); and
- Victory Boulevard at northbound on-ramp (ODOT).

During the morning and afternoon/evening peak hours, all four of the intersections operate at acceptable service levels and meet ODOT's 0.85 V/C ratio standard or Portland's intersection standard of LOS D or E. **Exhibits 5-55** and **5-56** lists the intersection operations of the four intersections during the morning and afternoon/evening peak hours.

During the afternoon/evening peak hour, the Victory Boulevard northbound ramp terminals experience vehicular queues caused by northbound highway congestion on I-5, resulting in blockage of some eastbound left-turning vehicles at the intersection.

However, the intersection operates at an acceptable LOS. The list of intersections with queues that exceed storage or backup into upstream intersections can be seen in **Exhibits 5-55** and **5-56**.

5.3.2.10 Interstate Avenue Analysis Area Operational Performance

The Interstate Avenue analysis area consists of the following four study intersections as shown in **Exhibit 5-59**:

- Going Street at Interstate Avenue (Portland);
- Alberta Street at Interstate Avenue (Portland);
- Rosa Parks Way at Interstate Avenue (Portland); and
- Lombard Street at Interstate Avenue (ODOT).

During the morning and afternoon/evening peak hours, all four of the intersections operate at acceptable service levels and meet either Portland's standard of LOS D or ODOT's 0.99 V/C ratio standard. **Exhibits 5-55** and **5-56** list the intersection operations of the four intersections during the morning and afternoon/evening peak hours.

The lists of intersections with queues that exceed storage or backup into upstream intersections are also shown in **Exhibits 5-55** and **5-56**. Going Street often experiences vehicular queues that extend beyond its westbound and northbound left-turn pockets. Alberta Street often experiences vehicular queues that extend beyond its southbound and northbound left-turn pockets. Rosa Parks Way experiences vehicular queues that extend beyond its westbound and northbound left-turn pockets. Lombard Street also experiences vehicular queues that extend beyond its westbound and northbound left-turn pockets.

5.3.2.11 Martin Luther King Jr. Boulevard Analysis Area Operational Performance

The Martin Luther King Jr. Boulevard analysis area consists of the following five study intersections as shown in **Exhibit 5-59**:

- Fremont Street at Martin Luther King Jr. Boulevard (Portland);
- Alberta Street at Martin Luther King Jr. Boulevard (Portland);
- Rosa Parks Way at Martin Luther King Jr. Boulevard (Portland);
- Lombard Street at Martin Luther King Jr. Boulevard (ODOT); and
- Columbia Boulevard at Martin Luther King Jr. Boulevard (ODOT).

During the morning and afternoon/evening peak hours, all intersections perform at acceptable service levels and meet either Portland's standard of LOS D or ODOT's 0.99 V/C ratio standard. **Exhibits 5-55** and **5-56** list the intersection operations of the five intersections during the morning and afternoon/evening peak hours.

Exhibits 5-55 and **5-56** list intersections with queues that exceed storage or backup into upstream intersections. Fremont Street often experiences vehicular queues that extend beyond its left-turn pockets on all approaches. Alberta Street experiences queues that extend beyond its left-turn pockets on all approaches except for the eastbound approach.

Rosa Parks Way experiences vehicular queues that extend beyond its northbound left-turn pocket. Lombard Street sees vehicular queues that extend beyond its left-turn pockets on all approaches. Columbia Boulevard experiences vehicular queues that extend beyond its left-turn pockets on all approaches except for the eastbound approach.

5.3.2.12 I-5 Ramp Terminals Analysis Area Operational Performance

The I-5 Ramp Terminals analysis area consists of the following seven study intersections as shown in **Exhibit 5-59**:

- Alberta Street at the I-5 southbound ramp terminal (ODOT);
- Alberta Street at the I-5 northbound ramp terminal (ODOT);
- Rosa Parks Way at the I-5 southbound ramp terminal (ODOT);
- Rosa Parks Way at the I-5 northbound ramp terminal (ODOT);
- Lombard Street at the I-5 southbound ramp terminal (ODOT);
- Lombard Street at the I-5 northbound ramp terminal (ODOT); and
- Columbia Boulevard at I-5 ramp terminal (ODOT).

During morning and afternoon/evening peak hours, all intersections perform at acceptable service levels and meet ODOT's 0.85 V/C ratio standard. **Exhibits 5-55** and **5-56** list the operations of the five intersections during the morning and afternoon/evening peak hours.

Exhibits 5-55 and **5-56** list intersections with queues that exceed storage or backup into upstream intersections. At the Alberta Street southbound ramp terminal, westbound traffic queues extend through the northbound ramp terminal during the morning peak. At the Rosa Parks Way southbound ramp terminal during the morning peak hour, westbound left-turning vehicular queues exceed the available storage. For both peaks, westbound right-turning vehicular queues exceed the available storage at the Columbia Boulevard and I-5 ramp terminal.

5.4 Pedestrian and Bicycle Circulation

5.4.1 Existing Circulation System

Pedestrians and bicyclists experience challenging conditions when crossing the Columbia River on the I-5 bridges. The width of the shared-use pedestrian and bicycle facility on the I-5 bridge is non-standard (generally no wider than four feet) and separated from traffic by low non-standard barriers (in Washington and Oregon, engineering standards state that shared-use paths should be a minimum of 14 feet wide). The mixing of pedestrians and bicycles in this narrow facility can cause safety problems. Pedestrians and bicyclists are exposed to high noise levels, exhaust, and debris. The grades on the bridge create high downhill speeds for bicyclists and difficult uphill climbs for some pedestrians and bicyclists.

There exist direct pedestrian and bicycle connections to the Marine Drive area on the east and west sides of I-5. In Vancouver, direct connections provide access to the downtown Vancouver area; however, pedestrian and bicycle connections between Vancouver, Hayden Island, and Marine Drive are circuitous and require users to navigate local street intersections. For example, no connection exists for pedestrians or bicyclists wanting to stay on the west side of the bridge between Hayden Island and Marine Drive.

On the south side of the Columbia River, connections to the large Portland bikeway network exist via Marine Drive to the west and east, Martin Luther King Jr. Boulevard to the southeast and Expo Road to the south. Directional way-finding signing can be confusing or non-existent in some places. Furthermore, the paths connecting the crossing to the larger bikeway network are narrow and place bicyclists close to high-speed traffic, which includes a high percentage of heavy vehicles.

Exhibit 5-60 illustrates existing and planned multi-use trails and bicycle lanes in the vicinity of the Interstate Bridge.

5.4.2 Travel Demand

Pedestrian and bicycle volumes across the Columbia River were measured by conducting counts at four locations on September 11, 2007: (1) shared-use pathway entrance to the I-205 Glenn Jackson Bridge near Northeast Airport Way in Portland, (2) the east pathway to the I-5 bridgehead on the Oregon side of the Columbia River, (3) the west pathway to the I-5 bridgehead on the Oregon side of the Columbia River, and (4) the shared-use pathway on the east side of the North Portland Harbor Bridge.

Exhibit 5-61 displays the river crossing results by direction of travel, time of day and by mode. A combined total of 566 pedestrian and bicycle trips were logged during the 14-hour period at the three river crossing locations. **Exhibit 5-62** shows that there were a total of 198 pedestrian and bicycle trips over the I-205 Glenn Jackson Bridge, or approximately 35 percent of the total river crossings. The remaining 368 trips used the two pathways on the I-5 Interstate Bridge. As seen in **Exhibit 5-63**, 237 (64 percent) traveled across the Interstate Bridge on the wider, west-side pathway. **Exhibit 5-64** shows the remaining 131 trips that made use of the east side pathway. It is noted that the data was collected during the Portland-Vancouver area's Bike Commute Challenge, an annual month-long local contest that promotes bicycle usage. Average daily traffic conditions are likely to be less than the volumes observed during the count day.

Pedestrian and bicycle trip activity is similar to vehicular traffic in that travel over the bridge is heavier in the southbound direction during the morning and in the northbound direction during the afternoon/evening. The morning peak hour for pedestrian and bicycle travel occurs between 7 and 8 a.m. The afternoon/evening peak period occurs between 5 and 7 p.m. There does not appear to be a midday peak.

Of the non-motorized modes, bicyclists far outnumber pedestrians, accounting for 492 out of 566 (87 percent) of the total trips as shown in **Exhibit 5-61**. A total of 188 bicycle trips were made on the I-205 Glenn Jackson Bridge as seen in **Exhibit 5-62**, or 38 percent of the total bicycle river crossings. Ten pedestrian trips, or 14 percent of the overall total pedestrian crossings, were made on the I-205 crossing as seen in **Exhibit 5-62**. For the I-5 Interstate Bridge, 65 percent of bicycle trips and 61 percent of pedestrian trips were conducted on the west-side pathway. For the 14-hour period, there were 21 percent more pedestrian and bicycle trips northbound than in the southbound direction.

5.4.3 Existing Issues

Exhibit 5-65 highlights and lists several existing pedestrian and bicycle issues related to pedestrian and bicycle circulation in the vicinity of the Interstate Bridge. Many of the concerns are related to non-standard facilities: narrow pathways, low traffic barriers, low clearances and steep grades. Pedestrians and bicyclists must travel close to vehicular traffic, where they are exposed to noise, exhaust and debris. Directional signage can be confusing or non-existent in some places.

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PRELIMINARY

Exhibit 5-1

Vancouver Analysis Intersections			
#	Intersection	#	Intersection
01	3rd/4th St. and Columbia St	38	Mill Plain Blvd. and C St.
02	4th St. and Columbia St.	39	Mill Plain Blvd. and I-5 SB On-/Off-Ramps
03	4th St. and Washington St.	40	Mill Plain Blvd. and I-5 NB On-/Off-Ramps
04	5th St. and Columbia St.	41	15th St. and Columbia St.
05	5th St. and Washington St.	42	15th St. and Washington St.
06	6th St. and Columbia St.	43	15th St. and Main St.
07	6th St. and Washington St.	44	15th St. and Broadway
08	6th St. and Main St.	45	15th St. and C St.
09	6th St. and Broadway	46	McLoughlin Blvd. and Columbia St.
10	6th St. and C St.	47	McLoughlin Blvd. and Main St.
11	8th St. and Esther St.	48	McLoughlin Blvd. and Broadway
12	8th St. and Columbia St.	49	McLoughlin Blvd. and Fort Vancouver Way
13	8th St. and Washington St.	50	24th St. and Columbia St.
14	8th St. and Main St.	51	24th St. and Main St.
15	8th St. and Broadway	52	4th Plain Blvd. and Columbia St.
16	8th St. and C St.	53	4th Plain Blvd. and Main St.
17	9th St. and Esther St.	54	4th Plain Blvd. and Broadway
18	9th St. and Columbia St.	55	4th Plain Blvd. and F St.
19	9th St. and Washington St.	56	4th Plain Blvd. and I-5 SB On-/Off-Ramps
20	9th St. and Main St.	57	4th Plain Blvd. and I-5 NB On-/Off-Ramps
21	9th St. and Broadway	58	4th Plain Blvd. and Post Cemetery
22	Evergreen Blvd. and Esther St.	59	4th Plain Blvd. and St. Johns Blvd.
23	Evergreen Blvd. and Columbia St.	60	28th St. and Main St.
24	Evergreen Blvd. and Washington St.	61	28th St. and Broadway
25	Evergreen Blvd. and Main St.	62	29th St. and Main St./Broadway
26	Evergreen Blvd. and Broadway	63	33rd St. and Main St.
27	Evergreen Blvd. and C St.	64	39th St. and Main St.
28	11th St. and Esther St.	65	39th St. and F St.
29	11th St. and Columbia St.	66	39th St. and H St.
30	11th St. and Washington St.	67	39th St. and I-5 SB On-/Off-Ramps
31	11th St. and Main St.	68	39th St. and I-5 NB On-/Off-Ramps
32	11th St. and Broadway	69	WSDOT/40th St. and Main St.
33	11th St. and C St.	70	45th St. and Main St.
34	Mill Plain Blvd. and Columbia St.	71	Hazel Dell and Main St. (West)
35	Mill Plain Blvd. and Washington St.	72	Ross St. and Main St.
36	Mill Plain Blvd. and Main St.	73	Ross St. and North Rd.
37	Mill Plain Blvd. and Broadway		

