Lake Oswego to Portland Transit Project

Hydrology and Water Quality Technical Report

November, 2010

TriMet and Metro

Melanie Gualotunia, David Evans and Associates, Inc. and Emily Whiteman, URS

The preparation of this report was financed in part by the U.S. Department of Transportation, Federal Transit Administration. The opinions, findings and conclusions expressed in this report are not necessarily those of the U.S. Department of Transportation, Federal Transit Administration.

TABLE OF CONTENTS

1. Introduction ... 1
1.1 Project Background ... 1
1.2 Purpose and Need ... 1
1.3 Alternatives/Options Considered ... 2
1.3.1 Alternatives Analysis ... 2
1.3.2 Scoping/Project Refinement Study ... 3
1.4 Description of Alternatives Analyzed in this Technical Report and the DEIS ... 4
1.4.1 No-Build Alternative ... 4
1.4.1.1 Capital Improvements ... 4
1.4.1.2 Transit Operations ... 10
1.4.2 Enhanced Bus Alternative ... 11
1.4.2.1 Capital Improvements ... 11
1.4.2.2 Transit Operations ... 12
1.4.3 Streetcar Alternative ... 14
1.4.3.1 Capital Improvements ... 14
1.4.3.2 Transit Operations ... 24
1.4.3.3 Construction Phasing Options ... 24
2. Related Laws and Regulations ... 27
2.1 Hydrology ... 29
2.2 Floodplains ... 29
2.3 Water Quality ... 30
3. Affected Environment ... 32
3.1 Hydrology ... 33
3.1.1 Willamette River ... 35
3.1.2 Tryon Creek ... 37
3.1.3 Stephens Creek ... 37
3.2 Floodplains ... 37
3.2.1 Willamette River ... 37
3.2.2 Tryon Creek ... 37
3.2.3 Stephens Creek ... 38
3.3 Water Quality ... 38
3.3.1 Willamette River ... 38
3.3.2 Tryon Creek ... 40
3.3.3 Stephens Creek ... 41
4. Environmental Consequences ... 43
4.1 Direct Impacts ... 43
4.1.1 Impact Overview ... 43
4.1.2 Direct Effects to Hydrology ... 44
4.1.2.1 No-Build Alternative ... 45
4.1.2.2 Enhanced Bus Alternative ... 45
4.1.2.3 Streetcar Alternative ... 46
Willamette River Basin ... 46
Tryon Creek Subbasin ... 47
Stephens Creek Subbasin ... 47
4.1.2.4 Summary of Direct Hydrologic Impacts ... 48
4.1.3 Direct Effects to Floodplains ... 48

4.1.3.1 No-Build Alternative 48
4.1.3.2 Enhanced Bus Alternative 48
4.1.3.3 Streetcar Alternative 48
4.1.3.4 Summary of Direct Effects to Floodplains 49
4.1.4 Direct Effects to Water Quality 49
4.1.4.1 No-Build Alternative 50
4.1.4.2 Enhanced Bus Alternative 50
4.1.4.3Streetcar Alternative 51
4.1.4.4 Summary of Direct Water Quality Impacts 54
4.1.4 Summary of Direct Impacts 54
4.2 Short-Term Impacts 55
4.2.1 Impact Overview 55
4.2.2 Hydrology 56
4.2.2.1 No-Build Alternative 56
4.2.2.2 Enhanced Bus Alternative 56
4.2.2.3 Streetcar Alternative 56
4.2.3 Floodplains 56
4.2.3.1 No-Build Alternative 56
4.2.3.2 Enhanced Bus Alternative 57
4.2.3.3 Streetcar Alternative 57
4.2.4 Water Quality 57
4.2.4.1 No Build Alternative 57
4.2.4.2 Enhanced Bus Alternative 57
4.2.4.3 Streetcar Alternative 57
4.2.5 Summary of Short-Term Impacts 57
4.3 Indirect and Cumulative Impacts 58
5. Potential Mitigation Measures 60
5.1 Mitigation for Long-Term Effects 60
5.2 Mitigation for Short-Term Effects 61
6. References 62
7. List of Preparers 64

Appendices

Appendix A List of Abbreviations
Appendix B Methods and Data
Appendix C Water Quality Calculations

List of Tables

Table 1-1 Transit Capital Improvements for the No-Build, Enhanced Bus, and Streetcar Alternatives (2035) 6
Table 1-2 Streetcar and Bus Network Operating Characteristics of No-Build, Enhanced Bus, and Streetcar[1] Alternatives (2035) 7
Table 2-1 Summary of Local Regulations Affecting Hydrology, Floodplains, and Water Quality ... 27
Table 2-2 Typical Sources and Problems Associated with Urban Stormwater Pollutants 31
Table 3-1 Percent Impervious Area by Land Use 33
Table 3-2 Existing Impervious Surface Area by Basin[1] 33

Table 3-3 Estimated Average Flows for Project Area Streams 35
Table 3-4 303(d) 2004/2006 Listed Reaches[1] within Project Area 38
Table 3-5 Lower Willamette River Water Quality 39
Table 3-6 Calculated Existing Once-in-Three-Year Total Pollutant Concentration Exceedance and Existing Annual Mass Loadings for the Willamette River Basin... 39
Table 3-7 Calculated Existing Once-in-Three-Year Total Pollutant Concentration Exceedance and Existing Annual Mass Loadings for the Tryon Creek Watershed 41
Table 3-8 Calculated Existing Once-in-Three-Year Total Pollutant Concentration Exceedance and Existing Annual Mass Loadings for the Stephens Creek Watershed 42
Table 4-1 Impact Intensity Threshold Criteria... 43
Table 4-2 Net New Impervious Surface Area in acres, by Basin and Alternative 44
Table 4-3 Floodplain Effects, by Alternative 49
Table 4-4 Change in Once-in-Three-Year Total Pollutant Concentration Exceedance and Annual Loadings in the Willamette River without Mitigation (Enhanced Bus Alternative) 51
Table 4-5 Change in Once-in-Three-Year Total Pollutant Concentration Exceedance in the Willamette River without Mitigation (Streetcar Alternative).. 52
Table 4-6 Change in Annual Loadings to the Willamette River without Mitigation (Streetcar Alternative) 52
Table 4-7 Change in Once-in-Three-Year Total Pollutant Concentration Exceedance and Annual Loadings in Tryon Creek without Mitigation (Streetcar Alternative) 53
Table 4-8 Change in Once-in-three-year Total Pollutant Concentration Exceedance and Annual Loadings in Stephens Creek without Mitigation (Streetcar Alternative)... 53
Table 4-9 Summary of Direct Impacts to Water Resources by Alternative 55
Table 4-10 Summary of Short-term Effects to Water Resources, by Alternative 58

List of Figures

Figure 1-1 No-Build Alternative Transportation Network and Facilities... 8
Figure 1-2 Enhanced Bus Alternative Transportation Network 13
Figure 1-3 Streetcar Alternative Transportation Network 16
Figure 1-4 Streetcar Alternative Design Option Locations 19
Figure 1-5 Streetcar and Enhanced Bus Alternatives and Design Options 21
Figure 1-6 Streetcar Alternative Design Option Details... 22
Figure 3-1 Project Study area Water Features 34
Figure 3-2 Project waterway Crossings 36

1. INTRODUCTION

This report contains the detailed analysis and documentation that is the basis for Chapter 3, Section 3.9 on hydrology and water quality in the Lake Oswego to Portland Transit Project (LOPT) Draft Environmental Impact Statement (DEIS) published by the Federal Transit Administration in December 2010. This chapter of the report includes a summary of the project background, the Purpose and Need, the alternatives/options considered and the description of the alternatives analyzed.

1.1 Project Background

Transit improvements in the Lake Oswego to Portland corridor have been studied several times in recent history. In the 1970s and 80s, a light rail alignment through Johns Landing was studied as part of the Westside Corridor Alternatives Analysis, and in the 1990s potential light rail alignments through Johns Landing were studied as part of the South/North Corridor Study.

The Willamette Shore Line right of way was first established in 1885-1887 as the Portland and Willamette Valley Railroad, which began operation in July 1887. The Southern Pacific Railroad (SPRR) later purchased the railway in 1914. The railroad had a major impact on the development of southwest Portland. Initially, 14 trains operated between Portland and Oswego (as it then was known), and it became the main transportation link for developing residential communities along the route. The line was electrified in 1914 and passenger traffic hit its peak in 1920 with SPRR running 64 daily trains between Portland and Oswego. Passenger service ended on October 5, 1929, while freight service continued until 1983.

In August of 1984, the Interstate Commerce Commission granted SPRR permission to abandon the line. In 1988, the Willamette Shore Line Consortium (the Consortium) purchased the 6.3-mile-long line from SPRR for approximately $2 million. The Consortium, comprised of the City of Lake Oswego, City of Portland, Oregon Department of Transportation (ODOT), Clackamas County, Multnomah County, Metro, and TriMet, purchased the line to preserve it for future passenger rail transit use. TriMet holds title for the Consortium and the City of Lake Oswego provides maintenance services funded by the Consortium.

In 2005, with the endorsement of the Joint Policy Advisory Committee on Transportation, the Metro Council directed staff to initiate the Lake Oswego to Portland Transit and Trail Alternatives Analysis. The alternatives analysis focused on improving the ability to serve travel demand in the corridor through improved transit service and development of a multi-use pathway.

1.2 Purpose and Need

The **Purpose** of the project is to optimize the regional transit system by improving transit within the Lake Oswego to Portland transit corridor, while being fiscally responsive and supporting regional and local land use goals. The project should maximize, to the extent possible, regional resources and economic development opportunities, and garner broad public support. The project should build on previous corridor transit studies, analyses, and conclusions and should be environmentally sensitive.

The **Need** for the project results from:

- Historic and projected increases in traffic congestion in the Lake Oswego to Portland corridor due to increases in regional and corridor population and employment;
- Lengthy and increasing transit travel times and deteriorating public transportation reliability in the corridor due to growing traffic congestion;
- Increasing operating expenses, combined with increasingly scarce operating resources and the demand for more efficient public transportation operations;
- Local and regional land use and development plans, goals, and objectives that target the corridor for residential, commercial, retail, and mixed-use development to help accommodate forecast regional population and employment growth, and previous corridor transit studies, analyses, and conclusions;
- The region's growing reliance on public transportation to meet future growth in travel demand in the corridor;
- The topographic, geographic, and built-environment constraints within the corridor that limit the ability of the region to expand the highway and arterial infrastructure in the corridor; and
- Limited options for transportation improvements in the corridor caused by the identification and protection of important natural, built, and socioeconomic environmental resources in the corridor.

1.3 Alternatives/Options Considered

Metro's 2004 Regional Transportation Plan (RTP) identified the need for a refinement plan for a high capacity transit option for the corridor, which included an analysis of several modal alternatives. Metro initiated the corridor refinement plan in July 2005 and issued the *Lake Oswego to Portland Transit and Trail Alternatives Analysis Evaluation Summary Public Review Draft* in June 2007.

On December 13, 2007, after reviewing and considering the alternatives analysis report, public comment, and recommendations from the Lake Oswego to Portland Transit and Trail Project Citizen Advisory Committee (CAC), the Lake Oswego to Portland Transit and Trail Project Management Group (PMG), Steering Committee, and partner jurisdictions and agencies, the Metro Council approved Resolution No. 07-3887A. The resolution adopted the *Lake Oswego to Portland Transit and Trail Alternatives Analysis: Alternatives to be Advanced into a Draft Environmental Impact Statement and Work Program Considerations* (December 13, 2007). (See Section 2.1 for additional detail on the process used to identify and narrow alternatives.) It also selected the No-Build, Enhanced Bus, and Streetcar alternatives to advance into the project's DEIS for further study, and directed staff to conduct a refinement study to identify design options in the Johns Landing Area and terminus options to advance into the project's DEIS. The resolution called for further refinement of the trail component to move forward as a separate process.

1.3.1 Alternatives Analysis

The project's alternatives analysis process developed a wide range of alternatives for evaluation and early screening, which included: a no-build alternative, widening of Highway 43, reversible lanes on Highway 43, river transit (three options), bus rapid transit (BRT) (three options); commuter rail, light rail, and streetcar (a wide range of alignment alternatives and terminus alternatives and options).

Through a screening process that assessed the ability of the alternatives to meet the project's Purpose and Need, the initial range of possible alternatives was narrowed. Appendix C of the DEIS provides a summary of the technical evaluation of the alternatives and options considered during the alternatives analysis phase.

The following alternatives were selected for further study through the alternatives analysis phase: 1) No-Build Alternative, 2) Bus Rapid Transit Alternative, and 3) Streetcar Alternative. Following is a description of those alternatives as they were studied in the alternatives analysis (see the *Lake Oswego to Portland Transit and Trail Study Evaluation Summary Public Review Draft* for more information).

- **No-Build Alternative.** Similar to the project's current No-Build Alternative, as described in Section 1.4.1.

- **Bus Rapid Transit Alternative.** The Bus Rapid Transit Alternative would operate frequent bus service with Line 35 on Highway 43 between downtown Portland and downtown Lake Oswego, generally in mixed traffic, with bus station spacing that would be longer than TriMet typically provides for fixed-route bus service. Transit queue bypass lanes would be constructed at congested intersections, where feasible.

- **Streetcar Alternative.** The Streetcar Alternative would extend the existing Portland Streetcar line, which currently operates between NW 23rd Avenue and SW Lowell Street, to downtown Lake Oswego. Study of this alternative includes an evaluation of whether the Willamette Shore Line right of wayright of way would be used exclusively of whether it would be used in combination with SW Macadam Avenue or other adjacent roadways.

1.3.2 Scoping/Project Refinement Study

This section describes the alignment and terminus options developed, evaluated, and screened in 2009 as a part of the project's scoping and refinement study phase. In November 2010, Metro published the *Lake Oswego to Portland Transit Project Refinement Report*, which detailed the study's results and summarized public comment. This phase focused on refinements in two areas: 1) alignment options for the Johns Landing area; and 2) terminus options in the Lake Oswego area. In summary, the project's Purpose Statement during the refinement phase was to:

- Optimize the regional transit system;
- Be fiscally responsive and maximize regional resources;
- Maximize the economic development potential of the project;
- Be sensitive to the built and social environments; and
- Be sensitive to the natural environment.

The options, evaluation measures, and results of the Johns Landing streetcar alignment refinement process and the Lake Oswego terminus refinement processes are summarized below.

A. Johns Landing Streetcar Alignment Refinement. For the refinement of streetcar design options within the Johns Landing area, the project used the following criteria: streetcar operations, streetcar performance, financial feasibility, traffic operations, accessibility and development potential, neighborhood sustainability, and adverse impacts to the natural environment. Measures for each of the criteria were developed and applied to each of the alignment options studied, which included:

- Hybrid 1: Macadam Avenue In-Street
- Hybrid 2: East Side Exclusive
- Hybrid 3: Macadam Avenue with New Northbound Lane
- Willamette Shore Line
- Full Macadam In-Street

B. Lake Oswego Terminus Option Refinement. For the refinement of terminus options in the Lake Oswego area, the project used the following criteria: expansion potential and regional context, streetcar operations, streetcar performance, financial feasibility, traffic operations, accessibility and development potential, and neighborhood sustainability. Measures for each of the criteria were developed and applied to each of the alignment options studied, which included: a) Safeway Terminus Option; b) Albertsons Terminus Option; and c) Trolley Terminus Option.

On June 1, 2009, in consultation with FTA and based on the findings of the analysis, public and agency comment and recommendations from the Lake Oswego to Portland Project Management Group, the Lake Oswego to Portland Transit Project Steering Committee selected the following options in the Johns Landing area to advance into the DEIS: Willamette Shore Line; Hybrid 1 – Macadam Avenue In Street (Boundary Street to Carolina Street); and Hybrid 3: Macadam Avenue with New Northbound Lane (Boundary Street to Carolina Street).

1.4 Description of Alternatives Analyzed in this Technical Report and the DEIS

This section summarizes the roadway and transit capital improvements and transit operating characteristics for the No-Build, Enhanced Bus, and Streetcar alternatives. Table 1-1 provides a summary of the transit capital improvements associated with the three alternatives, and Table 1-2 summarizes the operating characteristics of the alternatives. A more detailed description of the alternatives may be found in the *Lake Oswego to Portland Transit Project Detailed Definition of Alternatives Report* (Metro/TriMet: January 2010). Detailed drawings of the Streetcar Alternative, including the various design options, can be found in the *Streetcar Plan Set*, November 2009.

1.4.1No-Build Alternative

This section describes the No-Build Alternative, which serves as a reference point to gauge the benefits, costs, and effects of the Enhanced Bus and Streetcar alternatives. In describing the No-Build Alternative, this section focuses on: 1) the alternative’s roadway, bicycle and pedestrian, and transit capital improvements; and 2) the alternative’s transit operating characteristics. This description of the No-Build Alternative is based on conditions in 2035, the project’s environmental forecast year.

1.4.1.1 Capital Improvements

Following is a brief description of the roadway, bicycle and pedestrian, and transit capital improvements that would occur under the No-Build Alternative. Table 1-1 provides a summary of the transit capital improvements associated with the No-Build Alternative and Table 1-2 summarizes the operating characteristics of the alternatives. Figure 1-1 illustrates the location of those improvements.

- **Roadway Capital Improvements**. The No-Build Alternative includes the existing roadway network in the corridor, with the addition of roadway capital improvements that are listed in the financially constrained road network of Metro's 2035 RTP.[1]Following is a list of the roadway projects that would occur within the corridor by 2035.
  - *Moody/Bond Avenue Couplet* (create couplet with two lanes northbound on SW Bond Avenue and two lanes southbound on SW Moody Avenue);
  - *South Portal* (Phases I and II to extend the SW Moody Avenue/SW Bond Avenue couplet to SW Hamilton Street and realign SW Hood Avenue to connect with SW Macadam Avenue at SW Hamilton Street);
  - *I-5 North Macadam* (construct improvements in the South Waterfront District to improve safety and access); and
  - *Macadam Intelligent Transportation Systems* (install system and devices in the SW Macadam Avenue corridor to improve traffic flow).

[1] Metro, 2035 Regional Transportation Plan, approved Dec. 13, 2007.

Table 1-1 Transit Capital Improvements for the No-Build, Enhanced Bus, and Streetcar Alternatives (2035)

Capital Improvements	**No-Build**	**Enhanced Bus**	**Streetcar**[1]
New Streetcar Alignment Length[2]	N/A	N/A	5.9 to 6.0
One-Way Streetcar Track Miles			
Portland Streetcar System	15.7	15.7	26.2 to 27.0
Proposed Lake Oswego to Portland Project	0	0	10.5 to 11.3
Streetcar Stations			
Portland Streetcar System	69	69	79
Proposed Lake Oswego to Portland Project	0	0	10[3]
Streetcars (in service/spares/total)			
Portland Streetcar System	17/5/22	17/5/22	27/6/33
Proposed Lake Oswego to Portland Project	N/A	N/A	10/1/11
Streetcar Operations and Maintenance (O&M) Facilities			
Number of Facilities[4]	1	1	2
Maintenance Capacity (number of Streetcars)	36	36	36
Storage Capacity (number of Streetcars)	25	25	33
Line 35 Bus Stops			
Line 35 Bus Stops (Lake Oswego to SW Bancroft St.)	26	13	0
Buses (in service/spares)			
TriMet Systemwide	607/712	619/725	601/704
Difference from No-Build Alternative	N/A	13	- 8
Transit Centers[5]	1	1	1
Park-and-Ride Facilities			
Joint Use Surface – Lots/Spaces	3/76	3/76	3/76
Surface – Lots/Spaces	0/0	0/0	1/100
Structured – Lots/Spaces	0/0	1/300	1/300

Note: LO = Lake Oswego; O&M = operating and maintenance.

[1] The transit capital improvements of the Streetcar Alternative summarized in this table would not vary by design option, except when shown as a range and as noted for new streetcar alignment length and one-way track miles. The first number listed is under the Willamette Shore Line design option and the second number listed is under the Macadam design options (in the Johns Landing Segment).

[2] Under the No-Build and Enhanced Bus alternatives, the Portland Streetcar System would include two streetcar lines: a) the existing Portland Streetcar Line, between NW 23rd Avenue and SW Bancroft Street, and b) the Portland Streetcar Loop, which is currently under construction and will be completed when the Milwaukie Light Rail and Streetcar Close the Loop project are constructed. The Streetcar Alternative would extend the existing Portland Streetcar line south, from SW Bancroft Street to Lake Oswego. One-way track miles are calculated by multiplying the mileage of double-tracked sections and adding that to the mileage of single-track sections. Alignment length and one-way track miles are presented as a range, because they would vary by design option. The number of streetcar stations, streetcars in service or as spares and the number and size of streetcar O&M facilities would not change by streetcar design option.

[3] Two optional stations are also being considered for inclusion in the Streetcar Alternative (see Figure 1-5 and Figure 1-6): 1) the Pendleton Station under the Macadam In-Street and Macadam Additional Lane design options in the Johns Landing Segment; and the E Avenue Station in the Lake Oswego Segment.

[4] There is an existing streetcar operations and maintenance (O&M) facility at NW 16th Avenue, between NW Marshall and NW Northrup streets; under the Streetcar Alternative, additional storage for eight vehicles would be provided along the streetcar alignment under the Marquam Bridge. There would be no change in the number or size of bus O&M facilities under any of the alternatives or design options. Bus stops are those that would be served exclusively by Line 35 between Lake Oswego and SW Bancroft Street

[5] Under the No-Build and Enhanced Bus alternative, the Lake Oswego Transit Center would remain at its current location (on 4th Street, between A and B avenues); under the Streetcar Alternative, the transit center would be moved to be adjacent to the Lake Oswego Terminus Station.

Source: TriMet, January 2010.

Table 1-2 Streetcar and Bus Network Operating Characteristics of No-Build, Enhanced Bus, and Streetcar[1] Alternatives (2035)

Operating Characteristics by Vechicle Mode	No-Build	Enhanced Bus	Streetcar
Streetcar Network Operating Characteristics[1]			
Weekday Streetcar Vehicle Miles Traveled			
Systemwide	2,180	2,180	3,200 or 3,230
Difference from No-Build Alternative	N/A	0	1,020 or 1,050
Weekday Streetcar Revenue Hours			
Systemwide	267	267	326 or 332
Difference from No-Build Alternative	N/A	0	59 or 65
Corridor Weekday Streetcar Place Miles[2]	N/A	N/A	89,000 or 91,320
Corridor Streetcar Round-Trip Time[3]	N/A	N/A	37 or 44 minutes
Corridor Streetcar Headways[4]			
Lake Oswego to PSU	N/A	N/A	7.5 / 7.5 minutes
Bus Network Operating Characteristics			
Weekday Bus Miles Traveled			
Systemwide	76,560	77,560	75,520
Difference from No-Build Alternative	N/A	1,000	-1,040
Weekday Bus Revenue Hours			
Systemwide	5,300	5,400	5,210
Difference from No-Build Alternative	N/A	100	-90
Line 35 (bus) Weekday Place Miles[2]	37,000	57,840	0
Line 35 (bus) Headways[4]			
Lake Oswego to Downtown Portland	15 / 15 min.	6 / 15 min.	N/A
Oregon City to Lake Oswego	15/15 min.	15/15 min.	15/15 min.

Note: N/A = not applicable; LO = Lake Oswego; O&M = operating and maintenance; PSU = Portland State University.

[1] The operating characteristics of the Streetcar Alternative summarized in this table would not vary by design option, except when shown as a range and as noted for streetcar vehicle miles traveled, place miles, and round-trip time. The first number listed is under the Willamette Shore Line Design Option and the second number listed is under the Macadam design options (in the Johns Landing Segment).

[2] Place miles are a measure of the passenger carrying capacities of the alternatives, similar to airline seat miles. Place miles = transit vehicle capacity (seated and standing) of a vehicle type, multiplied by the number vehicle miles traveled for that vehicle type, summed across all vehicle types. The No-Build Alternative bus place miles are based on lines 35 and 36.

[3] Round-trip run time for the proposed streetcar line would include in-vehicle running time from SW Bancroft Street to the Lake Oswego Terminus Station and back to SW Bancroft Street; it does not include layover time at the terminus.

[4] Headways are the average time between transit vehicles per hour within the given time period that would pass by a given point in the same direction, which is inversely related to frequency (the average number of vehicles per hour in the given time period that would pass by a given point in the same direction). Weekday peak is generally defined as 7:00 to 9:00 a.m. and 4:00 to 6:00 p.m.; weekday off-peak is generally defined as 5:00 to 7:00 a.m., 9:00 a.m. to 4:00 p.m. and 6:00 p.m. to 1:00 a.m. There would be streetcar service every 12 minutes between SW Bancroft Street and the Pearl District (via PSU) under the No-Build and Enhanced Bus alternatives. The peak headways shown for the No-Build Alternative are the composite headways for Lines 35 and 36.

Source: TriMet – January 2010.

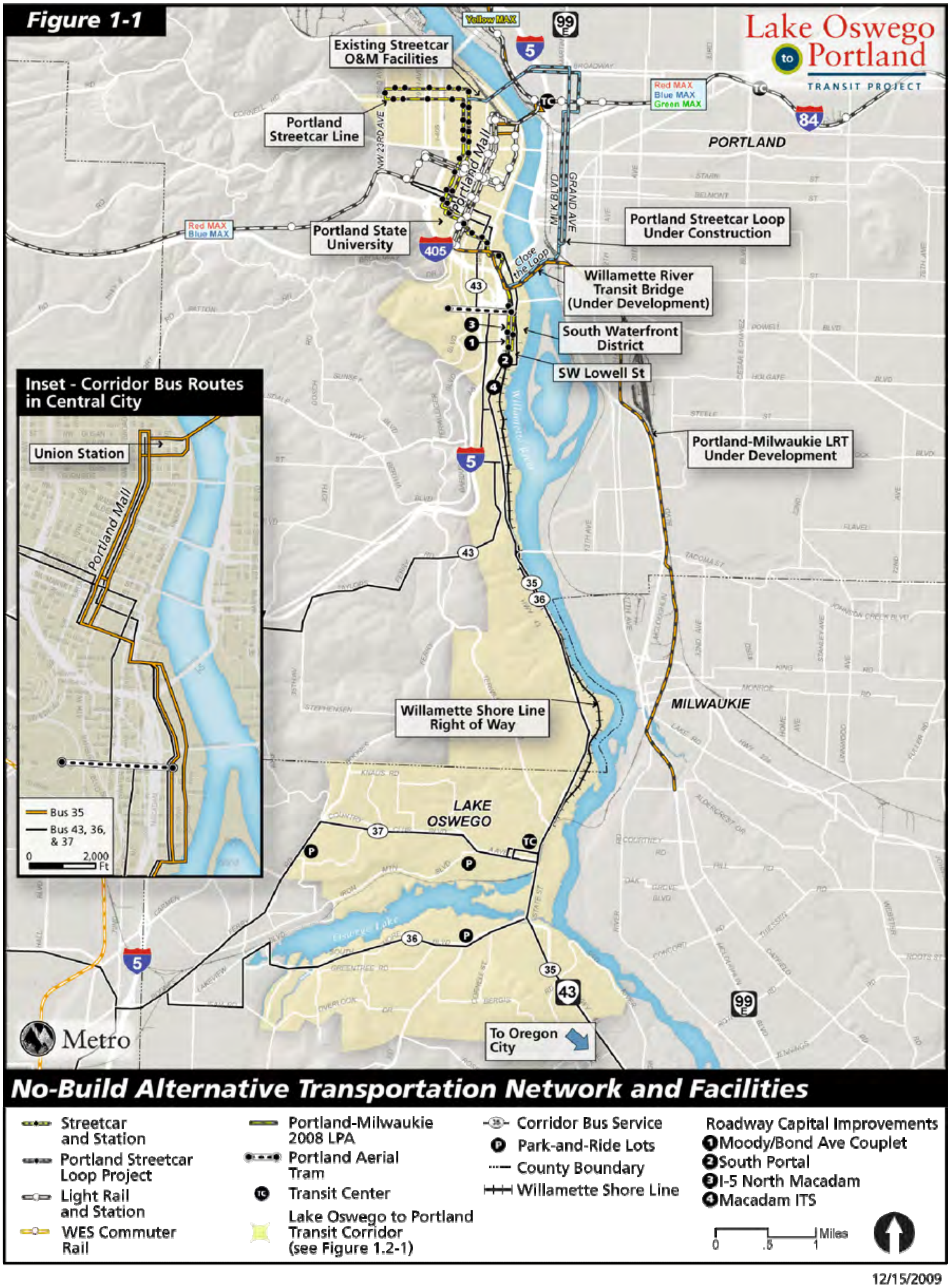


FIGURE 1-1 NO-BUILD ALTERNATIVE TRANSPORTATION NETWORK AND FACILITIES

- **Bicycle and Pedestrian Improvements**. The No-Build Alternative includes the existing bicycle and pedestrian network in the corridor, with the addition of bicycle and pedestrian capital improvements that are listed in the financially constrained road network of Metro's 2035 RTP. Following is a list of the bicycle and pedestrian projects that pedestrian projects proposed to occur within the corridor by 2035.
  - *Lake Oswego to Portland Trail* (extension of a multiuse path between Lake Oswego and Portland);
  - *I-5 at Gibbs Pedestrian/Bicycle Overcrossing* (construct a bicycle and pedestrian bridge over I-5 in the vicinity of SW Gibbs Street); and
  - *Tryon Creek Bridge* (construct a new pedestrian/bicycle bridge near the mouth of Tryon Creek).

- **Bus Capital Improvements.** There are currently two primary bus capital facilities in the corridor: *Lake Oswego Transit Center* (on 4th Street, between A and B avenues); and *Portland Mall* (bus and light rail lanes and shelters on NW/SW 5th and 6th avenues between NW Glisan Street and SW Jackson Street). These bus facilities would remain as-is under the No-Build Alternative. (The financially constrained transit project list of the RTP includes relocation of the Lake Oswego Transit Center to be adjacent to the Lake Oswego to Portland Streetcar alignment, which is also in the financially constrained project list. Neither would occur under the No-Build Alternative.) No additional bus capital improvements are planned for the corridor under the No-Build Alternative by 2035.

- **Light Rail Capital Improvements.** Under the No-Build Alternative, TriMet's existing Yellow Line light rail service would continue to operate on the Portland Mall (with a station at PSU added), across the Steel Bridge and into North Portland. Yellow Line facilities and service would be extended north from the existing Expo Center Station, across the Columbia River into Vancouver, Washington, and south from the Portland Mall, generally via SW Lincoln Street, across the Willamette River to Milwaukie, Oregon. In addition, downtown Portland would be served by the following TriMet light rail lines: Blue Line (Gresham to Hillsboro); Red Line (Beaverton to Portland International Airport); and Green Line (downtown Portland to Clackamas Town Center).

- **Excursion Trolley Capital Facilities.** Under the No-Build Alternative there would be no changes to the existing excursion trolley capital facilities that are located or operate within the corridor. Those excursion trolley capital facilities include approximately six miles of single-tracked Willamette Shore Line tracks and related facilities; stations at SW Bancroft and Moody streets and at N State Street at A Avenue; a trolley barn at approximately N State Street at A Avenue; and typically one vintage and/or other trolley vehicle propelled by externally attached diesel units.

- **Streetcar Improvements and Vehicles.** Under the No-Build Alternative, the existing Portland Streetcar Line would continue to operate between NW 23rd Avenue and SW Lowell Street. In addition, the No-Build Alternative includes the Eastside Streetcar Project (currently under construction), which would extend streetcar tracks and stations across the Broadway Bridge, serving NE and SE Portland on N and NE Broadway and NE and SE Martin Luther King Boulevard and Grand Avenue to OMSI. With the Close the Loop Project, the Eastside Streetcar will be extended across the Willamette River, to complete the planned Streetcar Loop, via a new transit, bicycle, and pedestrian bridge to be constructed under the Milwaukie Light Rail Project, connecting to the Streetcar line in the South Waterfront District. Under the No-Build Alternative in 2035, there would be 22 streetcars in the transit system (including spares), an increase of 11 compared to existing conditions.

- **Park-and-Ride Facilities.** Under the No-Build Alternative, the park-and-ride facilities in the corridor would be those that currently exist: a shared-use 30-space park-and-ride lot at Christ Church (1060 SW Chandler Road); a shared-use 34-space park-and-ride lot at Lake Oswego United Methodist Church (1855 South Shore Boulevard); and a shared use 12-space park-and-ride lot at Hope Church (14790 SW Boones Ferry Road).

- **Operations and Maintenance Facilities.** Under the No-Build Alternative, there would be one operations and maintenance facility within the corridor, which would be the existing streetcar maintenance building and storage yard on NW 16th Avenue under I-405. With the Streetcar Loop and Close the Loop Projects, the storage yard could accommodate 25 streetcars and the maintenance facility would have the capacity to service 36 streetcars (an increase in capacity of 13 and 18 vehicles, compared to existing conditions, respectively).

1.4.1.2 Transit Operations

This section summarizes the transit operating characteristics that would occur under the No-Build Alternative, focusing on bus and streetcar operations (see Table 1-2). Figure 1-1 illustrates the transit network for the No-Build Alternative in the vicinity of the corridor.

- **Bus Operations.** Bus operations under the No-Build Alternative would be similar to TriMet's existing fixed-route bus network with the addition of improvements included in the 2035 RTP's 20-year financially constrained transportation system (see Figure 1-1). Transit service improvements within the No-Build Alternative would be limited to those that could be funded using existing and readily-foreseeable revenue sources. Systemwide, those bus operations improvements would include: 1) increases in TriMet bus route frequency to avoid peak overloads and/or maintain schedule reliability; 2) increases in run times to maintain schedule reliability; and 3) incremental increases in TriMet systemwide bus service hours consistent with available revenue sources and consistent with the 2035 RTP's 20-year financially-constrained transit network, resulting in annual increases in service hours of approximately 0.5 percent per year. Specifically, the No-Build Alternative would include the operation of the TriMet bus route Line 35 between downtown Portland and Lake Oswego (continuing south to Oregon City).

- **Streetcar Operating Characteristics**. Under the No-Build Alternative, the City of Portland, through an operating agreement with the Portland Streetcar, Inc. (PSI), would continue to operate the existing Portland Streetcar line between Northwest Portland and the South Waterfront District, via downtown Portland (see Figure 1-1). On average weekdays in 2035, the Streetcar line would operate every 12 minutes during the peak and off-peak periods. Further, the City of Portland would operate the Streetcar Loop Project, serving downtown Portland, the Pearl District, northeast and southeast Portland, OMSI and the South Waterfront District. Frequency on the line for an average weekday in 2035 would be every 12 minutes during the peak and off-peak periods.

1.4.2 Enhanced Bus Alternative

This section describes the roadway, bicycle and pedestrian, and transit capital improvements and transit operating characteristics under the Enhanced Bus Alternative, generally compared to the No-Build Alternative. The intent of the Enhanced Bus Alternative is to address the project's Purpose and Need without a major transit capital investment.

1.4.2.1 Capital Improvements

This section summarizes the transit, bicycle and pedestrian, and transit capital improvements that would occur under the Enhanced Bus Alternative, compared to the No-Build Alternative (see Table 1-1 and Figure 1-2).

- **Roadway Capital Improvements.** Except for the addition of a two-way roadway connection between the proposed 300-space park-and-ride lot and Foothills Road, there would be no change in roadway improvements under the Enhanced Bus Alternative, compared to the No-Build Alternative.

- **Bicycle and Pedestrian Improvements.** There would be no change in bicycle and pedestrian improvements under the Enhanced Bus Alternative, compared to the No-Build Alternative.

- **Bus Capital Improvements.** Under the Enhanced Bus Alternative, the 26 bus stops that would be served by Line 35 between downtown Lake Oswego and SW Bancroft under the No-Build Alternative would be consolidated into 13 bus stops, which would continue to be served by the Line 35 (the other 13 bus stops would be removed). The bus stops served by Line 35 between Lake Oswego and Oregon City would be unchanged under the Enhanced Bus Alternative, compared to the No-Build Alternative.

- **Light Rail Capital Improvements.** There would be no change in light rail capital improvements under the Enhanced Bus Alternative, compared to the No-Build Alternative.

- **Excursion Trolley Capital Improvements.** There would be no change in excursion trolley capital improvements under the Enhanced Bus Alternative, from the No-Build Alternative.

- **Streetcar Improvements and Vehicles.** There would be no change in streetcar improvements and vehicles under the Enhanced Bus Alternative, compared to the No-Build Alternative.

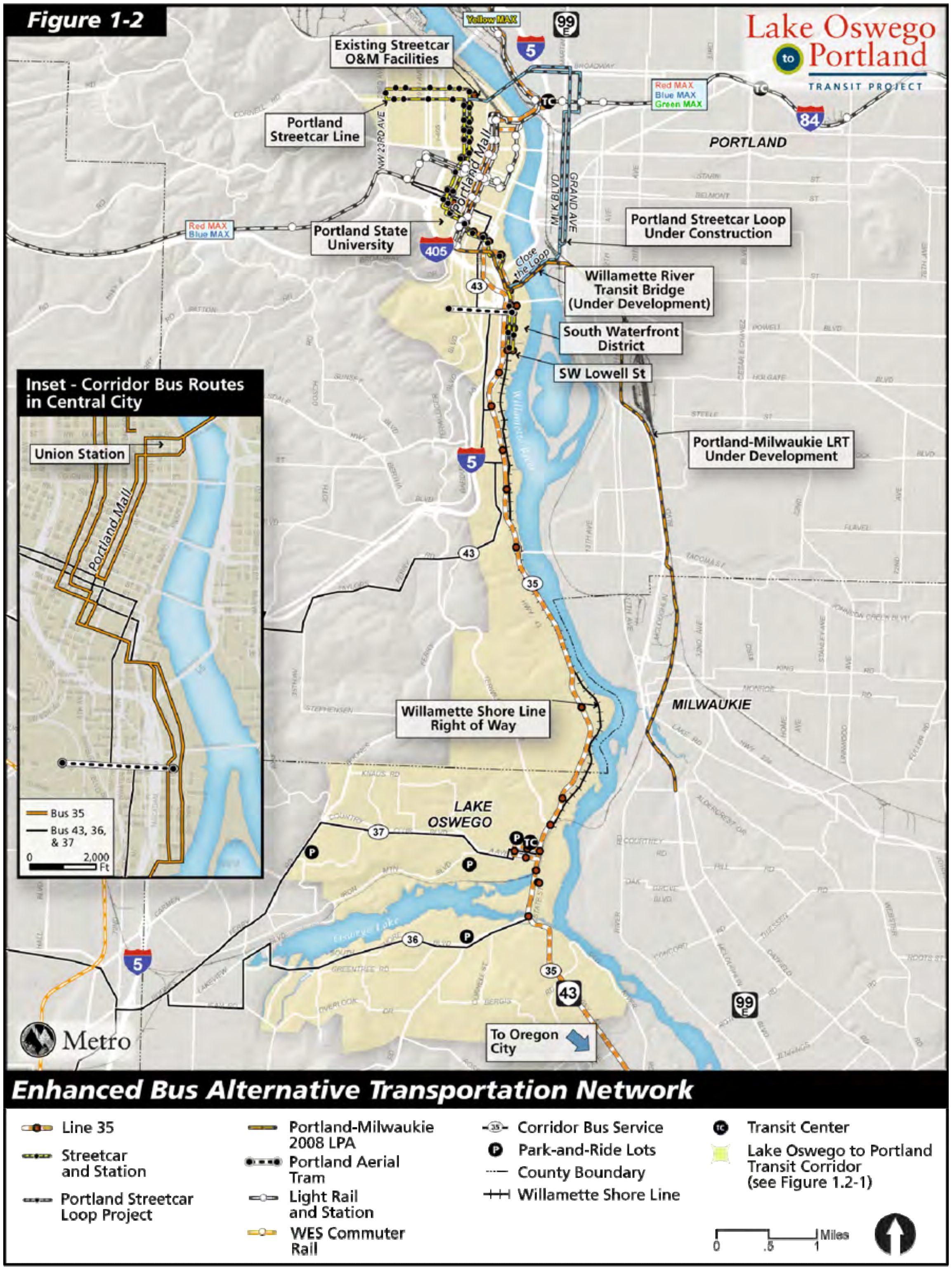
- **Park-and-Ride Facilities.** In addition to the park-and-ride facilities included under the No-Build Alternative, the Enhanced Bus Alternative would include a 300-space structured park-and-ride lot that would be located at Oswego Village Shopping Center on Highway 43 in downtown Lake Oswego. The park-and-ride lot would be served by Lines 35 and 36.

- **Operations and Maintenance Facilities.** There would be no changes to the region's operations and maintenance facilities under the Enhanced Bus Alternative, compared to the No-Build Alternative, except that the capacity of TriMet's bus operating and maintenance facilities at either the Center or Powell facility would be expanded to accommodate the additional 13 buses under the Enhanced Bus Alternative (see the *Detailed Definition of Alternatives Report* for additional information).

1.4.2.2 Transit Operations

This section summarizes the corridor's transit operations under the Enhanced Bus Alternative, focusing on bus and streetcar operations. Figure 1-2 illustrates the transit network for the Enhanced Bus Alternative in the vicinity of the corridor.

- **Bus Operations.** Except for changes to the routing, frequency, and number of stops of Line 35 and the elimination of Line 36 service between downtown Portland and downtown Lake Oswego, bus operations under the Enhanced Bus Alternative would be identical to the bus operations under the No-Build Alternative. Under the Enhanced Bus Alternative, Line 35's routing between Oregon City and Lake Oswego would remain unchanged relative to the No-Build Alternative. Further, between Lake Oswego and downtown Portland there would be two routing changes to Line 35, compared to the No-Build Alternative: 1) the bus would be rerouted to serve the new park-and-ride lot at the Oswego Village Shopping Center; and, 2) in downtown Portland, Line 35 would be rerouted to serve SW and NW 10th and 11th avenues, generally between SW Market and Clay streets and NW Lovejoy Street/Union Station to address the travel markets.



12/15/2009

FIGURE 1-2 ENHANCED BUS ALTERNATIVE TRANSPORTATION NETWORK

- **Streetcar Operating Characteristics.** Under the Enhanced Bus Alternative, there would be no change in streetcar operating characteristics, compared to the No-Build Alternative.

1.4.3 Streetcar Alternative

This section describes the roadway, bicycle and pedestrian, and transit capital improvements and transit operating characteristics under the Streetcar Alternative, generally compared to the No-Build Alternative.

1.4.3.1 Capital Improvements

This section summarizes the transit, bicycle and pedestrian, and transit capital improvements that would occur under the Streetcar Alternative, generally compared to the No-Build Alternative (see Table 1-1 and Figure 1-3). This section provides a general description of the capital improvements that would occur under the Streetcar Alternative, independent of design option, and it highlights the differences between design options within three of the corridor's segments.

A. Summary Description

Following is a general description of the roadway, bicycle and pedestrian, and transit improvements that would occur under the Streetcar Alternative. The next section provides a description of differences in capital improvements for design options that are under consideration in three of the project's six segments. See Figure 1-4 for an illustration of the project segments and the design options under consideration.

- **Roadway Capital Improvements.** There would be no roadway improvements under the Streetcar Alternative in the following corridor segments: 1) Downtown Portland; and 2) South Waterfront. The roadway capital improvements that would occur under the other corridor segments are described below for those segments. Changes to traffic controls at signalized and non-signalized intersections would occur throughout the corridor to accommodate the safe and efficient operation of the streetcar and local traffic. The *Detailed Definition of Alternatives Report* and the *Streetcar Plan Set* provide additional details on changes to traffic operations at intersections under the Streetcar Alternative.

- **Bicycle and Pedestrian Improvements.** There would be no change in bicycle and pedestrian improvements under the Streetcar Alternative, compared to the No-Build Alternative, except as noted in the following segment-by-segment description.

  Bus Capital Improvements. Under the Streetcar Alternative, all 26 bus stops that would be served by Line 35 on Highway 43 between downtown Lake Oswego and the Sellwood Bridge and on SW Macadam Boulevard north of SW Corbett Street under the No-Build Alternative would be removed, because Line 35 service would be replaced in the corridor by streetcar service. The bus stops served by Line 35 between Lake Oswego and Oregon City would be unchanged under the Streetcar Alternative, compared to the No-Build Alternative. In addition, under the Streetcar Alternative, the Lake Oswego Transit Center would be relocated to be adjacent to the Lake Oswego Terminus Station, from its existing location on 4th Street, between A and B avenues. The changes to the bus capital improvements under the Streetcar Alternative would not vary by any of the design options under consideration.

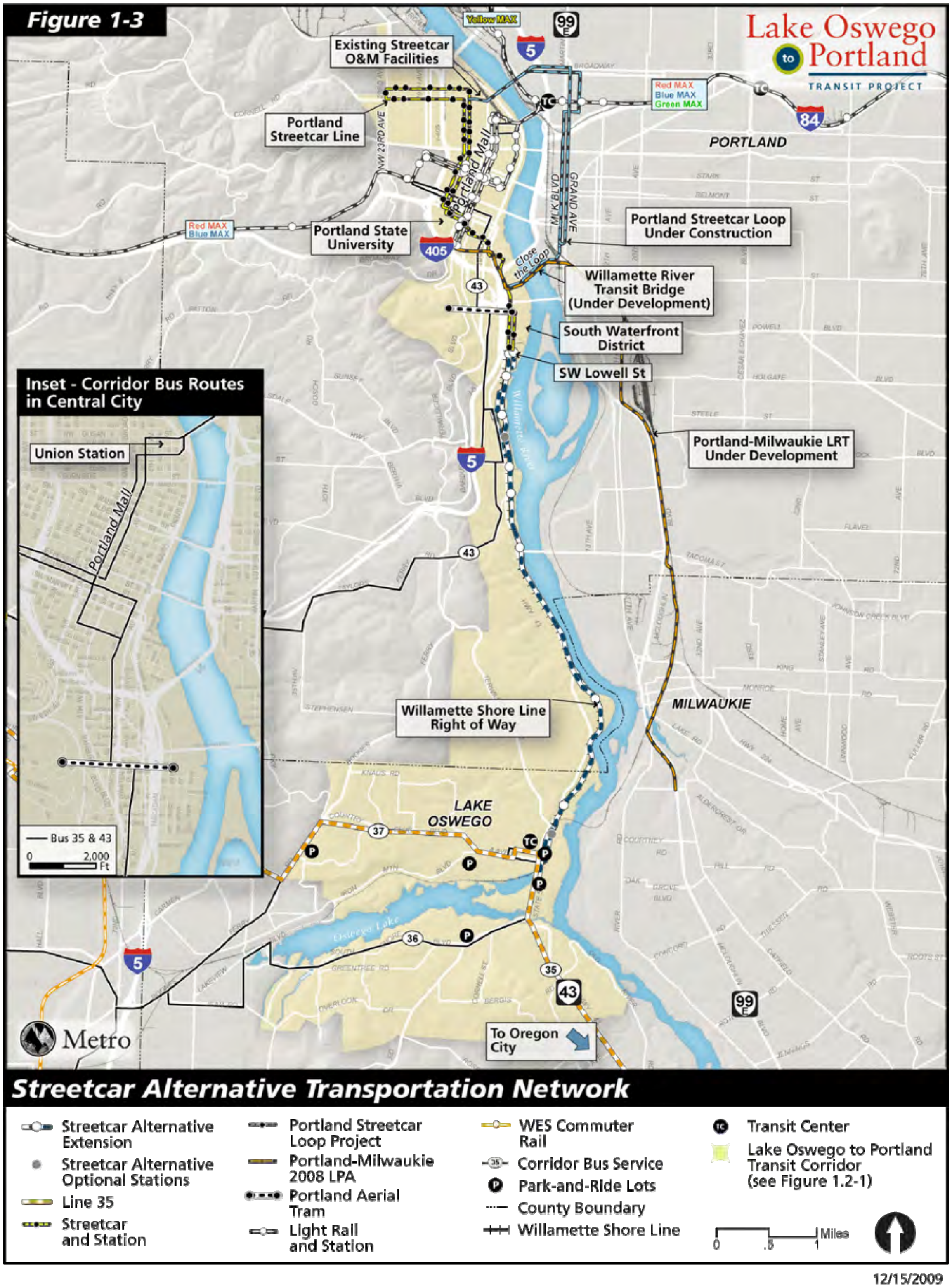


FIGURE 1-3 STREETCAR ALTERNATIVE TRANSPORTATION NETWORK

- **Light Rail Capital Improvements.** There would be no change in light rail capital improvements under the Streetcar Alternative, compared to the No-Build Alternative.

- **Interim Excursion Trolley Capital Improvements.** Under the Streetcar Alternative, there would no longer be an operating and maintenance agreement between the City of Lake Oswego and the Willamette Shore Line Consortium that would allow for the operations of the excursion trolley between SW Bancroft Street and Lake Oswego. Further, the Oregon Electric Railway Historical Society would no longer operate the vintage excursion trolley on the Willamette Shore Line alignment under agreement with the City of Lake Oswego, as they currently do and as they would under the No-Build and Enhanced Bus Alternatives.

- **Streetcar Improvements and Vehicles.** The Streetcar Alternative would extend streetcar tracks and stations south from the existing Portland Streetcar line that operates between NW 23rd Avenue and SW Bancroft Street. Compared to existing conditions and the No-Build Alternative, the Streetcar Alternative would add approximately 5.9 to 6.0 one-way miles of new streetcar tracks and catenary (overhead electrical wiring and support) and ten new streetcar stations between SW Bancroft Street and Lake Oswego. Except when crossing over waterways, roadways, or freight rail lines or through an existing tunnel, the new streetcar line would generally be at the same grade as existing surface streets. Of the approximately six miles of new streetcar tracks, 5.3 miles would be double-tracked (i.e., two one-way tracks) and 0.7 miles would be single-tracked (i.e., inbound and outbound streetcars would operate on the same tracks; see Figure 1-4 for an illustration of the location of single and double-track segments). The new streetcar stations would be of a design similar to the existing streetcar stations in downtown Portland and the Pearl District.

- **Park-and-Ride Facilities.** In addition to the park-and-ride facilities included under the No-Build Alternative, the Streetcar Alternative would include: a) a 100-space surface park-and-ride lot served by the proposed streetcar line at the B Avenue Station; and b) a 300-space structured park-and-ride lot that would be served by the proposed streetcar line at the Lake Oswego Terminus Station. The size and location of these park-and-ride lots would not vary by any of the design options under consideration.

- **Operations and Maintenance Facilities.** With the Streetcar Alternative, a new storage facility that would accommodate eight streetcars would be located adjacent to the streetcar alignment under the Marquam Bridge. The size and location of the streetcar operating and maintenance facilities would not vary by any of the design options under consideration.

B. Segment by Segment Description and Design Option Differences

For the purposes of description and analysis, the Lake Oswego to Portland Corridor has been divided into six segments for the Streetcar Alternative – those segments and design options within three of the segments are illustrated schematically in Figure 1-4. Figure 1-3 illustrates the proposed roadway improvements, streetcar alignment, stations, and park-and-ride lots that would occur in the corridor under the Streetcar Alternative. Figures 1-5 and 1-6 provide more detailed illustrations of the streetcar design options currently under study.

1. Downtown Portland Segment. There would be no roadway or bicycle and pedestrian improvements within the Downtown Portland Segment under the Streetcar Alternative, compared to the No-Build Alternative. Under the Streetcar Alternative, a connection would be added between westbound streetcar tracks on SW Market Street to southbound tracks on W 10th Avenue, which would allow inbound streetcars from Lake Oswego to turn back toward Lake Oswego, providing increased operational flexibility. There are no streetcar alignment design options within this segment and there would be no new streetcar stations within this segment.