Exhibit 5-2

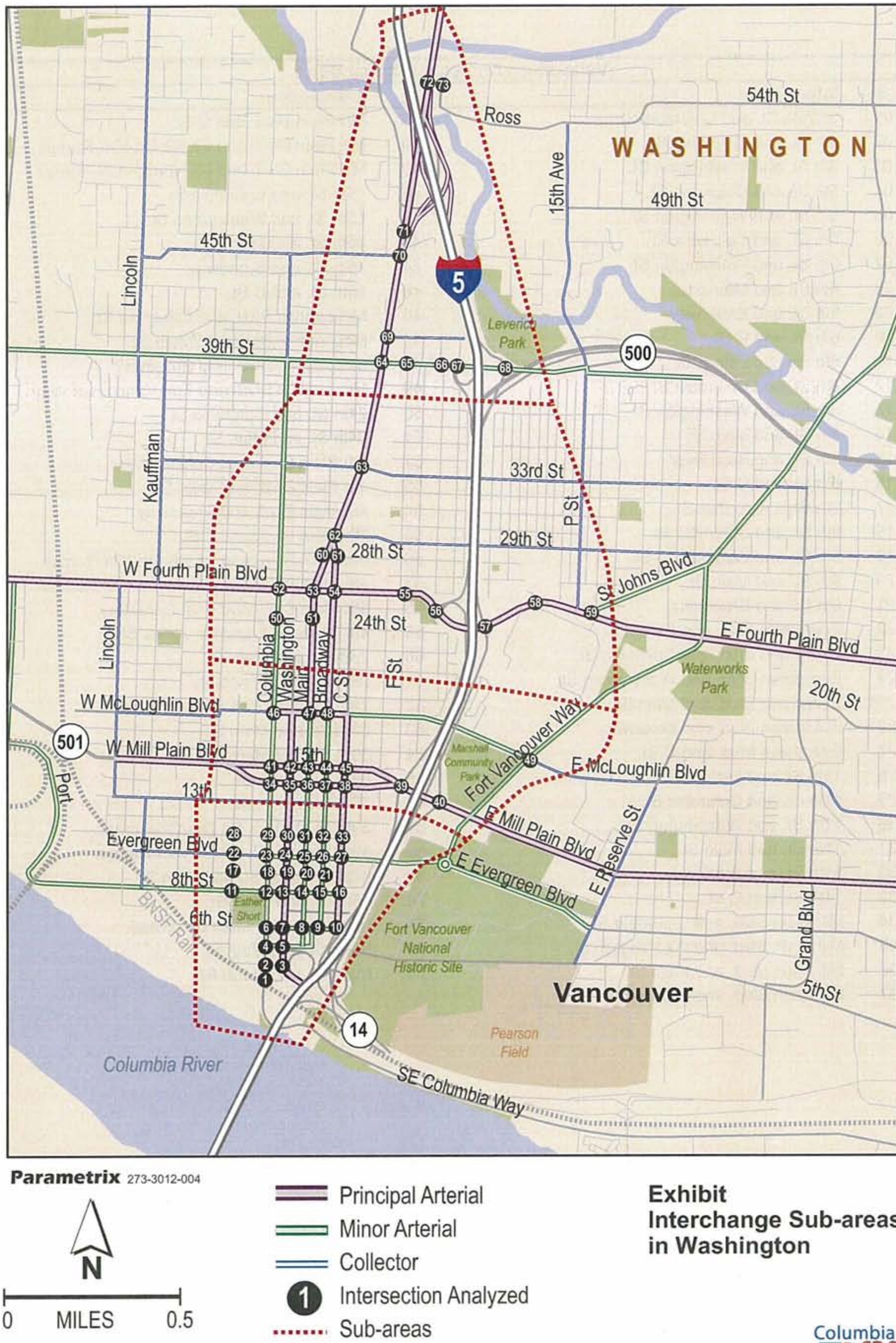


Exhibit
Interchange Sub-areas in Washington

Columbia River CROSSING

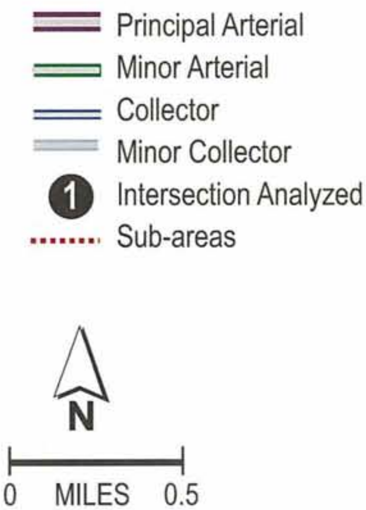
PRELIMINARY

Exhibit 5-3

Portland Analysis Intersections	
#	**Intersection**
01	Fremont and MLK Jr.
02	Going and Interstate
03	Alberta and Interstate
04	Alberta and SB I-5 Off-Ramp
05	Alberta and NB I-5 Off-Ramp
06	Alberta and MLK Jr.
07	Portland and Interstate
08	Portland and I-5 SB On-/Off Ramps
09	Portland and I-5 NB On-/Off Ramps
10	Portland and MLK Jr.
11	Lombard and Interstate
12	Lombard and I-5 SB On-Ramps
13	Lombard and I-5 NB Off-Ramps
14	Lombard and MLK Jr.
15	Interstate and Argyle
16	Columbia Blvd and I-5 Ramps
17	Columbia Blvd and MLK Jr.
18	Victory and Expo Road
19	Victory Blvd and I-5 SB On-Ramp
20	Victory Blvd and NB On-/Off-Ramps
21	Union Ct and I-5 NB Off-Ramp
22	Union Ct/Marine Way and Vancouver Way
23	Marine Dr and I-5 On-/Off-Ramps
24	Center Ave and I-5 SB On-/Off Ramps
25	Hayden Island Dr and Hayden Island Dr South

Exhibit 5-4

Exhibit
Interchange Sub-areas in Oregon



Columbia River CROSSING

Exhibit 5-5

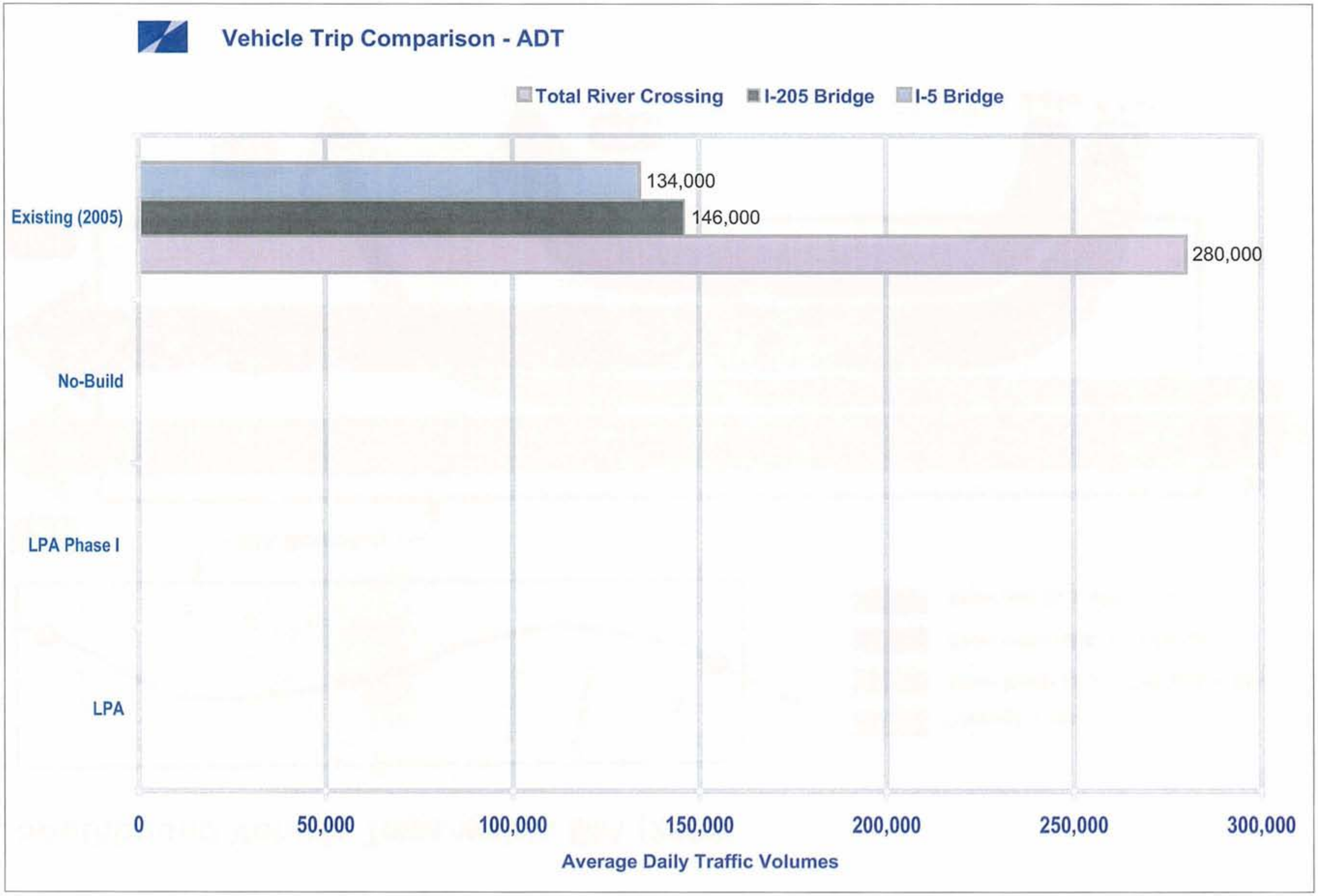

Vehicle Trip Comparison - ADT
Total River Crossing
I-205 Bridge
I-5 Bridge
Existing (2005)
No-Build
LPA Phase I
LPA
134,000
146,000
280,000
0
50,000
100,000
150,000
200,000
250,000
300,000
Average Daily Traffic Volumes

Exhibit 5-6

Southbound Vehicle Trips within BIA (2005)

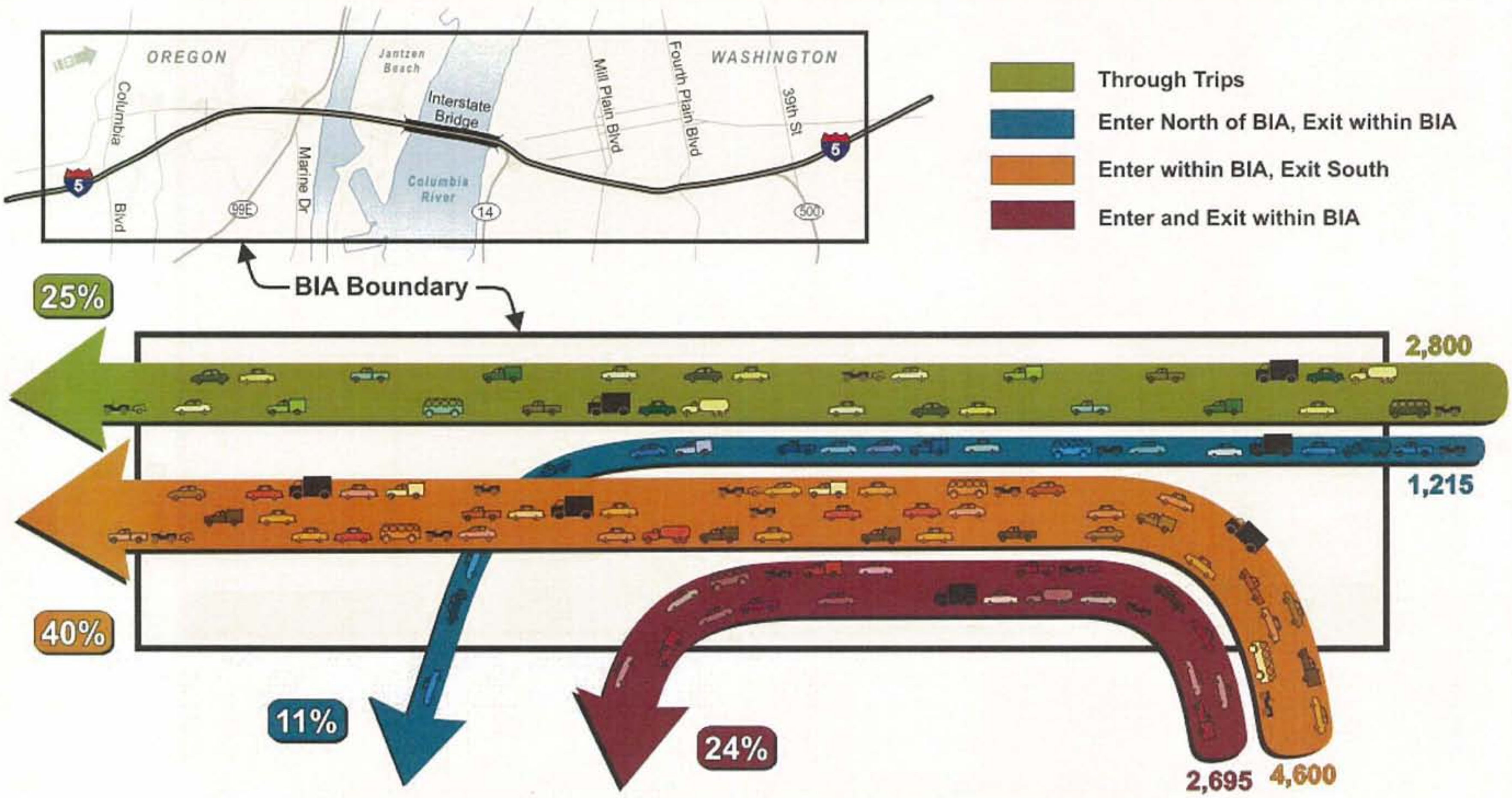
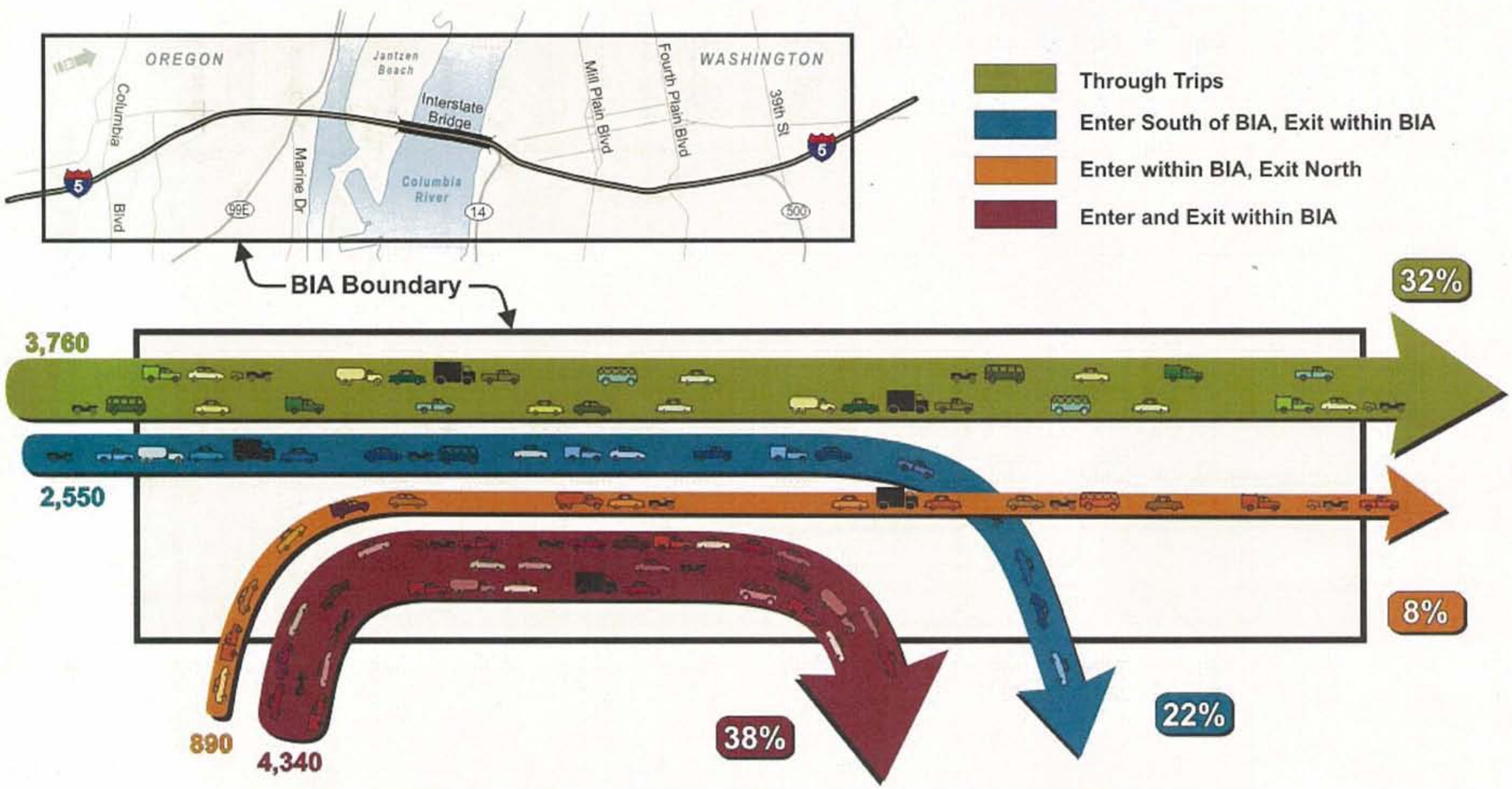