2. South Waterfront Segment. The South Waterfront Segment extends between SW Lowell Street to SW Hamilton Court. Streetcar tracks would be extended south of their existing southern terminus at SW Lowell Street, within the right of way of the planned Moody/Bond Couplet extension, to SW Hamilton Street. There would be two new streetcar stations within this segment (Bancroft and Hamilton stations).

3. Johns Landing Segment. The Johns Landing Segment extends between SW Hamilton Court to SW Miles Street. This segment includes three design options: Willamette Shore Line; Macadam In-Street; and Macadam Additional Lane. Under all options, the streetcar alignment would extend south from SW Hamilton to near SW Julia Street, generally within the existing Willamette Shore Line right of way. The three design options would include two new streetcar stations at varying locations, described below. To the south, all three options would share a common alignment between SW Carolina and SW Miles Street, generally via the existing Willamette Shore Line right of way, and they would share one common station at SW Nevada. Following is a description of how the design options would differ:

a. ***The Willamette Shore Line Design Option*** would continue the extension of streetcar tracks south within the existing Willamette Shore Line right of way from SW Julia Street to SW Carolina Street (extending to SW Miles Street). There would be three new streetcar stations (Boundary, Nebraska, and Nevada stations).

b. ***The Macadam In-Street Design Option*** would locate the new streetcar tracks generally within the existing outside lanes of SW Macadam Avenue, approximately between SW Boundary and Carolina streets. Between approximately SW Julia and Boundary streets, the streetcar alignment would be within the right of way of SW Landing Drive, which would be converted from a private to a public street. There would be three new streetcar stations (Boundary, Carolina, and Nevada stations). An optional station at Pendleton Street is also under consideration.

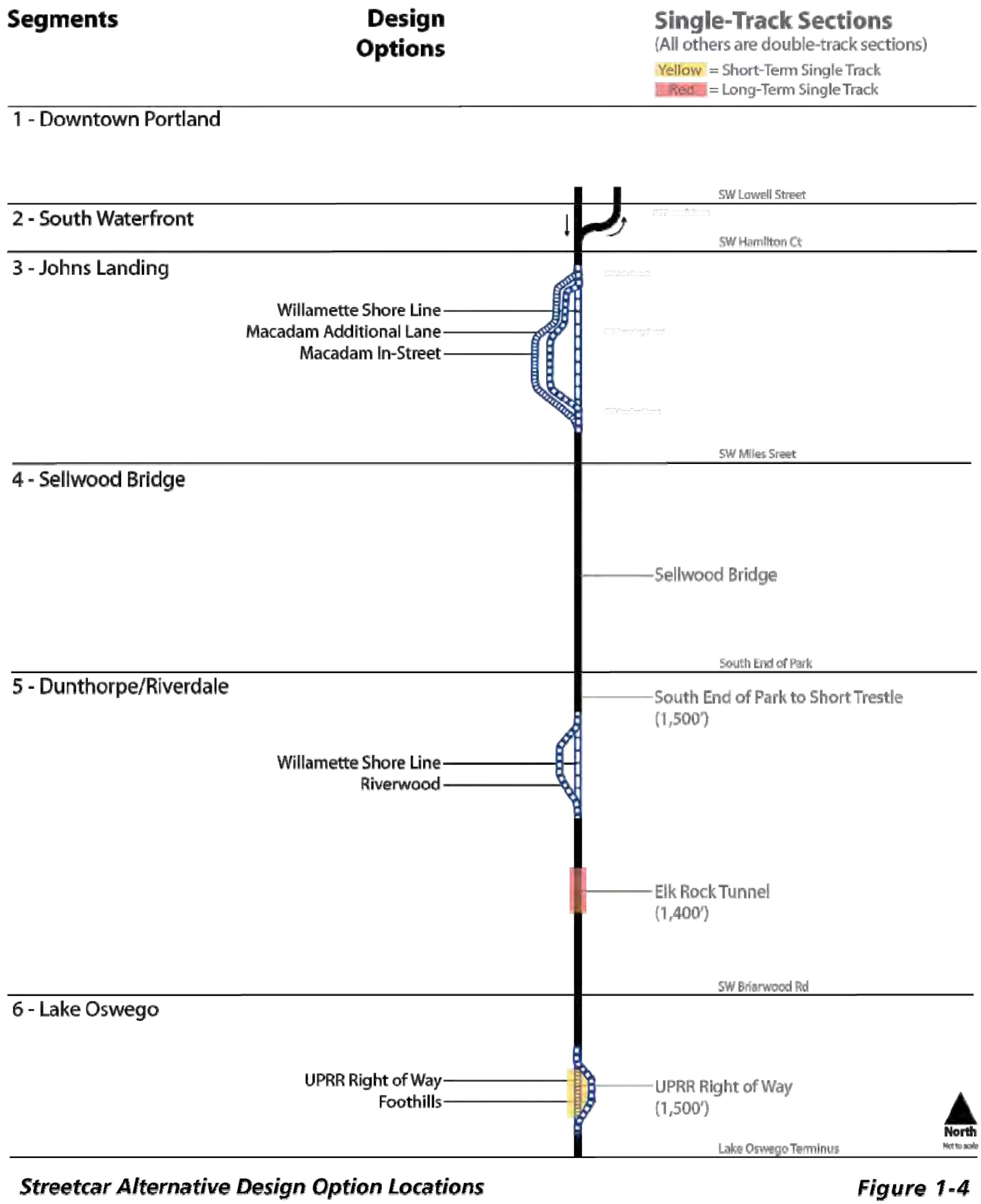


FIGURE 1-4 STREETCAR ALTERNATIVE DESIGN OPTION LOCATIONS

c. ***The Macadam Additional Lane Design Option*** would be similar to the Macadam In-Street Design Option, except that the new northbound streetcar tracks would be located within a new traffic lane just east of the existing general purpose lanes – streetcars would share the new lane with right-turning vehicles. Between approximately SW Julia and Boundary streets, the streetcar alignment would be within the right of way of SW Landing Drive, which would be converted from a private to a public street. There would be three new streetcar stations (Boundary, Carolina, and Nevada stations). An optional station at Pendleton Street is also under consideration.

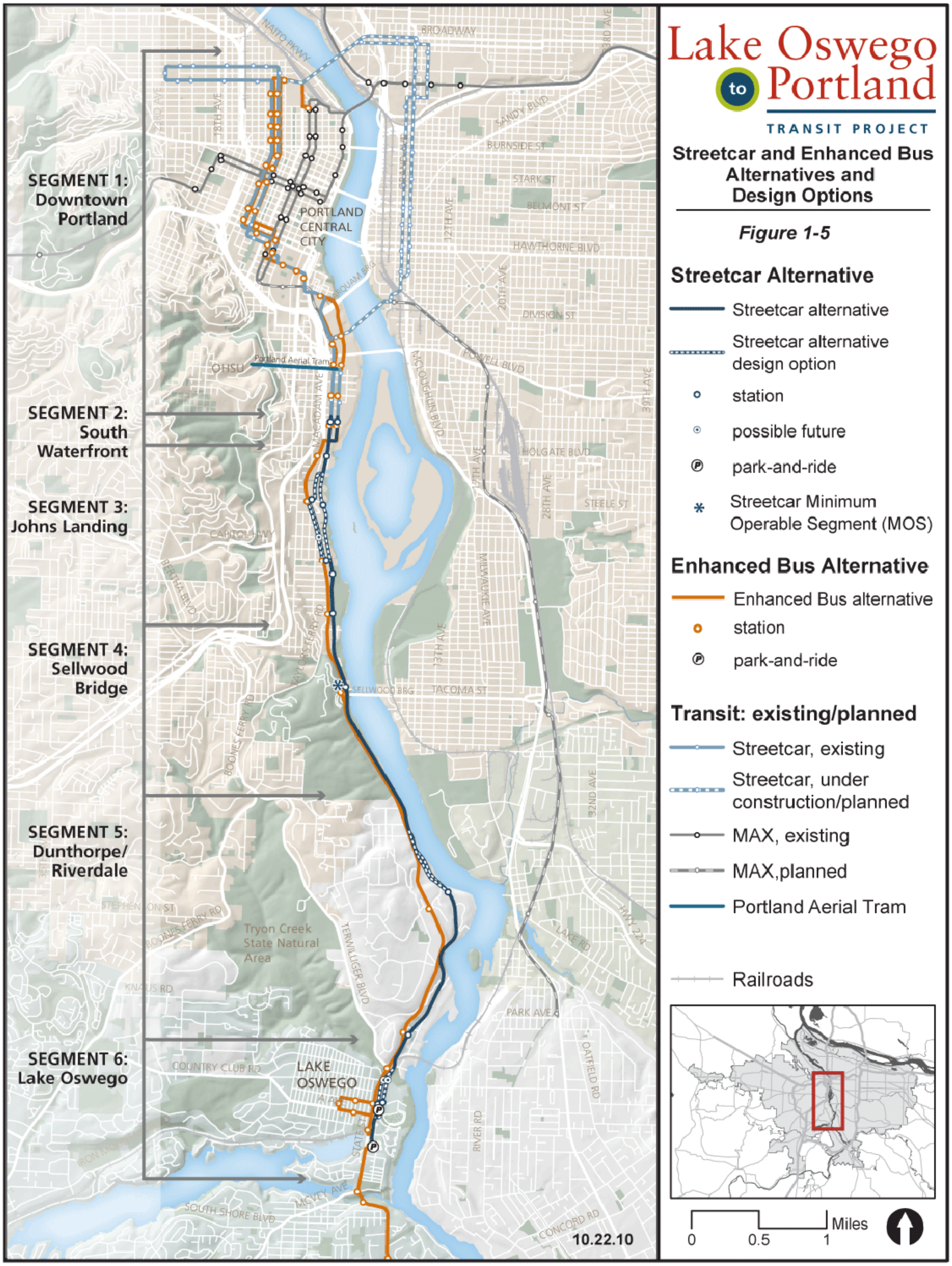


FIGURE 1-5 STREETCAR AND ENHANCED BUS ALTERNATIVES AND DESIGN OPTIONS

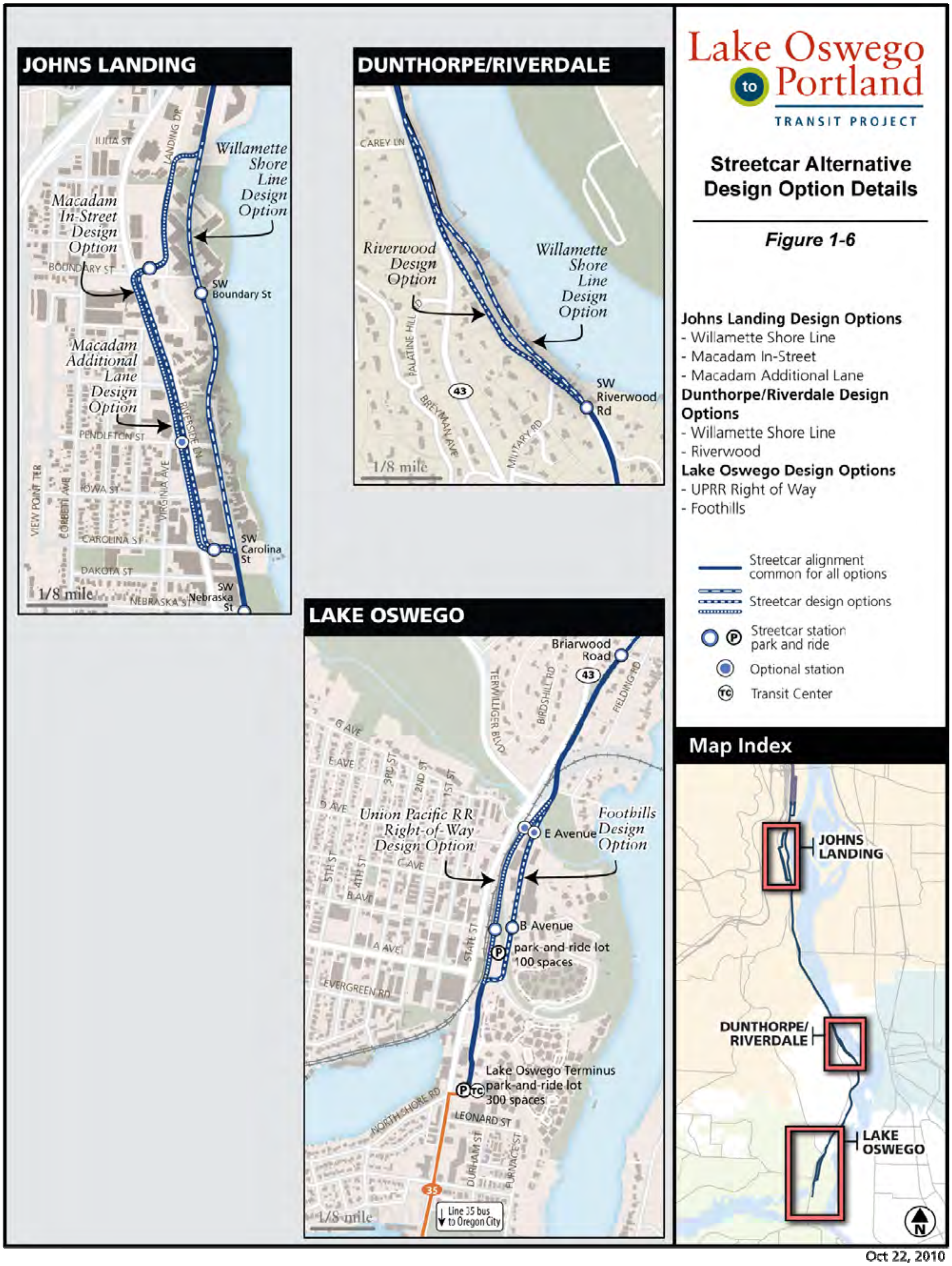


FIGURE 1-6 STREETCAR ALTERNATIVE DESIGN OPTION DETAILS

4. Sellwood Bridge Segment. The Sellwood Bridge Segment extends from Miles Street to the southern end of Powers Marine Park. Generally, the streetcar alignment would be located in the Willamette Shore Line right of way, except for the area between Stephens Creek and approximately 1,200 feet south of the Sellwood Bridge. In this area, the streetcar alignment would be constructed in conjunction with the planned west interchange improvements with the Sellwood Bridge (the streetcar would be located slightly east of the existing Willamette Shore Line right of way). The design and construction of the streetcar alignment under this design option would be coordinated with the design and construction of the new interchange for the Sellwood Bridge. There would be one new streetcar station within this segment (Sellwood Bridge Station).

5. Dunthorpe/Riverdale Segment. The Dunthorpe/Riverdale Segment extends between the southern end of Powers Marine Park and SW Briarwood Road. There are two design options in this segment: Willamette Shore Line Design Option and Riverwood In-Street Design Option. Both options would share a common alignment within the Willamette Shore Line right of way, generally north of where SW Riverwood Road intersects with Highway 43 and generally south of the intersection of SW Military Road and SW Riverwood Road. One new streetcar station is proposed within this segment, generally common to both design options (Riverwood Station). Following is a description of how the design options would differ:

a. ***The Willamette Shore Line Design Option*** would generally locate the new streetcar alignment in the existing Willamette Shore Line right of way between the intersections of SW Riverwood Road and Highway 43 and SW Riverwood Road and SW Military Road.

b. ***The Riverwood In-Street Design Option*** would locate the new streetcar alignment generally adjacent to Highway 43, south of SW Riverwood Road, and within the right of way of SW Riverwood Road, generally between where it intersects with Highway 43 (that intersection would be closed) and where it intersects SW Military Road. Except for the closure of the Highway 43 and SW Riverwood Road intersection, SW Riverwood Road would remain open to traffic with joint operation with streetcars.

6. Lake Oswego Segment. The Lake Oswego Segment extends between SW Briarwood Road and the Lake Oswego Terminus Station. There are two design options within this segment: the UPRR ROW design option and the Foothills Design Option. Both options would generally be the same in two sections: 1) the new streetcar line alignment would extend south from SW Briarwood Road to where the alignment would cross under the existing UPRR tracks; and 2) the new streetcar alignment would be located within a new roadway that would extend south from SW A Avenue to the alignment's terminus near the intersection of N State Street and Northshore Road. Both options would provide for a new bicycle and pedestrian connection under the existing UPRR tracks. There would be two stations within this segment, one that would be common to the two design options (Lake Oswego Terminus Station). An optional station at E Avenue is also under consideration.

This segment would include two park-and-ride lots, both of which would be generally common to the two design options. Following is a description of how the design options would differ:

a. ***The UPRR ROW Design Option*** would extend the streetcar alignment south, generally in the UPRR right of way, from its under crossing of the existing UPRR tracks to SW A Avenue.

The B Avenue Station would be located on the west side of the 100-space surface park-and-ride lot.

b. ***The Foothills Design Option*** would extend the streetcar alignment south from its under crossing of the UPRR tracks to SW A Avenue generally within the right of way of a new general purpose roadway (Foothills Road), which would be built as part of the Streetcar Alternative.

1.4.3.2 Transit Operations

This section describes transit operations under the Streetcar Alternative, generally compared to the No-Build Alternative (see Table 1-2). Figure 1-3 provides an illustration of the transit lines in the vicinity of the corridor under the Streetcar Alternative. There would be no difference in transit operations under any of the design options under consideration.

The Streetcar Alternative would extend the existing Portland Streetcar line from its current southern terminus at Lowell Street to the Lake Oswego Terminus Station in downtown Lake Oswego, expanding the streetcar length from 4 miles to 9.9 to 10 miles (depending on design option). The total round trip running time of the streetcar line between 23rd Avenue and downtown Lake Oswego (10 miles) in 2035 would be 105 or 112 minutes, excluding layover (based on the Willamette Shore Line and Macadam design options in the Johns Landing Segment, respectively). In comparison, under the No-Build Alternative the round trip running time for the streetcar line between 23rd Avenue and Lowell Street (4 miles) would be 68 minutes.

With the extension of streetcar service to Lake Oswego, Line 35 service between Lake Oswego and downtown Portland would be eliminated. The remainder of Line 35 between Oregon City and Lake Oswego would be combined with Line 78, in effect to create a new route between Oregon City and Beaverton. The new bus route and other TriMet transit routes serving downtown Lake Oswego would be rerouted to serve the relocated Lake Oswego Transit Center, which would be adjacent to Lake Oswego Terminus Station.

1.4.3.3 Construction Phasing Options

This section summarizes Streetcar Alternative construction phasing options currently under consideration – neither the No-Build Alternative nor the Enhanced Bus Alternative include construction phasing options. Currently, there are two types of construction phasing options or scenarios under consideration: 1) finance-related and 2) external project related. The Streetcar Alternative evaluated in this Technical Report and the DEIS is as Full-Project Construction. Should the Streetcar Alternative with phasing be selected as the Locally Preferred Alternative, during preliminary engineering (PE) additional analysis of environmental impacts resulting from the interim project alignment (as opposed to Full-Project Construction) will be conducted and additional opportunity for public review and comment may be required.

A. Finance-Related Phasing Options
Following is a description of the two finance-related phasing options currently under consideration.

- **Full-Project Construction.** Under the first construction phasing option, the project would be constructed and opened in its entirety as described within Section 2.2.2.

- **Sellwood Bridge Minimum Operable Segment (MOS).** Under the Sellwood Bridge MOS phasing option, the Streetcar Alternative would be initially constructed between SW Lowell Street and the Sellwood Bridge, with a second construction phase between the Sellwood Bridge and the Lake Oswego Terminus Station occurring prior to 2035. Under this construction phasing option, there would be no additional park-and-ride facilities in the corridor, compared to existing conditions. Under this phasing option, Line 35 would operate between Oregon City and the Nevada Street Station; frequencies would be adjusted to meet demand. Service and bus stops served exclusively by Line 35 would be deleted between the Nevada Station and downtown Portland.

B. External Project Coordination Related Phasing Options
Following is a description of phasing options related to the coordination of the Streetcar Alternative, if it is selected as the LPA, and other external projects. These external project coordination related phasing options represent interim steps in the construction process that would be taken to implement the Streetcar Alternative.

- **South Waterfront Segment Phasing Options.** If the planned and programmed South Portal roadway improvements are not in place or would not be constructed concurrently with the Streetcar Alternative, there would be two options for proceeding with construction of the streetcar alignment in the segment: 1) a different streetcar alignment using the Willamette Shore Line right of way would be initially constructed within the South Waterfront Segment; or 2) the streetcar alignment and its required infrastructure improvements would be constructed consistent with the alignment under the Full-Project Construction phasing option, but other non-project roadway improvements would be constructed at a later date by others. If the Willamette Shore Line right of way were to be used, then, when the South Portal roadway improvements were made, the streetcar alignment would be reconstructed consistent. The transit operating characteristics of the Streetcar Alternative would not be affected by this phasing option.

- **Sellwood Bridge Segment Phasing Options**. The Sellwood Bridge Segment includes two phasing options for the Streetcar Alternative that reflect two potential phasing options or scenarios for construction of the project in relationship to construction of a proposed new interchange that is planned to occur with the Sellwood Bridge replacement project. If the new interchange is constructed prior to or concurrently with the Streetcar Alternative, the initial and long-term streetcar alignment would be based on the new interchange design. The new interchange design is the basis for the analysis in this technical report and the DEIS. If the proposed interchange is constructed after the Streetcar Alternative, then the initial streetcar alignment to be constructed would be in the Willamette Shore Line right of way. Subsequently, when the proposed interchange is constructed, the Sellwood Bridge replacement project would relocate the streetcar alignment with the new interchange design. Therefore, the long-term streetcar alignment would be the new interchange and the Willamette Shore Line phasing option would only be implemented as an interim alignment. Therefore, the two design options in this segment do not constitute a choice of alignments – instead they represent two construction phasing scenarios, dependent upon how external conditions transpire.

- The Foothills Design Option. The Foothills design option of the Streetcar Alternative is based on roadway improvements that would occur under the City of Lake Oswego's Foothills redevelopment project. If those roadway improvements are not constructed prior to or concurrently with construction of the streetcar alignment, then the Lake Oswego to Portland Transit Project would construct the streetcar alignment and required infrastructure improvements using the same alignment and the roadway improvements would be added at a later date by others.

2. RELATED LAWS AND REGULATIONS

This section summarizes the federal, state, and local rules, regulations, and policies related to the hydrology, floodplains, and water quality of the affected environment. The methods used for this study are described in Appendix B. Water resources in the project area are protected by federal, state, and local regulations addressing stormwater quality and quantity and restrictions on modifying floodplains. In general, regulations governing stormwater quality and quantity have been developed and implemented primarily at the local and state level, while floodplain regulations (e.g., Executive Order 11988 – Floodplain Management) are developed at the federal level and implemented at the local level. The State of Oregon does not have specific stormwater quantity control or floodplain development guidelines; however, under authority of the U.S. Environmental Protection Agency (EPA), it implements federal water quality regulations. The City of Portland, City of Lake Oswego, Multnomah County, and Clackamas County regulate water quantity and quality through standards for new development and redevelopment. Generally, the regulations and standards intend to accomplish the following:

- Maintain predevelopment flow rates and timing (known as the hydrograph)
- Prevent flooding conditions from worsening
- Protect new facilities constructed in the floodplain from damage
- Protect water quality

The following sections list and briefly describe the rules, regulations, and policies pertinent to water resources in the project area. Local stormwater regulations are summarized in Table 2-1.

Table 2-1 Summary of Local Regulations Affecting Hydrology, Floodplains, and Water Quality

Local Jurisdiction	Water Quantity Regulations	Floodplain Regulations	Water Quality Regulations
Clackamas County Service District #1	Stormwater quantity control facilities must be designed to limit peak rates as follows: (1) post-development (post) 25-year discharges are limited to less than or equal to the peak rate of the predevelopment (pre) 5-year storm event, (2) Post 2-year discharges are limited to less than or equal to half the 2-year pre-event, and (3) stormwater and roof drains cannot be discharged directly to streams without approval of the district. Clackamas County has generally adopted the King County Surface Water Design Manual (1990) for all other standards dealing with the selection and design of stormwater quantity controls.	The Federal Emergency Management Agency (FEMA) 1-foot regulatory floodplain standard has been adopted. Floodplain fills require compensatory volume to be provided at the same elevation.	No person may discharge any quantity of stormwater or pollutant that will violate a discharger's permit, the District's NPDES permit or any water quality standard. Non-single-family development must provide an approved water quality facility before any discharge from a site. Erosion control measures are required during all construction and site disturbance activities and until permanent ground covers are installed. Additional ground cover controls are required between October 1 and April 30 each year. Erosion control must be designed so no visible or measurable erosion leaves the property during construction. The treatment design storm is listed as 2/3 of the 2-year, 24-hour storm.

Table 2-1 Summary of Local Regulations Affecting Hydrology, Floodplains, and Water Quality			
Local Jurisdiction	**Water Quantity Regulations**	**Floodplain Regulations**	**Water Quality Regulations**
Metro	Not Applicable	Title 3 standards apply to new development. New development is prohibited within flood management areas to the maximum extent possible. Limited development can occur if mitigation to balance cut and fill is provided to achieve a "zero rise" standard. Flood Hazard Areas include: (1) areas within the FEMA 100-year floodplain, and (2) other areas inundated in the February 1996 flood event.	Title 3 standards are intended to protect water quality associated with beneficial uses as defined by Oregon Water Resources Department (OWRD) and Oregon Department of Environmental Quality (DEQ). The current version of Title 3 requires: (1) erosion and sediment control for all new development to a “no visible” and measurable standard, (2) reservation of native vegetation, and (3) no use of hazardous materials in uncontained areas. Water Quality Resource Areas include areas: (1) along perennial streams and streams draining > 100 acres - minimum 50 feet from top of bank or 200 feet from top of bank on long, steep slopes (25% or greater) or an intermediate distance on shorter (150 square feet) steep slopes, (2) along intermittent streams draining 50 to 100 acres - 15 feet from top of bank or 50 feet from top of bank on steep slopes, and (3) 50 feet from the edge of wetlands or 200 feet from the edge of wetlands bordered by steep slopes.
City of Lake Oswego	The City of Lake Oswego Development Code Article 50.41 specifies that sufficient stormwater detention shall be provided to maintain runoff rates at their natural undeveloped levels for all anticipated intensities and durations of rainfall and provide necessary detention to accomplish this requirement. Detention volume shall be the maximum difference between: a. The stormwater runoff produced from the proposed development site by a 50-year storm, and b. The stormwater runoff produced from the predevelopment site area by a 10-year storm. Development shall be conducted in such a manner that alterations of drainage patterns (streams, ditches, swales, and surface runoff) do not adversely affect other properties.	The City of Lake Oswego administers the National Flood Insurance Program NFIP program. This includes the administration of the city’s floodplain ordinance, which ensures that any building in the floodway will not cause a rise in the water surface elevations during the base flood event.	The City of Lake Oswego Surface Water Management Design Manual has specified, depending on the type of water quality facility, a standard of removal of up to 65% of the phosphorous from 100% of the “newly constructed impervious surface.” The treatment design storm is listed as 0.36 inches of precipitation falling in 4 hours.
City of Portland	In areas with combined sewers, as much runoff as possible must be controlled on-site, where soils permit. On-site flow control must maintain post-development peak flows at magnitudes associated with undeveloped land for the 2-year, 5-year, and 10-year events, with limited exceptions.	Encroachments into the floodway by development and structures defined in 24.50.020 are prohibited unless technical analysis shows that the development will not result in an increase in the base flood elevation. The minimum width of the floodway must be 15 feet.	According to NPDES permit, 80% of total suspended solids (TSS) must be removed from one-third of the 2-year storm. Construction projects that will modify drainage facilities must include a plan to control erosion and sedimentation during construction and to permanently stabilize soils disturbed during construction.

2.1 Hydrology

Development can affect the volume and timing of stormwater runoff from a site. Such effects typically include an increase in the peak flow and volume discharging from a site during a rain event, through the removal of vegetation, the compaction of soils, and an increase in the contributing impervious area, which are all typical of development. These changes have the potential to reduce infiltration and vegetative uptake and reduce the time of concentration, which could increase the possibility for flooding and increase erosion potential in receiving streams. Regulations are in place in order to negate these types of effects.

Hydrology and water quantity are primarily regulated locally. The City of Lake Oswego, City of Portland, and Clackamas County regulate water quantity for new development and redevelopment through development standards by setting detention and flow reduction requirements to meet predevelopment conditions for specified rain events.

The following federal laws, state statutes, local ordinances, and guidance standards address hydrology issues associated with development:

- National Environmental Policy Act (NEPA)
- EPA National Pollutant Discharge Elimination System (NPDES) Permit Regulations
- National Marine Fisheries Service (NMFS) stormwater guidance standards
- Presidential Executive Orders 11990 and 11988
- Oregon Administrative Rules 340-41
- Metro Regulations – Title 3: Water Quality and Flood Management Conservation
- City of Portland Stormwater, Development, and Erosion Control ordinances (City of Portland Code (CPC) Titles 10 and 33)
- Local overlay districts, e.g., the City of Portland's Environmental Zones (E-zones) (CPC Title 3.430)
- City of Lake Oswego City Development Code
- Clackamas County Stormwater Rules and Regulations

2.2 Floodplains

Federal, state, and local regulations establish standards for floodplain regulation. In general, standards are established to (1) prevent flooding conditions from worsening due to new development and floodplain encroachment, and (2) protect new facilities located in the floodplain from damage. These regulations are administered through state and local agencies. Where floodplain impacts are expected to occur, projects must compensate for encroachments by providing floodplain storage equivalent to that lost as a result of those impacts. Facilities constructed in the floodplain must be flood-proofed to prevent damage during flood events.

The following federal and local regulations relate to flooding issues:

- U.S. Coast Guard Section 9
- National Flood Insurance Act (NFIA)
- Flood Disaster Protection Act (FDPA)
- NEPA
- Presidential Executive Orders 11990 and 11988
- U.S. Code of Federal Regulations, Title 33, Section 208.10

- Metro Regulations – Title 3: Water Quality and Flood Management Conservation
- Clackamas County Floodplain Regulations
- Multnomah County Floodplain Regulations
- City of Lake Oswego Community Development Code
- City of Portland Regulations, including the City of Portland's E-zones (CPC Title 33.430)

2.3 Water Quality

Water quality problems are typically related either to conventional pollutants or to nutrients. Conventional pollutants include suspended solids, metals, oil and grease, which are not usually found in a dissolved state, and turbidity. Nutrient pollutants include phosphorus, nitrogen, metals, and organics found in a dissolved state. Typical pollutants, as well as the common problems associated with those pollutants, are described in Table 2-2.

The following federal laws, state statutes, local ordinances, and guidance standards address water quality issues:

- NEPA
- Section 402 of the Clean Water Act (CWA), NPDES Permit Regulations (40 Code of Federal Regulations (CFR) 124)
- Section 401 of the CWA, State Water Quality Certification
- Safe Drinking Water Act of 1974, as amended, 42 United States Code (USC) 300f
- National Marine Fisheries Service (NMFS) water quality guidance standards
- Oregon Revised Statutes (ORS), "Water Quality," ORS 468B
- Oregon Administrative Rules (OAR), "Department of Environmental Quality: Regulations Pertaining to NPDES and Water Pollution Control Facilities WPCF Permits," OAR 340-045-0005 to 340-045-0080
- OAR, "Water Quality Standards: Beneficial Uses, Policies, and Criteria for Oregon," OAR 340-41
- Metro Regulations – Title 3: Water Quality and Flood Management Conservation (Draft)
- Clackamas County Water Quality Rules and Regulations
- Multnomah County Stormwater Regulations
- City of Lake Oswego Stormwater Regulations
- City of Portland Stormwater, Development, and Erosion Control ordinances (CPC Titles 10 and 33)

Local water quality regulations are outlined in federal water quality regulations that include standards maintained by the EPA. EPA's stormwater requirements have been promulgated as part of the CWA and the NPDES program. In most areas, including Oregon, the NPDES program implementation has been transferred to state environmental agencies. Under the NPDES program, permits are issued by the state agencies for various categories of industrial activities. Generally, these activities pertain to specific classes of operations, such as industrial sites, commercial land use, transportation, and residential uses. Best management practices (BMPs) must be implemented on each site where such activities take place.

Currently, the City of Portland, Multnomah County, Clackamas County, and the City of Lake Oswego have NPDES General Stormwater Permits. These permits require implementation of BMPs to control stormwater quality and quantity as a result of new development in the urban environment. At this time, there are no numerical performance criteria that are required to be met with these permits. However, the lower Willamette River is listed on the current 303(d) list by Oregon DEQ as water-quality limited for several constituents and has also been issued a Total Maximum Daily Load (TMDL) for bacteria, mercury, and temperature. Total Maximum Daily Load (TMDL) is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards. The jurisdictions listed above have set specific goals for pollutant removal efficiency of selected BMPs, or water quality treatment criteria as outlined in Table 2-1. These standards can be used as guidance for measuring potential impacts and selecting mitigation methods and criteria.

For construction activities that would disturb one acre of land or more, other NPDES permits are required for the construction phase. It is anticipated that NPDES permits from Oregon agencies will be required for the LOPT because of the areas that are anticipated to be disturbed by the project. However, these permits will be required only if the project progresses to a design and construction phase.

The EPA and most state agencies have established minimum water quality standards for different classes of surface waters. In OAR 340-41-445, DEQ has defined special water quality standards for the Willamette River Basin (DEQ, 2009a). These standards were adopted to protect the beneficial uses of surface waters within the basin and to provide minimum design criteria for waste treatment and control.

Table 2-2 Typical Sources and Problems Associated with Urban Stormwater Pollutants

Contaminants of Concern	Common Sources	Known Problems
Oil and grease	Primarily from automotive and heavy industrial sources.	Hazardous to fish and wildlife, cause aesthetic degradation, may be associated with noxious odors and toxic chemicals.
Nutrients	Phosphorous and nitrogen occur naturally in eroded soil. Anthropogenic sources include fertilizers, detergents, and mulch.	The principal nutrients are phosphorous and nitrogen. Releases of these elements, the availability of which is limited in aquatic environments, can cause algal blooms and other problems.
Oxygen-demanding organics	Natural organics washed from paved areas.	Can cause oxygen depletion when decomposed through bacterial action.
Toxic organics	Examples of toxic organics include pesticides, phenols, and PAHs.	In the greater Seattle area, EPA found 19 of 121 priority pollutants in stormwater runoff.
Metals	Concentrations of lead, zinc, cadmium, and copper primarily from automotive and industrial sources.	Toxic to aquatic and benthic organisms.
Bacteria and viruses	Fecal coliform from failing septic leaching systems, pet wastes, municipal system overflows, and other nonpoint sources.	Impacts to shellfish (harvest closures) and beneficial uses (e.g., restriction of recreation).
Eroded soil	Streets and construction sites.	Sediments in stormwater can smother habitat.

3. AFFECTED ENVIRONMENT

This section provides a description of the affected environment relating to hydrology, floodplains, and water quality in the LOPT project area. The project area is located entirely within the Willamette River Basin and more specifically, the Lower Willamette River Subbasin (refer to Figure 3-1). The project area crosses three named tributaries to the Willamette River: Tryon Creek, Stephens Creek, and Terwilliger Creek, and numerous unnamed tributaries to the Willamette. The Tryon Creek Subbasin and Stephens Creek Subbasin are analyzed separately throughout this report; however, the Terwilliger Creek Subbasin is included in the Willamette River Basin discussion, because it has been piped under the developed portion of Johns Landing. The Willamette River Basin discussion includes all areas within the project area that are outside of the Tryon Creek and Stephens Creek subbasins, and includes areas draining to the Willamette River via overland flow and unnamed tributaries.

Existing land use in the vicinity of the project area is primarily urban. Current land use includes single-family residential with pockets of other urban land use types (e.g., multifamily residential, mixed-use commercial, and industrial). Additionally, the study corridor crosses through several parks and open spaces. Much of the area in and adjacent to the project improvements is developed, with significant impervious surface coverage such as streets, roofs, and parking areas. Impervious surfaces affect the hydrology of a basin and the water quality within its receiving streams because they provide a medium for collecting pollutants and a conveyance mechanism for efficiently transporting these pollutants to local streams. Consequently, a primary indicator of a potential project's effect on hydrology and water quality is the amount of impervious surface area that could be added as a result of the project or converted to a higher intensity use. Additional factors that could produce effects to water resources include fill in floodplains and water bodies and changes to drainage patterns.

In order to determine the existing amount of impervious surface in the project corridor, the project team estimated the total existing impervious surface area for each watershed draining the LOPT project. Estimates were done by determining the area within each of Metro's land use (zoning) categories, then multiplying the area estimate by that zoning category's estimated percent imperviousness (Table 3-1). Table 3-2 presents the total estimated impervious surface area in each basin, which was calculated by summing the estimates for each category. The estimated total impervious surface area provides an approximation of existing basin conditions for comparison to the proposed project components.

Table 3-1 Percent Impervious Area by Land Use

Metro Land Use Categories	Impervious %[1]
Unknown[2]	40%
AGR - Agriculture	5%
COM - Commercial	72%
FOR - Forest	0%
IND - Industrial	70%
MFR - Multi-family Res	61%
RUR - Rural	10%
SFR - Single family res	42%
VAC - undeveloped	5%

Notes:
[1]. Impervious percentages associated with land use source, CCSD # 1 and SWMACC permit renewal (Clackamas County, 2008)
[2.] For estimating purposes, areas with unknown land use were assumed a moderate impervious percentage coverage of 40%

Table 3-2 Existing Impervious Surface Area by Basin[1]

Basin	Total Impervious Area (acres)
Willamette River[1,2]	27,517
Tryon Creek	1,121
Stephens Creek	207

[1] Source: Metro (2002)
[2] The Willamette River basin areas analyzed only include the portions of the basin within the Portland Metropolitan Tri-County area, as zoning information was not available for portions of the basin located outside of this area

3.1 Hydrology

Topography within the project area slopes from west to east, and runoff from Highway 43 and other upstream areas is directed downslope towards the existing railroad tracks via storm drains or overland flow, where it is frequently collected in trackside ditches and culverts. Fifty-four existing culverts that convey runoff as well as streams and ditches underneath the existing tracks were identified during field reconnaissance. The majority of these culverts are buried, blocked, or damaged such that they do not provide adequate conveyance. These culverts either discharge to the top of slope on the east side of the tracks before discharging to the Willamette River via overland flow, or they discharge to the Willamette River directly. Predominant soils in the project area are within hydrologic class C or D, and do not have favorable infiltration potential (NRCS, 2009).

As mentioned above, the study area crosses numerous observed waterways that discharge to the Willamette River, and includes three named waterways and many unnamed tributaries. Eight of the unnamed tributaries are located within Powers Marine Park. The majority of these waters currently receive runoff from roadways and other surfaces that is not treated to current design standards for quality or quantity. The Willamette River is also in proximity to the entire project area, and is immediately adjacent to the project area in some locations. However, the project area does not cross the Willamette River.

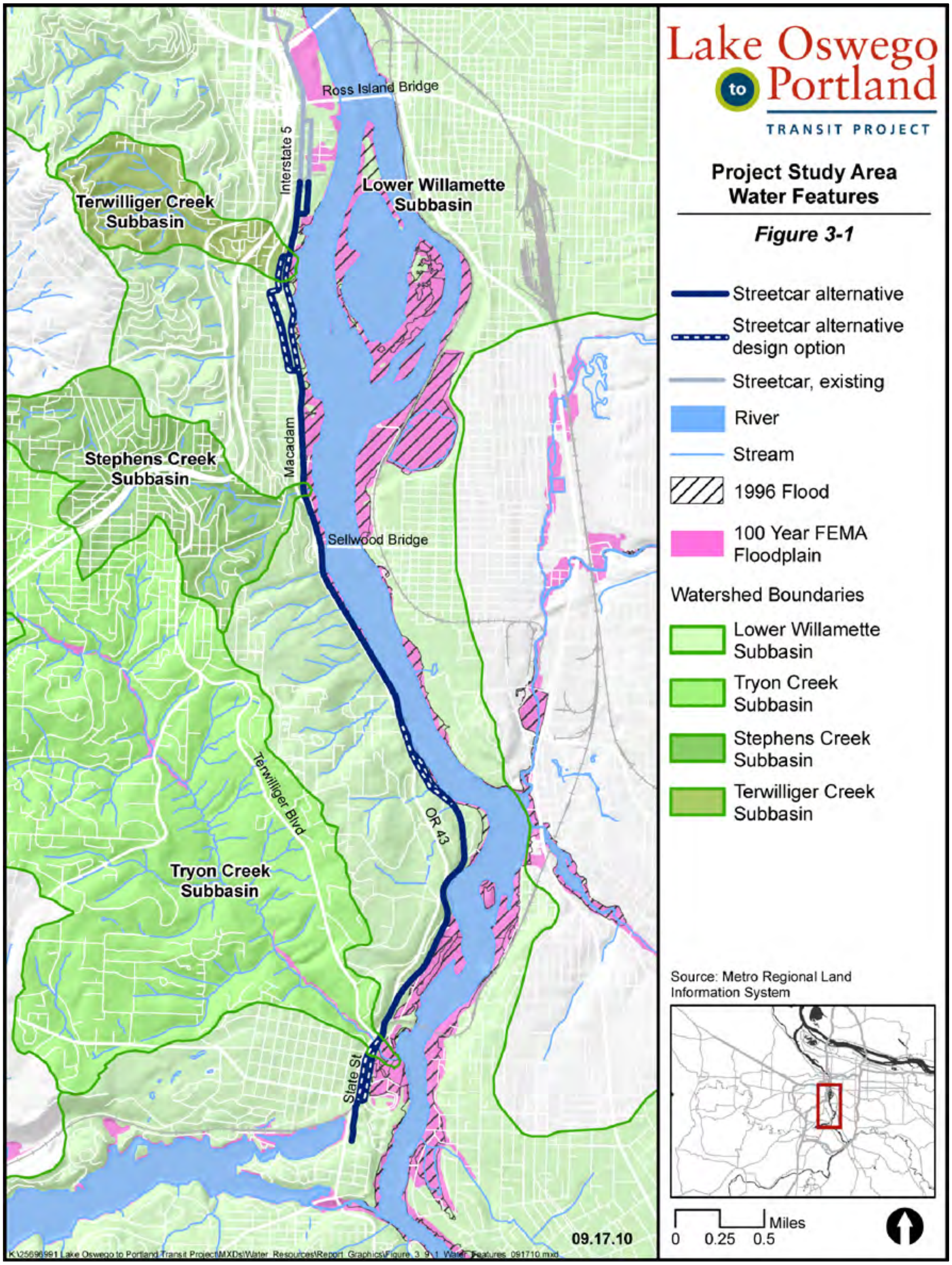


FIGURE 3-1 PROJECT STUDY AREA WATER FEATURES

3.1.1 Willamette River

The Willamette River Basin covers approximately 11,478 square miles in western Oregon (Metro, 2008). The river flows generally north, approximately 190 miles from its headwaters in the Cascade Mountains to its confluence with the Columbia River in the City of Portland. Oregon's three largest cities—Portland, Eugene, and Salem—are situated along the banks of the Willamette River. Approximately 41 percent of the basin is currently impervious surface (Metro, 2008). The Willamette River Basin in the vicinity of the project area is highly urbanized with residential, commercial, industrial and recreational land use (DEQ, 2006). Portions of the lower Willamette River have been channelized, with much of its banks either constrained by riprap or the Portland seawall. Most of the Willamette River's original off-channel and floodplain habitat has been eliminated or is highly degraded, and its channel largely lacks topographic and habitat diversity. The river is regulated by 11 multipurpose flood control/recreation/hydropower reservoirs, all located upstream of the project area, and operated by the U.S. Army Corps of Engineers (USACE). These facilities have substantially altered the hydraulics of the river compared to its original state (Metro, 2008).

The project area within the Lower Willamette Subbasin is mostly developed, with existing stormwater drainage infrastructure. Along the existing rail alignment within the project area, this includes existing ditches along the tracks and approximately 54 culverts that pass underneath the tracks. The source of drainage to these culverts is either stormwater discharge from upslope impervious areas or natural drainage features (or a combination of the two). The majority of water entering the existing rail alignment comes from culverts that outfall above the tracks. This water flows down-gradient through ditches at the base of the railroad embankment until it reaches a culvert inlet, which allows conveyance to the east, towards the Willamette River. Along Highway 43 and other existing roadways, existing stormwater infrastructure includes catch basins, ditches, culverts, and storm drain pipe that convey stormwater from Highway 43 and upgradient areas, and there are seasonal and perennial streams in some locations. Locations of stream crossings in the project area are depicted in Figure 3-2. Table 3-3 summarizes average flows of the project area streams in cubic feet per second (cfs).

Table 3-3 Estimated Average Flows for Project Area Streams

Water Body	Average Flow (cubic feet per second)
Willamette River[1]	32,000
Tryon Creek[2]	8.5
Stephens Creek[3]	1.5

[1] USGS, 2002, as reported by Metro.
[2] USGS, 2008 Average flow represents measurements taken from 2002-2008
[3] BES, 2010. This flow represents the average of a range of average flows provided on the Bureau of Environmental Services (BES) website for Stephens Creek.

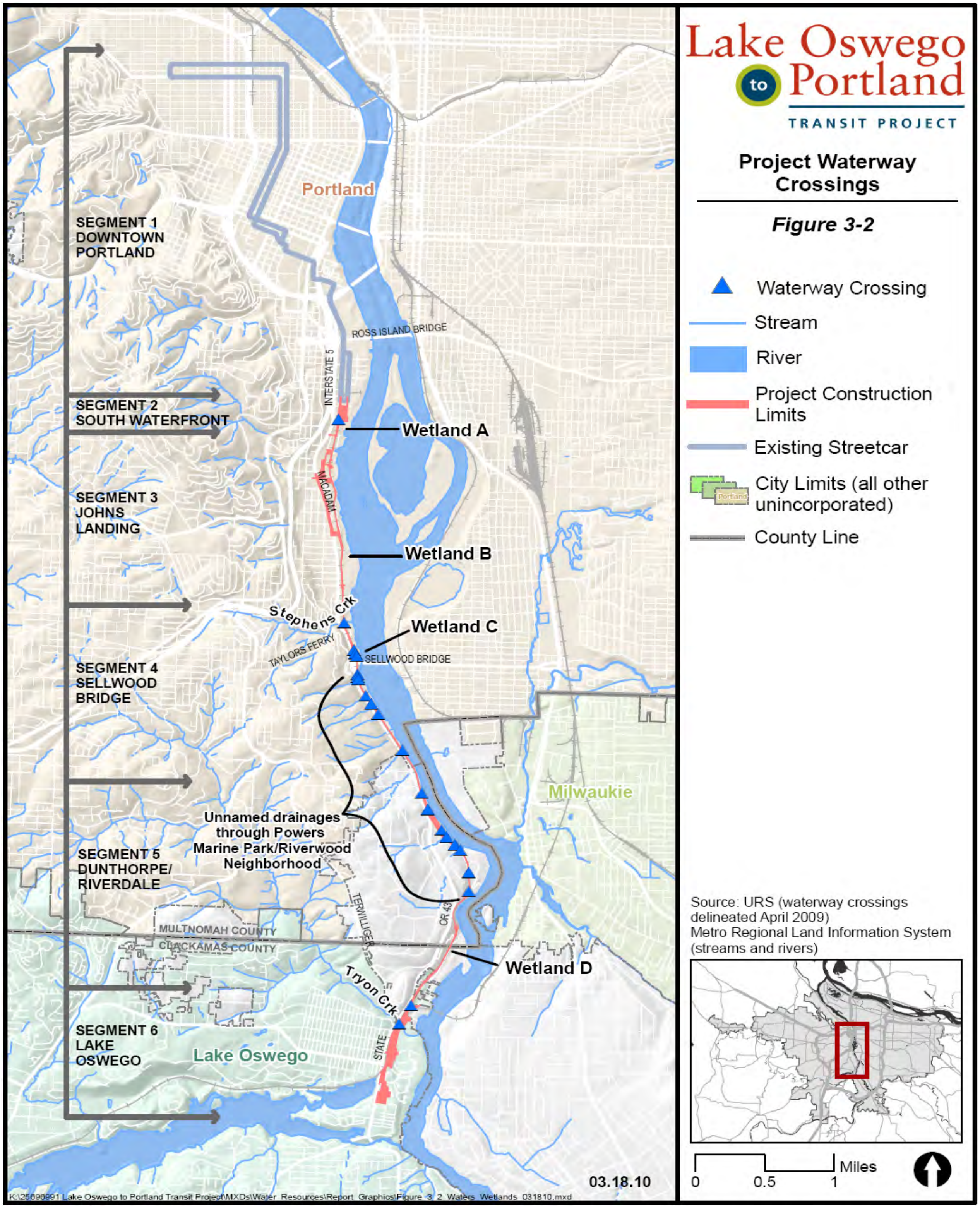


FIGURE 3-2 PROJECT WATERWAY CROSSINGS

3.1.2 Tryon Creek

The Tryon Creek Subbasin covers an area of approximately 4,200 acres. The Tryon Creek main stem is about seven miles long and flows southeast from its headwaters near Multnomah Village (just north of Interstate 5 and Highway 99) to its confluence with the Willamette River in the City of Lake Oswego at the Highway 43 crossing. Development in the Tryon Creek Subbasin is concentrated in the upper portion of the watershed, and therefore affects the hydrology of the entire main stem of Tryon Creek. The project area crosses Tryon Creek near its confluence with the Willamette River, so only a small portion of the subbasin has the potential to be affected by the LOPT. Tryon Creek passes underneath Highway 43 and the existing rail tracks through an 8-foot-by-8-foot concrete box culvert. The hydrology of the Tryon Creek watershed has been modified by the effects of development and urbanization; the most significant modifications include the loss of native vegetation including mature forest cover, an increase in impervious surfaces including travel corridors, and construction of closed-conveyance drainage systems including piped storm sewer systems and culverts.

3.1.3 Stephens Creek

The Stephens Creek Subbasin covers an area of approximately 760 acres and runs in a northwest-to-southeast direction through southwest Portland. Several segments of the creek flow into an enclosed conveyance system as it flows through urban areas of southwest Portland. Land use in the subbasin is dominated by residential and some commercial land uses, as well as parks and vacant areas. The project area crosses Stephens Creek very near its confluence with the Willamette River; therefore, only a small portion of the subbasin has the potential to be affected by the LOPT. Stephens Creek passes underneath the existing rail tracks via two parallel concrete culverts. The riparian area through this segment of the stream is wooded, with some rocks. Woody debris has been placed in the area as part of a City of Portland habitat restoration project in completed in 2008. The project was intended to improve in-stream, stream bank, and floodplain wetland habitat.

3.2 Floodplains

3.2.1 Willamette River

Portions of the project area are within the FEMA regulatory 100-year floodplain for the Willamette River (as shown on Figure 3-1). A major flood event occurred in the Portland metropolitan area in February 1996. Flooding during the February 1996 event within downtown Portland was, in many areas, more extensive than the 100-year floodplain area shown on the Flood Insurance Rate Map (FIRM). Most of the South Waterfront development south of the Marquam Bridge is within the 100-year floodplain, which is defined by the extents of the FEMA 100-year floodplain and the February 1996 flood inundation area combined (Metro, 2008).

3.2.2 Tryon Creek

Although the February 1996 flood event caused severe landslide, streambank, and streambed damage to Tryon Creek and its tributaries, it did not cause any significant flooding or property damage in the Tryon Creek watershed. The effects of flooding in the future will likely remain the same. Changing hydrologic conditions may continue to cause damage to the stream system in the Tryon Creek watershed, but may not result in any significant flooding of properties (BES, 2005).

3.2.3 Stephens Creek

A small portion of the downstream end of Stephens Creek lies within the 100-year floodplain of the Willamette River. The City of Portland recently completed a major habitat enhancement project at the confluence of Stephens Creek and the Willamette River. One aspect of the project was to remove artificial structures, such as an abandoned combined sewer overflow pipe, which helped to restore the natural floodplain connectivity in the area (BES, 2010).