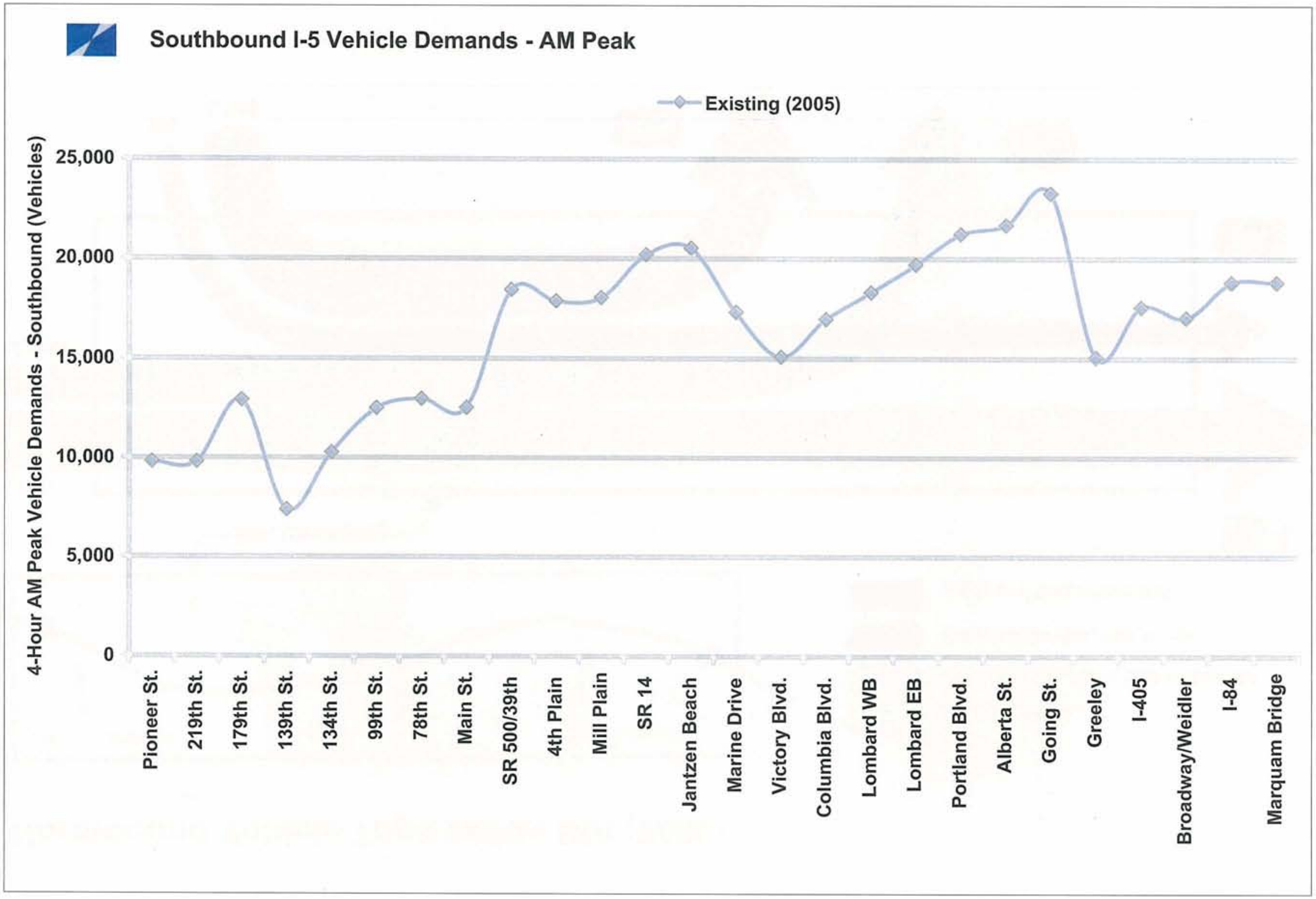
Exhibit 5-7

Northbound Vehicle Trips within BIA (2005)



PRELIMINARY

Exhibit 5-8



PRELIMINARY

Exhibit 5-9

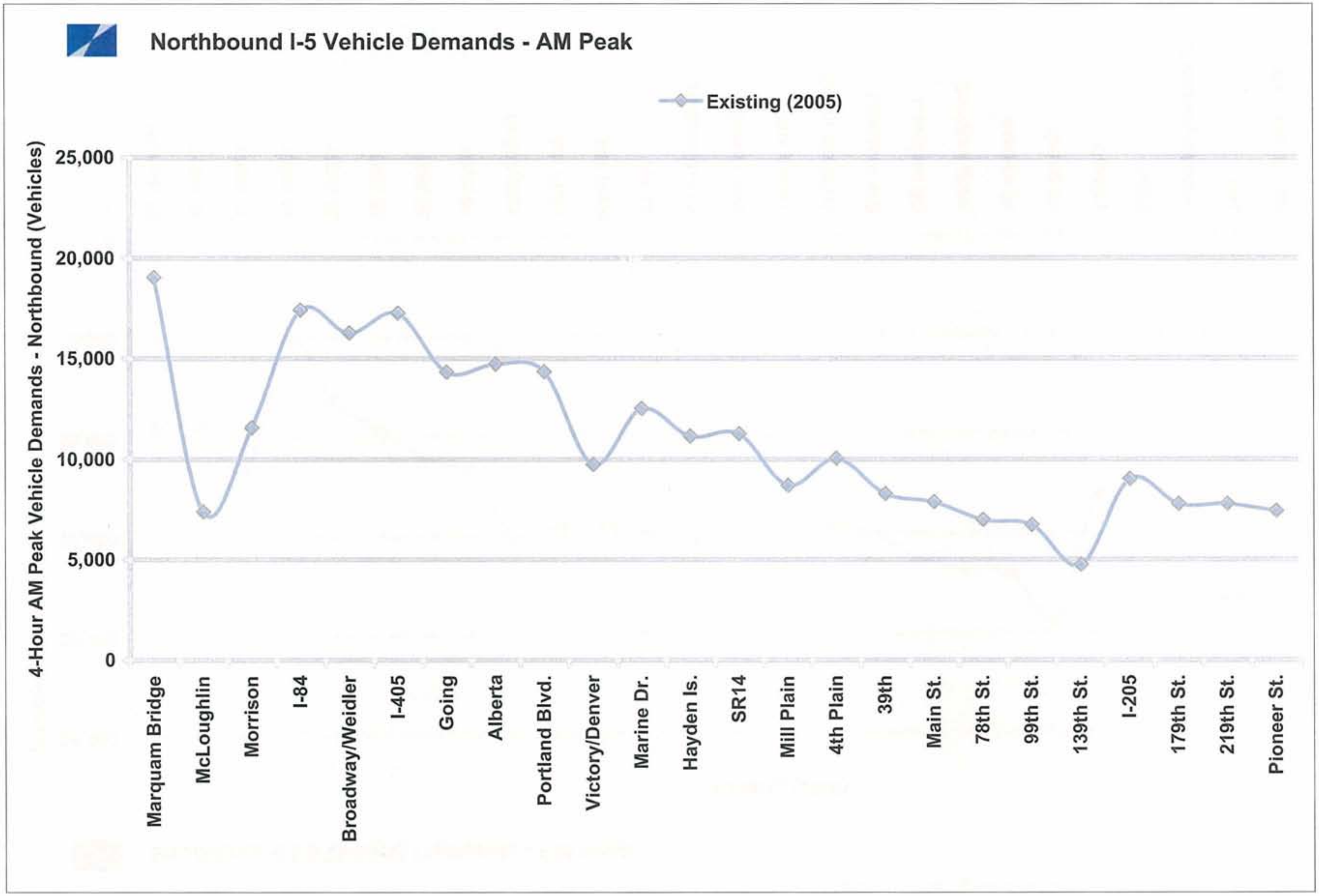


Exhibit 5-10

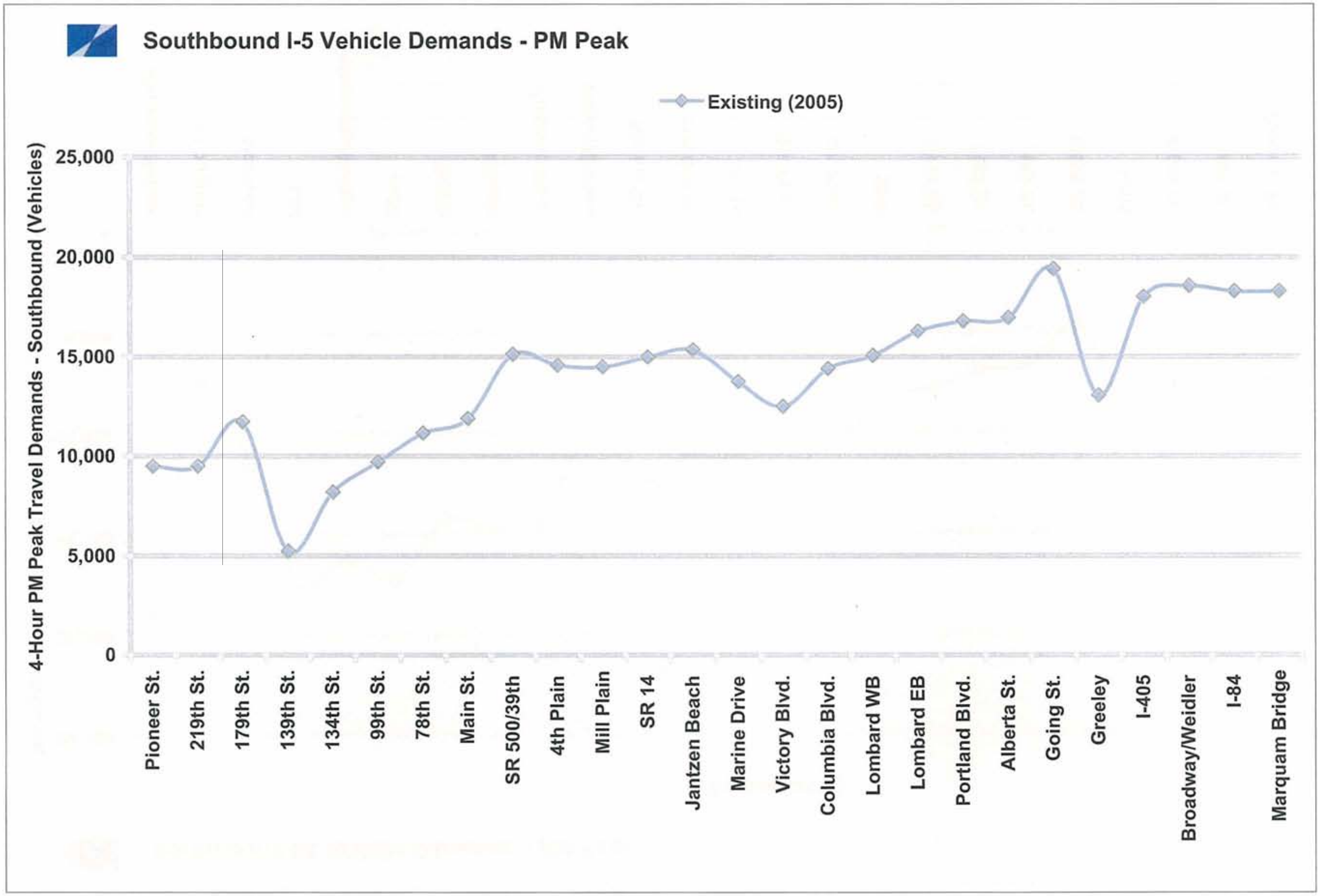

Southbound I-5 Vehicle Demands - PM Peak
Existing (2005)
4-Hour PM Peak Travel Demands - Southbound (Vehicles)
25,000
20,000
15,000
10,000
5,000
0
Pioneer St.
219th St.
179th St.
139th St.
134th St.
99th St.
78th St.
Main St.
SR 500/39th
4th Plain
Mill Plain
SR 14
Jantzen Beach
Marine Drive
Victory Blvd.
Columbia Blvd.
Lombard WB
Lombard EB
Portland Blvd.
Alberta St.
Going St.
Greeley
I-405
Broadway/Weidler
I-84
Marquam Bridge

Exhibit 5-11

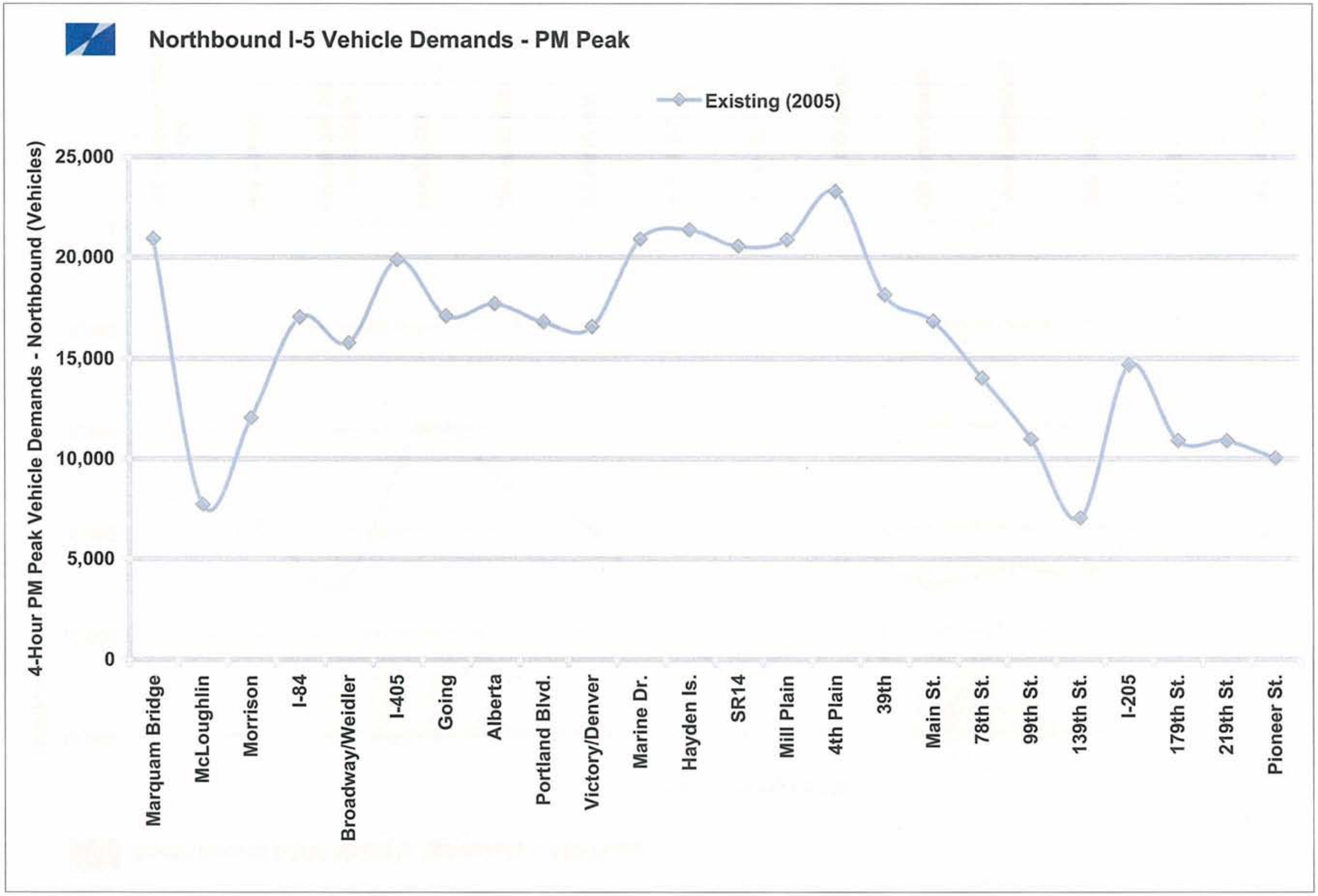

Northbound I-5 Vehicle Demands - PM Peak
Existing (2005)
4-Hour PM Peak Vehicle Demands - Northbound (Vehicles)
25,000
20,000
15,000
10,000
5,000
0
Marquam Bridge
McLoughlin
Morrison
I-84
Broadway/Weidler
I-405
Going
Alberta
Portland Blvd.
Victory/Denver
Marine Dr.
Hayden Is.
SR14
Mill Plain
4th Plain
39th
Main St.
78th St.
99th St.
139th St.
I-205
179th St.
219th St.
Pioneer St.