3.3 Water Quality

A TMDL was approved by the EPA in 2006 for the entire Willamette River Basin for temperature, bacteria, and mercury. This TMDL includes Tryon Creek, specifically, and Stephens Creek, as a tributary to the Willamette River. The Willamette River and Tryon Creek are listed on the DEQ's 2004/2006 list of impaired waterbodies (Section 303(d) of the CWA) (DEQ, 2009b). Table 3-4 presents the 303(d) parameters within the project area.

Table 3-4 303(d) 2004/2006 Listed Reaches[1] within Project Area

Water Body	Listed Reaches (RM)[2]	Parameter	Season
Tryon Creek	0 to 5	Temperature	Summer
Willamette River	0 to 186.4	E. Coli	Fall/Winter/Spring
Willamette River	0 to 24.8	Aldrin	Year-round
Willamette River	0 to 24.8	Biological Criteria	Undefined
Willamette River	0 to 24.8	DDT	Year-round
Willamette River	0 to 24.8	Dieldrin	Year-round
Willamette River	0 to 24.8	Fecal Coliform	Fall/Winter/Spring
Willamette River	0 to 24.8	Iron	Year-round
Willamette River	0 to 24.8	Manganese	Year-round
Willamette River	0 to 24.8	Mercury	Year-round
Willamette River	0 to 24.8	PCB	Year-round
Willamette River	0 to 24.8	Pentachlorophenol	Undefined
Willamette River	0 to 24.8	PAH	Year-round
Willamette River	0 to 50.6	Temperature	Year-round

Source: DEQ, 2009c.
[1] Listed reaches are those reaches or portions of reaches listed in the 303(d) 2004/2006 Integrated Report Database, which reports on streams or lakes identified as impaired for one or more pollutants and do not meet one or more water quality standards.
[2] RM = River Mile.

3.3.1 Willamette River

General water quality issues in the portion of the Willamette River located in the project area include aquatic ecosystem degradation, soil erosion from construction, and elevated concentrations of nutrients, synthetic compounds, and trace elements (e.g., heavy metals). The Willamette River TMDL was approved by EPA in 2006 for mercury, bacteria, and temperature within the Willamette River main stem (Lower Willamette River Subbasin). Additionally, the Willamette River is on DEQ's 303(d) list of water quality limited waterbodies for the following parameters: dieldrin, DDT, DDE, PAHs, aldrin, PCBs, manganese, iron, and pentachlorophenol (DEQ, 2009b).

The City of Portland's BES has several monitoring stations in the Willamette River. One of these locations is at the Morrison Bridge, which is just downstream of the project alignment. The data collected at this location is summarized in Table 3-5.

Table 3-5 Lower Willamette River Water Quality

Parameter	Units (Sample Type)	Mean	Median	Minimum (Date)	Maximum (Date)
Copper	(μg/l) (x-section composite)	1.35	1.02	0.61 (12/1/05)	7.13 (11/8/06)
Dissolved Copper	(μg/l) (x-section composite)	0.63	0.61	0.36 (4/10/02)	1.21 (11/8/06)
Lead	(μg/l) (x-section composite)	0.30	0.19	0.78 (5/2/07)	1.88 (12/19/00)
Dissolved Lead	(μg/l) (x-section composite)	NA(1)	0.043	0.011 (2/4/04)	0.024 (12/19/00)
Total Suspended Solids	(μg/l) (x-section composite)	9.8	5.8	2 (1/17/01)	154 (11/8/06)
Dissolved Oxygen	(mg/l) (mid-stream grab)	11.0	11.2	7.2 (7/25/01)	16.5 (1/18/07)
Temperature	^{o}C (mid-stream grab)	12.8	11.5	4.0 (1/18/07)	23.8 (8/9/00)

Source: BES collected these data from the Morrison Bridge monitoring station between January 2000 and March 2010.
(1) Mean value for dissolved lead are not available due to readings taken below limits of detection.

Using the Federal Highway Authority (FHWA, 1990) procedure discussed in Appendix B, the theoretical amount of pollutant loading into the Willamette River (annual mass loading) was estimated for existing conditions. The results from this probabilistic procedure were also used to predict the in-stream pollutant concentration exceeded an average of once in three years. Note that the results presented in Table 3-6 do not represent actual pollutant loading or concentrations within the drainage area.

Table 3-6 Calculated Existing Once-in-Three-Year Total Pollutant Concentration Exceedance and Existing Annual Mass Loadings for the Willamette River Basin

Parameter	Exceedance Concentration	Annual Mass Loading, lbs./year
TSS (mg/l)	113	49,065,866
BOD_5 (mg/l)	6.0	2,581,190
TKN (mg/l)	1.3	581,349
Ammonia-N (mg/l)	0.4	172,079
Total Phosphorus (mg/l)	0.2	97,667
Cadmium (μg/l)	1.1	488
Copper (μg/l)	21.0	9,069
Lead (μg/l)	34.4	14,882
Zinc (μg/l)	134	58,135
Dissolved Cadmium (μg/l)	0.0	0.0
Dissolved Copper(μg/l)	4.3	1,860
Dissolved Lead (μg/l)	0.0	0.0
Dissolved Zinc (μg/l)	32.2	13,952

3.3.2 Tryon Creek

Water quality issues in the Tryon Creek watershed include elevated temperatures, elevated instream bacteria concentrations, and elevated levels of suspended sediments and nutrients (phosphorous and nitrogen), especially during storm events (BES, 2005). The Willamette River TMDL approved by EPA in 2006 also established a separate TMDL for Tryon Creek for temperature.

The Portland BES established an instream water quality monitoring program in Tryon Creek in 1997. BES's water pollution control laboratory collects monthly grab samples from Tryon Creek at SW Boones Ferry Road (BES, 2005). In May 1998, BES installed a continuous temperature monitoring device to collect hourly temperature data from May through October. The monitoring results are consistent with the 303(d) listing and show that the seven-day average of the daily maximum temperatures frequently exceeds the water quality standard of 18.0° C during the summer period. Maximum summer-period daily temperatures ranged from 20.0° C to 21.9° C, and the seven-day average temperatures exceeded the standard from 25 to 42 days each summer (BES, 2005). Elevated temperatures are likely the result of low stream flows during the summer months, warmer air temperature resulting from urban heat island effects, reduced riparian vegetation (and consequent lack of stream shading), and stormwater runoff from impervious surfaces exposed to sunlight.

The BES monitoring results show that Tryon Creek occasionally exceeds water quality standards for *E. coli* concentrations. Most of the exceedances of the standard are during periods of precipitation and increased stream flows. TSS concentrations are generally less than 5 milligrams/liter (mg/l), except during storm events or extended wet periods when the TSS concentrations are elevated. The highest total phosphorus concentrations are typically correlated with increased suspended solids concentrations as a result of storm events. The median total phosphorus concentration for all samples was 0.085 mg/l. The monitoring results show that nitrate concentrations peak during the wet season (November – January), with a median concentration of 0.85 mg/l (BES, 2005).

The once-in-three-year exceedance concentrations and annual mass loading for the Tryon Creek watershed were calculated using the FHWA-RD-88-006 methodology, based on the existing conditions. The results are presented in Table 3-7. Note that the results presented in Table 3-7 do not represent actual pollutant loading or concentrations within the drainage area.

Table 3-7 Calculated Existing Once-in-Three-Year Total Pollutant Concentration Exceedance and Existing Annual Mass Loadings for the Tryon Creek Watershed

Parameter	Exceedance Concentration	Annual Mass Loading, lbs./year
TSS (mg/l)	17.7	1,998,867
BOD_5 (mg/l)	0.9	105,154
TKN (mg/l)	0.2	23,683
Ammonia-N (mg/l)	0.1	7,010
Total Phosphorus (mg/l)	0.0	3,979
Cadmium (μg/l)	0.2	20
Copper (μg/l)	3.3	369
Lead (μg/l)	5.4	606
Zinc (μg/l)	21.0	2,368
Dissolved Cadmium (μg/l)	0.0	0.0
Dissolved Copper(μg/l)	0.7	76
Dissolved Lead (μg/l)	0.0	0.0
Dissolved Zinc (μg/l)	5.0	568

3.3.3 Stephens Creek

Little is known about the water quality of Stephens Creek, but it currently receives untreated stormwater from adjacent and upstream roads and parking lots (PP&R, 2005). Portions of Stephens Creek run through urbanized areas, and it is subject to stormwater pollutants typical of urbanized areas such as sediments, pesticides, oil and grease, and metals. Stephens Creek is not specifically listed as water-quality limited by DEQ; however, as a tributary to the Willamette River it is incorporated into the Lower Willamette Subbasin TMDL for bacteria, mercury, and temperature.

The calculated once-in-three-year exceedance concentrations and annual mass loading for the Stephens Creek watershed were calculated using the FHWA-RD-88-006 methodology, based on the existing conditions. The results are presented in Table 3-8. Note that the results presented in Table 3-8 do not represent actual pollutant loading or concentrations within the drainage area.

Table 3-8 Calculated Existing Once-in-Three-Year Total Pollutant Concentration Exceedance and Existing Annual Mass Loadings for the Stephens Creek Watershed

Parameter	Exceedance Concentration	Annual Mass Loading, lbs./year
TSS (mg/l)	18.0	369,229
BOD_5 (mg/l)	0.9	19,424
TKN (mg/l)	0.2	4,375
Ammonia-N (mg/l)	0.1	1,295
Total Phosphorus (mg/l)	0.0	735
Cadmium (μg/l)	0.2	4
Copper (μg/l)	3.3	68
Lead (μg/l)	5.4	112
Zinc (μg/l)	21.3	437
Dissolved Cadmium (μg/l)	0.0	0
Dissolved Copper(μg/l)	0.7	14
Dissolved Lead (μg/l)	0.0	0
Dissolved Zinc (μg/l)	5.1	105

4. ENVIRONMENTAL CONSEQUENCES

This section describes the potential long- and short-term hydrologic, floodplain, and water quality impacts associated with the LOPT alternatives and associated alignment options. Long-term effects include direct, indirect, and cumulative effects, which are likely to affect the area for the operational life of the project and are discussed below. Short-term effects are those associated with construction. This impact analysis is based on the conceptual designs previously described in Section 1.

Table 4-1 shows the criteria used to assess adverse impacts associated with each alternative. Impacts were considered minor if a measurable but small change to the existing conditions of the receiving water body or floodplain would be expected. Impacts were considered moderate if there would be a readily apparent change in localized existing conditions. Impacts were considered major if there would be obvious regional changes to the existing conditions.

Table 4-1 Impact Intensity Threshold Criteria

Negligible	Changes in the water resource or resource-related values would be below or at the level of detection. If detected, effects would be considered slight with no perceptible consequences to health or overall water quality/quantity.
Minor	Changes in the water resource or resource-related values would be measurable; although the changes would be small, effects on the resource or the environment would be localized and would not affect water quality/quantity downstream from the project area.
Moderate	Changes in the water resource or resource-related values would be readily apparent. The effects would be sufficient to cause concern, although the effects would be relatively local and would be associated with short-term construction-related activities.
Major	Changes in resource or resource-related values would obvious; the effects would have substantial consequences to the resource and environment and could be noticed regionally.

4.1 Direct Impacts

4.1.1 Impact Overview

There are a variety of ways in which linear development projects have the potential to impact water resources. Direct effects to hydrology include the following:

- Alterations to the stormwater hydrograph (increased volume, altered timing)
- Changes in drainage flow paths, routing, and discharge locations
- Reduced infiltration potential and increase in volume of runoff conveyed to water bodies through the increase in impervious surfaces
- Modifications to channel conveyance capacity

Water quality effects associated with linear projects typically are a result of (Metro, 2008):

- Increases in the export of pollutants from impervious surfaces
- Reduced pollutant filtration and increased instream water temperatures as a result of riparian vegetation removal
- Export of pollutants from motor vehicles using park-and-ride lots and other associated infrastructure

In general, the impact to water quality and hydrology from rail projects is usually lower than other types of linear transportation facilities, such as roadways, since the bulk of rail track is constructed on permeable ballast surfaces. As a result, rail transit typically generates much less impervious area than other transportation facilities.

The increase in impervious surface is the main indicator used to classify water quality and hydrology effects for the LOPT. Modification to flow patterns could also result in effects to hydrology. Floodplain effects and impacts are primarily determined by estimating the amount of project work and fill that may occur within the floodplain. An increase in impervious surface can have an adverse effect on hydrology and water quality because impervious surfaces collect pollutants and prevent stormwater from infiltrating into the ground, therefore increasing runoff volumes and peak flow rates and providing a means of conveyance for accumulated pollutants to water bodies within the project area. As mentioned in Section 1, there are three alternatives associated with the LOPT: a No-Build Alternative and two build alternatives (the Enhanced Bus Alternative and the Streetcar Alternative, with design options). Each of these three alternatives has been analyzed for its effects to hydrology, floodplains, and water quality, and these are presented in the following subsections. Table 4-2 provides a summary of the new impervious surface area, by alternative and basin, which was used to analyze potential effects as discussed in the following sections. The increase in impervious surface is very low in relation to the size of the project area and negligible on a basin-wide scale, regardless of which alternative or design option is chosen. Therefore, rather than evaluating effects of each specific design option, impacts were assessed by reviewing the range of impervious surface area that could result from the different potential combinations of design options for the Streetcar Alternative. A detailed breakdown of impervious surface for each separate design option is included in Appendix C.

Table 4-2 Net New Impervious Surface Area in acres, by Basin and Alternative

Basin	Existing Impervious Area in the Basin (No-Build Alternative)	Enhanced Bus Alternative	Streetcar Alternative	
			Minimum	Maximum
Willamette River	27,517[1]	0.75	4.96	8.57
Tryon Creek	1,121[2]	0.00	0.11	0.19
Stephens Creek	207[2]	0.00	0.05	0.05

[1] Source: Metro, 2008
[2] Source: Metro RLIS GIS Database; Clackamas County, 2008
[3] Acreage in this table includes new impervious surface the project would construct on areas that were formerly pervious.

4.1.2 Direct Effects to Hydrology

Most of the direct project-related effects to hydrology are a direct result of the increase in impervious surface associated with construction of stations, park-and-ride lots, maintenance facilities, and segments of non-ballasted track. Direct hydrologic effects are also related to the encroachment of development on the stream channels as well as changes in drainage patterns. Potential hydrologic effects based on these three indicators were determined for the No-Build, Enhanced Bus, and Streetcar alternatives. The new impervious surface area created by the alternatives is summarized in Table 4-2.

4.1.2.1 No-Build Alternative

The No-Build Alternative represents conditions in the project area in 2035 without the Enhanced Bus or Streetcar Alternative. The No-Build Alternative would not include new streetcar or bus facilities in the area and associated new impervious surface and, therefore, would not induce project-related effects to hydrology. There would also be no effect to drainage patterns or channel conveyance capacity. However, in association with hydrologic effects, existing culverts along the existing tracks would not be improved and would likely continue to degrade, becoming further blocked.

4.1.2.2 Enhanced Bus Alternative

Implementation of the Enhanced Bus Alternative would include the construction of a 300-space park-and-ride facility located within the existing Lake Oswego Shopping Center parking area and an associated access road to accommodate commuter traffic. Modifications to the existing bus service would be made by eliminating some stops and increasing frequency, without major modification to existing roadway infrastructure.

Construction associated with this alternative would result in approximately 3.6 acres of new and redeveloped impervious surface. Of those 3.6 acres, only approximately 0.8 acres would be new added impervious surface. All construction associated with this alternative would occur within the Willamette River Basin, increasing impervious coverage in that basin by only approximately 0.002 percent. Therefore, on a basin-wide scale, direct hydrologic effects associated with an increase in impervious surface would be negligible.

Although the percent increase in impervious surface is negligible on a basin-wide scale, the potential for more localized effects to hydrology was also assessed to determine whether a localized increase in peak flows and volumes would have the potential to induce more significant effects. However, in accordance with the City of Lake Oswego design standards, stormwater runoff from the Enhanced Bus Alternative would be detained in a manner that maintains runoff rates at their natural, undeveloped levels (City of Lake Oswego, 2002), and then discharged to the Willamette River via an existing storm drainage system that currently serves the area. As part of the design and construction process, the downstream capacity of the existing storm drainage system would be assessed and redesigned as necessary to maintain flow. Therefore, effects to overall drainage patterns in the project area are not anticipated as a result of the Enhanced Bus Alternative. Although peak flows would be controlled through detention, the volume of runoff generated would increase slightly, prolonging the duration of stormwater discharge from the site. However, because the site discharges stormwater to the Willamette River, effects associated with the small increase in duration of discharge would produce negligible effects to such a large receiving water body. No new water body crossings would be constructed as part of the Enhanced Bus Alternative.

Due to the small increase in impervious surface associated with this alternative, adherence to City of Lake Oswego design standards, and the lack of modifications to site drainage patterns and stream encroachments, localized and basin-wide direct effects of the Enhanced Bus Alternative associated with hydrology are expected to be negligible.

4.1.2.3 Streetcar Alternative

As previously noted, the Streetcar Alternative would result in an increase in impervious surfaces in the Willamette River Basin, Tryon Creek Subbasin, and Stephens Creek Subbasin. These impervious areas consist of stations, park-and-ride lots, maintenance facilities, and segments of track embedded in concrete pavement. Note that tie and ballast track is considered pervious surface and therefore is not factored into the impervious area estimates. Although the Streetcar Alternative involves the possibility of several different combinations of design options, potential work is limited to previously developed areas. There are no significant differences in the design options with respect to potential hydrology impacts; therefore, the effects analysis does not specifically evaluate each design option or combination of design options. Where there are differences, these are discussed in the subbasin in which they occur.

Willamette River Basin

The majority of the project area, as well as the increase in impervious surface, drains to the Willamette River directly or via small unnamed tributaries. Depending on the combination of design options chosen, as little as approximately 4.96 acres or as much as approximately 8.57 acres of net new impervious surface would be added to those areas draining to the Willamette River directly or via unnamed tributaries This would result in an increase of up to approximately 0.031 percent of impervious surface over the entire Willamette River Basin.

The majority of the existing culverts underneath the existing rail tracks would be replaced or modified as a result of the rail construction associated with the Streetcar Alternative. In general, culverts would be replaced in their existing locations, and would be replaced to improve conveyance and provide fish passage, where appropriate. This could increase the amount of runoff directed to the culverts that are currently unable to properly convey flow due to their poorly maintained condition; however, as previously mentioned, since the majority of the runoff currently received by the culverts is from upland areas, a noticeable increase in flow associated with construction of the Streetcar Alternative would not be expected. In most cases, replaced and modified culverts would be longer than the existing culverts, to accommodate the wider ballast footprint resulting from the LOPT project. Replacement of culverts conveying streams and ditches could require instream construction.

In several locations along the western boundary of the track alignment, retaining walls are proposed. In these areas, a new drainage ditch on the upslope area of the retaining wall would be constructed, which would intercept runoff from Highway 43 that currently flows into the existing drainage ditches and would convey it to the existing (or replaced) culverts running underneath the track. Since these ditches would merely replace the existing ditches and maintain existing culvert locations for discharge toward the Willamette River, no noticeable effects to hydrology are anticipated as a result of the stormwater conveyance ditches.

Portions of the project area within the Willamette River Basin lie within Portland City limits, unincorporated Multnomah County, and Lake Oswego City limits. Stormwater quantity standards for areas within unincorporated Multnomah County are currently regulated by the City of Portland (Multnomah County, 2008). These standards require stormwater to be infiltrated to the maximum extent practicable before discharging any flows off-site (BES, 2008). In addition to infiltration requirements, there are specific flow control requirements for areas discharging to tributaries and storm sewers that drain to streams or overland storm drainage systems. Flow control in these areas should aim to avoid discharging flows that will cause channel erosion, which, unless more specific data is available, the City of Portland assumes to be one-half of the 2-year, 24-hour predevelopment (Lewis & Clark era) peak flow. The facilities must also control the post-development flows from the 5-, 10-, and 25-year, 24- hour peak flows to the predevelopment 5-, 10-, and 25-year, 24-hour levels. Areas draining directly to the Willamette River are exempt from flow control requirements for new development and redevelopment, because of the size of the receiving water body. Areas within the City of Lake Oswego jurisdiction would adhere to the City of Lake Oswego's stormwater quantity design standards as described in Section 2.

Due to the length of the alignment, number of culverts, small increase in impervious surface, maintenance of existing drainage patterns and culvert locations, and adherence to stormwater quantity standards, localized and basin-wide impacts to flow conveyed to the Willamette River via culverts and overland flow within the Willamette River Basin would be negligible.

Tryon Creek Subbasin

A small portion of the project area associated with the Streetcar Alternative would occur within the Tryon Creek Subbasin, which would result in an increase in impervious surface of approximately 0.11 acres to 0.19 acres to the basin, depending on the design option chosen. Near the intersection of Highway 43 (North State Street) and Stampher Road, the proposed track alignment is expected to cross beneath an existing Union Pacific Railroad (UPRR) freight line track via a new grade separation structure and then cross Tryon Creek over a new trestle. This design element, which is consistent for both design options in this project segment, is not expected to result in noticeable effects to hydrology. Although the new grade separation could result in some minor alterations to local drainage, stormwater management facilities would be designed to maintain existing discharge points. In addition, all construction of the Tryon Creek crossing is expected to occur above the OHWM (OBEC, 2009). There is one existing 8-foot-by-8-foot box culvert that currently passes underneath the existing rail tracks and SW Macadam Avenue, which conveys Tryon Creek. This culvert would not be altered or removed as part of the Streetcar Alternative.

Stormwater runoff in this portion of the project is regulated by the City of Lake Oswego and would adhere to the city's stormwater quantity design standards. In accordance with those standards, stormwater runoff from the Streetcar Alternative would be detained in a manner that maintains runoff rates at their natural, undeveloped levels (City of Lake Oswego, 2002).

The net new impervious surface associated with the Streetcar Alternative would result in an increase in the impervious percentage of the entire basin of up to 0.017 percent. Due to the negligible increase in impervious surface, the maintenance of existing drainage patterns, adherence to stormwater quantity standards, and lack of work that would be done within the OHWM, hydrologic impacts associated with the Streetcar Alternative within the Tryon Creek Subbasin are not anticipated on a basin-wide or local scale.

Stephens Creek Subbasin

A small portion of the project area associated with the Streetcar Alternative would occur within the Stephens Creek Subbasin, very near the creek's confluence with the Willamette River, which would result in an approximate 0.05-acre increase in impervious surface to the subbasin, regardless of design option. Stormwater runoff in this portion of the project is regulated by the City of Portland. Therefore, stormwater would be required to be infiltrated to the maximum extent practicable, and flow controlled to match predevelopment rates for the 2-, 5-, 10-, and 25-year, 24-hour levels (BES, 2008).

There are two parallel culverts that currently pass underneath the existing rail alignment within the Stephens Creek Subbasin that convey Stephens Creek. The Streetcar Alternative would provide for construction of the new double-tracked streetcar alignment in conjunction with the planned west interchange improvements for the Sellwood Bridge (the streetcar alignment would be located slightly east of the existing Willamette Shore Line right-of-way). Although this design option would extend the existing Stephens Creek crossing, based on preliminary design information, it is not anticipated to involve construction below the ordinary high water mark (OHWM) (OBEC, 2009).

The net new impervious surface associated with the Streetcar Alternative would result in an increase in the impervious percentage of the entire basin by approximately 0.02 percent. Due to the negligible increase in impervious surface, the maintenance of existing drainage patterns, adherence to stormwater quantity standards, and lack of work that would be done within the OHWM, hydrologic impacts associated with the Streetcar Alternative within the Stephens Creek Subbasin are not anticipated on a basin-wide or local scale.

4.1.2.4 Summary of Direct Hydrologic Impacts

Both the Enhanced Bus Alternative and the Streetcar Alternative will result in negligible increases in impervious areas over existing conditions. Additionally, alterations to drainage patterns are not anticipated for either of these build alternatives. Consequently, effects to hydrology for both the Enhanced Bus and Streetcar alternatives are expected to be negligible on a local and basin-wide scale.

4.1.3 Direct Effects to Floodplains

4.1.3.1 No-Build Alternative

No direct effects related to floodplains would be associated with the No-Build Alternative.

4.1.3.2 Enhanced Bus Alternative

The Enhanced Bus Alternative would encroach upon approximately 1.3 acres of the FEMA-designated floodplains of the Willamette River. Effects to 100-year floodplains would be analyzed in accordance with local regulations and Executive Order 11988, Floodplain Management. As required by these regulations, all lost storage would be mitigated by creating additional volume elsewhere in the floodplain. As a result, any direct effects to floodplains resulting from this alternative are considered minor.

4.1.3.3 Streetcar Alternative

Depending on the design option, the Streetcar Alternative would encroach on between 6.5 and 10.1 acres of the Metro-designated floodplains of the Willamette River, as summarized in Table 4-3. Based on these numbers, the Willamette Shore Line Design Option would have the largest effect on floodplains in each segment where it is a design option. Additional impacts to floodplains could potentially occur as a result of new stream crossings at Tryon Creek and Stephens Creek.

Table 4-3 Floodplain Effects, by Alternative

Alternative	Segment	Design Option	Area (acres)
Enhanced Bus	--	--	1.3
Streetcar	Segment 1 Downtown Portland	No design options	0.0
	Segment 2 South Waterfront[1]	No design options	0.1
	Segment 3 Johns Landing	Willamette Shore Line	2.5
		Macadam In-Street	1.6
		Macadam Additional Lane	1.6
	Segment 4 Sellwood Bridge[2]	No design options	4.4
	Segment 5 Dunthorpe/Riverdale	Willamette Shore Line	2.7
		Riverwood	0.0
	Segment 6 Lake Oswego	UPRR Right-of-Way	0.4
		Foothills	0.4

Source: Metro RLIS GIS Database. Accessed in 2009. Originally published in 1996/2004.
1 The South Waterfront Segment contains potential construction phasing options associated with the streetcar alignments. See Section 3.17 Phasing Effects of the Lake Oswego to Portland DEIS for more information regarding phasing options and differences between those options.
2 The Sellwood Bridge Segment contains potential construction phasing options associated with the streetcar alignments. See Section 3.17 Phasing Effects of the Lake Oswego to Portland DEIS for more information regarding phasing options and differences between those options.

Effects to 100-year floodplains would be analyzed in accordance with local regulations and Executive Order 11988, Floodplain Management. As required by these regulations, lost storage would be mitigated by creating additional storage elsewhere in the floodplain. Furthermore, where appropriate, culverts would be placed under the proposed track to allow water to flow underneath the elevated track and to provide access to adjacent floodplain storage areas and preserve their functionality. Potential effects to the floodplain resulting from this alternative are considered minor, because these two mitigation measures would combine to substantially minimize, and perhaps eliminate, any potential rise in flood elevation.

4.1.3.4 Summary of Direct Effects to Floodplains

The Enhanced Bus Alternative and Streetcar Alternatives would encroach upon FEMA-designated floodplains of the Willamette River. However, as required by regulations, all lost storage would be mitigated by creating additional volume elsewhere in the floodplain. As a result, any direct effects to floodplains resulting would be considered minor.

4.1.4 Direct Effects to Water Quality

The water quality impacts related to the alternatives are based on an increase in impervious surface area as shown in Table 4-2.

4.1.4.1 No-Build Alternative

The No-Build Alternative would not result in the increases in impervious surface area associated with the LOPT. Despite this, background development and other projects would still occur, causing an increase in impervious surface area and its related effects to water quality. Potential adverse effects associated with the No-Build Alternative could include:

- Stormwater runoff from currently untreated impervious surfaces would continue to flow untreated to project area streams and generally would not be improved unless there is redevelopment that adheres to current standards.

- Over time, an increase in traffic and congestion is likely, which will result in a likely increase in pollutant loading, including increases in sediment, heavy metals, and oil and grease concentrations from roadways and parking lots. These pollutants subsequently would be transported to project area water bodies by stormwater runoff. It is assumed that the Streetcar and Enhanced Bus alternatives would reduce vehicle congestion in their service areas; while the No-Build Alternative would either result in no change in or potentially an eventual increase in traffic congestion.

Therefore, pollutant transport is expected to be higher with No-Build Alternative than with the build alternatives.

4.1.4.2 Enhanced Bus Alternative

The new impervious surface associated with the Enhanced Bus Alternative would result in a small overall increase in total impervious surface area (approximately 0.002 percent) in the Willamette River Basin and no impervious area increase in the Stephens Creek and Tryon Creek subbasins (see Table 4-2).

The theoretical once-in-three-year exceedance concentrations and annual mass loading for the minimum and maximum increase in new impervious areas for the Willamette River Basin were calculated using the FHWA-RD-88-006 methodology. The results are presented in Table 4-4, along with the percent difference over existing conditions. As shown in Table 4-4, the increase in the once-in-three-year exceedance concentration and the annual loadings due to the Bus Alternative are less than 0.003 percent, which is considered negligible.

Table 4-4 Change in Once-in-Three-Year Total Pollutant Concentration Exceedance and Annual Loadings in the Willamette River without Mitigation (Enhanced Bus Alternative)

Parameter	3-Year Exceedance Concentration		Annual Loading	
	Concentration	% Difference	Loading (lbs./year)	% Difference
TSS (mg/l)	113.33	0.002%	49,067,203	0.003%
BOD_5 (mg/l)	5.96	0.002%	2,581,260	0.003%
TKN (mg/l)	1.34	0.002%	581,365	0.003%
Ammonia-N (mg/l)	0.40	0.002%	172,084	0.003%
Total Phosphorus (mg/l)	0.23	0.002%	97,669	0.003%
Cadmium (μg/l)	1.13	0.002%	488.35	0.003%
Copper (μg/l)	20.95	0.002%	9,069.3	0.003%
Lead (μg/l)	34.37	0.002%	14,883	0.003%
Zinc (μg/l)	134.28	0.002%	58,136	0.003%
Dissolved Cadmium (μg/l)	0.00	0.000%	0	0.000%
Dissolved Copper(μg/l)	4.30	0.002%	1,860.4	0.003%
Dissolved Lead (μg/l)	0.00	0.000%	0	0.000%
Dissolved Zinc (μg/l)	32.23	0.002%	13,953	0.003%

Approximately 2.9 acres of existing impervious area will be redeveloped as part of the Enhanced Bus Alternative. Most of this area was initially developed prior to current stormwater controls, and therefore has little, if any, stormwater treatment. Because current regulations require that stormwater from redeveloped areas be treated, water quality conditions could improve as a result of the Enhanced Bus alternative by managing runoff from replaced impervious surfaces and adhering to current regulations.

4.1.4.3Streetcar Alternative

As previously noted, the Streetcar Alternative would result in an increase in impervious surfaces in the Willamette River Basin, and the Tryon Creek and Stephens Creek subbasins. The resulting potential water quality impacts in each of the basins are presented below.

Willamette River Basin

The new impervious surface associated with the Streetcar Alternative represents a small overall increase in total impervious surface area of between 0.012 percent and 0.031 percent within the Willamette River Basin. The theoretical once-in-three-year exceedance concentrations and annual mass loading for the minimum and maximum increase in new impervious surface areas for the Willamette River Basin were calculated using the FHWA-RD-88-006 methodology. The results are presented in Tables 4-5 and 4-6, along with the percent difference over existing conditions. The increase in the once-in-three-year exceedance concentration and the annual loadings due to the Streetcar Alternative are all less than 0.03 percent, which is considered negligible.

Table 4-5 Change in Once-in-Three-Year Total Pollutant Concentration Exceedance in the Willamette River without Mitigation (Streetcar Alternative)

Parameter	3-Year Exceedance Concentration		3-Year Exceedance Difference (%)	
	Minimum	Maximum	Minimum	Maximum
TSS (mg/l)	113.34	113.36	0.016%	0.028%
BOD_5 (mg/l)	5.96	5.96	0.016%	0.028%
TKN (mg/l)	1.34	1.34	0.016%	0.028%
Ammonia-N (mg/l)	0.40	0.40	0.016%	0.028%
Total Phosphorus (mg/l)	0.23	0.23	0.016%	0.028%
Cadmium (μg/l)	1.13	1.13	0.016%	0.028%
Copper (μg/l)	20.95	20.95	0.016%	0.028%
Lead (μg/l)	34.38	34.38	0.016%	0.028%
Zinc (μg/l)	134.29	134.31	0.016%	0.028%
Dissolved Cadmium (μg/l)	0.00	0.00	0.000%	0.000%
Dissolved Copper(μg/l)	4.30	4.30	0.016%	0.028%
Dissolved Lead (μg/l)	0.00	0.00	0.000%	0.000%
Dissolved Zinc (μg/l)	32.23	32.23	0.016%	0.028%

Table 4-6 Change in Annual Loadings to the Willamette River without Mitigation (Streetcar Alternative)

Parameter	Annual Mass Loading, lbs./year		Annual Loading Difference (%)	
	Minimum	Maximum	Minimum	Maximum
TSS	49,074,621	49,081,058	0.018%	0.031%
BOD_5	2,581,651	2,581,989	0.018%	0.031%
TKN	581,453	581,529	0.018%	0.031%
Ammonia-N	172,110	172,133	0.018%	0.031%
Total Phosphorus	97,684	97,697	0.018%	0.031%
Cadmium	488.42	488.48	0.018%	0.031%
Copper	9,070.7	9,071.9	0.018%	0.031%
Lead	14,885	14,887	0.018%	0.031%
Zinc	58,145	58,153	0.018%	0.031%
Dissolved Cadmium	0	0	0.000%	0.000%
Dissolved Copper	1,860.6	1,860.9	0.018%	0.031%
Dissolved Lead	0	0	0.000%	0.000%
Dissolved Zinc	13,955	13,957	0.018%	0.031%

Tryon Creek Subbasin

The new impervious surface associated with the Streetcar Alternative represents a small overall increase in total impervious surface area of up to approximately 0.017 percent within the Tryon Creek Subbasin. The theoretical once-in-three-year exceedance concentrations and annual mass loading for the proposed increase in new impervious areas for Tryon Creek were calculated using the FHWA-RD-88-006 methodology. The results are presented in Table 4-7, along with the percent difference over existing conditions. The increase in the once-in-three-year exceedance concentration and the annual loadings due to the Bus Alternative are both less than 0.013 percent, which is considered negligible.

Table 4-7 Change in Once-in-Three-Year Total Pollutant Concentration Exceedance and Annual Loadings in Tryon Creek without Mitigation (Streetcar Alternative)

Parameter	3-Year Exceedance		Annual Loading	
	Concentration	% Difference	Loading (lbs./year)	% Difference
TSS (mg/l)	17.7	0.012%	1,999,135	0.013%
BOD_5 (mg/l)	0.93	0.012%	105,168	0.013%
TKN (mg/l)	0.21	0.012%	23,686	0.013%
Ammonia-N (mg/l)	0.06	0.012%	7,011	0.013%
Total Phosphorus (mg/l)	0.04	0.012%	3,979	0.013%
Cadmium *(μg/l)	0.18	0.012%	19.90	0.013%
Copper (μg/l)	3.27	0.012%	369.5	0.013%
Lead (μg/l)	5.37	0.012%	606	0.013%
Zinc (μg/l)	21.0	0.012%	2,369	0.013%
Dissolved Cadmium (μg/l)	0	0.000%	0	0.000%
Dissolved Copper(μg/l)	0.67	0.012%	75.8	0.013%
Dissolved Lead (μg/l)	0	0.000%	0	0.000%
Dissolved Zinc (μg/l)	5.04	0.012%	568	0.013%

Stephens Creek Subbasin

The new impervious surface associated with the Streetcar Alternative represents a small overall increase in total impervious surface area of approximately 0.02 percent within the Stephens Creek Subbasin. The theoretical once-in-three-year exceedance concentrations and annual mass loading for the proposed increase in new impervious areas for Stephens Creek were calculated using the FHWA-RD-88-006 methodology. The results are presented in Table 4-8, along with the percent difference over existing conditions. The increase in the once-in-three-year exceedance concentration and the annual loadings due to the Streetcar Alternative are not more than 0.02 percent, which is considered negligible.

Table 4-8 Change in Once-in-three-year Total Pollutant Concentration Exceedance and Annual Loadings in Stephens Creek without Mitigation (Streetcar Alternative)

Parameter	3-Year Exceedance		Annual Loading	
	Concentrations	% Difference	Loading (lbs/year)	% Difference
TSS (mg/l)	18.0	0.021%	369,318	0.024%
BOD_5 (mg/l)	0.95	0.021%	19,429	0.024%
TKN (mg/l)	0.21	0.021%	4,376	0.024%
Ammonia-N (mg/l)	0.06	0.021%	1,295	0.024%
Total Phosphorus (mg/l)	0.04	0.021%	735	0.024%
Cadmium *(μg/l)	0.18	0.021%	3.68	0.024%
Copper (μg/l)	3.32	0.021%	68.3	0.024%
Lead (μg/l)	5.45	0.021%	112	0.024%
Zinc (μg/l)	21.3	0.021%	438	0.024%
Dissolved Cadmium (μg/l)	0	0.000%	0	0.000%
Dissolved Copper(μg/l)	0.68	0.021%	14.0	0.024%
Dissolved Lead (μg/l)	0	0.000%	0	0.000%
Dissolved Zinc (μg/l)	5.11	0.021%	105	0.024%

In all three of the basins considered in this study, the relative increase in impervious area related to the Streetcar Alternative and the resulting increases in annual loading and pollutants concentrations are extremely low. Additionally, between 5.9 and 13.1 acres of existing impervious area will be redeveloped as part of the Streetcar Alternative. Similar to the Enhanced Bus Alternative, the majority of this area was likely developed without water quality treatment. Since any new and redeveloped impervious areas associated with this project will be treated, the project would improve water quality conditions over the No-Build Alternative, helping to offset potential water quality and quantity effects resulting from new impervious surfaces. Based on this, any impacts to water quality as a result of this project are considered negligible.

4.1.4.4 Summary of Direct Water Quality Impacts

Both the Enhanced Bus Alternative and the Streetcar Alternative will result in nearly negligible increases in impervious surface areas over existing conditions. Additionally, although operation of streetcar facilities has the capacity to release small amounts of pollutants (primarily sediment, oil and grease, and metals), pollutant generation typically is very low and, as stated above, the LOPT would adhere to all applicable stormwater regulations. Consequently, adverse water quality effects associated with impervious surfaces are not anticipated for the Streetcar Alternative.

4.1.4 Summary of Direct Impacts

The Enhanced Bus and Streetcar alternatives may have negligible to minor impacts on hydrology, floodplains, and water quality. Potential effects include addition of new impervious surfaces, floodplain fill, stream crossings, and limited pollutant loading. All of these impacts would be mitigated using approaches previously described in this section as well as those outlined in Section 5. Table 4-9 summarizes the assessment of impacts for each alternative.

Table 4-9 Summary of Direct Impacts to Water Resources by Alternative

Alternative	Basin(s)	Hydrology	Floodplains	Water Quality
No-Build	All	No direct effects.	No direct effects.	No direct effects.
Streetcar	Willamette River	**Negligible effects**. A negligible increase in impervious surface and, adherence to stormwater standards, and no change in drainage patterns would limit effects to negligible.	**Minor effects**. Between 9.1 and 10.4 acres of project area would be located within the Willamette River floodplain. Where applicable, lost storage would be mitigated. If they occur, impacts would be minor.	**Negligible effects**. With adherence to stormwater standards, impacts to water resources would be negligible. A beneficial impact may be realized with treatment of redeveloped existing impervious areas.
	Stephens Creek	**No direct effects.** Activity within the basin is limited to a very small area, and increases in impervious surface are negligible such that no effects are anticipated.	**Negligible effects**. Although minor impacts could be realized where the project crosses Stephens Creek, all fill would be mitigated by a balanced cut. Therefore, if they occur, impacts would be negligible.	**Negligible effects.** With adherence to stormwater standards, impacts to water quality would be negligible.
	Tryon Creek	**No direct effects.** Activity within the basin is limited to a very small area, increases in impervious surface are negligible, and existing drainage patterns will be maintained such that no effects are anticipated.	**Negligible effects**. Although minor impacts could be realized where the project crosses Tryon Creek, all fill would be mitigated by a balanced cut. Therefore, if they occur, impacts would be negligible.	**Negligible effects.** With adherence to stormwater standards, impacts to water quality would be negligible.
Enhanced Bus	All	**Negligible effects.** Very small impervious surface increase, no changes to drainage patterns, and adherence to stormwater standards would limit effects to negligible.	**Minor effects.** Up to 1.3 acres of project area would be located within the Willamette River floodplain. Where applicable, lost storage would be mitigated. If they occur, impacts would be minor.	**Negligible effects**. With adherence to stormwater standards, impacts to water resources would be negligible. A beneficial impact may be realized with treatment of redeveloped existing impervious areas.

4.2 Short-Term Impacts

4.2.1 Impact Overview

Short-term impacts are those that occur during and immediately after construction, and include increased rates and volumes of sediment-laden runoff, potential accidental spills and leaks from construction vehicles and equipment, and removal of riparian vegetation. Local regulations require that erosion control measures be utilized during construction to protect water resources. The LOPT would comply with all applicable stormwater regulations, including those required during project construction. Additionally, all in-water work would be conducted during agency-coordinated and approved in-water work windows. Details regarding construction equipment, methods, timing, and sequencing would be developed in conjunction with the appropriate regulatory agencies at a later date.

4.2.2 Hydrology

Typical construction effects for linear projects such as the LOPT as related to hydrology include the replacement, removal, addition, or extension of existing stormwater drainage features (culverts, crossings, and conveyance ditches) or facilities that could temporarily affect flow patterns and result in minor, short-term impacts to the instream flow conditions in the immediate proximity of construction. Temporary stormwater conveyance structures may need to be installed during construction, which would result in modification to existing drainage patterns. In addition, compaction of soils and removal of vegetation associated with construction activities could result in reduced infiltration capacity and temporarily increase flows.

4.2.2.1 No-Build Alternative

The No-Build Alternative would not involve any construction; therefore, no construction effects would be associated with the No-Build Alternative.

4.2.2.2 Enhanced Bus Alternative

Construction activity associated with the Enhanced Bus Alternative would be limited to a park-and-ride structure and an associated access road within the Willamette River Basin, and could result in approximately 7 acres of overall construction disturbance. Potential construction-related effects would be similar to those described in Subsection 4.2.1 above, and as a result, minor, short-term effects to the hydrology are expected as a result of construction activities for this alternative. However, a 1200-C construction permit would be required that would require an erosion and sediment control plan and BMPs, which could include temporary detention and flow controls. With the implementation of these requirements, construction effects to hydrology would be minimized and considered negligible.

4.2.2.3 Streetcar Alternative

Construction associated with the Streetcar Alternative would result in approximately 56 to 71 acres of overall construction disturbance, depending on the design options chosen. Potential construction-related effects would include the replacement, removal, addition, or extension of existing stormwater drainage features (culverts, crossings, and conveyance ditches) or facilities that could temporarily affect flow patterns and result in minor, short-term impacts to the instream flow conditions in the immediate proximity of construction. In addition, a 1200-C construction permit would be required that would require an erosion and sediment control plan and construction BMPs, which could include temporary detention and flow controls. With the implementation of these requirements, construction effects to hydrology would be minimized and considered negligible. The crossings at Stephens Creek and Tryon Creek are not anticipated to involve construction below the OHWM (OBEC, 2009).

4.2.3 Floodplains

4.2.3.1 No-Build Alternative

No construction effects would be associated with the No-Build Alternative.

4.2.3.2 Enhanced Bus Alternative

The Enhanced Bus Alternative would encroach upon approximately 1.3 acres of the FEMA-designated 100-year floodplain for the Willamette River. Construction within the floodplain could result in a temporary decrease in floodplain storage. No construction at stream crossings is proposed with this alternative.

4.2.3.3 Streetcar Alternative

The Streetcar Alternative would encroach upon the FEMA-designated 100-year floodplain for the Willamette River (see Table 4-3 for the area associated with various design options). This encroachment could potentially result in temporary decreases in floodplain storage. In addition, effects to floodplains from construction of the Streetcar Alternative could occur at stream crossings, particularly Tryon Creek and Stephens Creek.

4.2.4 Water Quality

4.2.4.1 No Build Alternative

No construction effects would be associated with the No-Build Alternative.

4.2.4.2 Enhanced Bus Alternative

Construction effects associated with water quality include increased rates and volumes of sediment-laden runoff during construction activities, accidental spills and leaks from construction vehicles and equipment, and removal of riparian vegetation. These effects are more likely to occur near stream crossings where slopes are greater and construction activities encroach on the stream channel. During construction, the likelihood of spills affecting surface water bodies also would be greatest in these areas. In the relatively flat areas of the proposed project area, sediment and erosion effects would be less likely to occur, and spills would be less likely to reach surface water bodies. The LOPT would comply with all applicable water quality regulations in all areas of construction, including the implementation of erosion control BMPs that prevent off-site sediment transport.

4.2.4.3 Streetcar Alternative

Construction effects for the Streetcar Alternative associated with water quality would be similar to those described for the Enhanced Bus Alternative. In addition, although new stream crossings at Tryon Creek and a potential new crossing at Stephens Creek would be constructed, preliminary design information suggests the structures will be above the OHWM, and thus would not require in-water construction. In the event that in-water construction cannot be avoided, all in-water work would be conducted during agency-coordinated and approved in-water work windows. Details regarding construction equipment, methods, timing, and sequencing would be developed in conjunction with the appropriate regulatory agencies at a later date, if this alternative were selected as the locally preferred alternative.

4.2.5 Summary of Short-Term Impacts

The construction of the build alternatives would likely have a minor effect on floodplains and water quality in each of the basins. Potential short-term impacts include increased rates and volumes of sediment-laden runoff, potential accidental spills and leaks from construction vehicles and equipment, and removal of riparian vegetation. All of these impacts would be mitigated using approaches previously described in this section as well as those outlined in Section 5. Table 4-10 summarizes the short-term impact assessment for each alternative.

Table 4-10 Summary of Short-term Effects to Water Resources, by Alternative

Alternative	Basin(s)	Hydrology	Floodplains	Water Quality
No-Build	All	**No effects.**	**No effects.**	**No effects.**
Streetcar	Willamette River	**Minor effects**. Effects could include slight increase in flows from temporary vegetation removal and compaction of soils and temporary effect to in-stream flow conditions from in-water work associated with culvert replacements. Incorporation of BMPs would limit effects to minor.	**Minor effects**. Potential impacts include temporary decrease in storage.	**Minor effects.** Potential impacts include sediment-laden runoff, accidental spills, and leaks from construction equipment. With BMPs, impacts would be minor.
	Stephens Creek	**Negligible effects.** Effects could include slight increase in flows from temporary vegetation removal and compaction of soils. Incorporation of BMPs would limit effects to negligible.	**Minor effects**. Potential impacts include temporary decrease in storage.	**Minor effects.** Potential impacts include sediment-laden runoff, accidental spills, and leaks from construction equipment. With BMPs, impacts would be minor.
	Tryon Creek	**Negligible effects**. No noticeable effects anticipated due to the negligible increases in impervious surface and adherence to stormwater quantity standards.	**Minor effects**. Potential impacts include temporary decrease in storage.	**Minor effects.** Potential impacts include sediment-laden runoff, accidental spills, and leaks from construction equipment. With BMPs, impacts would be minor.
Enhanced Bus	All	**Minor effects**. Effects could include slight increase in flows from temporary vegetation removal and compaction of soils and temporary effect to in-stream flow conditions from in-water work associated with culvert replacements. Incorporation of BMPs would limit effects to minor.	**Minor effects.** Potential impacts include temporary decrease in storage.	**Minor effects.** Potential impacts include sediment-laden runoff, accidental spills, and leaks from construction equipment. With BMPs, impacts would be minor.

4.3 Indirect and Cumulative Impacts

If the project enables future development or redevelopment to occur, compliance with water quantity and quality regulations would be required in order to prevent adverse effects to water quality and quantity. Development upstream and within the drainage basins intersected by this project will also be subject to the regulatory requirements relating to stormwater quality and quantity controls. The replacement of blocked or damaged culverts could result in indirect effects to hydrology because a new, unobstructed culvert will be able to convey more flow. Such effects are considered indirect since the majority of flow conveyed through these new culverts would be associated with stormwater from upgradient areas and not generated from the actual project area.

The region's land use plans envision that most of the future growth in population and employment will be focused on established regional and urban centers connected by high quality multimodal transportation systems. The No-Build Alternative would not include one of the major transportation investments assumed in regional growth management plans. One possible indirect effect of the No-Build Alternative would be increased pressure to develop in areas with lower congestion, which tend to be on the outskirts of the region. These areas would experience an increase in impervious surfaces as they are further developed.

In contrast, the Streetcar Alternative, and to a lesser extent (because of its impermanent nature), the Enhanced Bus Alternative, would help facilitate future development that reduces dependence on vehicular travel and is consistent with regional growth plans and density goals. Much of this development would occur in previously disturbed, existing impervious surface areas. Additionally, by focusing development in underutilized urban areas, development pressure in outlying rural areas could be lessened, which could potentially limit sprawl and help to protect forests and farmland in headwater reaches.

Past and future development within the watershed cumulatively affects the health of the watershed by removing natural cover, creating impervious surfaces, channelizing streams, altering flow regimes, and discharging contaminants into water bodies. With or without the implementation of the Enhanced Bus or Streetcar alternatives, there are a number of transportation development and redevelopment projects expected in and around the project area and throughout the Portland metropolitan area. Although the build alternatives will contribute to additional pollutant loadings and concentrations, by adhering to current water quality and quantity regulations, it is not expected that they would worsen conditions in the project area receiving water bodies. The LOPT, regardless of which alternative is chosen, is not expected to elevate the significance of cumulative effects associated with hydrology. Increases in impervious cover and long-term, hydrologic effects associated with LOPT are anticipated to be negligible, and would not contribute to an elevation in cumulative effects.

5. POTENTIAL MITIGATION MEASURES

This section presents potential mitigation measures that could be implemented to offset the project's potential impacts to water resources. Mitigation measures presented in this section are described in conceptual terms. More detailed development of mitigation designs, including the size and location of mitigation features, would occur during preliminary and final design stages.

5.1 Mitigation for Long-Term Effects

As previously noted, additional impervious area generated from the LOPT would cause an increase in stormwater runoff and pollutants without proper mitigation. The project would be required to meet local, state, and federal design guidelines, which require stormwater treatment and volume (flow control) via permanent structural best management practices (BMPs). Some examples of structural BMPs that could be included are detention and retention ponds, vaults, swales, constructed wetlands, and filters. Improvements to water quality would occur when pollutants are removed from stormwater runoff; filtered through the use of separators, screens, filter media, or soils; and/or taken up by plants. Hydrologic and water quality benefits would occur when stormwater is infiltrated on-site (retained) or discharged to the receiving water body at flow rates and durations consistent with predeveloped conditions.

Additional tools available to minimize water quality effects are nonstructural BMPs, which are source control activities related to maintenance, pollution prevention, or other housekeeping activities that help prevent stormwater from coming in contact with pollutants. They could include activities such as street sweeping, properly maintaining vehicles, and routine litter removal.

Finally, water quality and hydrologic impacts could be minimized by reducing the impervious surface area (especially new impervious surfaces). This could be accomplished through a variety of approaches, including using pervious pavement, utilizing multilevel parking structures, and minimizing the size of parking spaces. An additional way to minimize the impact of impervious areas is to create landscaped pervious areas within parking lots, stations, and other transit facilities. This can also include the use of ecoroofs on top of parking or other structures, which would largely eliminate stormwater runoff from these structures. However, ecoroofs would be costly and would reduce available parking area. Wherever possible, native plants should be used for landscaping, and the use of fertilizers, pesticides, and herbicides should be minimized or eliminated to further protect water quality.