Exhibit 5-12

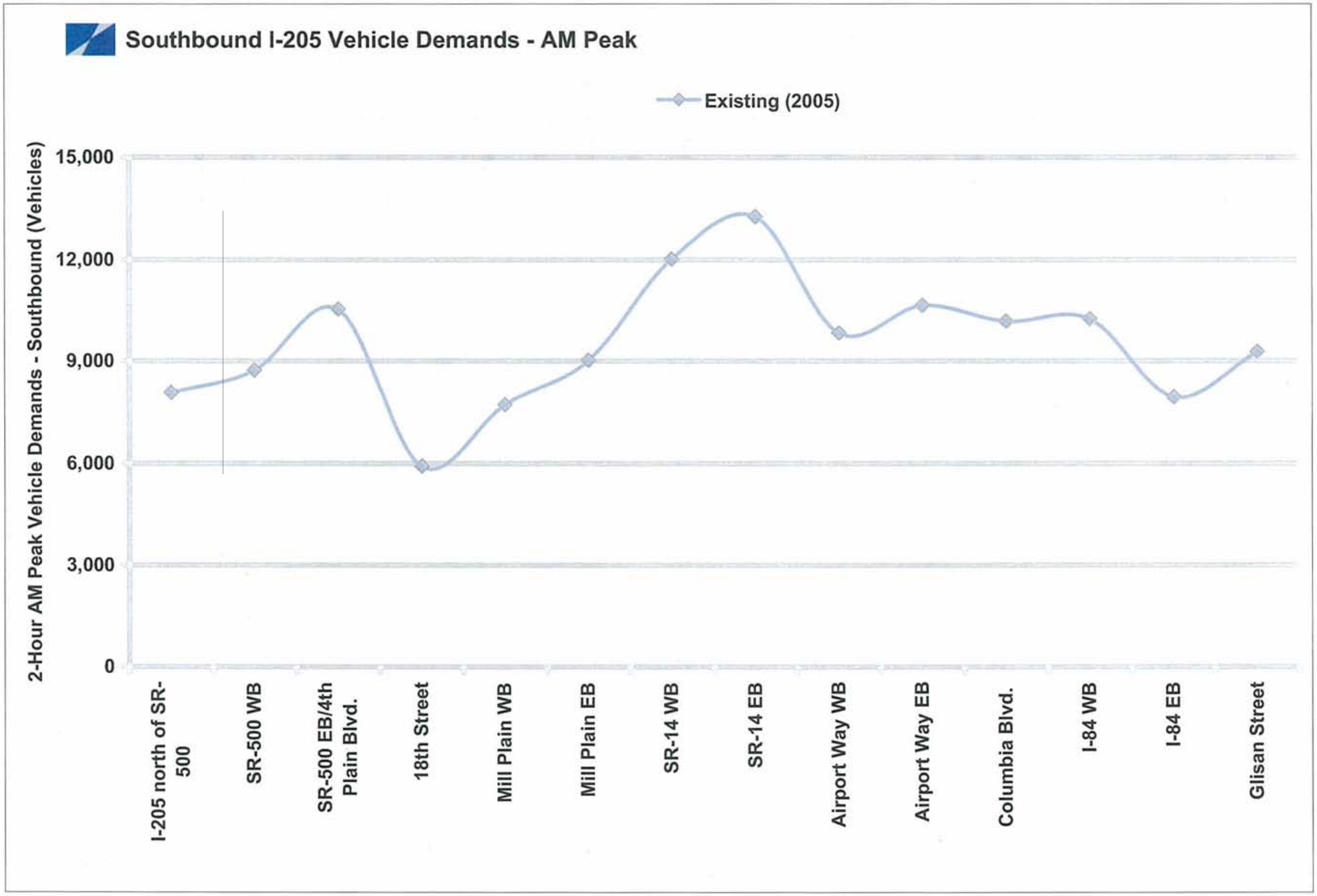

Southbound I-205 Vehicle Demands - AM Peak
Existing (2005)
2-Hour AM Peak Vehicle Demands - Southbound (Vehicles)
15,000
12,000
9,000
6,000
3,000
0
I-205 north of SR-500
SR-500 WB
SR-500 EB/4th Plain Blvd.
18th Street
Mill Plain WB
Mill Plain EB
SR-14 WB
SR-14 EB
Airport Way WB
Airport Way EB
Columbia Blvd.
I-84 WB
I-84 EB
Glisan Street

Exhibit 5-13

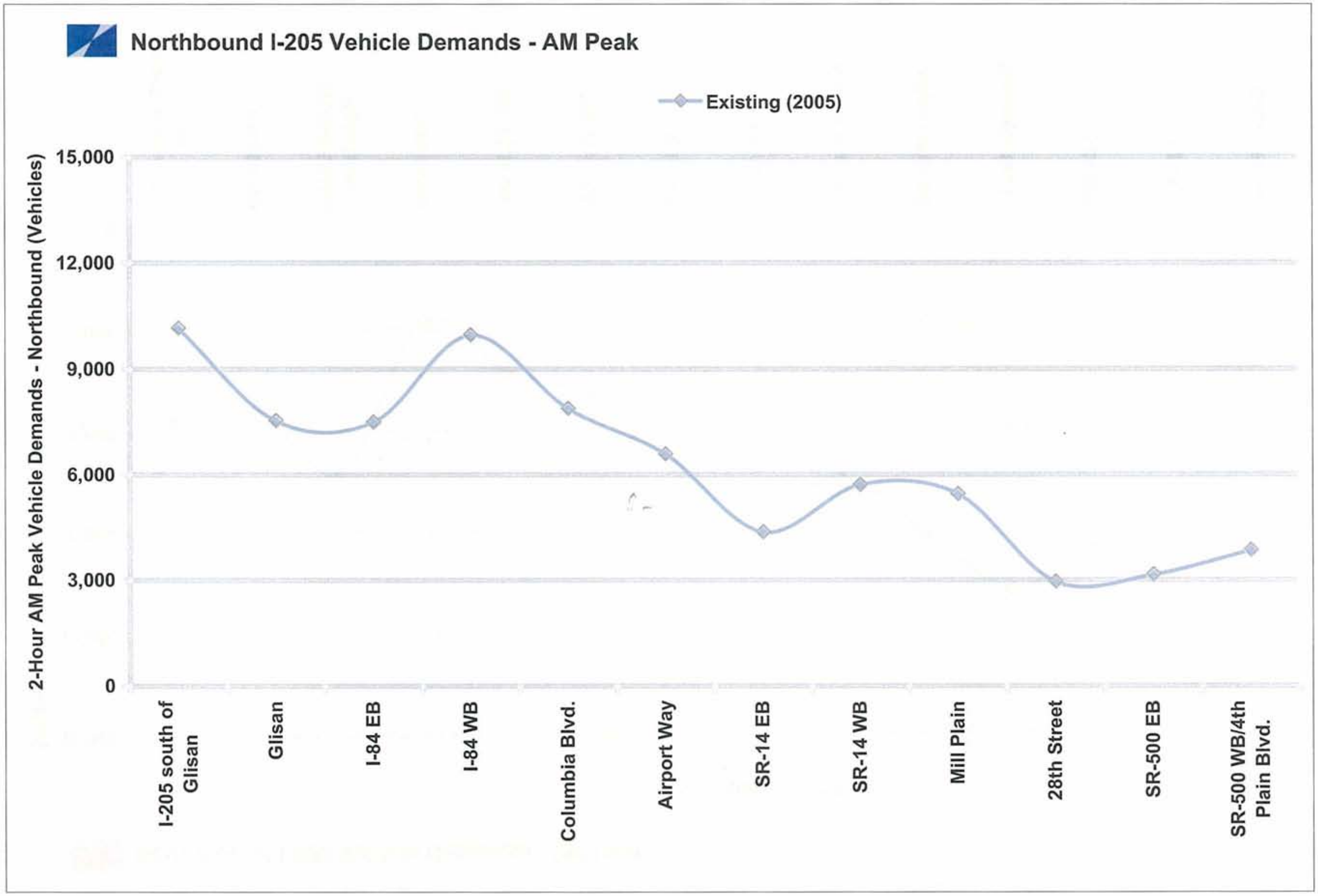

Northbound I-205 Vehicle Demands - AM Peak
Existing (2005)
2-Hour AM Peak Vehicle Demands - Northbound (Vehicles)
15,000
12,000
9,000
6,000
3,000
0
I-205 south of Glisan
Glisan
I-84 EB
I-84 WB
Columbia Blvd.
Airport Way
SR-14 EB
SR-14 WB
Mill Plain
28th Street
SR-500 EB
SR-500 WB/4th Plain Blvd.

Exhibit 5-14

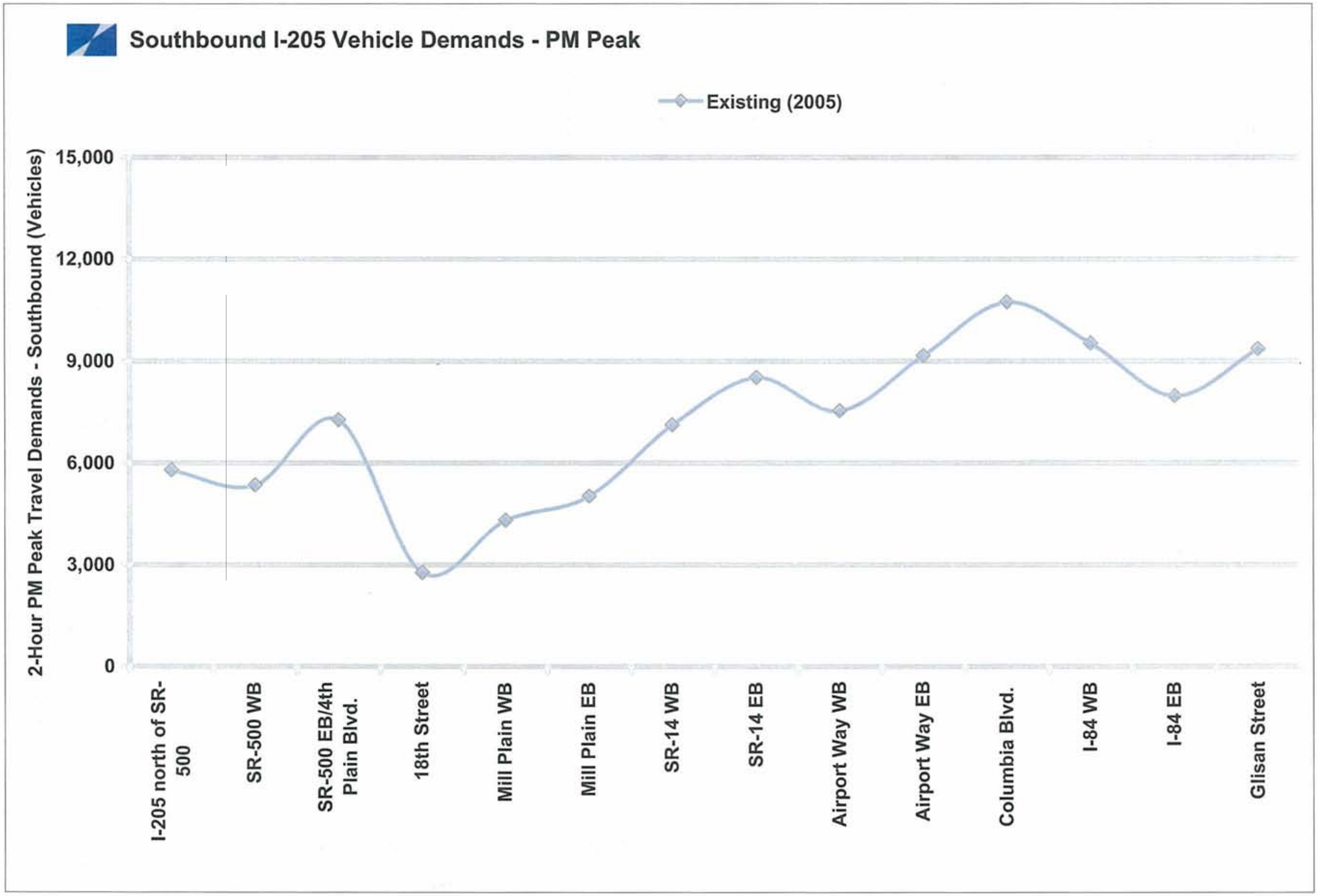
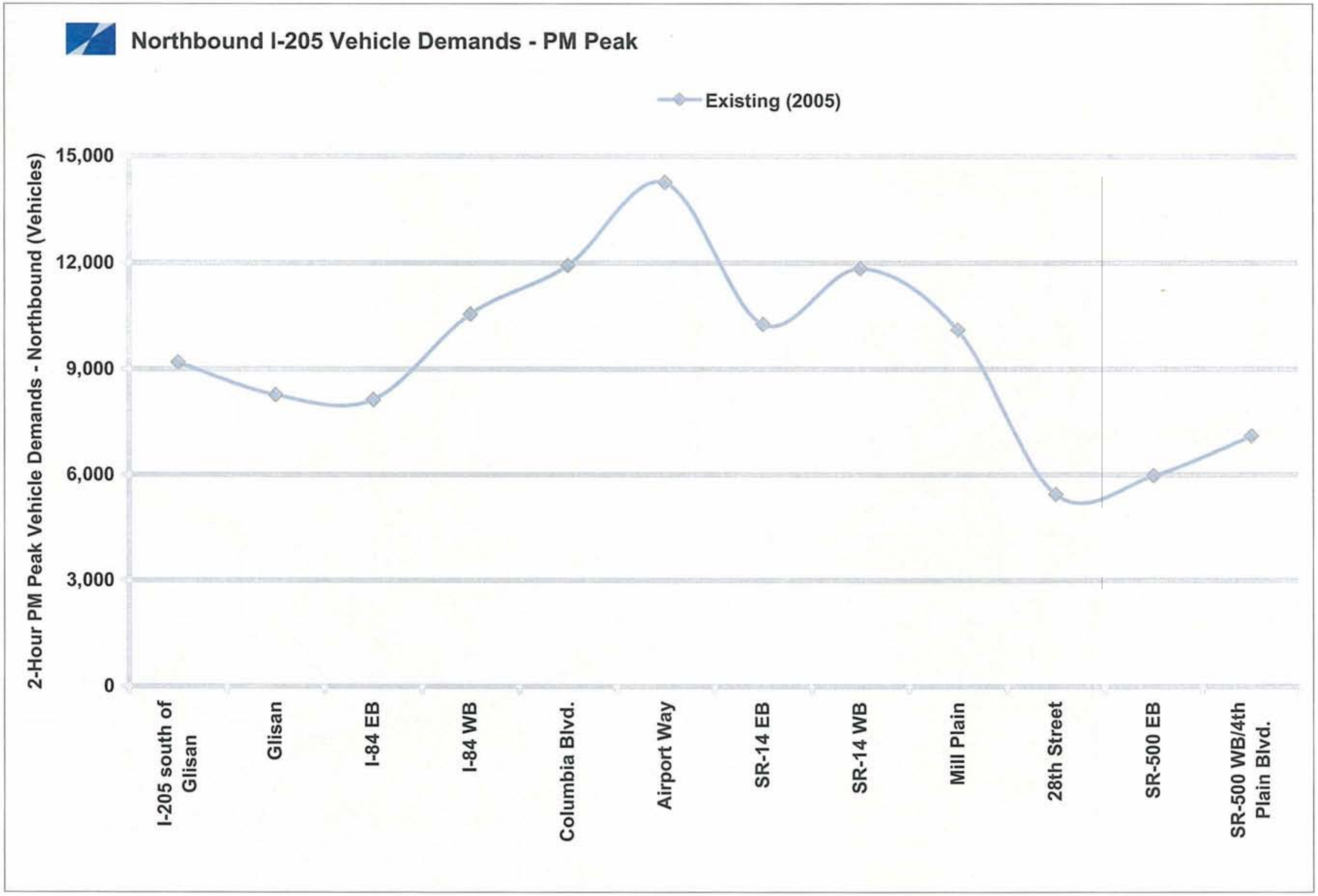

Southbound I-205 Vehicle Demands - PM Peak
Existing (2005)
2-Hour PM Peak Travel Demands - Southbound (Vehicles)
15,000
12,000
9,000
6,000
3,000
0
I-205 north of SR-500
SR-500 WB
SR-500 EB/4th Plain Blvd.
18th Street
Mill Plain WB
Mill Plain EB
SR-14 WB
SR-14 EB
Airport Way WB
Airport Way EB
Columbia Blvd.
I-84 WB
I-84 EB
Glisan Street

Exhibit 5-15



Northbound I-205 Vehicle Demands - PM Peak
Existing (2005)
2-Hour PM Peak Vehicle Demands - Northbound (Vehicles)
15,000
12,000
9,000
6,000
3,000
0
I-205 south of Glisan
Glisan
I-84 EB
I-84 WB
Columbia Blvd.
Airport Way
SR-14 EB
SR-14 WB
Mill Plain
28th Street
SR-500 EB
SR-500 WB/4th Plain Blvd.