The Streetcar and Enhanced Bus alternatives could mitigate channel/floodplain effects through full compliance with applicable regulations and implementation of other project design features to help maximize benefits to water resources. Local jurisdictions require balanced cut and fill for fill placed in the 100-year floodplain unless technical analysis shows that the development would not result in an increase in the base flood elevation. Removal of existing structures in the floodplain also may be used to partially or fully account for mitigation of floodplain effects. In addition to including the same volume of fill, floodplain mitigation should occur at the same land surface elevation as the effect. Wherever possible, it would be beneficial for floodplain cuts to be incorporated with projects that improve water quality, such as revegetating riparian areas that are currently in a degraded state.

5.2 Mitigation for Short-Term Effects

Short-term impacts occur during and immediately after construction, and include increased rates and volumes of sediment-laden runoff, potential accidental spills and leaks from construction vehicles and equipment, and removal of riparian vegetation (Metro, 2008).

Mitigation of short-term impacts primarily consists of erosion control BMPs that prevent the transport of sediment off-site. Some of the erosion control BMPs required by state and local jurisdictions include the following (Metro, 2008):

- Use of straw, plastic, or other coverings for exposed ground
- Protecting large trees and other components of vegetative buffers
- Restricting vegetation-clearing activities and site grading to dry weather periods
- Installing natural or synthetic geomembranes to prevent soil from eroding
- Use of barrier berms (such as hay bales or check dams), silt fencing, and/or temporary sediment detention basins to help control sediment transport

In addition to permanent structural BMPs, BMPs for pollution prevention and flow control would also be required under a 1200-C permit. BMPs addressing hydrologic effects could include temporary detention and flow controls and appropriate timing of in-water work. Potential mitigation measures for construction-related activities for control of accidental spills and leaks (to prevent water quality problems) could include diapering dump trucks, routine inspection and cleaning of heavy equipment and mandatory presence of spill control kits. Mitigation measures to protect riparian vegetation could include protecting large trees and other components of vegetative buffers, limiting construction footprints, and replanting after construction is complete (Metro, 2008).

6. REFERENCES

City of Portland Bureau of Environmental Services (BES). 2005. Fanno and Tryon Creeks Watershed Management Plan.

BES. 2010. Stephens Creek Confluence Habitat Enhancement Project website. Access March 29, 2010 at http://www.portlandonline.com/bes/index.cfm?a=192593&c=46964 .

Clackamas County, 2008. Clackamas County NPDES MS4 Permit Renewal.

BES. 2010. Water Pollution Control Laboratory Database. Accessed March 10, 2010, by written request.

BES. 2008. Portland Stormwater Management Manual. August 1, 2008.

City of Lake Oswego. 2002. City of Lake Oswego Development Standards. Article 50.41: Drainage Standard for Major Development.

DEQ (Oregon Department of Environmental Quality). 2006. Willamette Basin TMDL. Accessed on November 4, 2009, at http://www.deq.state.or.us/wq/tmdls/willamette.htm#w.

DEQ 2009a. Oregon Administrative Rules (OAR) 340 Division 41. Accessed on November 11, 2009, at http://arcweb.sos.state.or.us/rules/OARs_300/OAR_340/340_041.html.

DEQ 2009b. 2004/2006 Integrated Report Database. Accessed on November 4, 2009, at http://www.deq.state.or.us/wq/assessment/rpt0406.htm.

FEMA (Federal Emergency Management Agency). 1986. Flood Insurance Study for the City of Portland, Oregon.

FHWA (Federal Highway Administration), Research Development and Technology Turner-Fairbank Highway Research Center. 1990 (April). Pollutant Loadings and Impacts from Highway Stormwater Runoff, Volume I. FHWA-RD-88-006. U.S. Department of Transportation.

Metro. 2008. South Corridor Portland-Milwaukie Light Rail Project, Water Quality and Hydrology Results Report. May 2008.

Metro. RLIS GIS Database. Accessed November 9, 2009.

Multnomah County. 2008. Multnomah County MS4 NPDES Permit Renewal.

Natural Resources Conservation Service (NRCS). 2009. Online Web Soil Survey, Soil Water Features Report. http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm. Accessed November 30, 2009.

OBEC Consulting Engineers. 2009. Lake Oswego to Portland Transit Double Track Structures Recommendations Report. November 30, 2009.

Portland Parks & Recreation. 2005. A Functional Plan for Stephens Creek Nature Park. June 2005.

USGS (U.S. Geological Survey). 2002. "Surface Water Data for the Nation." Accessed by URS Corporation on June 12, 2002, at http://waterdata.usgs.gov/nwis/sw.

USGS. 2008. 14211315 Tryon Creek Near Lake Oswego, OR Water-Data Report 2008.

7. LIST OF PREPARERS

Gualotunia, Melanie. Water Resources Engineer, David Evans and Associates. M.S., Environmental Engineering, University of Florida, 2001, B.S., Civil Engineering, Purdue University, 1999.

Whiteman, Emily. Water Resources EIT, URS. B.S., Civil Engineering, University of Michigan, 2004.

Appendix A List of Abbreviations

Appendix A – List of Abbreviations

BES	City of Portland Bureau of Environmental Services
BRT	Bus Rapid Transit
BMP	Best Management Practice
CAC	Lake Oswego to Portland Transit and Trail Project Citizen Advisory Committee
cfs	Cubic Feet per Second
CPC	City of Portland Code
CWA	Clean Water Act
DEIS	Draft Environmental Impact Statement
DEQ	Department of Environmental Quality
DSL	Department of State Lands
EIS	Environmental Impact Statement
EPA	US Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
NFIP	National Flood Insurance Program
FHWA	Federal Highway Administration
FTA	Federal Transit Authority
JPACT	Joint Policy Advisory Committee on Transportation
LID	Low Impact Development
LOPT	Lake Oswego to Portland Transit Project
MS4	Municipal Separate Storm Sewer System
NEPA	National Environmental Protection Act
NFIA	National Flood Insurance Act
FDPA	Flood Disaster Protection Act
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
ODOT	Oregon Department of Transportation
OHWM	Ordinary High Water Mark
OWRD	Oregon Water Resources Department
PMG	Lake Oswego to Portland Transit and Trail Project Management Group
PSI	Portland Streetcar, Inc.
RTP	Regional Transportation Plan
RM	River Mile
ROW	Right-of-Way
SPRR	Southern Pacific Railroad
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UPRR	Union Pacific Railroad
USFS	US Forest Service
USFWS	US Fish and Wildlife Service

Appendix B Methods and Data

HYDROLOGY AND WATER QUALITY ANALYSIS METHODS

Introduction

The Lake Oswego to Portland Transit Project may affect rivers and streams through stormwater hydrology, floodplains, and water quality impacts. The stormwater hydrology, floodplain, and water quality analysis will be included in the Draft Environmental Impact Statement (DEIS) for the Lake Oswego to Portland Transit Project. The DEIS will highlight project alternatives that will be described and compared on the basis of their potential adverse and beneficial impacts. The alternatives will be compared and ranked to identify the least environmentally damaging alternative for each corridor segment. This portion of the study will deal with impacts associated with stormwater hydrology, floodplains, and water quality.

Related Laws and Regulations

Hydrology

Development can affect the amount and timing of runoff that leaves a site during a storm. The peak runoff rate and volume of stormwater discharges typically increase when construction removes vegetation, compacts soils, and/or covers portions of a site with buildings or pavement. Such changes: 1) reduce the precipitation intercepted by vegetation and infiltrated into the ground, thereby increasing runoff volume; and 2) reduce the effective time of concentration (Tc) of runoff from a site by collecting rain and runoff more efficiently with pavement and storm sewers. As a result, peak discharge rates increase, increasing the possibility of flooding if the capacities of downstream storm drainage system components (pipes, streams, or bridges) become constrained. Regulations are in place in order to negate these types of effects.

Hydrology and water quantity are primarily regulated locally. The City of Lake Oswego, City of Portland, and Clackamas County regulate water quantity for new and re-development through development standards by setting detention and flow reduction requirements to meet pre-development conditions for specified rain events.

The following Federal laws, state statutes, local ordinances, and guidance standards address hydrology issues associated with development:

- National Environmental Policy Act (NEPA)
- Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System
- (NPDES) Permit Regulations
- National Marine Fisheries Service (NMFS) stormwater guidance standards
- Presidential Executive Order 11990
- Oregon Administrative Rules 340-41
- Metro Regulations - Title 3: Water Quality and Flood Management Conservation
- City of Portland Stormwater, Development, and Erosion Control ordinances (City of Portland
- Code Titles 10 and 33)
- Local overlay districts, e.g., the City of Portland’s Environmental Zones (E-zones) (CPC Title
- 3.430)
- City of Lake Oswego City Development Code

- Clackamas County Stormwater Rules and Regulations

Local stormwater regulations relating to hydrology and water quantity are summarized in Table B-2 at the end of this section.

Floodplains

Federal, state, and local regulations establish standards for floodplain regulation. In general, established standards are to: 1) prevent flooding conditions from worsening due to new development and floodplain encroachment, and 2) to protect new facilities located in the floodplain from damage. These regulations are administered through state and local agencies. Where floodplain impacts are expected to occur, projects must compensate for encroachments by providing floodplain storage equivalent to that lost. Facilities constructed in the floodplain must be flood-proofed to prevent damage during flood events.

The following Federal and local regulations relate to flooding issues:

- U.S. Coast Guard Section 9
- National Flood Insurance Act
- Flood Disaster Protection Act
- National Environmental Policy Act (NEPA)
- Presidential Executive Order 11990
- U.S. Code of Federal Regulations, Title 33, Section 208.10
- Metro Regulations - Title 3: Water Quality and Flood Management Conservation
- Clackamas County Floodplain Regulations
- Multnomah County Floodplain Regulations
- City of Lake Oswego Community Development Code
- City of Portland Regulations, including the City's E-zones (CPC Title 33.430)

Local stormwater regulations relating to floodplains are summarized in Table B-2 at the end of this section.

Water Quality

Water quality problems are typically related either to conventional pollutants or to nutrients. Conventional pollutants include suspended solids, metals, oil and grease, not usually found in a dissolved state and turbidity. Nutrient pollutants include phosphorus, nitrogen, metals, and organics found in a dissolved state. Typical pollutants are described in Table B-1.

The following Federal laws, state statutes, local ordinances, and guidance standards address water quality issues:

- NEPA
- Section 402 of the Clean Water Act (CWA), National Pollutant Discharge Elimination System (NPDES) Permit Regulations (40 Code of Federal Regulations (CFR) 124)
- Section 401 of the CWA, State Water Quality Certification
- Safe Drinking Water Act of 1974, as amended, 42 United States Code (USC) 300f

- NMFS water quality guidance standards
- Oregon Revised Statutes (ORS), "Water Quality," ORS 468B
- Oregon Administrative Rules (OAR), "Department of Environmental Quality: Regulations Pertaining to NPDES and WPCF Permits," OAR 340-045-0005 to 340-045-0080
- OAR, "Water Quality Standards: Beneficial Uses, Policies, and Criteria for Oregon," OAR 340-41
- Metro Regulations – Title 3: Water Quality and Flood Management Conservation (Draft)
- Clackamas County Water Quality Rules and Regulations
- Multnomah County Stormwater Regulations
- City of Lake Oswego Stormwater Regulations
- City of Portland Stormwater, Development, and Erosion Control ordinances (City of Portland Code Titles 10 and 33)

Table B-1
Typical Sources and Problems Associated with Urban Stormwater Pollutants

Contaminants of Concern	Common Sources	Known Problems
Oil and grease	Primarily from automotive and heavy industrial sources.	Hazardous to fish and wildlife, aesthetic degradation, may be associated with noxious odors and toxic chemicals.
Nutrients	Phosphorous and nitrogen occur naturally in eroded soil. Anthropogenic sources include fertilizers, detergents, and mulch.	The principle nutrients are phosphorous and nitrogen. Releases of these elements, the availability of which is limited in aquatic environments, can cause algal blooms and other problems.
Oxygen-demanding organics	Natural organics washed from paved areas.	Can cause O2 depletion when decomposed through bacterial action.
Toxic organics	Examples of toxic organics include pesticides, phenols, and PAHs.	In the greater Seattle area, EPA found 19 of 121 priority pollutants in stormwater runoff.
Metals	Concentrations of lead, zinc, cadmium, and copper primarily from automotive and industrial sources.	Toxic to aquatic and benthic organisms.
Bacteria and viruses	Fecal coliform from failing septic leaching systems, pet wastes, municipal system overflows, and other non-point sources.	Impacts to shellfish (harvest closures) and beneficial uses (e.g., restriction of recreation).
Eroded soil	Streets and construction sites.	Sediments in stormwater can smother habitat.

EPA's stormwater requirements have been promulgated as part of the CWA and the NPDES program. In most areas, including Oregon, the NPDES program implementation has been transferred to state environmental agencies. Under the NPDES program, permits are issued by the state agencies for various categories of industrial activities. Generally, these activities pertain to specific classes of operations, such as industrial sites, commercial land use, transportation, and residential uses. Best management practices (BMPs) must be implemented on each site where such activities take place.

Currently, the City of Portland, Multnomah County, Clackamas County, and the City of Lake Oswego have NPDES General Stormwater Permits. These permits require implementation of BMPs to control stormwater quality and quantity as a result of new development in the urban environment. At this time, there are no numerical performance criteria that are required to be met with these permits. However, the lower Willamette River is listed on the current 303(d) list by Oregon Department of Environmental Quality (ODEQ) as water-quality limited for several constituents and has also been issued a TMDL for bacteria, mercury, and temperature. For this reason, the jurisdictions listed above have set specific goals for pollutant removal efficiency of selected BMPs,

Table B-2
Summary of Local Regulations Affecting Hydrology, Floodplains, and Water Quality

Local Jurisdiction	Water Quantity Regulations	Floodplain Regulations	Water Quality Regulations
Clackamas County Service District #1	Stormwater quantity control facilities must be designed to limit peak rates as follows: 1) post development (post) 25-year discharges to less than or equal to the peak rate of the predevelopment (pre) 5-year storm event, 2) Post 2-year discharges less than or equal to half the 2-year pre-event, and 3) stormwater and roof drains cannot be discharged directly to streams without approval of the district. Clackamas County has generally adopted the King County Surface Water Design Manual (1990) for all other standards dealing with the selection and design of stormwater quantity controls.	The FEMA 1-ft regulatory floodplain standard has been adopted. Floodplain fills require compensatory volume to be provided at the same elevation.	No person may discharge any quantity of stormwater or pollutant that will violate a discharger's permit, the District's NPDES permit or any water quality standard. Non-single-family development must provide an approved water quality facility prior to discharge from a site. Erosion control measures are required during all construction and site disturbance activities and until permanent ground covers are installed. Additional ground cover controls are required between October 1 and April 30 each year. Erosion control must be designed so no visible or measurable erosion leaves the property during construction. The treatment design storm is listed as 2/3 of the 2-year, 24-hour storm.
Metro		Title 3 standards apply to new development. New development is prohibited within flood management areas to the maximum extent possible. Limited development may occur if excavation and fill is performed in a manner to maintain or increase flood storage and does not increase flood elevations. Flood Hazard Areas include: 1) areas within the FEMA 100-year floodplain, and 2) other areas inundated in the February 1996 flood event.	Title 3 standards are intended to protect water quality associated with beneficial uses as defined by Oregon Water Resources Department (OWRD) and Oregon Department of Environmental Quality (ODEQ). The current version of Title 3 requires: (1) erosion and sediment control for all new development to a "no visible" and measurable standard, (2) reservation of native vegetation, and (3) no use of hazardous materials in uncontained areas. Water Quality Resource Areas include areas: (1) along perennial streams and streams draining > 100 acres - min. 50' from top of bank or 200' from top of bank on long steep slopes (25% or greater) or an intermediate distance on shorter (150 sq. ft.) steep slopes, (2) along intermittent streams draining 50 to 100 acres - 15' from top of bank or 50' from top of bank on steep slopes, and (3) 50' from the edge of wetlands or 200' from the edge of wetlands bordered by steep slopes.
City of Lake Oswego	The City Of Lake Oswego Development Code Article 50.41 specifies that sufficient storm water detention shall be provided to maintain runoff rates at their natural undeveloped levels for all anticipated intensities and durations of rainfall and provide necessary detention to accomplish this requirement. Detention volume shall be the maximum difference between: a. The storm water runoff produced from the proposed development site by a 50 year storm, and b. The storm water runoff produced from the pre-development site area by a 10 year storm. Development shall be conducted in such a manner that alterations of drainage patterns (streams, ditches, swales, and surface runoff) do not adversely affect other properties.	The City administers the NFIP program. This includes the administration of the City's floodplain ordinance, which insures that any building in the floodway will not cause a rise in the water surface elevations during the base flood event.	The City of Lake Oswego Surface Water Management Design Manual has specified, depending on the type of water quality facility, a standard of removal of up to 65 percent of the phosphorous from 100 percent of the "newly constructed impervious surface." The treatment design storm is listed as 0.36 inches of precipitation falling in 4 hours.
City of Portland	In areas with combined sewers, as much runoff as possible must be controlled on-site, where soils permit. Onsite flow control must maintain post-development peak flows at magnitudes associated with undeveloped land for the 2- year, 5-year and 10-year events with limited exceptions.	Encroachments into the floodway by development and structures defined in 24.50.020 are prohibited unless technical analysis shows that the development will not result in an increase in the base flood elevation. The minimum width of the floodway must be 15 ft.	According to NPDES permit, 80 percent of total suspended solids (TSS) must be removed from 1/3 of the 2-year storm. Construction projects that will modify drainage facilities must include a plan to control erosion and sedimentation during construction and to permanently stabilize soils disturbed during construction.

or water quality treatment criteria as outlined in Table B-2. These standards can be used as guidance for measuring potential impacts and selecting mitigation methods and criteria.

For construction activities that would disturb one acre of land or more, other NPDES permits are required for the construction phase. It is anticipated that NPDES permits from Oregon agencies will be required for the Lake Oswego to Portland Transit Project due to anticipated areas that would be disturbed by the project. However, these permits will be required only if the project progresses to a design and construction phase; they would not be required for an EIS.

The EPA and most state agencies have established minimum water quality standards for different classes of surface waters. In OAR 340-41-445, DEQ has defined special water quality standards for the Willamette River Basin. These standards were adopted to protect the beneficial uses of surface waters within the basin and to provide minimum design criteria for waste treatment and control.

Contacts, Coordination and Consultation

As part of the investigation of hydrologic, floodplain, and water quality issues pertaining to the Lake Oswego to Portland Transit Project, in addition to internal coordination, staff will gather information from and/or coordinate with some or all of the following Federal, state, and local government agencies:

A. Federal Agencies

- EPA
- National Marine Fisheries Service (NMFS)
- U.S. Army Corps of Engineers (Corps), Portland District
- U.S. Coast Guard
- Federal Emergency Management Agency (FEMA)

B. State Agencies

- Oregon Department of Environmental Quality (ODEQ)
- Oregon Department of Transportation (ODOT)
- Oregon Department of Fish and Wildlife (ODFW)
- Department of State Lands (DSL)

C. Local Agencies

- Metro
- Clackamas County Service District #1
- Multnomah County Department of Environmental Services
- City of Lake Oswego Engineering
- City of Portland Bureau of Environmental Services (BES)

Data Collection

Available information on existing hydrologic, floodplain, and water quality conditions within basins within the corridor will be obtained from Federal, state, and local sources. A variety of local sources will provide data that includes state water quality standards, basin plans, and published data compiled from monitoring efforts.

Affected Environment Profile

To quantify existing conditions with respect to hydrology, floodplains, and water quality in the study area, field reconnaissance will be conducted along the entire proposed streetcar alignment and design alternatives, including proposed crossings, streetcar stops, park-and-rides, and operations and maintenance (O&M) facilities. Information on existing systems will also be gathered from local jurisdictions, ODOT, TriMet, and other sources as available.

For purposes of the hydrologic, floodplain, and water quality assessment, project facilities refer to impervious track and nonlinear features including stations, maintenance facilities, bridges, and park-and-ride facilities. It will be assumed that in many locations, ballasted track has and or will be used, and in these locations the rail track would not increase runoff, because track ballast allows infiltration and storage of precipitation and prevents runoff. This assumption will be considered to be valid for the range of soil and vegetation conditions found along the entire corridor. Therefore, ballasted track (if used) will not add to existing or proposed impervious surface values.

Hydrology

Existing documents to be reviewed for assessing hydrologic conditions include existing basin studies, drainage basin plans, master plans, capital improvement plans, USGS streamflow data, precipitation data published by the National Weather Service, topographic maps, aerial photographs, National Resources Conservation Service (NCRS) maps, FIRM maps, and stormwater infrastructure as-built drawings.

Field reconnaissance will also be conducted to observe general drainage patterns in the project area, including locations, sizes, and flow direction of culverts and conveyance ditches. Evidence of high water marks, scouring, and standing water will also be observed to gain a general understanding of the movement of stormwater runoff in the project area.

Information gained from the document review and field reconnaissance described above will be used to determine direction of flows and delineate subbasins within the study area. Peak flow rates and volumes generated and discharged from the study area under existing conditions will be estimated based on impervious cover, adjacent land use, existing drainage system plans, and measuring of existing culverts during field reconnaissance.

Floodplains

Information on existing flooding conditions will be collected for rivers, streams, and tributaries that would be affected by the proposed study alternatives. General information on basin-wide flooding conditions will be collected and described in the description of the affected environment. Existing flooding conditions at individual sites, where major or minor crossings are proposed to occur, will be estimated as part of the Floodplains Impacts Analysis. FIRM maps generated by FEMA and Flood Management Area (FMA) maps generated by Metro will be reviewed in order to determine existing floodplain conditions.

Water Quality

To quantify existing water quality conditions in rivers, streams, and tributaries within the study area, published data from Federal, state, and local sources will be searched and documented. Pollutant export or loading from project facilities will be estimated based primarily on assessments of existing impervious area within the Lake Oswego to Portland Transit Project.

Pollutant loading analysis will be conducted using Federal Highway Administration (FHWA) Methodology from FHWA-RD-88-006 using site median concentrations and procedures developed by ODOT for the Portland Metro area. The analysis will show just the theoretical increase in annual loading and pollutant concentrations from existing and extra impervious area that may or may not be added by the Lake Oswego to Portland Transit Project. The results from this probabilistic procedure can be used to predict the possibility of a once-in-three-year exceedance of acute water quality criteria.

ODOT has modified the FHWA procedures outlined in FHWA-RD-88-006 as follows. Site median concentrations were taken from ODOT stormwater sampling data, as reported on its NPDES Municipal Separate Storm Sewer System (MS4) Permit application, instead of from the Nationwide Urban Runoff Program (NURP) data used by FHWA. ODOT site median concentrations, as taken from ODOT's MS4 permit application, were typically measured at sites with greater urbanization and higher traffic volumes than the NURP studies; therefore, the actual median concentrations for this project will probably be lower than those assumed. Water quality criteria are taken from the ODEQ acute and chronic requirements (Table 20 of ODEQ's water quality standards), instead of the EPA acute and threshold requirements as reported in FHWA-RD-88-006. Once a preferred alternative has been selected, future studies can continue to use the FHWA method with the ODOT MS4 permit data, or more specific median concentration data from on-site monitoring can be used.

Impact Assessment Analysis Methods

The analysis will assess direct, indirect and cumulative effects of the project alternatives.

Hydrology

To assess potential hydrologic impacts, peak stormwater discharge rates for existing and future (post construction) conditions will be estimated along the corridor at existing drainage ditches and culverts. These results will be evaluated based on new impervious surface estimates to allow for a qualitative assessment of pre- and post-development discharge rates to determine whether significant impacts would occur as a result of the Lake Oswego to Portland Transit Project.

At this stage of project development, the hydrological analysis is focused on defining the comparative magnitude of impacts and to help define potential mitigation measures. More detailed analysis will be performed during final design and permitting phases. The final design and supporting analyses will be used for permitting applications needed to satisfy the requirements of individual agencies.

Hydrologic impacts will be considered only in association with the long-term operation of proposed project facilities in the corridor. No specific hydrologic impacts will be assigned to construction activities because:

- In most cases, short-term runoff increases are temporary and related to vegetation removal; in the long-term, runoff would be reduced from areas where vegetation would be restored;
- Most jurisdictions require strict BMP measures to limit the specific impacts of construction and often include detention to promote removal of suspended sediments;
- Most construction occurs during the dry season when hydrologic impacts would not occur; and
- Most hydrologic and flooding impacts are permanent changes to individual sites and require site-specific mitigation to be incorporated into the final site design.

Construction-related BMPs will be discussed in the section on potential mitigation measures.

Floodplains

A qualitative analysis will be conducted of potential floodplain impacts at all stream and river crossings and at locations of potential floodplain encroachment along the various alternatives. The investigation of potential flooding impacts will rely on FEMA NFIP studies, Metro's FMA maps, and other more recent information if available.

Potential impacts of proposed stream and river crossings will be assessed on the basis of:

- Potential floodplain encroachments;
- Potential changes in channel capacity that could affect flood depths;
- Potential changes in flow velocities that could cause morphological changes in the adjacent channel; and
- Regulatory standards and requirements, such as FEMA floodplain regulations, U.S. Army Corps of Engineers 404 permit requirements regulating the discharge of dredge or fill in waters of the U.S., and Title 3 regulations promulgated by Metro.

Water Quality

Surface water quality degradation can result from: 1) pollutant increases in runoff from roads and parking lots, and 2) quantity-related problems that increase erosion and sediment loads to streams and wetlands. Urban stormwater often contains increased levels of oil and grease, nutrients, sediment, and various heavy metals. Two types of significant water quality degradation can occur in association with site development: short-term (construction-related) and long-term (operations-related).