Exhibit 5-16

PRELIMINARY

Mid-day (12:00-1:00 PM) Truck Ramp Volumes (% trucks relative to all traffic)

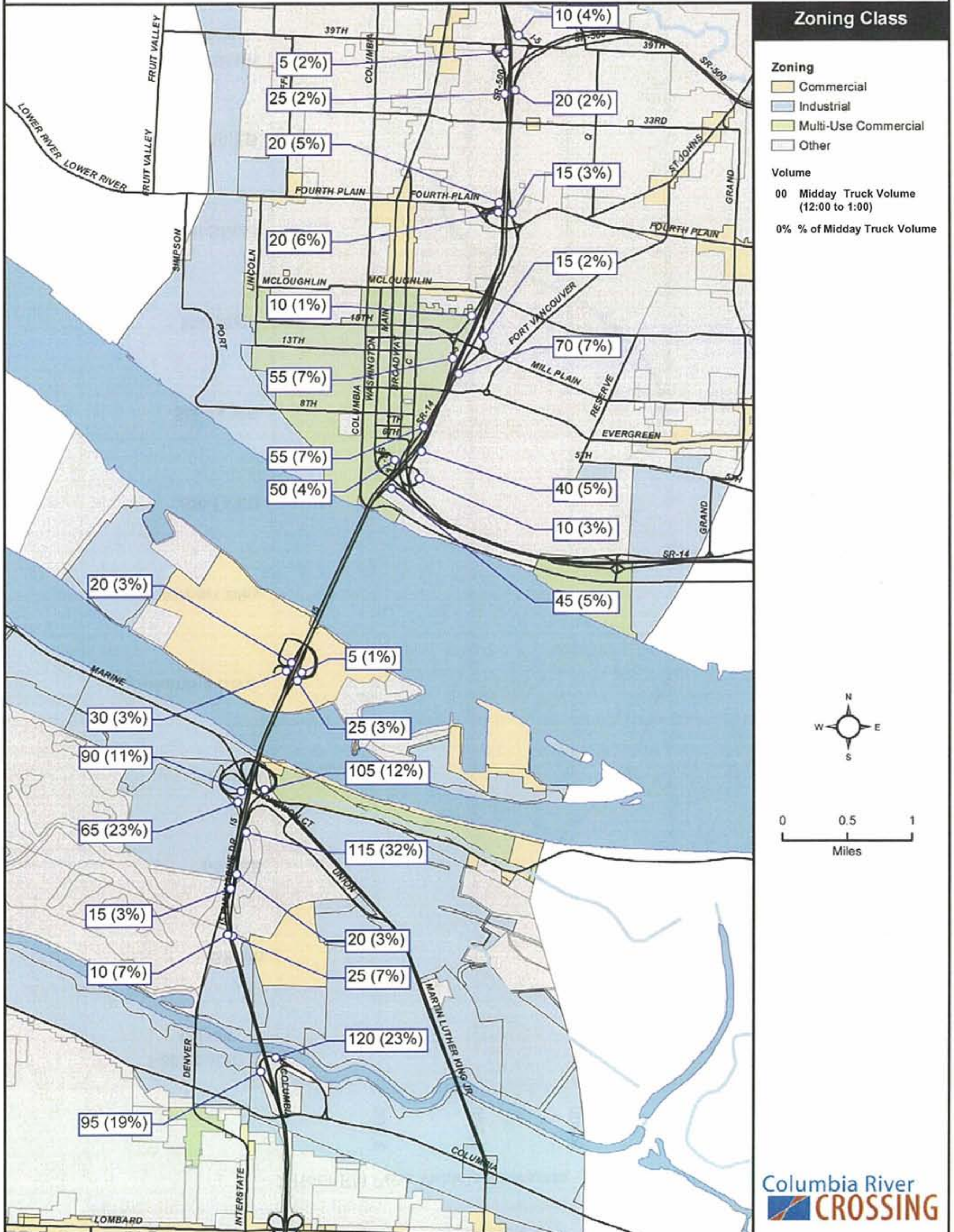


Exhibit 5-17

Portland-Vancouver Region Freight Tonnage by Mode		
	Year 2000 Volume	
Mode	**Tons (millions)**	**Market Share**
Truck	197.2	67%
Rail	32.9	11%
Ocean	28.4	10%
Barge	15.1	5%
Pipeline	22.2	7%
Air	0.4	< 1 percent
TOTAL	**296.2**	**100%**

Source: Portland/Vancouver International and Domestic Trade Capacity Analysis 2006

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Exhibit 5-18


I-5 Corridor - Existing 2005 Conditions Southbound Speed Profiles: 5:00 AM - 9:00 PM
LEGEND
0 - 10 MPH
10 - 20 MPH
20 - 30 MPH
30 - 40 MPH
40 - 50 MPH
> 50 MPH
5:00 - 6:00 AM
6:00 - 7:00 AM
7:00 - 8:00 AM
8:00 - 9:00 AM
9:00 - 10:00 AM
10:00 - 11:00 AM
11:00 AM - 12:00 PM
12:00 - 1:00 PM
1:00 - 2:00 PM
2:00 - 3:00 PM
3:00 - 4:00 PM
4:00 - 5:00 PM
5:00 - 6:00 PM
6:00 - 7:00 PM
7:00 - 8:00 PM
8:00 - 9:00 PM
Pioneer St. OFF
Pioneer St. ON
179th OFF
179th ON
I-205 OFF
134th St. ON
99th St. OFF
99th St. ON
78th St. OFF
78th St. ON
Main St. OFF
Main St. ON
39th St. OFF
39th ON / SR 500 ON
4th Plain OFF
4th Plain ON
Mill Plain OFF
Mill Plain ON
SR 14 OFF
SR-14 / Washington St. ON
Columbia River
Jantzen Beach OFF
Jantzen Beach ON
Marine Drive OFF
Marine Drive ON
Interstate Ave. / Victory OFF
Victory Blvd. ON
Columbia Blvd. ON
Lombard WB ON
Lombard EB ON
Portland Blvd. OFF
Portland Blvd. ON
Alberta / Going St. OFF
Alberta St. ON
Going St. ON
I-405 OFF
Greeley Ave. ON
I-405 ON
Broadway OFF
Weidler ON
I-84 OFF
Morrison St. OFF
I-84 ON
Direction of Travel
5:00 5:15 5:30 5:45 6:00 6:15 6:30 6:45 7:00 7:15 7:30 7:45 8:00 8:15 8:30 8:45 9:00 9:15 9:30 9:45 10:00 10:15 10:30 10:45 11:00 11:15 11:30 11:45 12:00 12:15 12:30 12:45 1:00 1:15 1:30 1:45 2:00 2:15 2:30 2:45 3:00 3:15 3:30 3:45 4:00 4:15 4:30 4:45 5:00 5:15 5:30 5:45 6:00 6:15 6:30 6:45 7:00 7:15 7:30 7:45 8:00 8:15 8:30 8:45

Exhibit 5-19

I-5 Corridor - Existing 2005 Conditions Northbound Speed Profiles: 5:00 AM - 9:00 PM

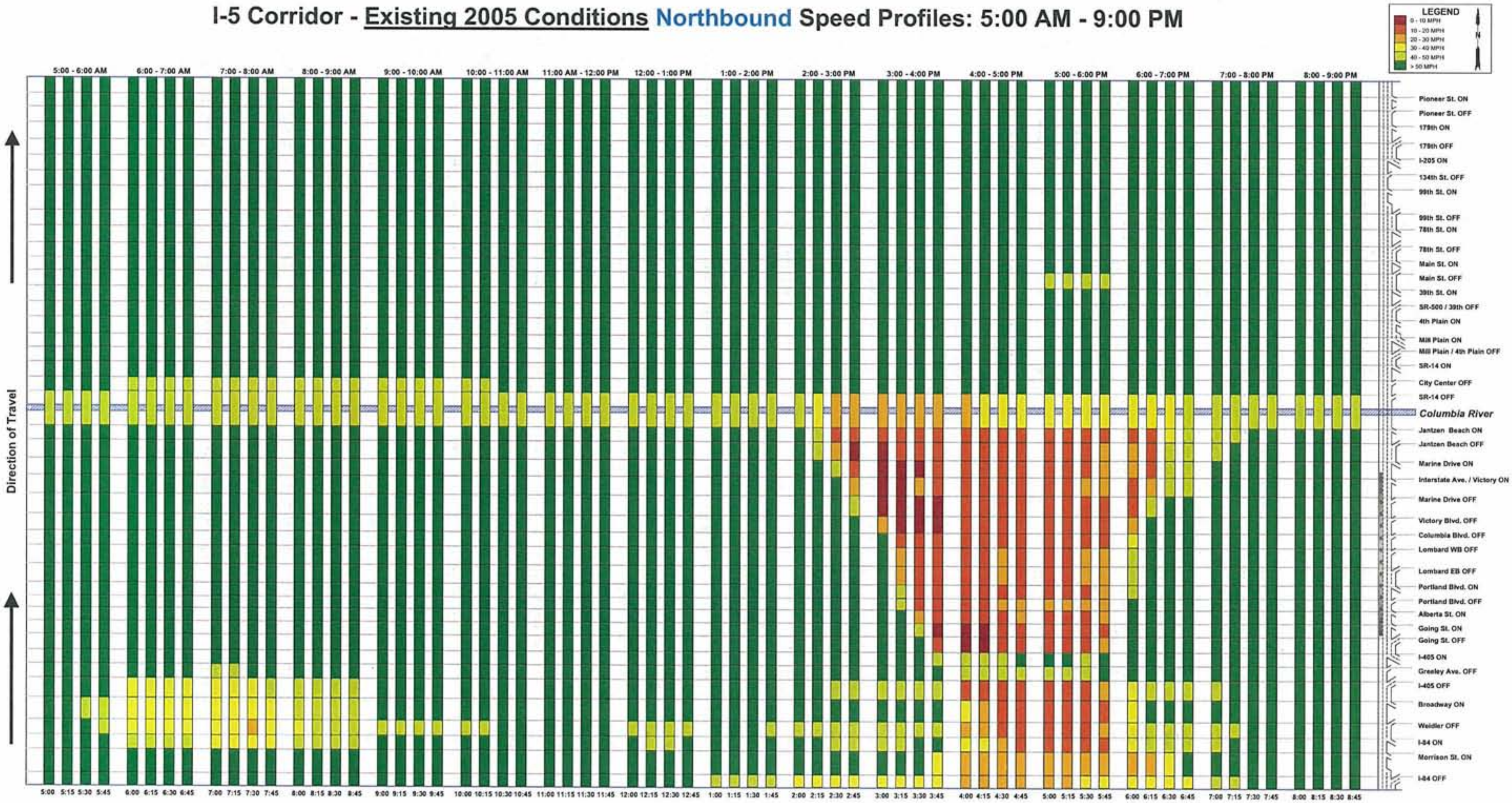


Exhibit 5-20

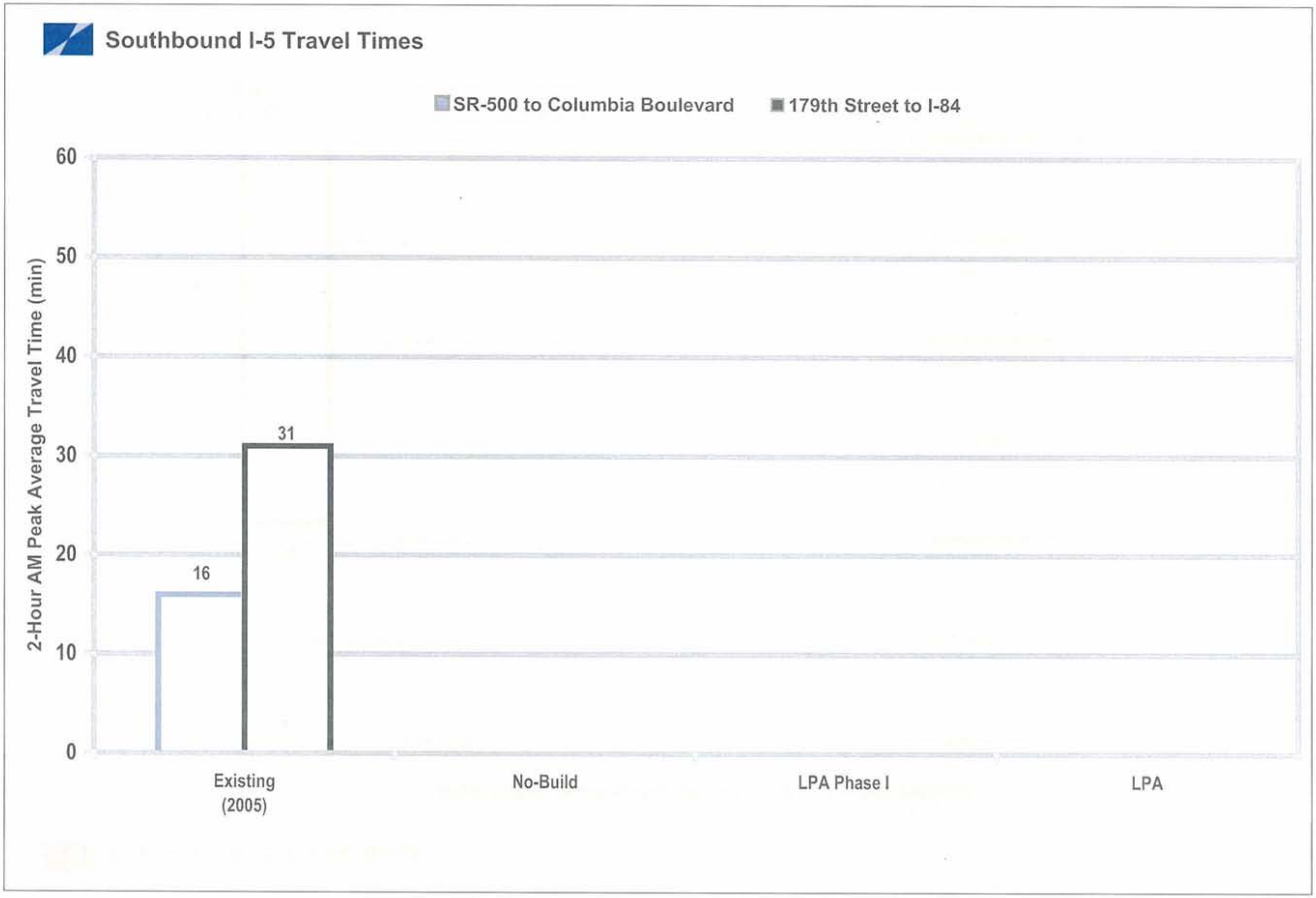
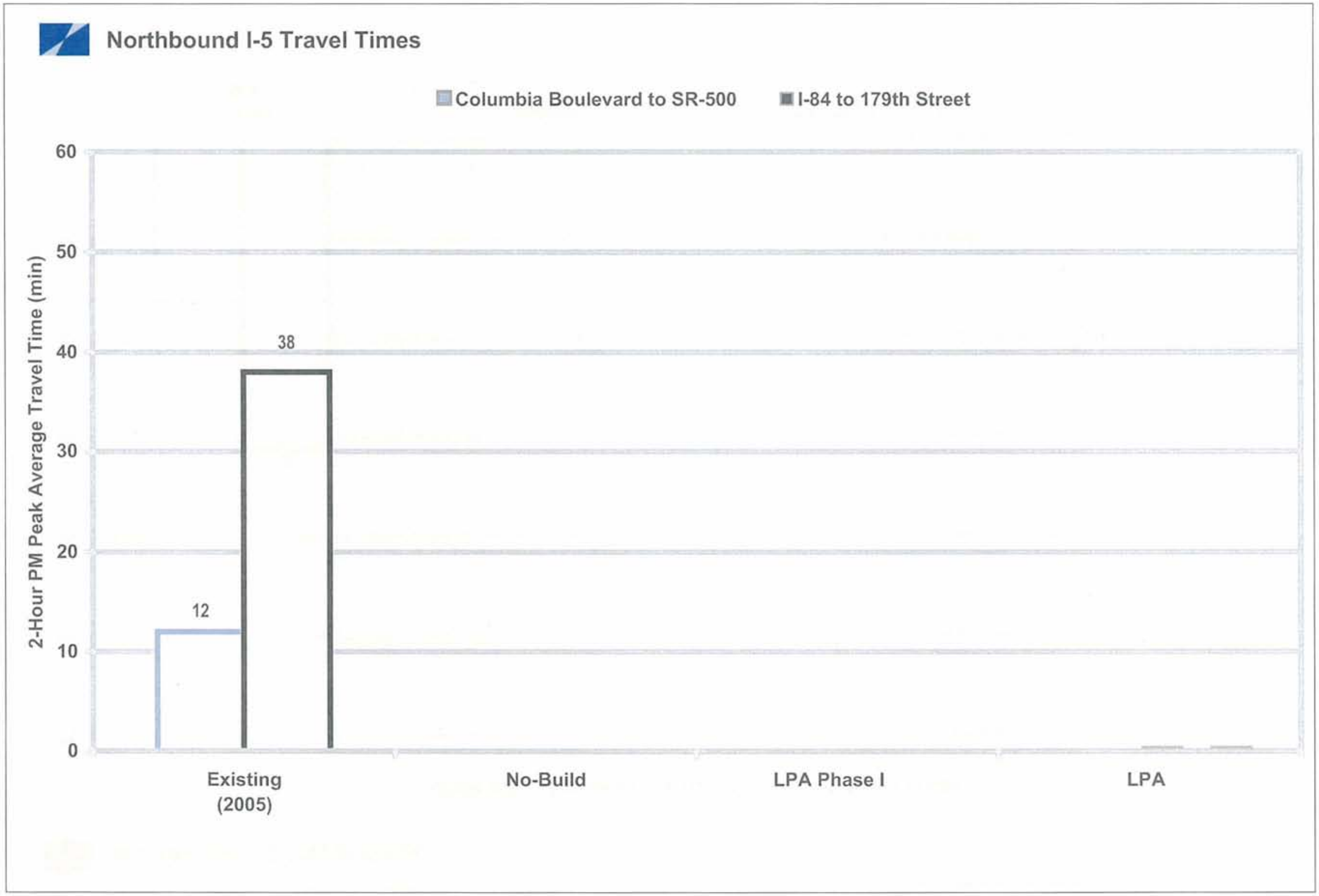

Southbound I-5 Travel Times
SR-500 to Columbia Boulevard
179th Street to I-84
2-Hour AM Peak Average Travel Time (min)
60
50
40
30
20
10
0
16
31
Existing (2005)
No-Build
LPA Phase I
LPA

Exhibit 5-21



Northbound I-5 Travel Times
Columbia Boulevard to SR-500
I-84 to 179th Street
2-Hour PM Peak Average Travel Time (min)
60
50
40
30
20
10
0
38
12
Existing (2005)
No-Build
LPA Phase I
LPA

Exhibit 5-22

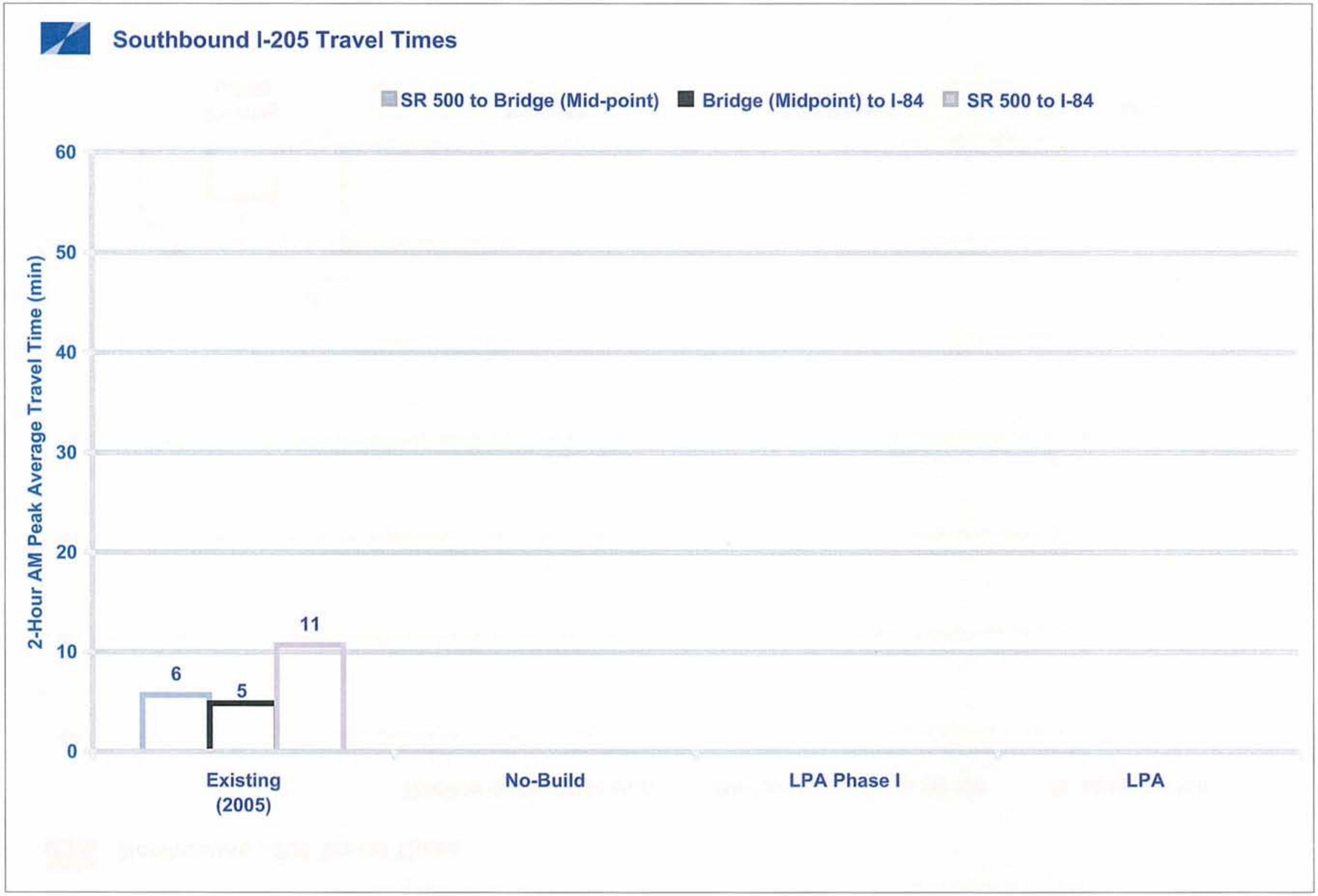
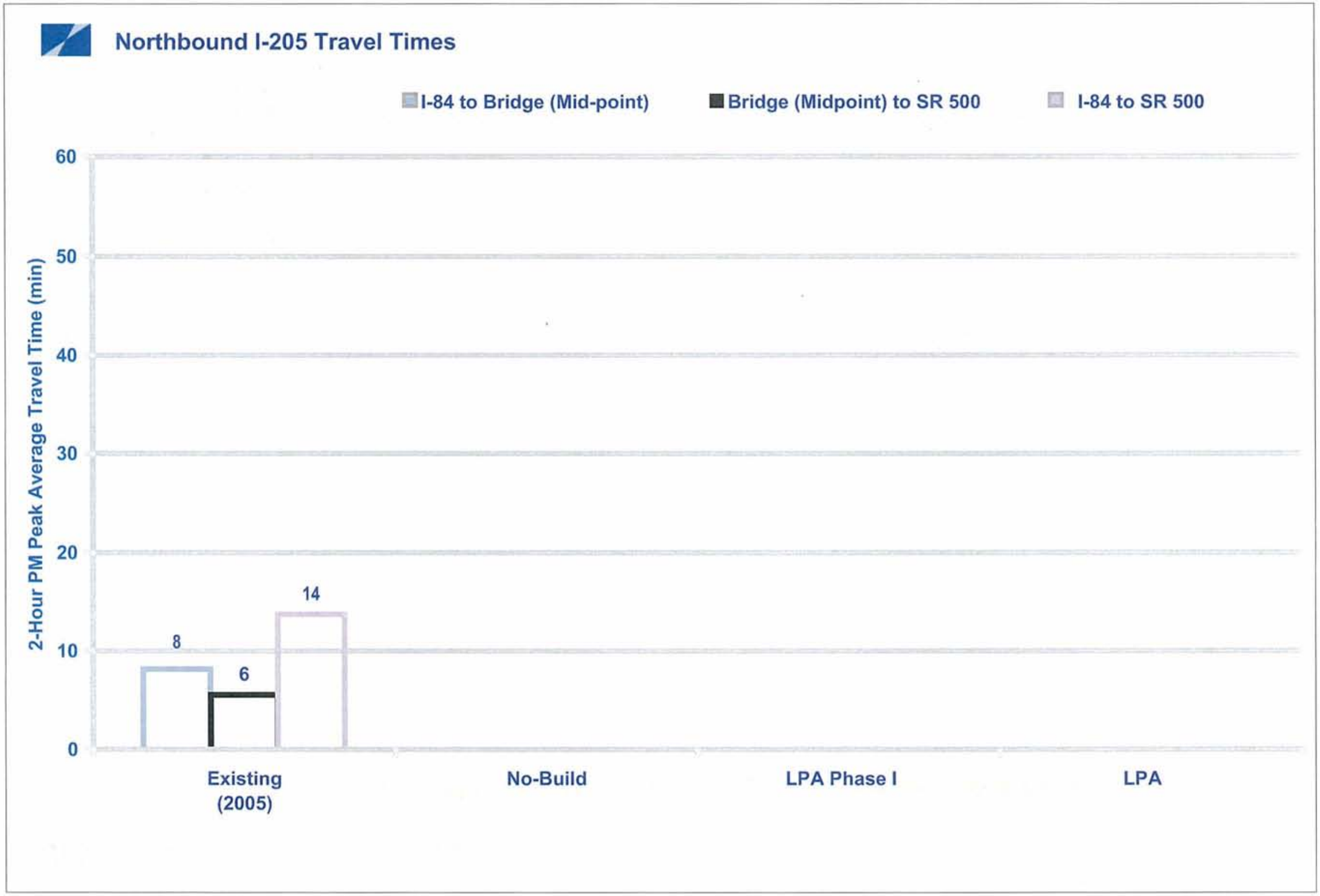
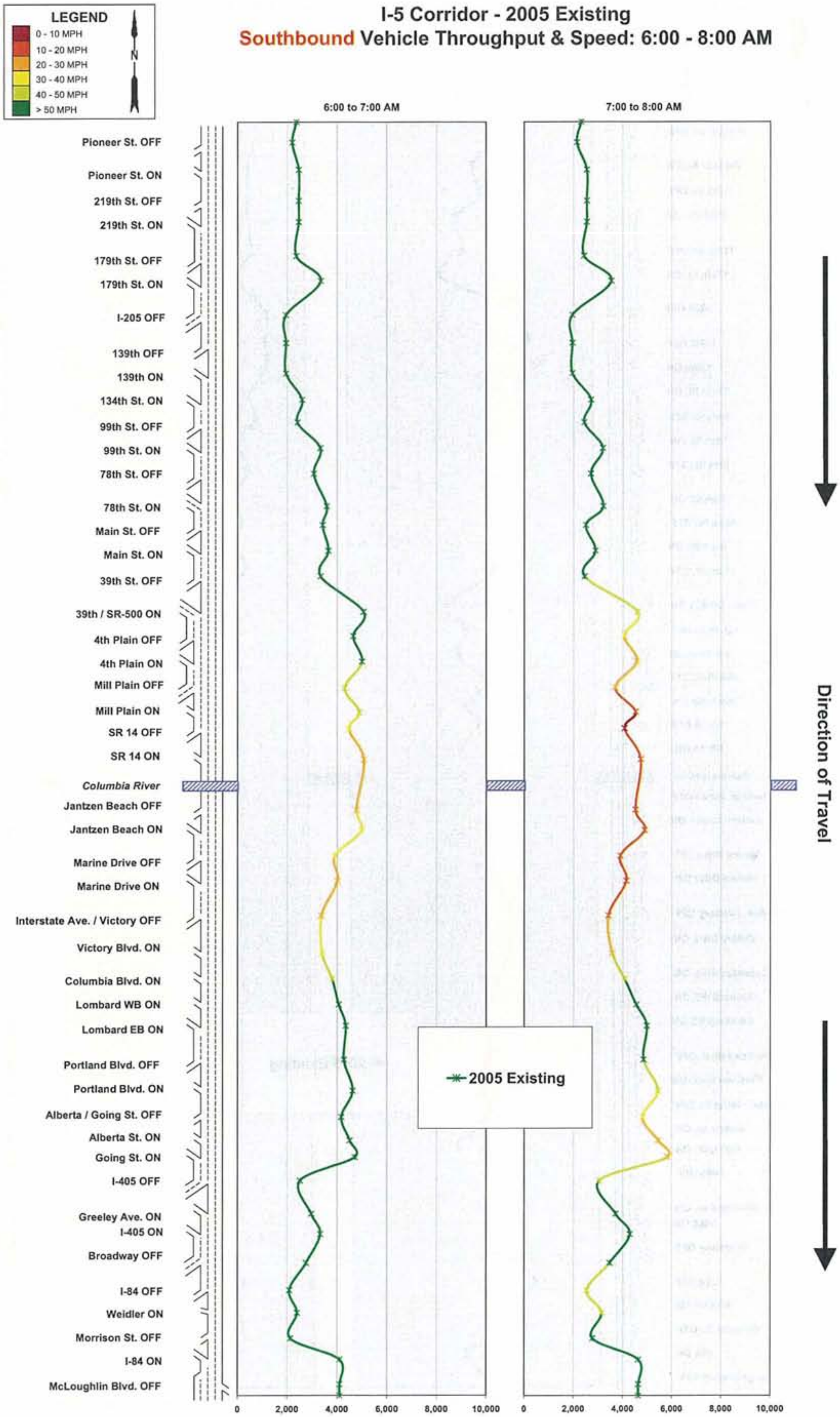