During construction, equipment operation can cause accidental releases of fuels, oil, and grease, and can degrade surface water quality by increasing erosion and sedimentation. Loss of protective vegetation cover during construction is another cause of increased sediment loading. For the analysis conducted for the EIS, it will be assumed that proper use of erosion control BMPs and spill control plans during construction would prevent significant water quality impacts. This assumption would be especially valid should construction activities involve working in a mapped FEMA floodplain. Long-term water quality impacts are associated with increases in impervious surfaces (e.g., pavement and buildings). Impervious surfaces prevent rainfall infiltration and promote the storage and wash-off of pollutants from vehicle emissions and other sources. Motorized vehicles are the primary source of water quality degradation from a variety of contaminants including oils and grease, metals, and other combustion by-products. Facilities that would cause significant increases in motorized vehicle usage can also be expected to generate significantly higher pollutant loadings. Landscaped areas, another significant source of pollutants from developed sites, can contribute fertilizer and pesticide residues, such as phosphates and nitrates, to stormwater runoff.

For this analysis, pollutant loads will be estimated for project facilities along the proposed alternatives and will be based on impervious surface estimates for the Lake Oswego to Portland Transit Project and its alignment and design options. It will be assumed that water quality treatment facilities would be provided at each site where significant development or redevelopment would occur, such as park-and-ride lots, operations and maintenance (O&M) facilities, and roadway improvements. Comparisons of baseline and post-construction loading, and general effectiveness of water quality treatment systems will be discussed qualitatively.

On a cumulative basis, impacts will be assessed qualitatively by comparing existing receiving water quality to expected impacts from proposed project facilities (railway alignments, park-and-ride lots, O&M facilities, and transit stations).

For the water quality analysis, the risk of oil and grease spills from train operations will be assumed to be negligible. Operational experience gained on the existing Eastside and Westside rail lines suggests that oil and grease releases from train operations along the proposed alignment would not be significant. It will be assumed that if the track segments were constructed with rail, ties, and ballast, then receiving water quality would not be significantly impacted by runoff from track segments.

Mitigation Measures

Mitigation alternatives will be identified and considered where the evaluation of existing and proposed hydrologic, floodplain, and water quality conditions along the alternatives indicates that potential adverse impacts could result. Mitigation alternatives will include identification of measures that could reduce and minimize potential impacts as they relate to water resources.

Documentation

The description of the affected environment, the results of the analysis, and the potential mitigation measures identified in the analysis will be documented and summarized in the DEIS. Additional documentation may be included in hydrology and water quality technical memorandum. Documentation will be provided for all calculations. Documentation of hydrologic calculations will include the results of existing and future condition peak flow estimates for various storms events; water quality analyses of existing and proposed conditions will include pollutant loading calculations; and the floodplain analysis will include conditions for all crossing locations along the study alternatives representing existing and proposed conditions. The hydrology and water quality analysis will be summarized and included in the DEIS.

Appendix C Water Quality Calculations

Impervious Surface Area Breakdown by Segment and Alternative

Segment	Alternative	Design Option	Entire Project		Willamette River-Direct		Terwilliger Creek		Tryon Creek		Stephens Creek	
			New and Redeveloped Impervious Surface (acres)	Net New Impervious Surface (acres)	New and Redeveloped Impervious Surface (acres)	Net New Impervious Surface (acres)	New and Redeveloped Impervious Surface (acres)	Net New Impervious Surface (acres)	New and Redeveloped Impervious Surface (acres)	Net New Impervious Surface (acres)	New and Redeveloped Impervious Surface (acres)	Net New Impervious Surface (acres)
1. Downtown Portland	Streetcar	Willamette Shore Line										
2. South Waterfront	Streetcar	No design options	3.54	1.54	3.54	1.54	0.00	0.00				
3. Johns Landing	Streetcar	Willamette Shore Line	0.69	0.29	0.69	0.29	0.00	0.00				
		Macadam In-Street	6.15	0.58	5.38	0.29	0.77	0.29				
		Macadam Additional Lane	7.20	1.51	5.78	1.22	1.42	0.29				
4. Sellwood Bridge	Streetcar	No design options	0.05	0.05	0.05	0.05					0.05	0.05
5. Dunthorpe/Riverdale	Streetcar	Willamette Shore Line	0.37	0.22	0.37	0.22						
		Riverwood	2.46	1.58	2.46	1.58						
6. Lake Oswego	Streetcar	UPRR ROW	2.75	1.75	2.63	1.64			0.11	0.11		
		Foothills	5.02	2.88	4.82	2.69			0.19	0.19		
Lake Oswego Terminus			3.61	1.22	3.61	1.22						
All	Enhanced Bus	No design options	3.61	0.75	3.61	0.75						

Basin Land Use Breakdown

Metro Land Use Categories	Acres within Tryon Creek	Acres within Stephens Creek
Unknown	21	0
AGR - Agriculture	12	0
COM - Commercial	164	81
FOR - Forest	7	0
IND - Industrial	5	0
MFR - Multi-family Res	83	42
PUB - Public/Semi-public	0	0
RUR - Rural	206	114
SFR - Single family res	2074	258
VAC - undeveloped	955	68
TOTAL AREA*	4178	759

** Total area of watershed*

Existing Impervious Areas

Metro Land Use Categories	Impervious %	Acres within Tryon Creek	Impervious Acres in Tryon Creek Watershed	Acres within Stephens Creek	Impervious Acres in Stephens Creek Watershed
Unknown***	40%	21	8	0	0
AGR - Agriculture	5%	12	1	0	0
COM - Commercial	72%	164	118	81	58
FOR - Forest	0%	7	0	0	0
IND - Industrial	70%	5	3	0	0
MFR - Multi-family Res	61%	83	51	42	26
PUB - Public/Semi-public		0	0	0	0
RUR - Rural	10%	206	21	114	11
SFR - Single family res	42%	2074	871	258	108
VAC - undeveloped	5%	955	48	68	3
TOTAL AREA*		**4178**	**1121**	**759**	**207**

Note: Existing Impervious Area in the Willamette Basin was determined from a previous report (Metro, 2008

***For unknown land use an impervious % of 40 is used as a best estimate

PROJECT No.: **URSX-00000046**
PROJECT NAME: **Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek**
DATE: **2/1/2010**
SHEET: **1**
Based on FHWA-RD-88-006 (April 1990)

SITE CHARACTERISTICS

Highway Drainage Area

Total ROW	**AROW:**	207.12	Acres
Paved Surface	**AHWY:**	207.12	Acres
Percent Impervious	**IMP:**	100	%

Rainfall Characteristics

MEANS

Volume	**MVP:**	0.36	Inch
Intensity	**MIP:**	0.023226	Inch/Hour
Duration	**MDP:**	15.5	Hour
Interval	**MTP:**	83	Hour

COEF of VARIATION

Volume	**CVVP:**	1.51
Intensity	**CVIP:**	0.79
Duration	**CVDP:**	1.09
Interval	**CVTP:**	1.32

Number of storms per year **NST:** 105.5422 No. of Events

RUNOFF CHARACTERISTICS

Runoff Coefficient	**Rv:**	0.80	(FHWA Eq. 3.4)
Flow from Mean Storm	**MQR:**	3.8484	cfs
	CVIP:	0.79	
Mean Storm Volume	**MVR:**	216,532	cubic feet
CV of Runoff Volume	**CVVP:**	1.51	
Flow Ratio	**MQS/MQR:**	887.51	
Stream Conc. Unit Exceedence	**CU:**	0.085	
Q3 Probability	**PR:**	0.3158295	%

Surrounding Area

ADT usually over 30,000 vpd	X	Urban
or		
ADT usually under 30,000 vpd		Rural

Stream Flow

Watershed Drainage Area	**ATOT:**	759	Square Miles
	QSM:	4.5	cfs/Square Miles
Average Stream Flow	**MQS:**	3415.5	cfs
Coef fo variation of Stream Flow	**CVQS:**	1.5	

MQS/MQR ratio in range.

PROJECT No.: URSX-00000046
PROJECT NAME: Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek
DATE: 2/1/2010
SHEET: 2

Pollutant Analysis

Pollutant for Analysis: TSS

Site median Concentration	**TCR:**	211	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	0	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**		mg/l
Threshold Effect Level	**CTT:**		mg/l

Mass Loads

Mean Event Conc	**MCR:**	**258.774**	mg/l
Mean Event Mass Load	**M(MASS):**	**3499.245**	pounds
Annual Mass Load	**ANMASS:**	**369,318**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.00
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0**	mg/l
Total Exceedence Conc.	**TCO:**	**17.96761**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	
Target Threshold Conc. Ratio	**CRTE:**	
Target Total Conc. Ratio	**TCRAT:**	
Target Threshold Total Conc. Ratio	**TCRTE:**	

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0**	mg/l
Total Exceedence Conc.	**TCO:**	**5.390284**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	
Target Threshold Conc. Ratio	**CRTE:**	
Target Total Conc. Ratio	**TCRAT:**	
Target Threshold Total Conc. Ratio	**TCRTE:**	

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**77.632**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**1049.774**	pounds
Annual Mass Load	**R-ANMASS:**	**110,795**	pounds/year

PROJECT No.: URSX-00000046
PROJECT NAME: Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek
DATE: 2/1/2010
SHEET: 3

Pollutant Analysis

Pollutant for Analysis: **BOD5**

Site median Concentration	**TCR:**	11.1	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	0.40	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**		mg/l
Threshold Effect Level	**CTT:**		mg/l

Mass Loads

Mean Event Conc	**MCR:**	**13.613**	mg/l
Mean Event Mass Load	**M(MASS):**	**184.084**	pounds
Annual Mass Load	**ANMASS:**	**19,429**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.00
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.378086**	mg/l
Total Exceedence Conc.	**TCO:**	**0.9452**	mg/l

Target Soluble Conc. Ratio	**CRAT:**
Target Threshold Conc. Ratio	**CRTE:**
Target Total Conc. Ratio	**TCRAT:**
Target Threshold Total Conc. Ratio	**TCRTE:**

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.378086**	mg/l
Total Exceedence Conc.	**TCO:**	**0.5482**	mg/l

Target Soluble Conc. Ratio	**CRAT:**
Target Threshold Conc. Ratio	**CRTE:**
Target Total Conc. Ratio	**TCRAT:**
Target Threshold Total Conc. Ratio	**TCRTE:**

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**7.896**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**106.768**	pounds
Annual Mass Load	**R-ANMASS:**	**11,269**	pounds/year

PROJECT No.: URSX-00000046
PROJECT NAME: Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek
DATE: 2/1/2010
SHEET: 4

Pollutant Analysis

Pollutant for Analysis: TKN

Site median Concentration	TCR:	2.5	mg/l
CV for Median Concentration	CVCR:	0.71	
Soluble Fraction	FSOL:	0.40	

Receiving Water

Total Hardness	TH:	100	mg/l
EPA Acute Criterion	CTA:		mg/l
Threshold Effect Level	CTT:		mg/l

Mass Loads

Mean Event Conc	MCR:	3.066	mg/l
Mean Event Mass Load	M(MASS):	41.460	pounds
Annual Mass Load	ANMASS:	4375.8	pounds/year
Stream Conc. Unit Exceedence	CU:	0.085	

Pollutant Reduction

Soluble Fraction Reduction	R-CO:	0.00
TSS Reduction	R-TCO:	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	CO:	0.085	mg/l
Total Exceedence Conc.	TCO:	0.212886	mg/l
Target Soluble Conc. Ratio	CRAT:		
Target Threshold Conc. Ratio	CRTE:		
Target Total Conc. Ratio	TCRAT:		
Target Threshold Total Conc. Ratio	TCRTE:		

Treated Stream Concentrations

Soluble Exceedence Conc.	CO:	0.085	mg/l
Total Exceedence Conc.	TCO:	0.123474	mg/l
Target Soluble Conc. Ratio	CRAT:		
Target Threshold Conc. Ratio	CRTE:		
Target Total Conc. Ratio	TCRAT:		
Target Threshold Total Conc. Ratio	TCRTE:		

Treated Mass Loadings

Mean Event Conc	R-MCR:	1.778	mg/l
Mean Event Mass Load	R-M(MASS):	24.047	pounds
Annual Mass Load	R-ANMASS:	2,538.0	pounds/year

PROJECT No.: URSX-00000046
PROJECT NAME: Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek
DATE: 2/1/2010
SHEET: 5

Pollutant Analysis

Pollutant for Analysis: Ammonia N

Site median Concentration	**TCR:**	0.74	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	0.10	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**		mg/l
Threshold Effect Level	**CTT:**		mg/l

Mass Loads

Mean Event Conc	**MCR:**	**0.9075**	mg/l
Mean Event Mass Load	**M(MASS):**	**12.2722**	pounds
Annual Mass Load	**ANMASS:**	**1295.24**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.00
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.006301** mg/l		Target Soluble Conc. Ratio	**CRAT:**	
				Target Threshold Conc. Ratio	**CRTE:**	
Total Exceedence Conc.	**TCO:**	**0.063014** mg/l		Target Total Conc. Ratio	**TCRAT:**	
				Target Threshold Total Conc. Ratio	**TCRTE:**	

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.006301** mg/l		Target Soluble Conc. Ratio	**CRAT:**	
				Target Threshold Conc. Ratio	**CRTE:**	
Total Exceedence Conc.	**TCO:**	**0.02332** mg/l		Target Total Conc. Ratio	**TCRAT:**	
				Target Threshold Total Conc. Ratio	**TCRTE:**	

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**0.3358**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**4.5407**	pounds
Annual Mass Load	**R-ANMASS:**	**479.24**	pounds/year

PROJECT No.: **URSX-00000046**
PROJECT NAME: **Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek**
DATE: **2/1/2010**
SHEET: **6**

Pollutant Analysis

Pollutant for Analysis: **Total Phosphorus**

Site median Concentration	**TCR:**	0.42	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	0.50	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**		mg/l
Threshold Effect Level	**CTT:**		mg/l

Mass Loads

Mean Event Conc	**MCR:**	**0.5151**	mg/l
Mean Event Mass Load	**M(MASS):**	**6.9653**	pounds
Annual Mass Load	**ANMASS:**	**735.14**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.00
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.017882**	mg/l
Total Exceedence Conc.	**TCO:**	**0.035765**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	
Target Threshold Conc. Ratio	**CRTE:**	
Target Total Conc. Ratio	**TCRAT:**	
Target Threshold Total Conc. Ratio	**TCRTE:**	

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.017882**	mg/l
Total Exceedence Conc.	**TCO:**	**0.0232**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	
Target Threshold Conc. Ratio	**CRTE:**	
Target Total Conc. Ratio	**TCRAT:**	
Target Threshold Total Conc. Ratio	**TCRTE:**	

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**0.3348**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**4.5275**	pounds
Annual Mass Load	**R-ANMASS:**	**477.84**	pounds/year

PROJECT NAME: Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek
DATE: 02/01/10
SHEET: 7

Pollutant Analysis

Pollutant for Analysis:		**Cadmium**	
Site median Concentration	**TCR:**	0.0021	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	0.10	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**	0.0039	mg/l
Chronic Criteria	**CTT:**	0.0011	mg/l

Mass Loads

Mean Event Conc	**MCR:**	**0.00258**	mg/l
Mean Event Mass Load	**M(MASS):**	**0.03483**	pounds
Annual Mass Load	**ANMASS:**	**3.676**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.00
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**1.79E-05**	mg/l
Total Exceedence Conc.	**TCO:**	**0.000179**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0.004585
Target Chronic Conc. Ratio	**CRTE:**	0.016257
Target Total Conc. Ratio	**TCRAT:**	0.045852
Target Chronic Total Conc. Ratio	**TCRTE:**	0.162568

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**1.79E-05**	mg/l
Total Exceedence Conc.	**TCO:**	**6.62E-05**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0.004585
Target Chronic Conc. Ratio	**CRTE:**	0.016257
Target Total Conc. Ratio	**TCRAT:**	0.016965
Target Chronic Total Conc. Ratio	**TCRTE:**	0.06015

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**0.00095**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**0.01289**	pounds
Annual Mass Load	**R-ANMASS:**	**1.360**	pounds/year

PROJECT No.: **URSX-00000046**
PROJECT NAME: **Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek**
DATE: **02/01/10**
SHEET: **8**

Pollutant Analysis

Pollutant for Analysis:		**Copper**	
Site median Concentration	**TCR:**	0.039	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	0.40	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**	0.018	mg/l
Chronic Criteria	**CTT:**	0.012	mg/l

Mass Loads

Mean Event Conc	**MCR:**	**0.0478**	mg/l
Mean Event Mass Load	**M(MASS):**	**0.6468**	pounds
Annual Mass Load	**ANMASS:**	**68.26**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.00
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.001328**	mg/l	Target Soluble Conc. Ratio	**CRAT:**	0.073801
				Target Chronic Conc. Ratio	**CRTE:**	0.110701
Total Exceedence Conc.	**TCO:**	**0.003321**	mg/l	Target Total Conc. Ratio	**TCRAT:**	0.184502
				Target Chronic Total Conc. Ratio	**TCRTE:**	0.276752

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.001328**	mg/l	Target Soluble Conc. Ratio	**CRAT:**	0.073801
				Target Chronic Conc. Ratio	**CRTE:**	0.110701
Total Exceedence Conc.	**TCO:**	**0.00193**	mg/l	Target Total Conc. Ratio	**TCRAT:**	0.107011
				Target Chronic Total Conc. Ratio	**TCRTE:**	0.160516

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**0.0277**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**0.3751**	pounds
Annual Mass Load	**R-ANMASS:**	**39.59**	pounds/year

PROJECT No.: URSX-00000046
PROJECT NAME: Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek
DATE: 02/01/10
SHEET: 9

Pollutant Analysis

Pollutant for Analysis: **Lead**

Site median Concentration	**TCR:**	0.064	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	0.10	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**	0.082	mg/l
Chronic Criteria	**CTT:**	0.0032	mg/l

Mass Loads

Mean Event Conc	**MCR:**	**0.0785**	mg/l
Mean Event Mass Load	**M(MASS):**	**1.0614**	pounds
Annual Mass Load	**ANMASS:**	**112.02**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.00
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.000545**	mg/l
Total Exceedence Conc.	**TCO:**	**0.00545**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0.006646
Target Chronic Conc. Ratio	**CRTE:**	0.170309
Target Total Conc. Ratio	**TCRAT:**	0.066462
Target Chronic Total Conc. Ratio	**TCRTE:**	1.703091

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.000545**	mg/l
Total Exceedence Conc.	**TCO:**	**0.002016**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0.006646
Target Chronic Conc. Ratio	**CRTE:**	0.170309
Target Total Conc. Ratio	**TCRAT:**	0.024591
Target Chronic Total Conc. Ratio	**TCRTE:**	0.630144

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**0.0290**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**0.3927**	pounds
Annual Mass Load	**R-ANMASS:**	**41.45**	pounds/year

PROJECT No.: URSX-00000046
PROJECT NAME: Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek
DATE: 2/1/2010
SHEET: 10

Pollutant Analysis

Pollutant for Analysis:		**Zinc**	
Site median Concentration	**TCR:**	0.25	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	0.40	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**	0.12	mg/l
Chronic Criteria	**CTT:**	0.110	mg/l

Mass Loads

Mean Event Conc	**MCR:**	**0.3066**	mg/l
Mean Event Mass Load	**M(MASS):**	**4.1460**	pounds
Annual Mass Load	**ANMASS:**	**437.58**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.00
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.008515**	mg/l
Total Exceedence Conc.	**TCO:**	**0.021289**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0.0709621
Target Chronic Conc. Ratio	**CRTE:**	0.0774132
Target Total Conc. Ratio	**TCRAT:**	0.1774054
Target Chronic Total Conc. Ratio	**TCRTE:**	0.1935331

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.0085**	mg/l
Total Exceedence Conc.	**TCO:**	**0.012347**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0.0709621
Target Chronic Conc. Ratio	**CRTE:**	0.0774132
Target Total Conc. Ratio	**TCRAT:**	0.1028951
Target Chronic Total Conc. Ratio	**TCRTE:**	0.1122492

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**0.1778**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**2.4047**	pounds
Annual Mass Load	**R-ANMASS:**	**253.80**	pounds/year

PROJECT No.: **URSX-00000046**
PROJECT NAME: **Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek**
DATE: **02/01/10**
SHEET: **11**

Pollutant Analysis

Pollutant for Analysis: **Dissolved Cadmium**

Site median Concentration	**TCR:**	0	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	1.00	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**	0.0039	mg/l
Threshold Effect Level	**CTT:**	0.0011	mg/l

Mass Loads

Mean Event Conc	**MCR:**	**0.0000**	mg/l
Mean Event Mass Load	**M(MASS):**	**0.0000**	pounds
Annual Mass Load	**ANMASS:**	**0.00**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.00
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0**	mg/l	Target Soluble Conc. Ratio	**CRAT:**	0
				Target Chronic Conc. Ratio	**CRTE:**	0
Total Exceedence Conc.	**TCO:**	**0**	mg/l	Target Total Conc. Ratio	**TCRAT:**	0
				Target Chronic Total Conc. Ratio	**TCRTE:**	0

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0**	mg/l	Target Soluble Conc. Ratio	**CRAT:**	0
				Target Chronic Conc. Ratio	**CRTE:**	0
Total Exceedence Conc.	**TCO:**	**0**	mg/l	Target Total Conc. Ratio	**TCRAT:**	0
				Target Chronic Total Conc. Ratio	**TCRTE:**	0

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**0.0000**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**0.0000**	pounds
Annual Mass Load	**R-ANMASS:**	**0.00**	pounds/year

PROJECT No.: **URSX-00000046**
PROJECT NAME: **Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek**
DATE: **02/01/10**
SHEET: **12**

Pollutant Analysis

Pollutant for Analysis: **Dissolved Copper**

Site median Concentration	**TCR:**	0.008	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	1.00	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**	0.018	mg/l
Threshold Effect Level	**CTT:**	0.012	mg/l

Mass Loads

Mean Event Conc	**MCR:**	**0.0098**	mg/l
Mean Event Mass Load	**M(MASS):**	**0.1327**	pounds
Annual Mass Load	**ANMASS:**	**14.00**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.30
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.000681**	mg/l
Total Exceedence Conc.	**TCO:**	**0.000681**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0.037846
Target Chronic Conc. Ratio	**CRTE:**	0.05677
Target Total Conc. Ratio	**TCRAT:**	0.037846
Target Chronic Total Conc. Ratio	**TCRTE:**	0.05677

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.000477**	mg/l
Total Exceedence Conc.	**TCO:**	**0.000477**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0.026493
Target Chronic Conc. Ratio	**CRTE:**	0.039739
Target Total Conc. Ratio	**TCRAT:**	0.026493
Target Chronic Total Conc. Ratio	**TCRTE:**	0.039739

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**0.0069**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**0.0929**	pounds
Annual Mass Load	**R-ANMASS:**	**9.80**	pounds/year

PROJECT No.: URSX-00000046
PROJECT NAME: Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek
DATE: 02/01/10
SHEET: 13

Pollutant Analysis

Pollutant for Analysis: **Dissolved Lead**

Site median Concentration	**TCR:**	0	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	1.00	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**	0.082	mg/l
Threshold Effect Level	**CTT:**	0.0032	mg/l

Mass Loads

Mean Event Conc	**MCR:**	**0.0000**	mg/l
Mean Event Mass Load	**M(MASS):**	**0.0000**	pounds
Annual Mass Load	**ANMASS:**	**0.00**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.00
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0**	mg/l
Total Exceedence Conc.	**TCO:**	**0**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0
Target Chronic Conc. Ratio	**CRTE:**	0
Target Total Conc. Ratio	**TCRAT:**	0
Target Chronic Total Conc. Ratio	**TCRTE:**	0

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0**	mg/l
Total Exceedence Conc.	**TCO:**	**0**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0
Target Chronic Conc. Ratio	**CRTE:**	0
Target Total Conc. Ratio	**TCRAT:**	0
Target Chronic Total Conc. Ratio	**TCRTE:**	0

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**0.0000**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**0.0000**	pounds
Annual Mass Load	**R-ANMASS:**	**0.00**	pounds/year

PROJECT No.: **URSX-00000046**
PROJECT NAME: **Lake Oswego to Portland Transit Project - Proposed Streetcar - Stephens Creek**
DATE: **02/01/10**
SHEET: **14**

Pollutant Analysis

Pollutant for Analysis: **Dissolved Zinc**

Site median Concentration	**TCR:**	0.060	mg/l
CV for Median Concentration	**CVCR:**	0.71	
Soluble Fraction	**FSOL:**	1.00	

Receiving Water

Total Hardness	**TH:**	100	mg/l
EPA Acute Criterion	**CTA:**	0.12	mg/l
Threshold Effect Level	**CTT:**	0.110	mg/l

Mass Loads

Mean Event Conc	**MCR:**	**0.0736**	mg/l
Mean Event Mass Load	**M(MASS):**	**0.9950**	pounds
Annual Mass Load	**ANMASS:**	**105.02**	pounds/year
Stream Conc. Unit Exceedence	**CU:**	0.085	

Pollutant Reduction

Soluble Fraction Reduction	**R-CO:**	0.30
TSS Reduction	**R-TCO:**	0.70

Untreated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.005109**	mg/l
Total Exceedence Conc.	**TCO:**	**0.005109**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0.0425773
Target Chronic Conc. Ratio	**CRTE:**	0.0464479
Target Total Conc. Ratio	**TCRAT:**	0.0425773
Target Chronic Total Conc. Ratio	**TCRTE:**	0.0464479

Treated Stream Concentrations

Soluble Exceedence Conc.	**CO:**	**0.003576**	mg/l
Total Exceedence Conc.	**TCO:**	**0.003576**	mg/l

Target Soluble Conc. Ratio	**CRAT:**	0.0298041
Target Chronic Conc. Ratio	**CRTE:**	0.0325136
Target Total Conc. Ratio	**TCRAT:**	0.0298041
Target Chronic Total Conc. Ratio	**TCRTE:**	0.0325136

Treated Mass Loadings

Mean Event Conc	**R-MCR:**	**0.0515**	mg/l
Mean Event Mass Load	**R-M(MASS):**	**0.6965**	pounds
Annual Mass Load	**R-ANMASS:**	**73.51**	pounds/year