Southbound I-205 Travel Times
SR 500 to Bridge (Mid-point)
Bridge (Midpoint) to I-84
SR 500 to I-84
2-Hour AM Peak Average Travel Time (min)
60
50
40
30
20
10
0
6
5
11
Existing (2005)
No-Build
LPA Phase I
LPA

Exhibit 5-23



Northbound I-205 Travel Times
I-84 to Bridge (Mid-point)
Bridge (Midpoint) to SR 500
I-84 to SR 500
2-Hour PM Peak Average Travel Time (min)
60
50
40
30
20
10
0
8
6
14
Existing (2005)
No-Build
LPA Phase I
LPA

Exhibit 5-24



Continued on next page

Exhibit 5-24 - Continued

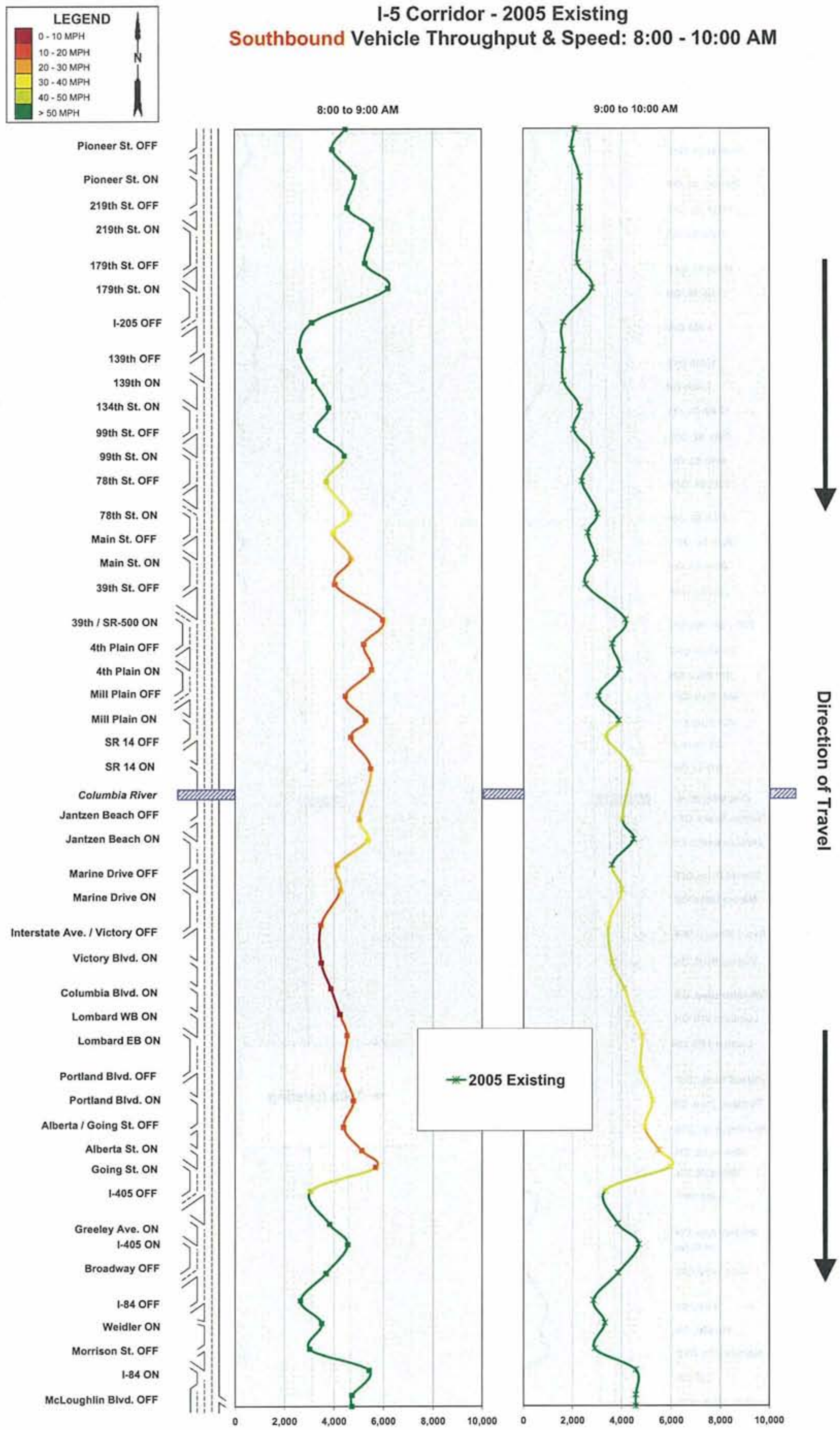
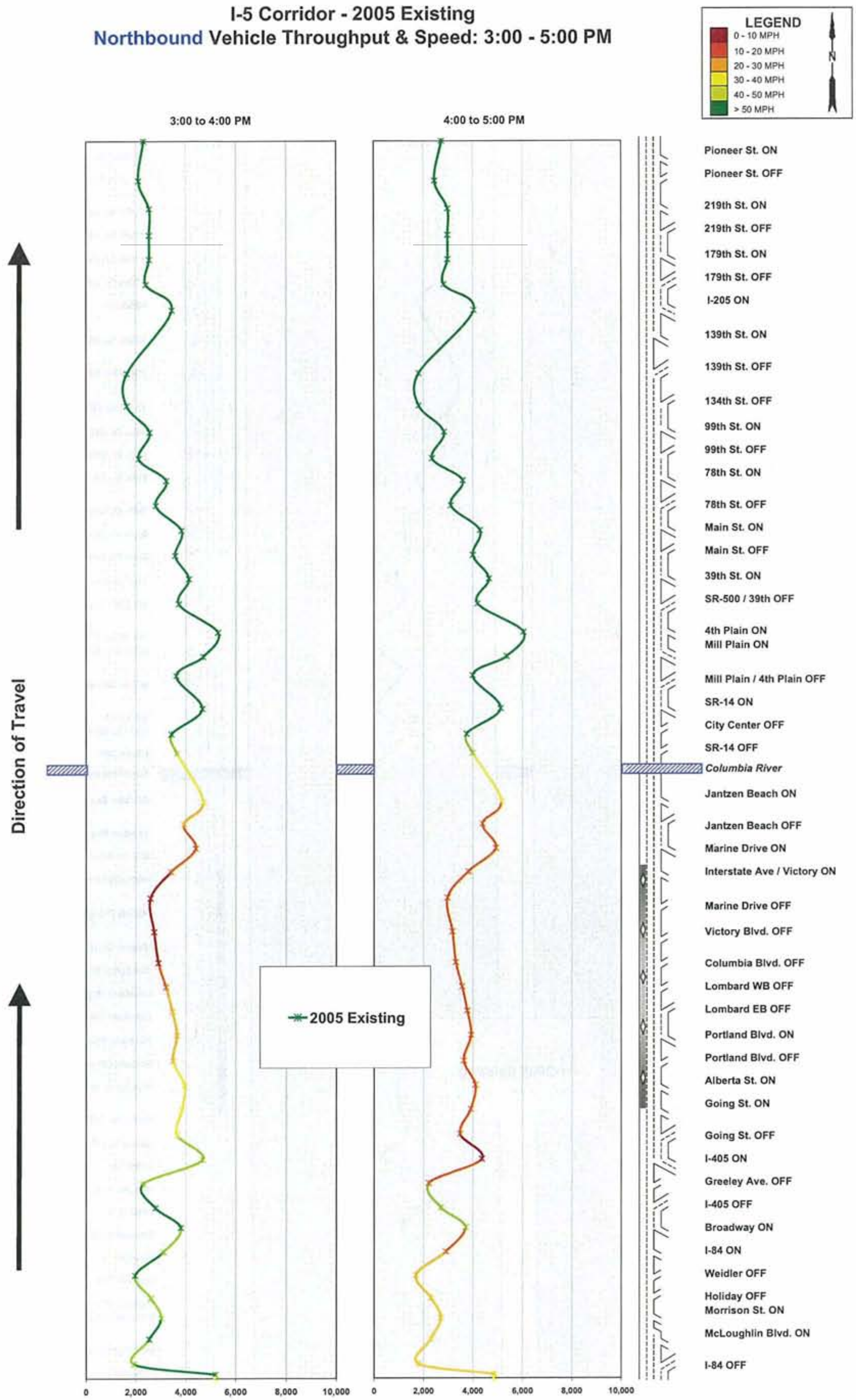


Exhibit 5-25



Continued on next page

Exhibit 5-25 - Continued

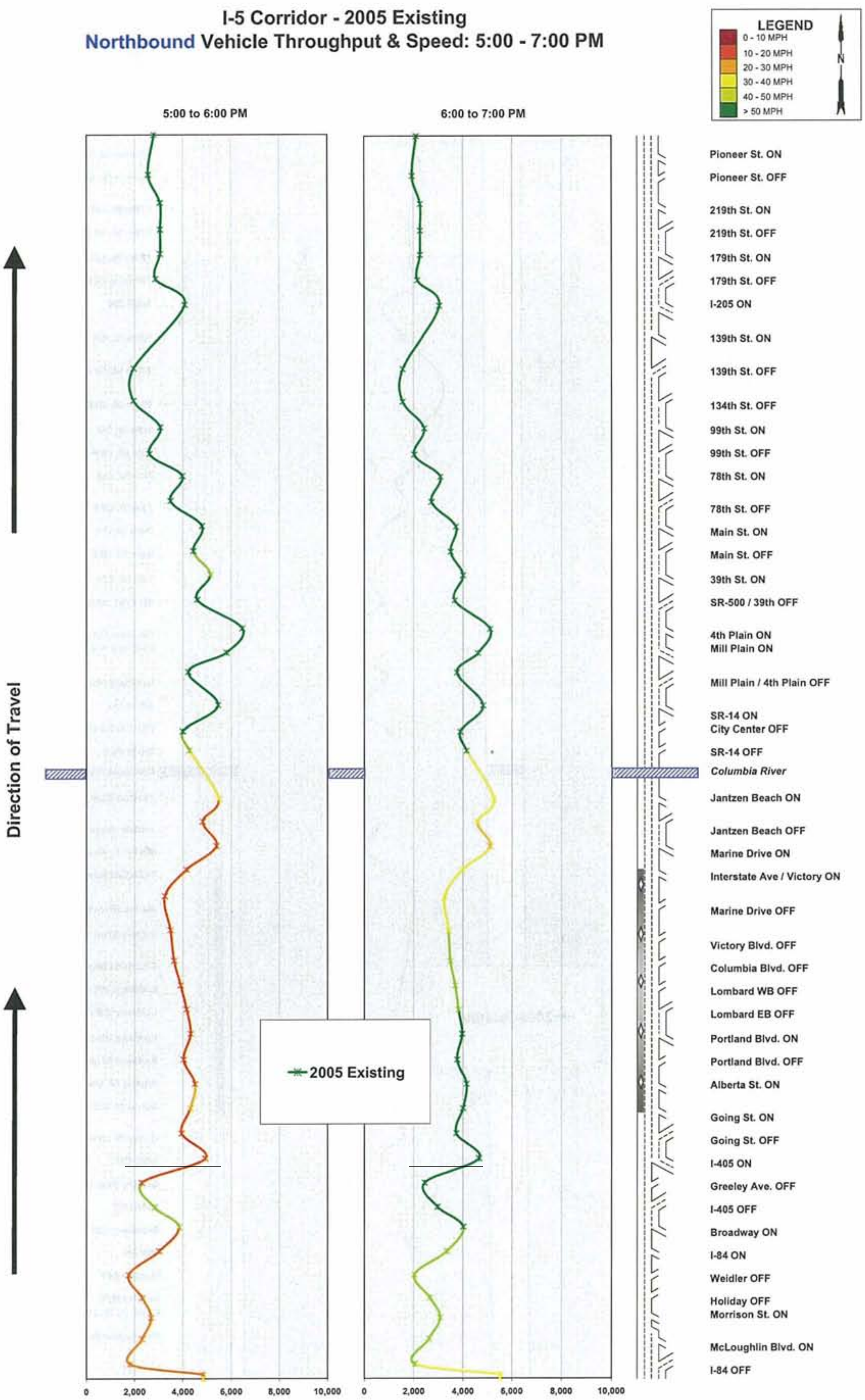
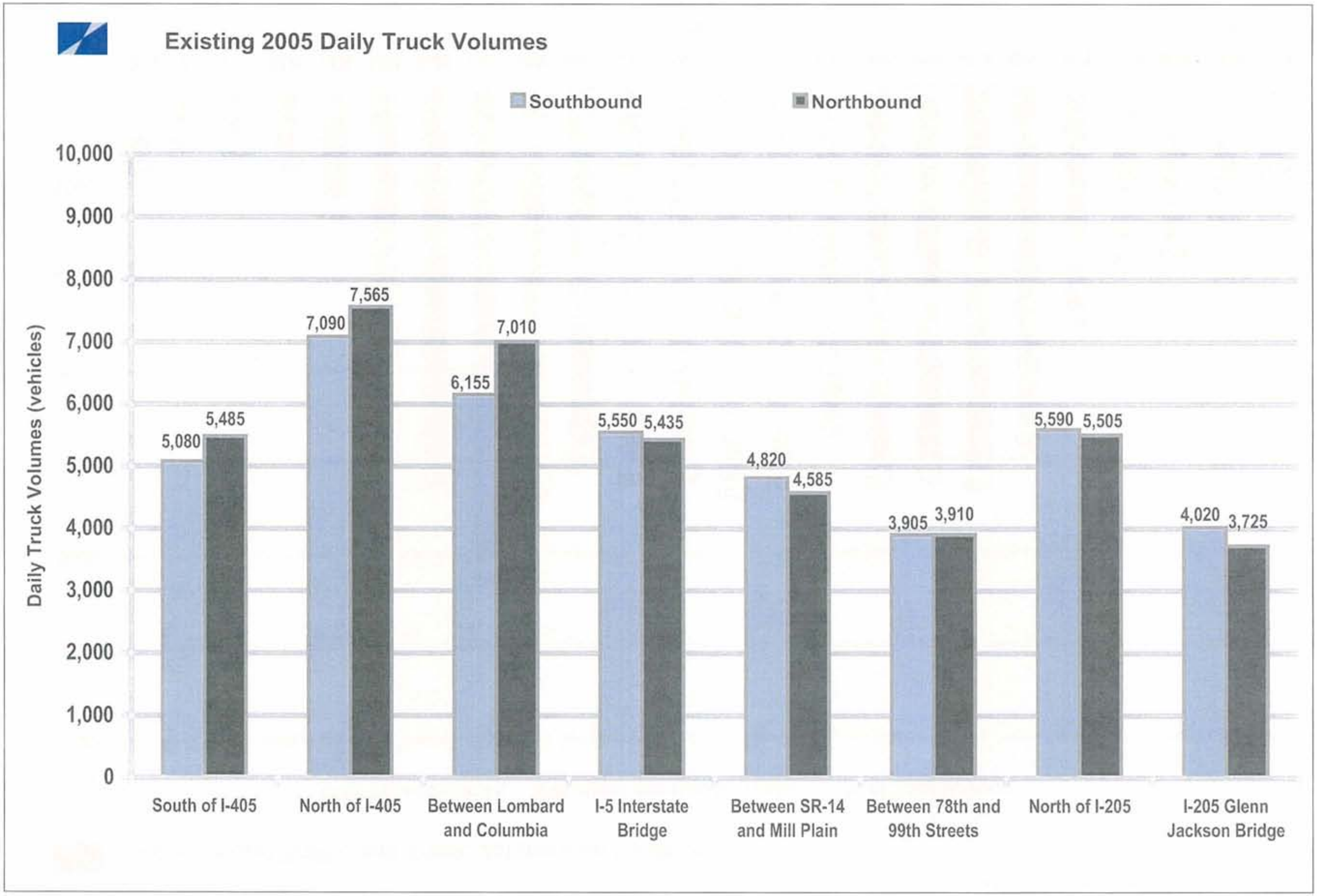


Exhibit 5-26


Existing 2005 Daily Truck Volumes
Southbound
Northbound
Daily Truck Volumes (vehicles)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
5,080
5,485
7,090
7,565
6,155
7,010
5,550
5,435
4,820
4,585
3,905
3,910
5,590
5,505
4,020
3,725
South of I-405
North of I-405
Between Lombard and Columbia
I-5 Interstate Bridge
Between SR-14 and Mill Plain
Between 78th and 99th Streets
North of I-205
I-205 Glenn Jackson Bridge

PRELIMINARY

Exhibit 5-27

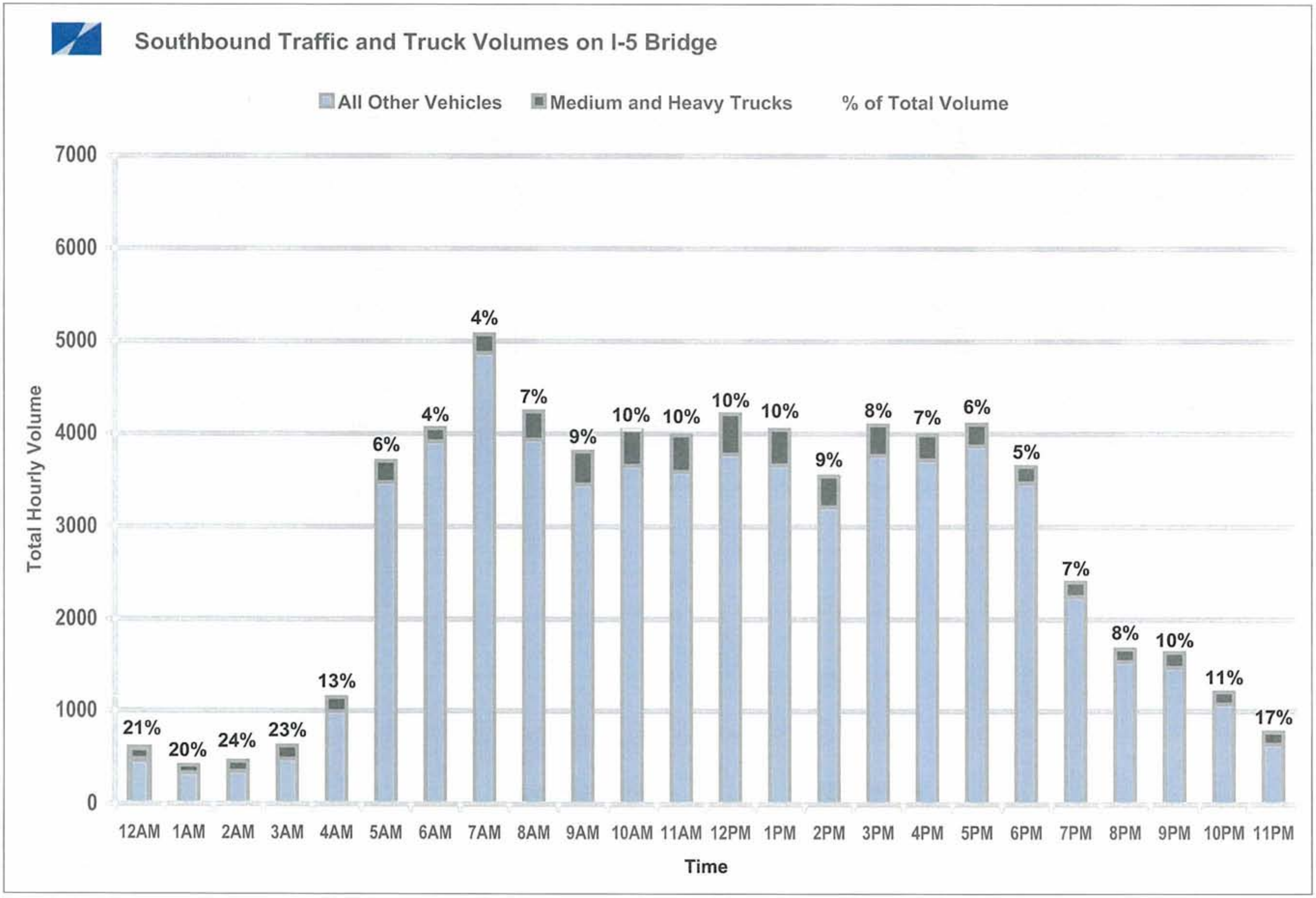


Exhibit 5-28

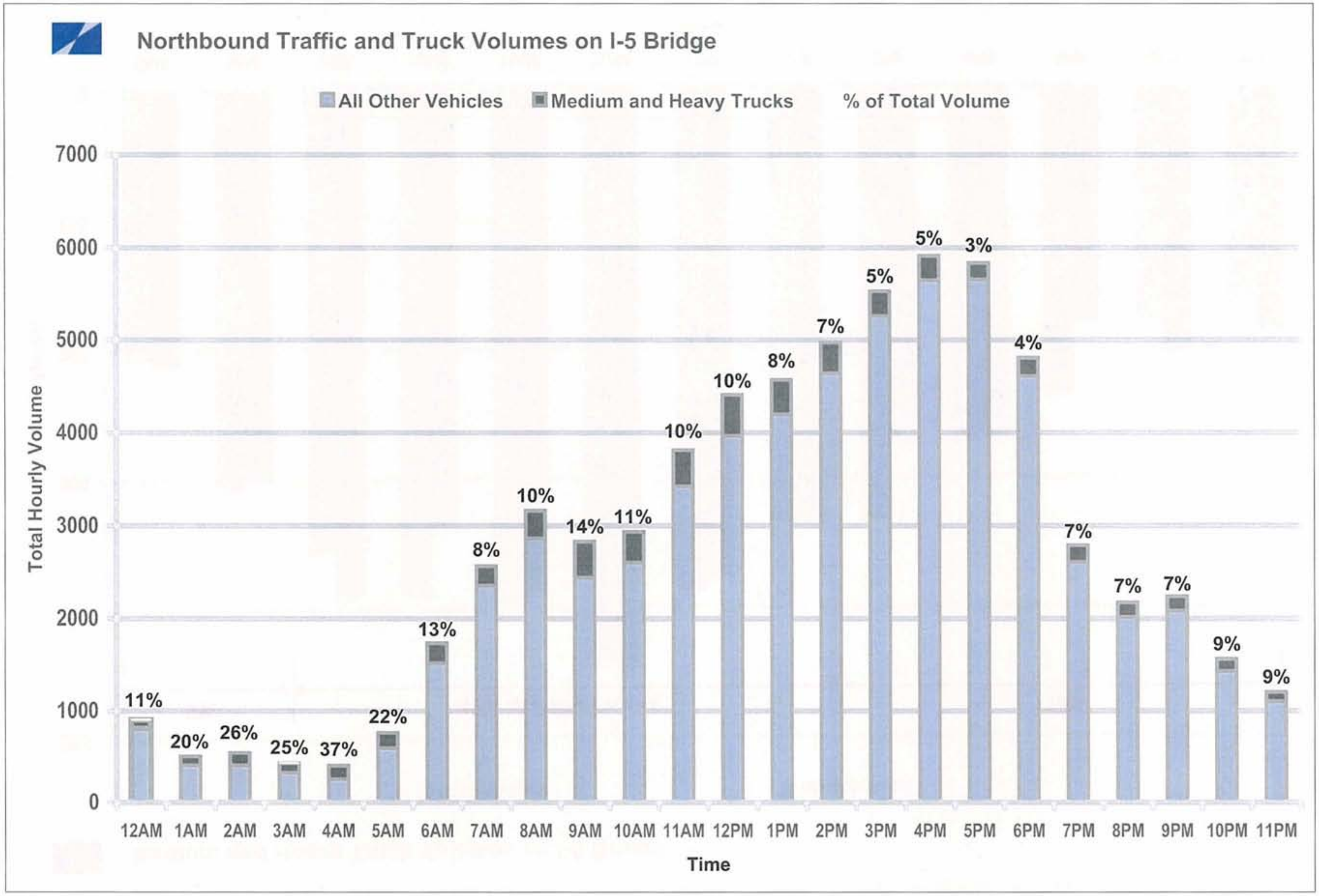
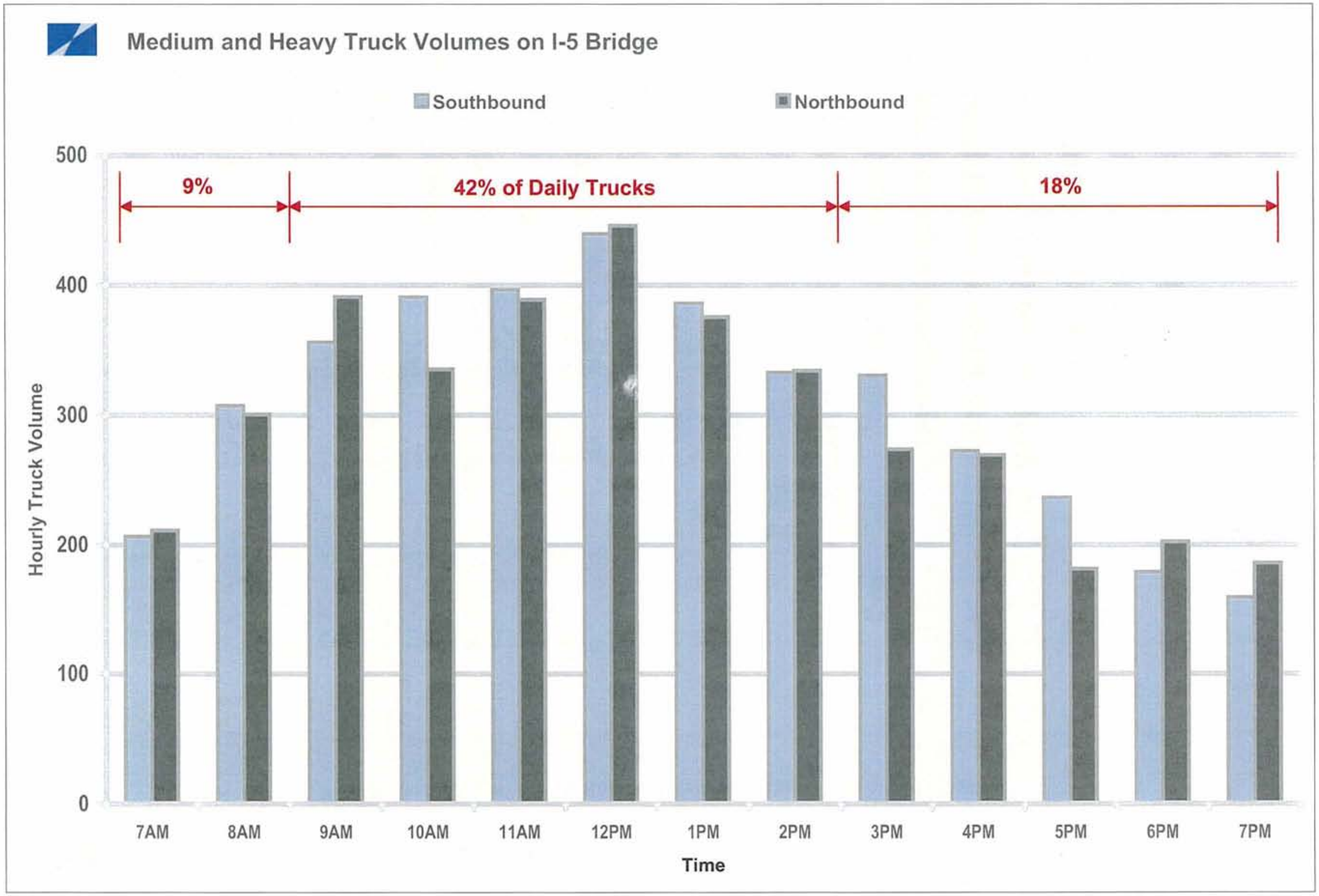

Northbound Traffic and Truck Volumes on I-5 Bridge
All Other Vehicles
Medium and Heavy Trucks
% of Total Volume
Total Hourly Volume
0
1000
2000
3000
4000
5000
6000
7000
11%
20%
26%
25%
37%
22%
13%
8%
10%
14%
11%
10%
10%
8%
7%
5%
5%
3%
4%
7%
7%
7%
9%
9%
12AM 1AM 2AM 3AM 4AM 5AM 6AM 7AM 8AM 9AM 10AM 11AM 12PM 1PM 2PM 3PM 4PM 5PM 6PM 7PM 8PM 9PM 10PM 11PM
Time

Exhibit 5-29


Medium and Heavy Truck Volumes on I-5 Bridge
Southbound
Northbound
9%
42% of Daily Trucks
18%
500
400
300
200
100
0
Hourly Truck Volume
7AM
8AM
9AM
10AM
11AM
12PM
1PM
2PM
3PM
4PM
5PM
6PM
7PM
Time